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AB Harambe Engineering and Construction

February 2021

## **GEOTECHNICAL INVESTIGATION REPORT**

#### FOR

## THE PROJECT FOR IMPROVEMENT OF WASTE MANGEMENT IN JUBA, THE REPUBLIC OF SOUTH SUDAN

#### PREPARED BY

## AB HARAMBE ENGINEERING AND CONSTRUCTION LTD



## FOR: Yachiyo Engineering Co., Ltd. (yec)



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	MINISTRY OF LOCAL GOVERNMENT GOVERMENT OF SOUTH SUDAN						
Geo technical investigation report for the Project for Improvement of Waste Management in Juba, the Republic of South Sudan.							
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#### **AB Harambe Engineering and Construction** 1.0 INTRODUCTION

#### 1.1 Background

Juba is the capital of Republic of South Sudan and serves as the Head quarter of Central Equatorial state. It has spectacular rugged high relief landscape and plains recording an average altitude of 468 meter above sea level. The mountain covers the East, west and north part of Juba forming sharp scenic peaks and wide valley. The project area is situated 400 meters from the **White Nile River plains**.

In November 2020 **AB HARAMBE ENGINEERING AND CONSTRUCTION Ltd** Was contracted by **Yachiyo Engineering Co., Ltd. (yec)** to carry out ground investigation for the proposed development of Building for maintenance of waste collection vehicle in down town Juba. The ground investigations were required to determine Geo technical information including design parameters for the proposed structural foundations and any associated infrastructure. The Geo technical investigations were conducted taking into account BS 5930: 1999 "Code of Practice for Site Investigations".

**AB HARAMBE ENGINEERING AND CONSTRUCTION Ltd** sub contracted a professional Geo technical and Material Engineering firm trading as **Drecomatts Limited** based in Nairobi Kenya, to undertake the laboratory tests and analysis.

The Geotechnical investigations were performed from the 09<sup>the</sup> of November to 19<sup>th</sup> of December 2020 and **4** boreholes were drilled to a maximum depth of 20m and 2 excavated pits to a depth of 2m below ground level. In total, 70 m were drilled & 4 m were excavated, Standard Penetration Tests were performed. Disturbed soil samples were abstracted for each change of layer in each borehole for further laboratory analyses.

The Geotechnical contractor's responsibility under this contract is to carry intrusive sampling, collection of field data, laboratory testing and interpretation of ground conditions encountered during the ground investigation (and any results of the desk study) to aid in the design of the proposed underground structures. AB Harambe Engineering and Construction Ltd personnel are not the designers and are not responsible for validation of any proposed design. The information

#### AB Harambe Engineering and Construction February 2021 provided is however expected to be sufficient for a competent designer to undertake the design of all relevant parts of the structures.

#### 1.2 Objective

The purpose of this report is to investigate and provide reliable, specific and detailed information about the physical, mechanical properties, thickness of the foundation ground, as well as to provide the designer with the necessary information which will be required for a safe and economic design and excavation of the engineering works, such as the soil bearing capacity, recommended foundation depth and type and other special recommendation which depends on the nature of the site .The overall purpose was to evaluate the conditions of the existing soils to generate necessary data for foundation structural design.

#### The specific objectives are to:

- Ascertain the soil profiles at the locations of the proposed substructure (foundation).
- Establish strength (allowable bearing capacities) and classify soils of proposed project area.

#### **1.3 Scope of Geotechnical Investigation**

The scope of the Ggeotechnical investigations comprised of the following:

1. Review of available data pertinent to the site.

2. Making visits to the site in order to collect information about site nature, topography of the site, geological features and other properties concerning the project site.

3. Drilling of Four boreholes (BH) and sampling of disturbed and undisturbed samples. Excavating two inspection trenches (EP) in addition to the above 4 bore holes. Logging of all the boreholes and inspection pits for strata profiling.

4. Performing the necessary field and laboratory tests, and carrying out the geological description of the obtained materials including Logging of all the boreholes and inspection pits for strata profiling;Carrying out Standard Penetration Tests at 1.5m intervals; Registering the ground water occurrence (depth of water table) for each borehole and inspection pit and

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Laboratory testing of disturbed and undisturbed samples for classification properties i.e. particle size distribution and grading curve,Atterberg limit, moisture content, triaxial test and Unconfined Comprehensive strength;

5. Applying engineering analysis of field findings and laboratory results.

6. Developing conclusions and recommendations concerning design and construction of the safest and economical foundations.

#### **1.4 Site Description**

The project is intended for the construction of the new workshop building which is to maintain the condition of waste collection vehicle at Juba Town. The project area is located inside the premises of the Ministry of Local Government opposite Juba prison.

The six test points are located at the following coordinates

BH1: - lcoated at Easting's: 346592.67 and Northings: 536232.032) at elevation of 460.124

BH2: - Ilocated at easting: 346226.944 and Northings: 536226.841) at elevation of 460.137

BH3: - located at easting: 346617.885 and Northings: 536232.24) at elevation of 460.360

BH4: - llocated at easting: 346634.756 and Northings: 536218.853) at elevation of 460.130

EP1: - llocated at easting: 346605.475 and Northings: 536231893) at elevation of 460.130

EP2: - Ilocated at easting: 346638.406 and Northings: 536214.336) at elevation of 459.760

The site location map/view is depicted in Figure 1 and Figure 2 below.

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Figure 1: Map of The Project Site of the Republic of South Sudan



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Figure 2: Map of Juba City





Figure 3: Topographic Map of the proposed site

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Figure 4: Site location map of the boreholes (BH) and Excavation pits (EP)

#### 1.5 Geology

The geological maps (e.g. **Figure 4**) indicate the site is underlain by a metamorphic complex which forms basement complex intruded by granitic and dolerite rocks. The basement is overlain by alluvial and surficial deposits. The geophysical study that was done by University f Juba, Geology & Mining College of Natural Resources and Environmental Studies reveals the basement complex comprises of four types of Gneiss i.e. 1) banded Gneiss, 2) Biotitic gneiss, 3) augend gneiss and 4) Nile gneiss.

1) The Banded Gneiss has clear bands which are light Grey on fresh surface and light brown on weathered surface. They are composed principally of quartz, feldspar mica and pyroxenes with

**AB Harambe Engineering and Construction** subordinate amphiboles. They are high grade metamorphic rock that occurs as parent rock hosting many intrusions such as granitic, plutons and dykes. Foliations and quartz veins are highly visible. The texture is medium to coarse grained.

2) Biotitic Gneisshey looks Grey on the fresh surface and dark on weathered surface. It is composed of Biotitic, amphiboles, hornblende, quartz, feldspar and it has a coarse-grained texture.

3) Amgen Gneiss they form very large exposure associated with quartz-Feld spathic with some which are wholly porphyroblastic. The main constituents of Augend are the quartz, feldspar or amphiboles. Weathered surface of this Amgen gneiss is greyish to brownish and fresh surface is light Grey.

4) Nile gneisses are composed principally of gneisses of amphibolite facies with subordinate meta-sediments and amphibolite. Foliations trends are poorly defined but generally in Northerly direction.

Site geology: The site falls in a pre-cabrian shield underlain by metamorphic rock composed dominantly of Gneisses and granitic rocks that are medium to high grade metamorphic deformed during end pre-cabrian Pan African organic even. The rocks are generally hard and impermeable and occurs at shallow depths (2.5 to 10m) mainly underlain by predominantly alluvial cays and silts with some particles of sand and gravel. The depth of groundwater in Juba remain constant at 1.5-2m during the drilling period. The water level was take about 10-35 days on completion of drilling exercise and after heavy rains had hit the area. This water table will vary during the rainy season and it might disappear completely during the dry season yet it's the longest.

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BASELINE MAPPING OF JUBA TOWN - SOUTHERN SUDAN Q2 te 9 USAID A B I 

Figure 5: Baseline map of Juba City

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Figure 6: Geological map of Republic of South Sudan

#### 2.0 GEOTECHNICAL INVESTIGATION

#### **2.1 Introduction**

All exploratory activities were conducted in accordance with BS 5930: 1990 "Code of Practice for Site Investigations" and included Excavation of 2 inspection pits and drilling of **4** Boreholes using XY-100 rotary drilling rig, sampling, logging, backfilling of the boreholes, SPT testing and laboratory testing of the recovered samples. Subsequent sections of this report show the details recorded during the investigation. The boreholes field-work summary is presented in **Table 1** 

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below. The exact location of the drilling points is shown on a site drawing attached in **Appendix1**.

#### 2.2 Boring, Sampling and Logging

Each borehole was profiled according to 'A Guide to Practical Geotechnical Engineering in Southern Africa: 1995' and BS 5930:1990, sampled as instructed by the client. The test points were later backfilled. Detailed soil profiles of the exploratory boreholes are presented in **Appendix 3** of this report. The photographic record of the investigation is shown in **Appendix 3** and **Appendix 14**.

BH	BH Elevation(m)		Coordinates		Finished	Drilling	No. of Disturbed	No. of Undisturbed	No. of
No.		Х	Y	Date	Date	Depth (m)	Samples	Samples	SPTs
BH1	460.124	346592.67	536232.032	23-11-20	26-11-20	15.0	5	0	3
BH2	460.137	346226.944	536226.841	16-12-20	20-12-20	15.0	5	0	2
BH3	460.360	346617.885	536232.24	16-11-20	18-11-20	20.0	5	0	4
BH4	460.130	346634.756	536218.853	18-12-20	20-12-20	20.0	5	0	2
EP1	460.130	346602.475	536231.893	15-12-20	15-12-20	2.0	2	0	0
EP2	459.760	346634.756	536218.853	15-12-20	15-12-20	2.0	2	0	0

 Table 1: Borehole Coordinates, Depth Investigated & Position of GWT

#### 2.3 Ground Water Table

Ground water table (GWT) was not recorded during the drilling period but after 9-30 days it was recorded. On BH1 it stood at 2.0m, BH2 at 1.5m, BH3 at 1.3m, BH4 at 1.2, at EP1 at 1.1m and EP2 at 1.4m below ground level.

#### Table 2; -Water level

Location	Water level (m)	Elapsed time (days)	
BH1	2.0	20	
BH2	1.5	30	
BH3	1.3	14	
BH4	1.2	16	
EP1	1.1	10	
EP2	1.4	10	

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#### 2.4 Field Investigation Challenges

Two challenges were encountered in the field, on bore hole one (BH1) the upper layers collapsed on the drilling tool at 15m. The drilling head gear systems and associated jaws holding the spindle rod broke down while trying to remove the stuck tools. Two drillers left work mid-way without notice.

Another challenge was accessing drilling spare parts and experienced Engineering Workshop in Juba. The problem was solved with experts for drilling machine, who was able to get a solution with capability to fabricate the gear systems.

#### 2.5 Standard Penetration Tests (SPT)

Standard Penetration Tests (SPTs) were performed in each borehole at intervals presented in **Table 3** below and comprised of the following:

- Conducted using a 63.5 kg driving hammer falling ("free fall") from a height of 760 mm.
- Driving the standard split-barrel sampler of internal and external diameters 35mm and 50mm respectively to reach a distance of 450 mm into the soil at the bottom of the boring at every 1.5m depth interval.
- Counting the number of blows required to drive the sampler each 150 mm increment of a total of 450 mm penetration. The blow count for the first 150 mm increment was discarded and the sum of the blow counts for the last 300 mm increment was recorded as the SPT 'N' value.

According to Clayton (1993), apart from the soil conditions in which the test is made, the result of the SPT test is influenced by three main groups of factors associated with: drilling or boring technique, SPT test equipment and test procedure. The influence of these factors is considered below.

The measured SPT 'N' values were corrected for the overburden, equipment and borehole to establish the corrected SPT 'N<sub>cor</sub>' values, from which estimated soil design parameters were ascertained and presented in **Appendix 6** of this report. The overburden correction factor for clayey soil is 1.0. The equipment and borehole factor correction factors used are highlighted below.

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- Equipment correction and borehole size correction factors apply.
- The effect of overburden is negligible for cohesive soils, and no overburden correction factor C<sub>N</sub> is required.
- The energy ratio is normalized to 60% of total energy,  $N_{60}$ .
- Corrected SPT 'N' value, N<sub>cor</sub> = N<sub>60</sub> =C<sub>N</sub> C<sub>ER</sub> N. Where, N is measured SPT 'N' value and C<sub>ER</sub> is equipment & borehole correction factor given by:
- $C_{ER} = C_H C_R C_s C_B$ .

Energy ratio correction factors to be applied to SPT value to account for equipment and borehole size (Adapted from Skempton, 1986 and Takimatsu and Seed, 1987). Extracted from "Hand book of Geotechnical investigation and design tables 2nd Edition page 51 table 4.9

To account for Parameter		Correction factor
Hammer – release –	country	
Hammer (C <sub>H</sub> )		
Donut – free fall (To	ombi) – Japan	1.3
Donut – rope and pu	lley – Japan	1.1
Safety – rope and pu	lley – USA	1.0
Donut – free fall (Tr	ip) – Europe,	1.0
China, Australia		
Donut – rope and pu	lley – China	0.8 •
Donut – rope and pu	lley – USA	0.75
Rod length (C <sub>R</sub> )		
>10m		1.0
10m to 6m		0.95
6m to 4m		0.85 •
4m to 3m		0.75 •
Sampler (C <sub>s</sub> )		
Standard		1.0 ●
US sampler without	liners	1.2
Borehole 65m	m – 115mm	1.0
Diameter $(C_B)$ 150	nm	1.05 •
200	nm	1.15

Note: The corrected (Ncor) values of 0.6 was determined between rod lengths of 0-4m while a corrected Ncor value of 0.68 was used between 6-4m.

#### 2.5.1 Bearing Capacity Determination

The corrected SPT 'N' values ( $N_{cor}$ ) in **Table 3** were averaged for the entire depth investigated from the borehole logs, the borehole soils are generally Sands in nature, mixed with significant amounts of gravel; silts were also present. For the purpose of computing the soils' bearing

**AB Harambe Engineering and Construction** capacities, all soils were considered cohesive soils. Thus the empirical relationship established by Peck et al., (1974) between corrected SPT 'N' values (N<sub>cor</sub>) and unconfined compressive strength  $(q_u)$  holds and is given below.

$$q_u = kN_{cor} kPa$$

Where, k is the proportionality factor established from empirical correlations between the unconfined compressive strength (qu) and the corrected SPT 'N' values (N<sub>cor</sub>)

A value of k = 12 has been recommended by Bowles (1996) for a standard energy ratio,  $R_{es} =$ 70%. However, based on the 60% standard energy ratio adopted in United Kingdom, a value of k= 13.27 has been recommended and was used in the computation of the unconfined compressive strength. Thereafter the undrained cohesion (cu) was obtained from the unconfined compressive strength  $(q_u)$  as,

$$c_u = q_u/2 \ kPa$$

The ultimate bearing capacity  $(q_{ult})$  was computed from the relationship,

 $q_{ult} = c_u N_c k P a$ 

Where  $N_c$  is the bearing capacity factor for clay/silt soils

Skempton (1951) gives different bearing capacity factor N<sub>c</sub> for clay soil with respect to depth and foundation width ratio for different shapes of foundations. For purposes of computations, the least bearing capacity factor N<sub>c</sub> of 5.14 was used.

The approximate allowable bearing capacity  $(q_{all})$  in **Table 3** was obtained by dividing the ultimate bearing capacity (qult) by the Factor of Safety (Fs) of 3.0 irrespective of the site conditions.

$$q_{all}=q_{ult}/Fs$$
 where stands for Factor of Safety.

For comparison purposes, Clayton (1993) stated that it is better to always make a rapid, albeit crude estimate of the allowable bearing capacities using more than one method. In this report a quick approximation of the allowable bearing capacities is given by the Terzaghi and Peck (1948) relationship below:

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Where  $q_a$  is in kPa.

The allowable bearing capacities from the two methods were identical as shown in **Table 3**. Detailed results for bearing capacities are shown in **Appendix 6**.

BH No.	Depth (m)	Corrected SPT 'N' Value, (N <sub>1)60</sub>	Unconfined Compressive Strength q <sub>u</sub> (kPa)	Undrained Cohesion C <sub>u</sub> (kPa)	Allowable Bearing Capacity- Terzaghi and Peck (1948) Qall=Ncor (kPa)	Allowable Bearing Capacity Terzaghi and Peck, 1967 Q <sub>all</sub> (kPa)
BH 1	1.5	>30	>390	>195	>300	>341
	3.0	>30	>390	>195	>300	>341
BH 2	1.5	>30	>390	>195	>300	>341
	2.5	>30	>390	>195	>300	>341
	1.5	>30	>390	>195	>300	>341
	3.0	>30	>390	>195	>300	>341
BH 3	4.5	>34	>398	>226	>340	>387
	5.8	>34	>398	>226	>340	>387
	1.5	>30	>390	>195	>300	>341
	3.0	>30	>390	>195	>300	>341
BH 4						

Table 3: A	pproximate /	Allowable	Bearing (	Capacity	from	Corrected	SPT 'N'	Values
	approximate 1	mowable	Dearing v	Capacity	nom	Concelled		varues

#### 2.6 Stratigraphy

The site investigation indicates that the geological sequence at the site generally comprises of mainly clays, silts and sands. **Figure 7** shows drilling logs to a maximum depth of 20m. It shows that ground is very variable across the site.



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**Figure 7: Borehole profiles** 

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#### **3.0 LABORATORY WORK**

Soil samples recovered from the boreholes were tested in accordance with the test standard procedures listed in **Table 4** below.

**Table 4:** Tests on Samples from the Boreholes.

Test Description	International Standard			
1. Disturbed Samples				
In-situ Moisture Content	BS 1377: Part 2, Clause 3:1990			
Particle Size Distribution	BS 1377: Part 2, Sub cl. 9.2: 1990			
Plastic Limit & Plasticity Index	BS 1377: Part 2, Clause 4,5&6:1990			
Specific gravity	BS 1377:Part 2, Clause 8: 1990			
Compaction test	BS 1377 part 4 1990			
2. Undisturbed Samples				
Unconfined Compression	BS 1377:Part 7: 1990			
Consolidation test	BS 1377:Part 51990			
Triaxial Shear Test	BS 1377:Part 7: 1990			
Unconfined compression test-Rock	BS 5930 :Part 7: 2015			

#### 3.1 Borehole Laboratory Test Results

Laboratory tests included index property tests and triaxial compression tests.

#### 3.1.1 Moisture content Test Results

Natural moisture content values ranges from 0.3% to 19.5%. A detailed assessment of the data reveals that moisture contents are low. From visual examination, the water content of the stone fraction alone was found to be negligible. Moisture content results are shown on the summary for classification test results attached in **appendix 7**.

#### **3.1.2** Classification Test Results

Borehole soils were classified according to their particle size distribution (PSD) and Natural moisture test results. The summary of the laboratory results is attached in **appendix 7** of the report.

#### **3.1.3** Particle size distribution

Particle size distribution curves for the formations at the site are shown on **Appendix 8**. Results show that the site is underlain by Sandstone, Gravels, Sands and some silts. This is indicated by majority of the grading curves.

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#### **3.1.4** Atterberg Limit test results.

A paste specimen made from 150 gm thoroughly mixed portion of air dried material passing 425 micron IS sieve is used to determine the Liquid Limit (LL). This is repeated at least to have four sets of values of penetration in the range of 14 to 28 mm. The plastic limit (the moisture at which the specimen changes from liquid state to solid is determined. The difference between the liquid limit and plastic limit is calculated and reported as Plasticity Index (PI).

#### PI=LL-PL

The fine grained portions of the material showed a range of plasticity from PI zero to 8.2% as shown on **Appendix 9**. Majority of the samples tested plotted below the A-line on the plasticity chart. It can therefore be concluded that all the fine grained portion of the materials on site predominantly behave as sand and gravel of vary plasticity.

#### 3.1.5 Triaxial tests

a) Triaxial tests included the Undrained Unconsolidated Triaxial test (UU). UU test was carried out in accordance with BS1377:1975 and ASTM D 2850 standard procedure. The nominal specimen sizes were 38mm diameter by 76mm length. Compression was carried out at a rate of about 1.5 mm/min (2 % per minute). Disturbed soil samples were remoulded to attain a maximum dry density (MDD) of 70-80% and optimum moisture content (OMC). The resultant specimen was subjected to a confining fluid pressure of 0.5, 1.5 and 2.5Kg/cm2 in a triaxial chamber. Visual classification had shown the soils on test points E1 and E2 to be clays silt and hence adapted UU test method. The laboratory gradation and Atterberg tests classified the soils as Sands and hence the adaption of Direct shear test in the later samples. Test results are as summarised in Table 6. Detailed results are attached as Appendix 11.

EP1 (0.0-1.0M)	Cell pressure (kg/cm²) σ3	Deviator stress (kg/cm²) (σ1 - σ3)	Major Princ.stress kg/cm²) σ1
TEST 1	0.5	0.94	1.44
TEST 2	1.5	2.18	3.68
TEST 3	2.5	3.42	5.92

EP2 (0.0-1.0M)	Cell pressure (kg/cm²) σ3	Deviator stress (kg/cm <sup>2</sup> ) (σ1 - σ3)	Major Princ.stress kg/cm²) σ1
TEST 1	0.5	0.97	1.47
TEST 2	1.5	2.01	3.51
TEST 3	2.5	3.15	5.65

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b) **Direct shear test**. The bulk samples (disturbed) were prepared in the same way as UU (above) and applied a load of 1.02, 2.04 and 3.04Kg/cm2 and shear force at failure recorded in the shear box apparatus. The shear parameters were determined from remoulded specimen to attain 70-80% of, MDD/OMC.

Note two (2) compaction tests were carried out to determine the MDD/OMC for the calculation remolded soils.

The number of test trials carried out on each sample is as summarised in **Table 5**. It should be noted that as a result of the nature of the soils at site, in some cases, the quantity of the sample was inadequate to carry out all test. In all cases no undisturbed samples were recovered.

Location	Donth (m)	Number of Test Trials per sample		
Location	Deptn (m)	UU	Direct Shear	
EP1	0.00-1.00	1		
BH1	0.00-1.00		1	
BH2	1.00-1.50		1	
BH3	0.00-1.00		1	
BH4	0.00-1.00		1	
EP2	0.00-1,00	1		

**Table 5:** Summary of Triaxial and shear box tests carried out- (Remoulded specimens).

The full and construction for the feature of the fe					
Specimen diameter = 38mm		Bulk Density (kg/m <sup>3</sup>	Average Moisture Content (%)	Angle of Internal friction	Cohesion (Kg/cm2)
Location	Depth(m)			(degrees).	
EP1	0.0 1.00	2183	9.4	21	0.12
EP2	0.00 - 1.00	1878	19.5	20	0.16
BH1	0.00 - 1.00	1712		27	0.02
BH2	0.00 - 1.00	1680		23	0.12
BH2	1.00 - 2.00	1680		25	0.13
BH3	0.00 - 1.00	1565		26	0.03
BH4	0.00 - 1.00	1580		25	0.09

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**Table 6:** Undrained Unconsolidated triaxial compression and Shear box test results.

Results show the bulk densities for Sands are relatively high ranging between 1565 and 2183kg/m<sup>3</sup>. This is attributed to unsaturated soil conditions at site. The angle of internal friction was generally moderate ranging between 20 to 27°. This is attributed to the fact that the site is underlain by mainly silt sands. The Undrained cohesion was ranging between 0.03 to 0.16 kg/cm2.

Note; In practice undisturbed soil samples (i.e. U100) usually gives reliable results but it was practically impossible to recovered this type of sample) and hence the adoption of remoulded specimens.

#### 3.1.6 Water Table

Occurrence of ground water was monitored in all the Boreholes and water was encountered in all the 6 test points (refer table 2 above).

#### 4 CONCLUSIONS AND RECOMMENDATION

#### 4.1 Conclusion

According to the field exploration, laboratory testing, subsurface conditions and engineering analysis, it can be concluded that the existing ground at the proposed site for Juba City Council Sanitary and Environmental Building is strong enough to support the expected building loads without special modifications and the following recommendations are given:

Ground water table (GWT) was encountered in all the boreholes.

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The site is predominantly underlain by Silky-Reddish brown grey clayey silt Sands and highly weather gravelly, Salty Sand.

The drilling logs and bearing capacity results show that the ground is marginally/minimal variable both in the lateral and vertical direction. The consistency for cohesive soils varies from firm to very stiff and that for cohesion less soils varies from dense to very dense.

The soils have a moisture content ranging from 5.6% - 19.5% and the plasticity index is deduced as Non Plastic with LL ranging from from 28.5% to 45.5% which indicates sands/silts of low to none to plasticity tendency.

Less than twenty percent of the soil particles passed sieve 75mm which confirms that the type of soils found in Juba town predominantly silts and sands.

The bearing capacities computed using the two empirical relationships are fairly identical. Estimates of allowable bearing capacities derived from corrected SPT 'N' values vary from each borehole location. There is no direct correlation of the magnitude of SPT N-values with depth especially due to changes in the type of material encountered. In all cases refusal(N-Value>50 was attained at1.5m below ground level giving, allowable bearing capacity of greater than 334Kpa.Abearing capacity of 350 can be adopted for this site.

The soil has angle of internal friction in the range between  $20^{\circ} 23^{\circ}$ . The cohesion is in the range between 0.03-0.16 kg/cm and the unconfined compressive strength of underlying weathered rock between 13 to 53N/mm2. The soils at the site are well draining but the rock is impervious.

#### 4.2 Recommendations

1. Depending on the applied stresses from the structures intended to be placed, suitable founding depths should be chosen in such a way that the total net foundation pressure is less than the allowable bearing capacity.

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- 2. Foundation ground; -Based on our findings and analyses of the encountered material, it is recommended that the foundations of the proposed building be laid on moderately weathered Gneiss rock.
- 3. Foundation depth; Found at 1.5m across the site.
- 4. Type of foundation; Pad type of foundation is recommended (The Engineer to use his preferred type of foundation).
- 5. Riperbility and method of excavation; The congenital excavation equipment such as Loaders and Dozers will be needed for excavation works.
- 6. Surface run off; It is recommended to protect the foundation ground and excavation from surface water both during and after construction by providing proper drainage and protection system. Surface water, if existed, should be diverted away from the edges of the excavations.
- 7. All excavations should be supervised by a competent person.

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# 資料8 車両整備ワークショップ建設予定地 地盤・地質調査結果

AB Harambe Engineering and Construction

February 2021

## **GEOTECHNICAL INVESTIGATION REPORT**

#### FOR

## THE PROJECT FOR IMPROVEMENT OF WASTE MANGEMENT IN JUBA, THE REPUBLIC OF SOUTH SUDAN

#### PREPARED BY

## AB HARAMBE ENGINEERING AND CONSTRUCTION LTD



## FOR: Yachiyo Engineering Co., Ltd. (yec)



**AB Harambe Engineering and Construction** 

	MINISTRY OF LOCAL GOVERNMENT GOVERMENT OF SOUTH SUDAN					
Geo technical investigation report for the Project for Improvement of Waste Management in Juba, the Republic of South Sudan.						
D. 1.1	C. ( ) . 10/11/00	20.4.20/12/2020				
Period	of study: 12/11/20	J20 to 20/12/2020				
0	15th,February, 2021	ABHEC	ABHEC		149	First submission
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DRECO-MATTS Drilling, Engineering & Construction Technical Support		Laboratory Cor	ntractor: LIMITED			

#### **AB Harambe Engineering and Construction**

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#### **AB Harambe Engineering and Construction** 1.0 INTRODUCTION

#### 1.1 Background

Juba is the capital of Republic of South Sudan and serves as the Head quarter of Central Equatorial state. It has spectacular rugged high relief landscape and plains recording an average altitude of 468 meter above sea level. The mountain covers the East, west and north part of Juba forming sharp scenic peaks and wide valley. The project area is situated 400 meters from the **White Nile River plains**.

In November 2020 **AB HARAMBE ENGINEERING AND CONSTRUCTION Ltd** Was contracted by **Yachiyo Engineering Co., Ltd. (yec)** to carry out ground investigation for the proposed development of Building for maintenance of waste collection vehicle in down town Juba. The ground investigations were required to determine Geo technical information including design parameters for the proposed structural foundations and any associated infrastructure. The Geo technical investigations were conducted taking into account BS 5930: 1999 "Code of Practice for Site Investigations".

**AB HARAMBE ENGINEERING AND CONSTRUCTION Ltd** sub contracted a professional Geo technical and Material Engineering firm trading as **Drecomatts Limited** based in Nairobi Kenya, to undertake the laboratory tests and analysis.

The Geotechnical investigations were performed from the 09<sup>the</sup> of November to 19<sup>th</sup> of December 2020 and **4** boreholes were drilled to a maximum depth of 20m and 2 excavated pits to a depth of 2m below ground level. In total, 70 m were drilled & 4 m were excavated, Standard Penetration Tests were performed. Disturbed soil samples were abstracted for each change of layer in each borehole for further laboratory analyses.

The Geotechnical contractor's responsibility under this contract is to carry intrusive sampling, collection of field data, laboratory testing and interpretation of ground conditions encountered during the ground investigation (and any results of the desk study) to aid in the design of the proposed underground structures. AB Harambe Engineering and Construction Ltd personnel are not the designers and are not responsible for validation of any proposed design. The information

#### AB Harambe Engineering and Construction February 2021 provided is however expected to be sufficient for a competent designer to undertake the design of all relevant parts of the structures.

#### 1.2 Objective

The purpose of this report is to investigate and provide reliable, specific and detailed information about the physical, mechanical properties, thickness of the foundation ground, as well as to provide the designer with the necessary information which will be required for a safe and economic design and excavation of the engineering works, such as the soil bearing capacity, recommended foundation depth and type and other special recommendation which depends on the nature of the site .The overall purpose was to evaluate the conditions of the existing soils to generate necessary data for foundation structural design.

#### The specific objectives are to:

- Ascertain the soil profiles at the locations of the proposed substructure (foundation).
- Establish strength (allowable bearing capacities) and classify soils of proposed project area.

#### **1.3 Scope of Geotechnical Investigation**

The scope of the Ggeotechnical investigations comprised of the following:

1. Review of available data pertinent to the site.

2. Making visits to the site in order to collect information about site nature, topography of the site, geological features and other properties concerning the project site.

3. Drilling of Four boreholes (BH) and sampling of disturbed and undisturbed samples. Excavating two inspection trenches (EP) in addition to the above 4 bore holes. Logging of all the boreholes and inspection pits for strata profiling.

4. Performing the necessary field and laboratory tests, and carrying out the geological description of the obtained materials including Logging of all the boreholes and inspection pits for strata profiling;Carrying out Standard Penetration Tests at 1.5m intervals; Registering the ground water occurrence (depth of water table) for each borehole and inspection pit and

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Laboratory testing of disturbed and undisturbed samples for classification properties i.e. particle size distribution and grading curve,Atterberg limit, moisture content, triaxial test and Unconfined Comprehensive strength;

5. Applying engineering analysis of field findings and laboratory results.

6. Developing conclusions and recommendations concerning design and construction of the safest and economical foundations.

#### **1.4 Site Description**

The project is intended for the construction of the new workshop building which is to maintain the condition of waste collection vehicle at Juba Town. The project area is located inside the premises of the Ministry of Local Government opposite Juba prison.

The six test points are located at the following coordinates

BH1: - lcoated at Easting's: 346592.67 and Northings: 536232.032) at elevation of 460.124

BH2: - Ilocated at easting: 346226.944 and Northings: 536226.841) at elevation of 460.137

BH3: - located at easting: 346617.885 and Northings: 536232.24) at elevation of 460.360

BH4: - llocated at easting: 346634.756 and Northings: 536218.853) at elevation of 460.130

EP1: - llocated at easting: 346605.475 and Northings: 536231893) at elevation of 460.130

EP2: - Ilocated at easting: 346638.406 and Northings: 536214.336) at elevation of 459.760

The site location map/view is depicted in Figure 1 and Figure 2 below.
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Figure 1: Map of The Project Site of the Republic of South Sudan



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Figure 2: Map of Juba City





Figure 3: Topographic Map of the proposed site

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Figure 4: Site location map of the boreholes (BH) and Excavation pits (EP)

#### 1.5 Geology

The geological maps (e.g. **Figure 4**) indicate the site is underlain by a metamorphic complex which forms basement complex intruded by granitic and dolerite rocks. The basement is overlain by alluvial and surficial deposits. The geophysical study that was done by University f Juba, Geology & Mining College of Natural Resources and Environmental Studies reveals the basement complex comprises of four types of Gneiss i.e. 1) banded Gneiss, 2) Biotitic gneiss, 3) augend gneiss and 4) Nile gneiss.

1) The Banded Gneiss has clear bands which are light Grey on fresh surface and light brown on weathered surface. They are composed principally of quartz, feldspar mica and pyroxenes with

**AB Harambe Engineering and Construction** subordinate amphiboles. They are high grade metamorphic rock that occurs as parent rock hosting many intrusions such as granitic, plutons and dykes. Foliations and quartz veins are highly visible. The texture is medium to coarse grained.

2) Biotitic Gneisshey looks Grey on the fresh surface and dark on weathered surface. It is composed of Biotitic, amphiboles, hornblende, quartz, feldspar and it has a coarse-grained texture.

3) Amgen Gneiss they form very large exposure associated with quartz-Feld spathic with some which are wholly porphyroblastic. The main constituents of Augend are the quartz, feldspar or amphiboles. Weathered surface of this Amgen gneiss is greyish to brownish and fresh surface is light Grey.

4) Nile gneisses are composed principally of gneisses of amphibolite facies with subordinate meta-sediments and amphibolite. Foliations trends are poorly defined but generally in Northerly direction.

Site geology: The site falls in a pre-cabrian shield underlain by metamorphic rock composed dominantly of Gneisses and granitic rocks that are medium to high grade metamorphic deformed during end pre-cabrian Pan African organic even. The rocks are generally hard and impermeable and occurs at shallow depths (2.5 to 10m) mainly underlain by predominantly alluvial cays and silts with some particles of sand and gravel. The depth of groundwater in Juba remain constant at 1.5-2m during the drilling period. The water level was take about 10-35 days on completion of drilling exercise and after heavy rains had hit the area. This water table will vary during the rainy season and it might disappear completely during the dry season yet it's the longest.

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BASELINE MAPPING OF JUBA TOWN - SOUTHERN SUDAN Q2 te 9 USAID A B I 

Figure 5: Baseline map of Juba City

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Figure 6: Geological map of Republic of South Sudan

#### 2.0 GEOTECHNICAL INVESTIGATION

#### **2.1 Introduction**

All exploratory activities were conducted in accordance with BS 5930: 1990 "Code of Practice for Site Investigations" and included Excavation of 2 inspection pits and drilling of **4** Boreholes using XY-100 rotary drilling rig, sampling, logging, backfilling of the boreholes, SPT testing and laboratory testing of the recovered samples. Subsequent sections of this report show the details recorded during the investigation. The boreholes field-work summary is presented in **Table 1** 

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below. The exact location of the drilling points is shown on a site drawing attached in **Appendix1**.

#### 2.2 Boring, Sampling and Logging

Each borehole was profiled according to 'A Guide to Practical Geotechnical Engineering in Southern Africa: 1995' and BS 5930:1990, sampled as instructed by the client. The test points were later backfilled. Detailed soil profiles of the exploratory boreholes are presented in **Appendix 3** of this report. The photographic record of the investigation is shown in **Appendix 3** and **Appendix 14**.

BH	Elevation(m)	Coordinates		Started	Finished	Drilling	No. of Disturbed	No. of Undisturbed	No. of
No.		Х	Y	Date	Date	Depth (m)	Samples	Samples	SPTs
BH1	460.124	346592.67	536232.032	23-11-20	26-11-20	15.0	5	0	3
BH2	460.137	346226.944	536226.841	16-12-20	20-12-20	15.0	5	0	2
BH3	460.360	346617.885	536232.24	16-11-20	18-11-20	20.0	5	0	4
BH4	460.130	346634.756	536218.853	18-12-20	20-12-20	20.0	5	0	2
EP1	460.130	346602.475	536231.893	15-12-20	15-12-20	2.0	2	0	0
EP2	459.760	346634.756	536218.853	15-12-20	15-12-20	2.0	2	0	0

 Table 1: Borehole Coordinates, Depth Investigated & Position of GWT

#### 2.3 Ground Water Table

Ground water table (GWT) was not recorded during the drilling period but after 9-30 days it was recorded. On BH1 it stood at 2.0m, BH2 at 1.5m, BH3 at 1.3m, BH4 at 1.2, at EP1 at 1.1m and EP2 at 1.4m below ground level.

#### Table 2; -Water level

Location	Water level (m)	Elapsed time (days)	
BH1	2.0	20	
BH2	1.5	30	
BH3	1.3	14	
BH4	1.2	16	
EP1	1.1	10	
EP2	1.4	10	

#### 2.4 Field Investigation Challenges

Two challenges were encountered in the field, on bore hole one (BH1) the upper layers collapsed on the drilling tool at 15m. The drilling head gear systems and associated jaws holding the spindle rod broke down while trying to remove the stuck tools. Two drillers left work mid-way without notice.

Another challenge was accessing drilling spare parts and experienced Engineering Workshop in Juba. The problem was solved with experts for drilling machine, who was able to get a solution with capability to fabricate the gear systems.

#### 2.5 Standard Penetration Tests (SPT)

Standard Penetration Tests (SPTs) were performed in each borehole at intervals presented in **Table 3** below and comprised of the following:

- Conducted using a 63.5 kg driving hammer falling ("free fall") from a height of 760 mm.
- Driving the standard split-barrel sampler of internal and external diameters 35mm and 50mm respectively to reach a distance of 450 mm into the soil at the bottom of the boring at every 1.5m depth interval.
- Counting the number of blows required to drive the sampler each 150 mm increment of a total of 450 mm penetration. The blow count for the first 150 mm increment was discarded and the sum of the blow counts for the last 300 mm increment was recorded as the SPT 'N' value.

According to Clayton (1993), apart from the soil conditions in which the test is made, the result of the SPT test is influenced by three main groups of factors associated with: drilling or boring technique, SPT test equipment and test procedure. The influence of these factors is considered below.

The measured SPT 'N' values were corrected for the overburden, equipment and borehole to establish the corrected SPT 'N<sub>cor</sub>' values, from which estimated soil design parameters were ascertained and presented in **Appendix 6** of this report. The overburden correction factor for clayey soil is 1.0. The equipment and borehole factor correction factors used are highlighted below.

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- Equipment correction and borehole size correction factors apply.
- The effect of overburden is negligible for cohesive soils, and no overburden correction factor C<sub>N</sub> is required.
- The energy ratio is normalized to 60% of total energy,  $N_{60}$ .
- Corrected SPT 'N' value, N<sub>cor</sub> = N<sub>60</sub> =C<sub>N</sub> C<sub>ER</sub> N. Where, N is measured SPT 'N' value and C<sub>ER</sub> is equipment & borehole correction factor given by:
- $C_{ER} = C_H C_R C_s C_B$ .

Energy ratio correction factors to be applied to SPT value to account for equipment and borehole size (Adapted from Skempton, 1986 and Takimatsu and Seed, 1987). Extracted from "Hand book of Geotechnical investigation and design tables 2nd Edition page 51 table 4.9

To account for	Parameter	Correction factor
Hammer – release –	country	
Hammer (C <sub>H</sub> )		
Donut – free fall (To	ombi) – Japan	1.3
Donut – rope and pu	lley – Japan	1.1
Safety – rope and pu	lley – USA	1.0
Donut – free fall (Tr	ip) – Europe,	1.0
China, Australia		
Donut – rope and pu	lley – China	0.8 •
Donut – rope and pu	lley – USA	0.75
Rod length (C <sub>R</sub> )		
>10m		1.0
10m to 6m		0.95
6m to 4m		0.85 •
4m to 3m		0.75 •
Sampler (C <sub>s</sub> )		
Standard		1.0 ●
US sampler without	liners	1.2
Borehole 65m	m – 115mm	1.0
Diameter $(C_B)$ 150	nm	1.05 •
200	nm	1.15

Note: The corrected (Ncor) values of 0.6 was determined between rod lengths of 0-4m while a corrected Ncor value of 0.68 was used between 6-4m.

#### 2.5.1 Bearing Capacity Determination

The corrected SPT 'N' values ( $N_{cor}$ ) in **Table 3** were averaged for the entire depth investigated from the borehole logs, the borehole soils are generally Sands in nature, mixed with significant amounts of gravel; silts were also present. For the purpose of computing the soils' bearing

**AB Harambe Engineering and Construction** capacities, all soils were considered cohesive soils. Thus the empirical relationship established by Peck et al., (1974) between corrected SPT 'N' values (N<sub>cor</sub>) and unconfined compressive strength  $(q_u)$  holds and is given below.

$$q_u = kN_{cor} kPa$$

Where, k is the proportionality factor established from empirical correlations between the unconfined compressive strength (qu) and the corrected SPT 'N' values (N<sub>cor</sub>)

A value of k = 12 has been recommended by Bowles (1996) for a standard energy ratio,  $R_{es} =$ 70%. However, based on the 60% standard energy ratio adopted in United Kingdom, a value of k= 13.27 has been recommended and was used in the computation of the unconfined compressive strength. Thereafter the undrained cohesion (cu) was obtained from the unconfined compressive strength  $(q_u)$  as,

$$c_u = q_u/2 \ kPa$$

The ultimate bearing capacity  $(q_{ult})$  was computed from the relationship,

 $q_{ult} = c_u N_c k P a$ 

Where  $N_c$  is the bearing capacity factor for clay/silt soils

Skempton (1951) gives different bearing capacity factor N<sub>c</sub> for clay soil with respect to depth and foundation width ratio for different shapes of foundations. For purposes of computations, the least bearing capacity factor N<sub>c</sub> of 5.14 was used.

The approximate allowable bearing capacity  $(q_{all})$  in **Table 3** was obtained by dividing the ultimate bearing capacity (qult) by the Factor of Safety (Fs) of 3.0 irrespective of the site conditions.

$$q_{all}=q_{ult}/Fs$$
 where stands for Factor of Safety.

For comparison purposes, Clayton (1993) stated that it is better to always make a rapid, albeit crude estimate of the allowable bearing capacities using more than one method. In this report a quick approximation of the allowable bearing capacities is given by the Terzaghi and Peck (1948) relationship below:

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Where  $q_a$  is in kPa.

The allowable bearing capacities from the two methods were identical as shown in **Table 3**. Detailed results for bearing capacities are shown in **Appendix 6**.

BH No.	Depth (m)	Corrected SPT 'N' Value, (N <sub>1)60</sub>	Unconfined Compressive Strength q <sub>u</sub> (kPa)	Undrained Cohesion C <sub>u</sub> (kPa)	Allowable Bearing Capacity- Terzaghi and Peck (1948) Qall=Ncor (kPa)	Allowable Bearing Capacity Terzaghi and Peck, 1967 Q <sub>all</sub> (kPa)
BH 1	1.5	>30	>390	>195	>300	>341
	3.0	>30	>390	>195	>300	>341
BH 2	1.5	>30	>390	>195	>300	>341
	2.5	>30	>390	>195	>300	>341
	1.5	>30	>390	>195	>300	>341
	3.0	>30	>390	>195	>300	>341
BH 3	4.5	>34	>398	>226	>340	>387
	5.8	>34	>398	>226	>340	>387
	1.5	>30	>390	>195	>300	>341
	3.0	>30	>390	>195	>300	>341
BH 4						

Table 3: A	pproximate /	Allowable	Bearing (	Capacity	from	Corrected	SPT 'N'	Values
	approximate 1	mowable	Dearing v	Capacity	nom	Concelled		varues

#### 2.6 Stratigraphy

The site investigation indicates that the geological sequence at the site generally comprises of mainly clays, silts and sands. **Figure 7** shows drilling logs to a maximum depth of 20m. It shows that ground is very variable across the site.



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**Figure 7: Borehole profiles** 

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#### **3.0 LABORATORY WORK**

Soil samples recovered from the boreholes were tested in accordance with the test standard procedures listed in **Table 4** below.

**Table 4:** Tests on Samples from the Boreholes.

Test Description	International Standard						
1. Disturbed Samples							
In-situ Moisture Content	BS 1377: Part 2, Clause 3:1990						
Particle Size Distribution	BS 1377: Part 2, Sub cl. 9.2: 1990						
Plastic Limit & Plasticity Index	BS 1377: Part 2, Clause 4,5&6:1990						
Specific gravity	BS 1377:Part 2, Clause 8: 1990						
Compaction test	BS 1377 part 4 1990						
2. Undisturbed Samples							
Unconfined Compression	BS 1377:Part 7: 1990						
Consolidation test	BS 1377:Part 51990						
Triaxial Shear Test	BS 1377:Part 7: 1990						
Unconfined compression test-Rock	BS 5930 :Part 7: 2015						

#### 3.1 Borehole Laboratory Test Results

Laboratory tests included index property tests and triaxial compression tests.

#### 3.1.1 Moisture content Test Results

Natural moisture content values ranges from 0.3% to 19.5%. A detailed assessment of the data reveals that moisture contents are low. From visual examination, the water content of the stone fraction alone was found to be negligible. Moisture content results are shown on the summary for classification test results attached in **appendix 7**.

#### **3.1.2** Classification Test Results

Borehole soils were classified according to their particle size distribution (PSD) and Natural moisture test results. The summary of the laboratory results is attached in **appendix 7** of the report.

#### **3.1.3** Particle size distribution

Particle size distribution curves for the formations at the site are shown on **Appendix 8**. Results show that the site is underlain by Sandstone, Gravels, Sands and some silts. This is indicated by majority of the grading curves.

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#### **3.1.4** Atterberg Limit test results.

A paste specimen made from 150 gm thoroughly mixed portion of air dried material passing 425 micron IS sieve is used to determine the Liquid Limit (LL). This is repeated at least to have four sets of values of penetration in the range of 14 to 28 mm. The plastic limit (the moisture at which the specimen changes from liquid state to solid is determined. The difference between the liquid limit and plastic limit is calculated and reported as Plasticity Index (PI).

#### PI=LL-PL

The fine grained portions of the material showed a range of plasticity from PI zero to 8.2% as shown on **Appendix 9**. Majority of the samples tested plotted below the A-line on the plasticity chart. It can therefore be concluded that all the fine grained portion of the materials on site predominantly behave as sand and gravel of vary plasticity.

#### 3.1.5 Triaxial tests

a) Triaxial tests included the Undrained Unconsolidated Triaxial test (UU). UU test was carried out in accordance with BS1377:1975 and ASTM D 2850 standard procedure. The nominal specimen sizes were 38mm diameter by 76mm length. Compression was carried out at a rate of about 1.5 mm/min (2 % per minute). Disturbed soil samples were remoulded to attain a maximum dry density (MDD) of 70-80% and optimum moisture content (OMC). The resultant specimen was subjected to a confining fluid pressure of 0.5, 1.5 and 2.5Kg/cm2 in a triaxial chamber. Visual classification had shown the soils on test points E1 and E2 to be clays silt and hence adapted UU test method. The laboratory gradation and Atterberg tests classified the soils as Sands and hence the adaption of Direct shear test in the later samples. Test results are as summarised in Table 6. Detailed results are attached as Appendix 11.

EP1 (0.0-1.0M)	Cell pressure (kg/cm²) σ3	Deviator stress (kg/cm²) (σ1 - σ3)	Major Princ.stress kg/cm²) σ1				
TEST 1	0.5	0.94	1.44				
TEST 2	1.5	2.18	3.68				
TEST 3	2.5	3.42	5.92				

EP2 (0.0-1.0M)	Cell pressure (kg/cm²) σ3	Deviator stress (kg/cm <sup>2</sup> ) (σ1 - σ3)	Major Princ.stress kg/cm²) σ1
TEST 1	0.5	0.97	1.47
TEST 2	1.5	2.01	3.51
TEST 3	2.5	3.15	5.65

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b) **Direct shear test**. The bulk samples (disturbed) were prepared in the same way as UU (above) and applied a load of 1.02, 2.04 and 3.04Kg/cm2 and shear force at failure recorded in the shear box apparatus. The shear parameters were determined from remoulded specimen to attain 70-80% of, MDD/OMC.

Note two (2) compaction tests were carried out to determine the MDD/OMC for the calculation remolded soils.

The number of test trials carried out on each sample is as summarised in **Table 5**. It should be noted that as a result of the nature of the soils at site, in some cases, the quantity of the sample was inadequate to carry out all test. In all cases no undisturbed samples were recovered.

Location	Donth (m)	Number of Test Trials per sample						
Location	Deptn (m)	UU	Direct Shear					
EP1	0.00-1.00	1						
BH1	0.00-1.00		1					
BH2	1.00-1.50		1					
BH3	0.00-1.00		1					
BH4	0.00-1.00		1					
EP2	0.00-1,00	1						

**Table 5:** Summary of Triaxial and shear box tests carried out- (Remoulded specimens).

Specimen diam	neter = 38mm	Bulk Density (kg/m <sup>3</sup>	Average Moisture Content (%)	Angle of Internal friction	Cohesion (Kg/cm2)					
Location	Depth(m)			(degrees).						
EP1	0.0 1.00	2183	9.4	21	0.12					
EP2	0.00 - 1.00	1878	19.5	20	0.16					
BH1	0.00 - 1.00	1712		27	0.02					
BH2	0.00 - 1.00	1680		23	0.12					
BH2	1.00 - 2.00	1680		25	0.13					
BH3	0.00 - 1.00	1565		26	0.03					
BH4	0.00 - 1.00	1580		25	0.09					

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**Table 6:** Undrained Unconsolidated triaxial compression and Shear box test results.

Results show the bulk densities for Sands are relatively high ranging between 1565 and 2183kg/m<sup>3</sup>. This is attributed to unsaturated soil conditions at site. The angle of internal friction was generally moderate ranging between 20 to 27°. This is attributed to the fact that the site is underlain by mainly silt sands. The Undrained cohesion was ranging between 0.03 to 0.16 kg/cm2.

Note; In practice undisturbed soil samples (i.e. U100) usually gives reliable results but it was practically impossible to recovered this type of sample) and hence the adoption of remoulded specimens.

#### 3.1.6 Water Table

Occurrence of ground water was monitored in all the Boreholes and water was encountered in all the 6 test points (refer table 2 above).

#### 4 CONCLUSIONS AND RECOMMENDATION

#### 4.1 Conclusion

According to the field exploration, laboratory testing, subsurface conditions and engineering analysis, it can be concluded that the existing ground at the proposed site for Juba City Council Sanitary and Environmental Building is strong enough to support the expected building loads without special modifications and the following recommendations are given:

Ground water table (GWT) was encountered in all the boreholes.

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The site is predominantly underlain by Silky-Reddish brown grey clayey silt Sands and highly weather gravelly, Salty Sand.

The drilling logs and bearing capacity results show that the ground is marginally/minimal variable both in the lateral and vertical direction. The consistency for cohesive soils varies from firm to very stiff and that for cohesion less soils varies from dense to very dense.

The soils have a moisture content ranging from 5.6% - 19.5% and the plasticity index is deduced as Non Plastic with LL ranging from from 28.5% to 45.5% which indicates sands/silts of low to none to plasticity tendency.

Less than twenty percent of the soil particles passed sieve 75mm which confirms that the type of soils found in Juba town predominantly silts and sands.

The bearing capacities computed using the two empirical relationships are fairly identical. Estimates of allowable bearing capacities derived from corrected SPT 'N' values vary from each borehole location. There is no direct correlation of the magnitude of SPT N-values with depth especially due to changes in the type of material encountered. In all cases refusal(N-Value>50 was attained at1.5m below ground level giving, allowable bearing capacity of greater than 334Kpa.Abearing capacity of 350 can be adopted for this site.

The soil has angle of internal friction in the range between  $20^{\circ} 23^{\circ}$ . The cohesion is in the range between 0.03-0.16 kg/cm and the unconfined compressive strength of underlying weathered rock between 13 to 53N/mm2. The soils at the site are well draining but the rock is impervious.

#### 4.2 Recommendations

1. Depending on the applied stresses from the structures intended to be placed, suitable founding depths should be chosen in such a way that the total net foundation pressure is less than the allowable bearing capacity.

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- 2. Foundation ground; -Based on our findings and analyses of the encountered material, it is recommended that the foundations of the proposed building be laid on moderately weathered Gneiss rock.
- 3. Foundation depth; Found at 1.5m across the site.
- 4. Type of foundation; Pad type of foundation is recommended (The Engineer to use his preferred type of foundation).
- 5. Riperbility and method of excavation; The congenital excavation equipment such as Loaders and Dozers will be needed for excavation works.
- 6. Surface run off; It is recommended to protect the foundation ground and excavation from surface water both during and after construction by providing proper drainage and protection system. Surface water, if existed, should be diverted away from the edges of the excavations.
- 7. All excavations should be supervised by a competent person.

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# **APPENDICES**

### Appendix 1 – Site Layout



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### **Appendix 2 – Test Points Layout**











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### **Appendix 4 – Cross section/Bore hole profile**



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### **Appendix 5 – Drilling Logs**

### BH1 log

Client: Contracto	r:	JUBA MUNICIPAL COUNCIL PROJECT AB HARAMBE CONSTRUCTION	SANITAT	ION AND ENV	IRON	MENT	A				L	ab T	este	ed :	DRECO-MATTS DRECO-MATTS Construction Support Construction Support infb@drecomatts.co.ke
				BORE	HOLE	RE	CORI	D							
Project:		Geotechnical Investigation: J Council Sanitary & Environm	luba City ental.	Bore Hole No	<b>.</b> :			вн	1						
Location :	2	Juba South Sudan		Water table :	2.0m	l.		Isa	ac						
Elevation		460.124		Test Method	:			BS	5930	0:19	90				
Coordinat	es:	E:- 346592.67 N:- 536232	2.032	Date: Start	12-11-	2020						Enc	1:1	6-11-2020	0
						Sam &Te	ple est	ROCK				SPT			Remarks
Ground water	Depth (m)	Description of strata	Legend	Level	Danth (m)	Туре	No	% CR	150	75	75	75	75	N	Remarks
_	0.00	Back fill soil Dark Grev_silty Clay (black cotton		0.00			046	NIA							Ŧ
-	2.00	soil) with cobbles		2.00			1	NA	7	12	18	22	Relund	N>50	Water Table
				35					11	13	14	14	Related	N>50	Sample Types
	4.00			4.00		R	1	27							U Undisturbed
	6.00	Stiff Brownish Grey high to completely weathered grading to light brown gravelly sand.		6.00		R	1	13							
		1926 (1999 88%),				-	1.00	07							D:Disturbed
	8.00			8.00		R	1.	21							W Water sample
	10.00			10.00		R	1	33							R Rock sample
						R	11	40							Rock sample
	12.00	Grey weak to firm. moderately Weathered Gneiss Rock		12.00		R	1	47	1						SPT Standard Penetration Test
	14.00			14.00		R	1	53							Brownish Grey high-completeh Gneiss rock grading Gravelly Brownish Grey highy Weathere
			End of BH			-	-		-	G					decomposed Gneiss Rock granding to gravelly sands
	16.00			16.00	=										moderately. Weathered Gneiss Rock
	18.00			18.00											Very strong Fresh Gneiss Rock (Grey)
					Ξ										Dark Grey silty Clay -fill material
	20.00			20.00					Ļ						
	Lorged	S Omitu (Geologiat)	Chacked	DV - EN Cab	aiga ((	Pootos	hnical	Matorial	Engin	loor	Ann	101/5	i by :		K Wamhugu (Technical Director)
	Logged	y,- G.Ogutu (Geologist)	Checksa	by ,- E.N Gith	aiga (C	seutec	dincai d	www.enal	Engin	eer)	App	0%80	г бу ;	- 6	a.n. wambugu (Tecrinical Director)

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### BH2 log

Client: Contracte	or :	JUBA MUNICIPAL COUNCIL PROJECT AB HARAMBE CONSTRUCTION	SANITAT	ION AND EN	VIRON	MENT	A					Lab	Test	ed :			DEECO-MATTS Define: fragmental & metroretic Technical Support info@drecomatts.co.ke
				BORE	HOLI	ERE	COR	D									
Project:		Geotechnical Investigation: J Council Sanitary & Environm	uba City ental.	Bore Hole N	lo:			вн	2								
Location		Juba South Sudan		Water table	:1.5m			Drii	ler;-	Rob	ert						
Elevation	1:	460.137		Test Methor	d :			BS	5930	:199	90						
Coordina	ites:	Easting;-346226.944 orthi	ing 536227	Date: Start	16-12	-2020						End	4 <u>. 1</u>	6-12-	2020		
						Sam &Te	ple	ROCK				SP	т				Remarks
Ground water	Depth (m)	Description of strata	Legend	Level	Total Carl	Туре	No	% CR	150	75	75	75	75	N	N		Remarks
₹	0.00	Very stiff ,Greyish brown Sandy silty CLAY (Top Soil)	,	0.00		D	1	N/A								호	Water Table
E	2.00	and		2.00	-	D	1	NA	18	17	16	18	18	Facture	>50		
	4.00	Very stiff GNEISS, high weathered layered, coarse grained Gneiss rock		4.00		R	R	25	19	19	22			Eenteel	>50		Sample Types
	6.00	Strong ,Moderately,grey,coarse		6.00		R	1	30									U :Un disturbed
	8.00	grained ,layered whitish Grey Gneiss.		8.00		R	1	55								W	D Disturbed
				1000			1	60								R	Rock sample
	10.00			10.00					-								Rock recovery Rock sample
	12.00	Grey Coarse Grained, moderately wearthered ,weak to firm GNEISS Rock	•	12.00		R	1	75								SPT	Standard Penetration Test
	14.00			14.00		R	1	61									Brownish Grey high- completely Gneiss roc Brownish Grey higly Weathered decompose
	16.00		End of Sh	16.00													Gneiss Rock granding Grey weak to firm. moderately Weathered Gneiss
	18.00			18.00		1											Very strong Fresh Gneiss Rock ( Grey )
						-											Dark Grey silty Clay -fill material
E	20.00			20.00	=								E			1	
		Recommeded Foundation Layer.	1.5 m		Very a	diff ,Grey	lag brow	n Sandy all	ty CLA	Ŷ.,			N-Va K pa)	lue (Be -Facto	aring cap aron 3	pacity)	

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BH3 Log

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  |   |  |
|           | Geotechnical Investigation: Ju<br>Council Sanitary & Environme  | uba City<br>ental.   | Bore Hole No: BH3 - formr BH 2   |  |   
   
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  |   |  
   |  |  | | | |
  |   |  |
|           | Juba South Sudan  |  | Water tabl   | e:   |   
   
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  |   |  
   |  | Driller ;- ISAAC   | | | |
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|           |   |  | Test Meth  | od :   |   
   
   | BS 5930:1   |  |   |   | 0  
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| es:       | त   |  | Date: Star   | t 7-11   | -2020   
   
   |   | 1  |   |   |  
  | End   | 1:1:   
   | 3-11-202   | 20   |   
  |   |  |
|           |   |  |  |  | Sample  
   
   | &Test   | Rock   |   |   | SPT  
  |   |  
   |  |  |   
  | Remarks   |  |
| Depth (m) | Description of strata   | Legend   | Leve   | 1  | Depth (m)<br>Add (m)  
   
   | No  | % CR   | 150   | 75  | 75   
  | 75  | 75   
   | N  | Allowable<br>Bearing<br>capacity<br>(Kpa) F=2  |   
  | Remarks   |  |
| 0.00      | Very stiff ,Greyisg brown Sandy silty CLAY (Top Soil)   |  | 0.00   |  | D   
   
   | 1   | NA   |   |   |  
  |   |  
   |  |  | T   
  |   |  |
| 2.00      | Very stiff dark grey Gravelly Silty<br>CLAY, with traces of Sand with<br>cobbles/boulders.                    |  | 2.00   |  | D   
   
   | 1   | NA   | 18  | 17  | F  
  | Refus   | al   
   | N>50   |  | | | |
  | Water Table   |  |
| 4.00      | Very stiff GNEISS, high   |  | 2.8 Rock   | 3.0  |   
   
   | 1   | Nil  | 22  | 18  | F  
  | Refus   | al   
   | N>50   |  |   
  | Sample Typ  |  |
|           | weathered / decomposedGneiss ,<br>grading to Gravelly SAND, greyish<br>Brown                                  |  | 4.5  | 4.5  | cutting   
   
   | 1   | Nil  | 23  | 17  | F  
  | Refus   | al   
   | N>50   |  | | | |
  | U:Undisturbe  |  |
| 6.00      |   |  | 6.00   | 6.0  |   
   
   |   |  | 23  | 17  | F  
  | Refus   | al   
   | N>50   |  | F   
  | Factor of safet   |  |
| 8.00      | Hard GNEISS, high to completely<br>weathered, grading to Gravelly<br>SAND, greyish Brown                      |  | 7.5 8.00   |  | R   
   
   |   | 13   |   |   |  
  |   |  
   |  |  | w   
  | D:Disturbed   |  |
|           |   |  | 8.8  |  |   
   
   | 1   | 23   | 10  |   |  
  |   |  
   |  |  | R   
  | Rock sample   |  |
| 10.00     |   |  | 10.00  |  | R   
   
   | 1   | 30   | 10  |   |  
  |   |  
   |  |  | CR  
  | Rock recove   |  |
| 12.00     | Grey corase grained Gneiss rock<br>, slightly weathered, Moderatelt<br>strong with sections between           |  | 11.0   |  | R   
   
   | 1   | 20   |   |   |  
  |   |  
   |  |  | SPT   
  | Rock sample<br>Standard<br>Penetration  |  |
|           | 12.00 to 12.80m completely<br>weartherd grading to Greyish<br>brown Gravelly SANDS cuttinf=gs                 |  | 13.0   |  | Cutting   
   
   | js 1  | 20   |   |   |  
  |   |  
   |  |  |   
  | <br>Brownish Gre  |  |
| 14.00     |   |  | 14.00  |  | Rock  
   
   | 1   | 25   |   |   |  
  |   |  
   |  |  |   
  | Silty Clay<br>Weathered Gn<br>Rock (Brown<br>Grey)  |  |
| 16.00     |   |  | 16.00  |  | R   
   
   | 1   | 15   |   |   |  
  |   |  
   |  |  |   
  | Weathered Gr<br>Rock ( Grey )   |  |
| 18.00     | Grey Coarse grained ,Strong<br>Fresh Gneiss Rock with fissures  |  | 17.0   |  | R   
   
   | 1   | 25   | 1   |   |  
  |   |  
   |  |  | | | |
  | Fresh Gneiss<br>Rock ( Grey )   |  |
| 20.00     |   | End of   | 19.5   |  |   
   
   |   | 100  |   |   |  
  |   |  
   |  |  |   
  | Grey Silty CL   |  |
|           | Recommeded Foundation Layer.  | 1.5m   | Very stiff c   | lark grey<br>oulders.  | Gravelly Silty  
   
   | CLAY, wi  | th traces of   | Sand w  | ith   |  
  | _   | N-Va<br>Facto  
   | lue (Bearin<br>prof 3  | ng capacity ) Kp   | a) -  
  |   |  |
|           | 5:<br>Depth (m)<br>0.00<br>2.00<br>4.00<br>6.00<br>8.00<br>10.00<br>12.00<br>14.00<br>16.00<br>18.00<br>20.00 | Geotechnical Investigation: Jula South Sudan         Juba South Sudan         s:       Depth (m)       Description of strata         0.00       Very stiff, Greyisg brown Sandy silty CLAY (Top Soil)         2.00       Very stiff dark grey Gravelly Silty CLAY, With traces of Sand with cobbles/boulders.         4.00       Very stiff GNEISS, high weathered / decomposedGneiss, grading to Gravelly SAND, greyist Brown         6.00       Hard GNEISS, high to completely weathered, grading to Gravelly SAND, greyist Brown         10.00       Grey corase grained Gneiss rock strong with sections between 12.00 to 12.80m completely weathered, Moderatelt strong with sections between 14.00         16.00       Grey Coarse grained Gneiss rock strong with sections between 14.00         16.00       Fresh Gneiss Rock with fissures 20.00         18.00       Grey Coarse grained Sneiss Rock with fissures 20.00 | Geotechnical Investigation: Juba City<br>Council Sanitary & Environmental.         Juba South Sudan         s:         Depth (m)       Description of strata       Legend         0.00       Very stiff, Greyisg brown Sandy<br>silty CLAY (Top Soll)       Image: CLAY (Top Soll)         2.00       Very stiff GNE ISS, high<br>weathered / decomposedGneiss,<br>grading to Gravelly SAND, greyish<br>Brown       Image: CLAY (Top Soll)         6.00       Hard GNE ISS, high to completely<br>weathered, grading to Gravelly<br>SAND, greyish Brown       Image: CLAY (Top Soll)         10.00       Grey corase grained Gneiss rock<br>strong with sections between<br>12.00 to 12.80m completely<br>weathered grading to Gravelly<br>SAND greyish Brown       Image: CLAY (Top Soll)         11.00       Grey corase grained Gneiss rock<br>strong with sections between<br>12.00 to 12.80m completely<br>weathered grading to Greyish<br>brown Gravelly SANDS cuttinf=gs         14.00       Grey Coarse grained Shorg<br>Fresh Gneiss Rock with fissures         14.00       Grey Coarse grained ,Strong<br>Fresh Gneiss Rock with fissures         14.00       End of | Geotechnical Investigation: Juba City<br>Council Sanitary & Environmental.       Bore Hole         Juba South Sudan       Water table         Test Methics       Test Methics         s:       Date: Star         Depth (m)       Description of strata       Legend         0.00       Very stiff, Greylsg brown Sandy<br>silty CLAY (Top Soll)       0.00         2.00       Very stiff GAR (grey Gravelly Silty<br>CLAY, with traces of Sand with<br>cobbles/boulders.       338 Bock         4.00       Very stiff GAREISS, high<br>weathered/ decomposed Gneiss,<br>grading to Gravelly SAND, greyish<br>Brown       4.00         8.00       Hard GNEISS, high to completely<br>weathered, grading to Gravelly<br>SAND, greyish Brown       8.6         10.00       Grey corase grained Gneiss rock<br>, slightly weathered, Moderatelit<br>strong with sections between<br>12.00 to 12.60m completely<br>weathered grading to Greyish<br>brown Gravelly SANDS cuttinf=gs       133         14.00       Grey Coarse grained Gneiss rock<br>, slightly weathered grading to Greyish<br>brown Gravelly SANDS cuttinf=gs       133         14.00       Grey Coarse grained Gneiss rock<br>grey Coarse grained Gneiss rock<br>horwn Gravelly SANDS cuttinf=gs       134         14.00       Grey Coarse grained Gneiss rock<br>grey Coarse grained Strong<br>fresh Gneiss Rock with fissures       150         16.00       Grey Coarse grained Strong<br>Fresh Gneiss Rock with fissures       150         150       Grey Coarse grained Strong | Geotechnical Investigation: Juba City<br>Council Sanitary & Environmental.       Bore Hole No:         Juba South Sudan       Water table :         Test Method :         Set Method :         Date: Start 7-11         Depth (m)       Description of strata       Legend       Level         0.00       Very stiff Greyisg brown Sandy<br>silty CLAY (Top Soil)       0.00       1       2.00       1         2.00       Very stiff GNEISS, high<br>weathered / decomposedGneiss,<br>grading to Gravelly SAND, greyish<br>Brown       1       4.00       3.0         4.00       Weathered, grading to Gravelly SAND, greyish<br>Brown       1       1       0.00       3.0         10.00       Grey corase grained Gneiss rock<br>signating to Gravelly SAND greyish<br>Brown Gravelly SANDS cuttinf=gs       1       1       1       1         14.00       Grey corase grained Gneiss rock<br>signating grading to Gravelly SANDS cuttinf=gs       1 <td>Geotechnical Investigation: Juba City<br/>Council Sanitary &amp; Environmental.       Bore Hole No:         Juba South Sudan       Water table :         Test Method :       Test Method :         s:       Date: Start 7-11-2020         Depth (m)       Description of strata       Legend         10.00       Very stiff, Greyisg brown Sandy<br/>silly CLAY (Top Soil)       0.00       15         2.00       Very stiff GNEISS, high<br/>weathered / decomposedGneiss,<br/>grading to Gravelly SAND, greyish<br/>Brown       4.00       xx         6.00       Frew       6.00       xx       Rock         10.00       Grey, corase grained Gneiss rock<br/>istong with sections between<br/>t 2.00 to 12.00 normpletely<br/>weathered, grading to Gravely<br/>SAND, greyish Brown       8.00       R         10.00       Grey, corase grained Gneiss rock<br/>istong with sections between<br/>t 2.00 to 12.00 normpletely<br/>weathered grading to Gravely<br/>SAND, greyish Brown       13.00       R         14.00       Grey Coarse grained Gneiss rock<br/>istong with sections between<br/>t 2.00 to 12.00 normpletely<br/>weathered grading to Greyish<br/>brown Gravelly SANDS cutinf=gr       14.00       R         14.00       Grey Coarse grained Gneiss rock<br/>istong with sections between<br/>t 12.00       14.00       R         14.00       Grey Coarse grained Gneiss rock<br/>istong with sections between<br/>t 12.00 to 12.00 normpletely<br/>weathered grading to Greyish<br/>brown Gravelly SANDS cutinf=gr       14.00       R</td> <td>Geotechnical Investigation: Juba City<br/>Council Sanitary &amp; Environmental.       Bore Hole No:         Juba South Sudan       Water table :         Test Method :       Test Method :         s:       Date: Start 7-11-2020         Depth (m)       Description of strata       Legend         0.00       Very stiff Greyisg brown Sandy<br/>silty CLAY (Top Soli)       0.00         2.00       Very stiff Greyisg brown Sandy<br/>silty CLAY (Top Soli)       0.00         2.00       Very stiff Gravelly Silty<br/>Cobbles/boulders.       0.00         4.00       Very stiff Gravelly SAND, greyish<br/>Brown       4.00       8.00         6.00       raw of the completely<br/>weathered / decomposed Greiss,<br/>Brown       10.00       R       1         10.00       Grey corase grained Greiss rock<br/>sing with schose by the completely<br/>weathered ading to Gravelly<br/>SAND, greyish Brown       10.00       R       1         12.00       12.00 to 12.80m completely<br/>weathered ading to Gravelly<br/>SANDS cuttinfig       14.00       R       1         14.00       Fresh Greiss Rock, with Tissures       15.00       R       1         14.00       Reck in 1       1       1       1       1         10.00       Reck in 1       1       1       1       1       1         12.00       Reck in 1</td> <td>Gestechnical Investigation: Juba City<br/>Council Sanitary &amp; Environmental.         Bore Hole No:         Image: State State</td> <td>Geotechnical Investigation: Juba City<br/>Council Sanitary &amp; Environmental.         Bore Hole No:         EH3 - f           Juba South Sudan         Water table :         ES 5930           Juba South Sudan         Test Method :         ES 5930           S:         Date: Start 7-11-2020         Sample &amp; Test         Rock         Investigation: Juba South Sudan           Depth (m)         Description of strata         Legend         Level         Sample &amp; Test         Rock         Investigation: Juba South Sudan           0.00         Very stiff Greyisg brown Sandy<br/>silly CLAY (Top Soil)         0.00         Investigation: Juba South Sudan         Rock         Investigation: Juba South Sudan           4.00         Very stiff Greyisg brown Sandy<br/>silly CLAY (Top Soil)         Investigation: Juba South Sudan         Investigation: Juba South Sudan         Investigation: Juba South Sudan           4.00         Very stiff Greyisg brown Sandy<br/>silly GLAY (Top Soil)         Investigation: Juba South Sudan         Investigation: Juba South Sou</td> <td>Geotechnical Investigation: Juba City<br/>Council Sanitary &amp; Environmental.         Bore Hole No:         BH3 - form           Juba South Sudan         Water table :         ES 5930:199           Juba South Sudan         Test Method :         BS 5930:199           S:         Date: Start 7-11-2020         E           Depth (m)         Description of strata         Legend         E         E         Rock         150           0.00         Very stlfr Greysg brown Sandy<br/>silly CLAY (TOp Soil)         0.00         0         1         NA         18         17           2.00         Very stlfr Greysg brown Sandy<br/>silly CLAY (TOp Soil)         0.00         0.00         Rock         10         1         NA         18         17           4.00         Very stlfr Greysg brown Sandy<br/>silly CLAY (TOp Soil)         0.00         Rock         10         1         NA         18         17           6.00         Rock         1         NIII         23         17           6.00         Rock         1         NIII         23         17           8.00         Rock         1         20         1         20         1           10.00         Grey Corase grained Greiss rock<br/>subgrained to Greavely<br/>SAND, greyish Brown         10.00         <td< td=""><td>Geotechnical Investigation: Juba City<br/>Council Sanitary &amp; Environmental.         Bore Hole No:         BH3 - form: BH           Juba South Sudan         Water table :         Image: Council Sanitary &amp; Environmental.         Sample &amp; Test         BS 5930:1990           s:         Date: Start 7:11-2020         Image: Council Sanitary &amp; Environmental.         Sample &amp; Test         Rock         Image: Council Sanitary &amp; Environmental.           Depth (m)         Description of strata         Legend         Level         Sample &amp; Test         Rock         Image: Council Sanitary &amp; Environmental.           0.00         Very stiff (Greying Drown Sandy<br/>Stiff CLAY, With Traces of Sandy With<br/>CLAY, With Traces of Sandy With CLAY, With Traces of Sandy With Transet         Row of the With Transet of With Traces of With Transet of With Transet of With Transet of With Tra</td><td>Geotechnical Investigation: Juba City<br/>Council Sanitary &amp; Environmental.         Bore Hole No:         BH3 - formr BH 2           Juba South Sudan         Water table :        </td><td>Geotechnical Investigation: Juba City<br/>Council Sanitary &amp; Environmental.         Bore Hole No:         BH3 - formr BH2           Juba South Sudan         Water table :         Test Method :         BS 5930:1990           s:         Date: Start 7:11-2020         Ead         Ead           Depth (m)         Description of strata         Legend         Level         Sample &amp; Test         Rock         SPT           0.00         Very stiff Greying brown Sandy<br/>2.00         Very stiff Greying brown Sandy<br/>CALY, with Tack of Sand with<br/>cobles/boulders.         0.00         D         1         NA         18         17         Refuel<br/>Park           4.00         Very stiff Greying brown Sandy<br/>school (CALY, with Tacks of Sand with<br/>cobles/boulders.         10         1         NA         18         17         Refuel<br/>Park         1         NA         18         17         Refuel<br/>Park           4.00         Very stiff GNEISS, high<br/>room         1         1         NA         18         17         Refuel<br/>Park         1         NB         23         17         Refuel<br/>Park           10.00         Freed Gravely SAND greyinh<br/>room Gravely SAND greyinh<br/>room Gravely SAND greyinh<br/>room Gravely SAND Scuttings         1         10.00         R         1         23         17         Refuel<br/>Park         1           10.00<!--</td--><td>Generationical Investigation: Juba City<br/>Sunce I Sanitary &amp; Environmental.         Bore Hole No:         EH3 - formr EH 2           Juba South Sudan         Water table :         Image: Start 7-11 - 2020         Image: Start 7-11 - 2020         Image: Start 7-11 - 2020           Sample &amp; Test Method :         Image: Start 7-11 - 2020           Depth (m)         Description of strata         Legend         Image: Start 7-11 - 2020         Image: Start 7-11 - 2020&lt;</td><td>Geotechnical investigationJuba City<br/>Cucucit Sanitary &amp; Environmental.         Bore Hole No:         EH3 - formr BH 2           Juba South Sudan         Water table :         Second Sanitary &amp; Environmental.         Driller : I           Second Sanitary &amp; Environmental.         Test Method :         BS 5930:1990           Second Sanitary &amp; Environmental.         Date: Start 7.11-2020         Test 1.11-2020         Test 1.11-2020           Second Sanitary &amp; Environmental.         Description of strata         Level         Sample &amp; Test Rehow         Second Sanitary &amp; Sanita</td><td>Geotechnical Investigation Juba Cary<br/>Council Samitary &amp; Environmental.Bore Hole No:BIB - formr BH 2Juba South SudanWater table :Driller :-I SAACTest Method :B S 5930:1990Sample &amp; Test Method :S Sep30:1990Depth (m)Description of strata<br/>LegendLegend<br/>LevelSample &amp; Test Method :Rock<math>- SPT</math>Depth (m)Description of strata<br/>Very stiff Gray tag provide and with<br/>Council description of strata<br/>Council description of strata<br/>2.00Legend<br/><math>- 2.00</math>Sample &amp; Test Method :Rock<math>- SPT</math>NAlterebia<br/>Berging<br/>Description of strata<br/>Berging<br/>2.00Part I in the strata<br/>in the strata in the strata<br/>in the strataRock<math>- SPT</math>In the strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strataNo. Strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strataNo. Strata<br/>in the strata<br/>in the strata<br/>in the strataNo. Strata<br/>in the strata<br/>in the strata10.00Very stiff drama (stret) Gravely Strata<br/>in the strata in the strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strataNo. Strata<br/>in the strataNo. Strata<br/>in the stra</td></td></td<></td> | Geotechnical Investigation: Juba City<br>Council Sanitary & Environmental.       Bore Hole No:         Juba South Sudan       Water table :         Test Method :       Test Method :         s:       Date: Start 7-11-2020         Depth (m)       Description of strata       Legend         10.00       Very stiff, Greyisg brown Sandy<br>silly CLAY (Top Soil)       0.00       15         2.00       Very stiff GNEISS, high<br>weathered / decomposedGneiss,<br>grading to Gravelly SAND, greyish<br>Brown       4.00       xx         6.00       Frew       6.00       xx       Rock         10.00       Grey, corase grained Gneiss rock<br>istong with sections between<br>t 2.00 to 12.00 normpletely<br>weathered, grading to Gravely<br>SAND, greyish Brown       8.00       R         10.00       Grey, corase grained Gneiss rock<br>istong with sections between<br>t 2.00 to 12.00 normpletely<br>weathered grading to Gravely<br>SAND, greyish Brown       13.00       R         14.00       Grey Coarse grained Gneiss rock<br>istong with sections between<br>t 2.00 to 12.00 normpletely<br>weathered grading to Greyish<br>brown Gravelly SANDS cutinf=gr       14.00       R         14.00       Grey Coarse grained Gneiss rock<br>istong with sections between<br>t 12.00       14.00       R         14.00       Grey Coarse grained Gneiss rock<br>istong with sections between<br>t 12.00 to 12.00 normpletely<br>weathered grading to Greyish<br>brown Gravelly SANDS cutinf=gr       14.00       R | Geotechnical Investigation: Juba City<br>Council Sanitary & Environmental.       Bore Hole No:         Juba South Sudan       Water table :         Test Method :       Test Method :         s:       Date: Start 7-11-2020         Depth (m)       Description of strata       Legend         0.00       Very stiff Greyisg brown Sandy<br>silty CLAY (Top Soli)       0.00         2.00       Very stiff Greyisg brown Sandy<br>silty CLAY (Top Soli)       0.00         2.00       Very stiff Gravelly Silty<br>Cobbles/boulders.       0.00         4.00       Very stiff Gravelly SAND, greyish<br>Brown       4.00       8.00         6.00       raw of the completely<br>weathered / decomposed Greiss,<br>Brown       10.00       R       1         10.00       Grey corase grained Greiss rock<br>sing with schose by the completely<br>weathered ading to Gravelly<br>SAND, greyish Brown       10.00       R       1         12.00       12.00 to 12.80m completely<br>weathered ading to Gravelly<br>SANDS cuttinfig       14.00       R       1         14.00       Fresh Greiss Rock, with Tissures       15.00       R       1         14.00       Reck in 1       1       1       1       1         10.00       Reck in 1       1       1       1       1       1         12.00       Reck in 1 | Gestechnical Investigation: Juba City<br>Council Sanitary & Environmental.         Bore Hole No:         Image: State | Geotechnical Investigation: Juba City<br>Council Sanitary & Environmental.         Bore Hole No:         EH3 - f           Juba South Sudan         Water table :         ES 5930           Juba South Sudan         Test Method :         ES 5930           S:         Date: Start 7-11-2020         Sample & Test         Rock         Investigation: Juba South Sudan           Depth (m)         Description of strata         Legend         Level         Sample & Test         Rock         Investigation: Juba South Sudan           0.00         Very stiff Greyisg brown Sandy<br>silly CLAY (Top Soil)         0.00         Investigation: Juba South Sudan         Rock         Investigation: Juba South Sudan           4.00         Very stiff Greyisg brown Sandy<br>silly CLAY (Top Soil)         Investigation: Juba South Sudan         Investigation: Juba South Sudan         Investigation: Juba South Sudan           4.00         Very stiff Greyisg brown Sandy<br>silly GLAY (Top Soil)         Investigation: Juba South Sudan         Investigation: Juba South Sou | Geotechnical Investigation: Juba City<br>Council Sanitary & Environmental.         Bore Hole No:         BH3 - form           Juba South Sudan         Water table :         ES 5930:199           Juba South Sudan         Test Method :         BS 5930:199           S:         Date: Start 7-11-2020         E           Depth (m)         Description of strata         Legend         E         E         Rock         150           0.00         Very stlfr Greysg brown Sandy<br>silly CLAY (TOp Soil)         0.00         0         1         NA         18         17           2.00         Very stlfr Greysg brown Sandy<br>silly CLAY (TOp Soil)         0.00         0.00         Rock         10         1         NA         18         17           4.00         Very stlfr Greysg brown Sandy<br>silly CLAY (TOp Soil)         0.00         Rock         10         1         NA         18         17           6.00         Rock         1         NIII         23         17           6.00         Rock         1         NIII         23         17           8.00         Rock         1         20         1         20         1           10.00         Grey Corase grained Greiss rock<br>subgrained to Greavely<br>SAND, greyish Brown         10.00 <td< td=""><td>Geotechnical Investigation: Juba City<br/>Council Sanitary &amp; Environmental.         Bore Hole No:         BH3 - form: BH           Juba South Sudan         Water table :         Image: Council Sanitary &amp; Environmental.         Sample &amp; Test         BS 5930:1990           s:         Date: Start 7:11-2020         Image: Council Sanitary &amp; Environmental.         Sample &amp; Test         Rock         Image: Council Sanitary &amp; Environmental.           Depth (m)         Description of strata         Legend         Level         Sample &amp; Test         Rock         Image: Council Sanitary &amp; Environmental.           0.00         Very stiff (Greying Drown Sandy<br/>Stiff CLAY, With Traces of Sandy With<br/>CLAY, With Traces of Sandy With CLAY, With Traces of Sandy With Transet         Row of the With Transet of With Traces of With Transet of With Transet of With Transet of With Tra</td><td>Geotechnical Investigation: Juba City<br/>Council Sanitary &amp; Environmental.         Bore Hole No:         BH3 - formr BH 2           Juba South Sudan         Water table :        </td><td>Geotechnical Investigation: Juba City<br/>Council Sanitary &amp; Environmental.         Bore Hole No:         BH3 - formr BH2           Juba South Sudan         Water table :         Test Method :         BS 5930:1990           s:         Date: Start 7:11-2020         Ead         Ead           Depth (m)         Description of strata         Legend         Level         Sample &amp; Test         Rock         SPT           0.00         Very stiff Greying brown Sandy<br/>2.00         Very stiff Greying brown Sandy<br/>CALY, with Tack of Sand with<br/>cobles/boulders.         0.00         D         1         NA         18         17         Refuel<br/>Park           4.00         Very stiff Greying brown Sandy<br/>school (CALY, with Tacks of Sand with<br/>cobles/boulders.         10         1         NA         18         17         Refuel<br/>Park         1         NA         18         17         Refuel<br/>Park           4.00         Very stiff GNEISS, high<br/>room         1         1         NA         18         17         Refuel<br/>Park         1         NB         23         17         Refuel<br/>Park           10.00         Freed Gravely SAND greyinh<br/>room Gravely SAND greyinh<br/>room Gravely SAND greyinh<br/>room Gravely SAND Scuttings         1         10.00         R         1         23         17         Refuel<br/>Park         1           10.00<!--</td--><td>Generationical Investigation: Juba City<br/>Sunce I Sanitary &amp; Environmental.         Bore Hole No:         EH3 - formr EH 2           Juba South Sudan         Water table :         Image: Start 7-11 - 2020         Image: Start 7-11 - 2020         Image: Start 7-11 - 2020           Sample &amp; Test Method :         Image: Start 7-11 - 2020           Depth (m)         Description of strata         Legend         Image: Start 7-11 - 2020         Image: Start 7-11 - 2020&lt;</td><td>Geotechnical investigationJuba City<br/>Cucucit Sanitary &amp; Environmental.         Bore Hole No:         EH3 - formr BH 2           Juba South Sudan         Water table :         Second Sanitary &amp; Environmental.         Driller : I           Second Sanitary &amp; Environmental.         Test Method :         BS 5930:1990           Second Sanitary &amp; Environmental.         Date: Start 7.11-2020         Test 1.11-2020         Test 1.11-2020           Second Sanitary &amp; Environmental.         Description of strata         Level         Sample &amp; Test Rehow         Second Sanitary &amp; Sanita</td><td>Geotechnical Investigation Juba Cary<br/>Council Samitary &amp; Environmental.Bore Hole No:BIB - formr BH 2Juba South SudanWater table :Driller :-I SAACTest Method :B S 5930:1990Sample &amp; Test Method :S Sep30:1990Depth (m)Description of strata<br/>LegendLegend<br/>LevelSample &amp; Test Method :Rock<math>- SPT</math>Depth (m)Description of strata<br/>Very stiff Gray tag provide and with<br/>Council description of strata<br/>Council description of strata<br/>2.00Legend<br/><math>- 2.00</math>Sample &amp; Test Method :Rock<math>- SPT</math>NAlterebia<br/>Berging<br/>Description of strata<br/>Berging<br/>2.00Part I in the strata<br/>in the strata in the strata<br/>in the strataRock<math>- SPT</math>In the strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strataNo. Strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strataNo. Strata<br/>in the strata<br/>in the strata<br/>in the strataNo. Strata<br/>in the strata<br/>in the strata10.00Very stiff drama (stret) Gravely Strata<br/>in the strata in the strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strataNo. Strata<br/>in the strataNo. Strata<br/>in the stra</td></td></td<> | Geotechnical Investigation: Juba City<br>Council Sanitary & Environmental.         Bore Hole No:         BH3 - form: BH           Juba South Sudan         Water table :         Image: Council Sanitary & Environmental.         Sample & Test         BS 5930:1990           s:         Date: Start 7:11-2020         Image: Council Sanitary & Environmental.         Sample & Test         Rock         Image: Council Sanitary & Environmental.           Depth (m)         Description of strata         Legend         Level         Sample & Test         Rock         Image: Council Sanitary & Environmental.           0.00         Very stiff (Greying Drown Sandy<br>Stiff CLAY, With Traces of Sandy With<br>CLAY, With Traces of Sandy With CLAY, With Traces of Sandy With Transet         Row of the With Transet of With Traces of With Transet of With Transet of With Transet of With Tra | Geotechnical Investigation: Juba City<br>Council Sanitary & Environmental.         Bore Hole No:         BH3 - formr BH 2           Juba South Sudan         Water table : | Geotechnical Investigation: Juba City<br>Council Sanitary & Environmental.         Bore Hole No:         BH3 - formr BH2           Juba South Sudan         Water table :         Test Method :         BS 5930:1990           s:         Date: Start 7:11-2020         Ead         Ead           Depth (m)         Description of strata         Legend         Level         Sample & Test         Rock         SPT           0.00         Very stiff Greying brown Sandy<br>2.00         Very stiff Greying brown Sandy<br>CALY, with Tack of Sand with<br>cobles/boulders.         0.00         D         1         NA         18         17         Refuel<br>Park           4.00         Very stiff Greying brown Sandy<br>school (CALY, with Tacks of Sand with<br>cobles/boulders.         10         1         NA         18         17         Refuel<br>Park         1         NA         18         17         Refuel<br>Park           4.00         Very stiff GNEISS, high<br>room         1         1         NA         18         17         Refuel<br>Park         1         NB         23         17         Refuel<br>Park           10.00         Freed Gravely SAND greyinh<br>room Gravely SAND greyinh<br>room Gravely SAND greyinh<br>room Gravely SAND Scuttings         1         10.00         R         1         23         17         Refuel<br>Park         1           10.00 </td <td>Generationical Investigation: Juba City<br/>Sunce I Sanitary &amp; Environmental.         Bore Hole No:         EH3 - formr EH 2           Juba South Sudan         Water table :         Image: Start 7-11 - 2020         Image: Start 7-11 - 2020         Image: Start 7-11 - 2020           Sample &amp; Test Method :         Image: Start 7-11 - 2020           Depth (m)         Description of strata         Legend         Image: Start 7-11 - 2020         Image: Start 7-11 - 2020&lt;</td> <td>Geotechnical investigationJuba City<br/>Cucucit Sanitary &amp; Environmental.         Bore Hole No:         EH3 - formr BH 2           Juba South Sudan         Water table :         Second Sanitary &amp; Environmental.         Driller : I           Second Sanitary &amp; Environmental.         Test Method :         BS 5930:1990           Second Sanitary &amp; Environmental.         Date: Start 7.11-2020         Test 1.11-2020         Test 1.11-2020           Second Sanitary &amp; Environmental.         Description of strata         Level         Sample &amp; Test Rehow         Second Sanitary &amp; Sanita</td> <td>Geotechnical Investigation Juba Cary<br/>Council Samitary &amp; Environmental.Bore Hole No:BIB - formr BH 2Juba South SudanWater table :Driller :-I SAACTest Method :B S 5930:1990Sample &amp; Test Method :S Sep30:1990Depth (m)Description of strata<br/>LegendLegend<br/>LevelSample &amp; Test Method :Rock<math>- SPT</math>Depth (m)Description of strata<br/>Very stiff Gray tag provide and with<br/>Council description of strata<br/>Council description of strata<br/>2.00Legend<br/><math>- 2.00</math>Sample &amp; Test Method :Rock<math>- SPT</math>NAlterebia<br/>Berging<br/>Description of strata<br/>Berging<br/>2.00Part I in the strata<br/>in the strata in the strata<br/>in the strataRock<math>- SPT</math>In the strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strataNo. Strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strataNo. Strata<br/>in the strata<br/>in the strata<br/>in the strataNo. Strata<br/>in the strata<br/>in the strata10.00Very stiff drama (stret) Gravely Strata<br/>in the strata in the strata<br/>in the strata<br/>in the strata<br/>in the strata<br/>in the strataNo. Strata<br/>in the strataNo. Strata<br/>in the stra</td> | Generationical Investigation: Juba City<br>Sunce I Sanitary & Environmental.         Bore Hole No:         EH3 - formr EH 2           Juba South Sudan         Water table :         Image: Start 7-11 - 2020         Image: Start 7-11 - 2020         Image: Start 7-11 - 2020           Sample & Test Method :         Image: Start 7-11 - 2020           Depth (m)         Description of strata         Legend         Image: Start 7-11 - 2020         Image: Start 7-11 - 2020< | Geotechnical investigationJuba City<br>Cucucit Sanitary & Environmental.         Bore Hole No:         EH3 - formr BH 2           Juba South Sudan         Water table :         Second Sanitary & Environmental.         Driller : I           Second Sanitary & Environmental.         Test Method :         BS 5930:1990           Second Sanitary & Environmental.         Date: Start 7.11-2020         Test 1.11-2020         Test 1.11-2020           Second Sanitary & Environmental.         Description of strata         Level         Sample & Test Rehow         Second Sanitary & Sanita | Geotechnical Investigation Juba Cary<br>Council Samitary & Environmental.Bore Hole No:BIB - formr BH 2Juba South SudanWater table :Driller :-I SAACTest Method :B S 5930:1990Sample & Test Method :S Sep30:1990Depth (m)Description of strata<br>LegendLegend<br>LevelSample & Test Method :Rock $- SPT$ Depth (m)Description of strata<br>Very stiff Gray tag provide and with<br>Council description of strata<br>Council description of strata<br>2.00Legend<br>$- 2.00$ Sample & Test Method :Rock $- SPT$ NAlterebia<br>Berging<br>Description of strata<br>Berging<br>2.00Part I in the strata<br>in the strata in the strata<br>in the strataRock $- SPT$ In the strata<br>in the strata<br>in the strata<br>in the strata<br>in the strata<br>in the strataNo. Strata<br>in the strata<br>in the strata<br>in the strata<br>in the strata<br>in the strataNo. Strata<br>in the strata<br>in the strata<br>in the strataNo. Strata<br>in the strata<br>in the strata10.00Very stiff drama (stret) Gravely Strata<br>in the strata in the strata<br>in the strata<br>in the strata<br>in the strata<br>in the strataNo. Strata<br>in the strataNo. Strata<br>in the stra |  |

#### **AB Harambe Engineering and Construction**

February 2021

**BH4 Log** 

Client: Contrac	tor:		The second second	JUBA MUNICIPAL COUNCIL PROJECT AB HARAMBE CONSTRUCTIO	SANITAT	ION AND I	ENV	/IRONI	MENT	A				Ĩ	Lab	Test	ed :			DRECO-MATTS Delling, Engineering & Construction Technical Suppor info@drecomatts.co.ke
						BOR	E )	HOLE	RE	OR	D									
Project:	C) (D)			Geotechnical Investigation: Ju Council Sanitary & Environme	uba City ental.	Bore Hol	e N	o:			BH4									
Locatio	n :		8	Juba South Sudan		Water tal	ble				Dri	iler;-	Rob	pert						
Elevatio	n:					Test Met	BS	5930	0:199	90										
Coordin	ates:					Date: Sta	art	18-12-	-2020						End	d: 1	9-12-	-2020		
									Sam &Te	ple	ROCK				SP	T				Remarks
Ground water	D	epth (m)		Description of strata	Legend	Lev	/el	Denth.(m)	Туре	No	% CR	150	75	75	75	75	N	N		Remarks
•		0.00		Very stiff ,Greyisg brown Sandy silty CLAY .		0.0	0		D	1	N/A	21	10	10	19	1.0	03	>50	오	Water Table
		4.00		Stiff, high weathered coorse grained Gneiss disintegrating grading to Grev Gravelly SAND.		4.0	°		R	1	34	21	10	10	10	10	30	250		Sample Types
		6.00				6.0	° _		R	1	27									U:Undisturbed
		9.00		Very stiff, weathered highly fissured coarse grained dark grey Gneiss rock		80	°		R	1	26									D:Disturbed
		10.00				10./	00 00		R	1	32								R	Water sample Rock sample
		12.00				12./	00		R	1	50								SPI	Rock sample Standard
		14.00				14./	00		R	1	40									Penetration Test Brownish GreySilty Clay
		16.00		Moderatelt strong slightly weathered, whitish Grey coarse grained Gneiss rock ,		16./	00		R	1	40	1								Rock (Brownish Grey) Weathered Gneiss
		18.00				18.	00		R	1	80									Fresh Gneiss Rock ( Grey )
						E		13.5												
	_	20.00		Recommeded Foundation Layer.	End of BH	20.0	00	Very st	tiff ,Grey	visg brov	wn Sandy sil	Ity CLA	Г. Y.			N-Va Kpa)	lue (B -Facto	earing ca or of 3	apacity)	
		Logged b	y;-	G.Ogutu (Geologist) Ch	reckod by ;	E.N Git Engine	thaig er)	ja (Geo	technic	cal &M	laterial		Арр	rovad	dby;	- (	G.K V	Vam bu	igu ( <mark>Techr</mark>	nical Director)

**AB Harambe Engineering and Construction** 

#### **EP1** JUBA MUNICIPAL COUNCIL SANITATION AND ENVIRONMENTA PROJECT CO-MA Client: Lab Tested : AB HARAMBE CONSTRUCTION COMPANY Contractor : info@drecomatts.co.ke EXCAVATION PIT RECORD Geotechnical Investigation: Juba City Council Sanitary & Environmental. Project: Bore Hole No: EP1 Location : Juba South Sudan Water table : Elevation: Test Method : BS 5930:1990 Coordinates: Date: Start 19-12-2020 End: 19-12-2020 Sample &Test ROCK SPT Remarks Ground Depth (m) Description of strata Legend Level water enth (m) N Type No % CR 150 75 75 75 75 N Remarks 0.00 0.00 Firm Light brown sandy silty CLAY (Top Soil) 1111111111 $\overline{\nabla}$ Stiff, whitish yellow/Brownish grey weathered caarse grained Gneiss disintegrating grading to Grey Gravelly SAND Water Table 0.50 0.50 Sample Types 1.00 1.00 U:Undisturbed /ery stiff, moderately weathered fissured aorse grained dark grey Gneiss 1.50 1.50 FFFFFFFFFFFFF D:Disturbed 2.00 2.00 w Water sample Rock sample R 2.50 2.50 CR Rock recovery 111111 Rock sample 3.00 3.00 SPT Penetration Test 1111 Brownish GreySiltyClay Weathered Gneiss Rock (Brownish Grey) 14.00 14.00 Weathered Gneis Rock ( Grey ) 16.00 16.00 Fresh Gneiss Rock ( Grey ) 18.00 18.00 d of B 20.00 20.00 1.5m Stiff, whitish yellow/Brownish grey weathered caarse grained Gneiss disintegrating grading to Grey Gravelly SAND meded Foundation Layer. Reco Checked by ;- E.N Githalga (Geotechnical & Material Engineer) Approved by ;- G.K Wambugu (Technical Director) Logged by;-G.Ogutu (Geologist)

	AB Harambe Engineering and Construction EP2  ATTACL SANITATION AND ENVIRONMENTA PROJECT TARACTOR PROJECT TARACTOR SANITATION AND ENVIRONMENTA PROJECT ADD SANITATION COMPANY  Lab Tes					Febr	uary 2021													
	E	P	2																	
Client:			JUBA MUNICIPAL COUNCIL	SANITAT		AND EN	VIRO	MM	ENT	4				L	.ab 1	Test	ed :		c	DRECO-MATTS DRECO-MATTS anstruction Technical Support
Contrac	tor :		AB HARAMBE CONSTRUCTIO	ON COMP	ANY														i	info@drecomatts.co.ke
X				i i	EX	CAVA	ΓΙΟΝ	P	IT F	ECO	DRD									
Project:			Geotechnical Investigation : Jo Council Sanitary & Environme	uba City ental.	Bor	e Hole N	10:				EP2	2								
Locatio	n :	3	Juba South Sudan		Wat	er table	-													
Elevatio	n:				Test	t Metho	d :				BS	5930	:199	0						
Coordin	ates:				Date	e: Start	19-1:	2-20	020						End	: 19	9-12-	2020		
									Samı &Te	ole st	ROCK				SP	r				Remarks
water	Depth (m)		Description of strata	Legend		Level		hepth (m)	Туре	No	% CR	150	75	75	75	75	N	N		Remarks
	0.00	≣	Firm Light brown sandy silty CLAY (Top Soil)		E	0.00	=												л,	
	0.50		Stiff, Yellow/Brownish grey Clayey silty Gravel SAND	-		0.50		+		-									$\geq$	Water Table
			Stiff whitish vellow/Brownish arev				=		-											Sample Types
	1.00		weathered caarse grained Gneiss disintegrating grading to Grey Gravelly SAND		_	1.00														
л			Providence		E		Ξ	Ť												U:Undisturbed
<b>×</b>	1.50				Ē		=													
	2.00					2.00													w	D:Disturbed
				End of EP		-14 -14	Ξ	+	_	<u>.</u>		~							R	Water sample
	2.50				E	2.50	Ξ												CR	Rock recovery
					E			+	_	<u>.</u>		-								Rock sample
	3.00	=				3.00	=												SPT	Standard Penetration Test
	14.00					14.00														Brownish GreySilty Clay
					Ē	-	Ξ					3								Weathered Gneiss Rock ( Brownish Grey )
	16.00				E	16.00	Ξ													Weathered Gneiss Rock ( Grey )
																				Fresh Gneiss
	18.00					18.00	=											3		Rock ( Grey )
					=		19.5													
Т	20.00	=	Recommeded Foundation Layer.		1.6	20.00	Stiff, wh	iitish	yellow	Browni	sh grey weat	heredic	aarse	graine	d Gne	iss di	sinteg	rating gr	ading to Gre	y Gravelly SAND
+		_																		
	Logged b	y;-	G.Ogutu (Geologist) Ch	eckod by ;	E	.N Githai	ga (Ge	ote	chnica	al &Ma	terial Engi	neer)	Арр	rovec	iby;-	G	6.K W	/ambug	ju (Techni	ical Director)

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### **Appendix 6 – Photographic Records**

### **BH1 core box Photo**



BH2 core box photo.



February 2021

### BH3 core box photo.





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### **EP1 Excavation Pit Photo**



### **EP2** Excavation Pit Photo



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### **Appendix 7– Bearing capacity**

### a) N-Values

PROJEC CLIENT LOCATI GEOTEC CONTRA	T: : ON: CHNICAL ACTOR	JUBA CITY COU AB HARAMBER JUBA ,SOUTH S DRECOMATTS	UNCIL SA CONTR. SUDAN LIMITEI	NITARY A ACTORS	ND ENVIR	ONMENT	AL MUL	TI USE BI	UILDING					Date:	Doc -04 21/12/2020
BH No.	Depth	Predominant Soil Fraction	Measured SPT N Value	Overburden Correction Factor	Hammer Donut rope and pulley Correction Factor	Rod length factor (4- 3m) 4-1.5m	Sampler factor Standard	Bore hole Diamete correction	Equipment & Borehole Correction	Corrected SPT N' Value Ncor	Correction for Water Table Position	Unconfined Compressive Strength QueNov113.27	Undrained Cohesion Cu=qu2	Allowable Bearing Capacity By Terzaghi and Peck (1948) Qall=Nore10	Allowable Bearing Capacity Terzaghi and Peck, 1967 Qall=5.144aw3
	(m)		50	1.00	0.80	0.75	1.00	1.00	0.60	30	1.00	(KPa) 308	(KPa)	(kPa) 300	(kPa) 341
BH1	1.50	Gravels,Sands ,Silts & Clays		1.00	0.00	0.75	1.00	1.00	0.00	20	1.00	590		500	
	3.00		50	1.00	0.80	0.75	1.00	1.00	0.60	<u>30</u>	1.00	398	199	300	341
DUA	1.50	Carda Silk & Clark	50	1.00	0.80	0.75	1.00	1.00	0.60	<u>30</u>	1.00	398	199	300	341
BH 2	2.50	- Sands "Sints & <u>Clays</u>	50	1.00	0.80	0.75	1.00	1.00	0.60	<u>30</u>	1.00	398	199	300	341
	1.50		50	1.00	0.80	0.75	1.00	1.00	0.60	<u>30</u>	1.00	398	199	300	341
DULA	3.00	Gravels,Sands ,Silts	50	1.00	0.80	0.75	1.00	1.00	0.60	<u>30</u>	1.00	398	199	300	341
внэ	4.50	& Clays	50	1.00	0.80	0.85	1.00	1.00	0.68	<u>34</u>	1.00	451	226	340	387
	5.80		50	1.00	0.80	0.85	1.00	1.00	0.68	<u>34</u>	1.00	451	226	340	387
BH 4	1.50	Gravels,Sands ,Silts & <u>Clays</u>	50	1.00	0.80	0.75	1.00	1.00	0.60	<u>30</u>	1.00	398	199	300	341

For cohesive soils, the relationship qu = 13.00 x Design N-value is used for evaluation of the Unconfined Compressive Strength qu, the cohesion Cu = qu/2 and qult = 5.14 x Cu. qall is evaluated using a factor of safety of 3.0

Allowable bearing capacity with settlement limited to approximately 25mm for cohesionless soils read off directly from the Chart (Published by Terzaghi and Peck, 1967). (For 2m width footing)

Estimates of presumed allowable bearing capacity values for scheme design not detail design

Neor of 0.6 is adapted for rod length 0-4m and 0.68 for depth ranges 4-6m in accordance to Peck et al Neor = N60 =CN CER CER =CH CR Cs CB.

Vincent Kimeu Laboratory Manager Drecomatts Limited

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### b) UCS-Rock

ROPO		NSTRUC	TION CO	OMPANY						
	SED JUBA	CITY CC	UNCIL	SANITAR	Y AND EN	IVIRONME	NT BUI	DING .		
UBA T	OWN							Date		9/2/20
	UN	ICONF	INED	COMP	RESSIC	ON TES	T (UC	S)-ROC	K	
Bore hole	Depth range (m)	sample length	Diameter	cross sectional area	Volume	Height:Dia meter ratio	Weight	Unit weight	Load	Unconfined Compressi
From	То	mm	mm	mm2	mm3		g	kg/m3	KN	N/mm
10.65	10.75	80	70	3850	308000	1.14	540	1,753	54	14.03
12.00	12.15	85	70	3850	327250	1.21	560	1,711	75	19.4
13.60	13.75	80	70	3850	308000	1.14	900	2,922	107	27.7
14.80	15.00	100	70	3850	385000	1.43	1105	2,870	125	32.4
65	4.75	80	80	5029	402286	1.00	650	1,616	80	15.9
05	6.15	75	80	5029	377143	0.94	535	1,419	70	13.9
90	9.10	110	80	5029	553143	1.38	980	1,772	130	25.8
52	9.68	160	80	5029	804571	2.00	1,770	2,200	153	30.4
0.30	10.50	100	80	5029	502857	1.25	1,110	2,207	160	31.8
.40	11.60	145	80	5029	729143	1.81	1,515	2,078	145	28.8
3.20	13.80	160	80	5029	804571	2.00	1,730	2,150	142	28.2
8.40	18.60	160	80	5029	804571	2.00	1,730	2,150	K Wamb	33.8
80	5.90	95	70	3850	365750	1.36	670	1,832	158	41.0
.40	10.60	110	70	3850	423500	1.57	845	1,995	140	36.3
5.10	15.30	90	70	3850	346500	1.29	630	1,818	168	43.6
6.70	16.80	85	70	3850	327250	1.21	630	1,925	185	48.0
.30	19.50	130	70	3850	500500	1.86	980	1,958	205	53.2
80	4.00	70	70	3850	269500	1.00	400	1,484	65	16.8
80	7.00	90	70	3850	346500	1.29	420	1,212	105	27.2
.40	11.60	110	83	5413	595406	1.33	845	1,419	140	25.8
3.60	13.80	140	83	5413	757790	1.69	1,132	1,494	125	23.0
.20	17.40	140	83	5413	757790	1.69	1,405	1,854	165	30.4
	Pipe           10.65           12.00           13.60           14.80           5           30           40           20           40           20           40           30           40           30           40           30           40           30           40           10           70           30           40           10           70           30           60           20	Prom         To           10.65         10.75           12.00         12.15           13.60         13.75           14.80         15.00           5         6.15           00         9.10           52         9.68           30         13.80           4.00         11.60           20         13.80           4.01         15.00           5         9.10           5         9.10           5         9.10           5         9.10           5         9.10           5         9.10           5         9.10           5         9.10           5         9.10           5         9.10           6         15.00           70         13.80           70         16.80           30         9.50           30         19.50           30         10.00           30         10.60           30         10.50           30         10.50           30         10.50           30         10.50	Image: Properties of the second sec	Image: Properties of the section of the sec	UNCONFINED COMF           is         is<         is         is         <	UNCONFINED COMPRESSION           000000000000000000000000000000000000	UNCONFINED COMPRESSION TESS           age for the set         age for the set <tha< td=""><td>UNCONFINED COMPRESSION TEST (UC           0<td>UNCONFINED COMPRESSION TEST (UCS)-ROCC           no         no</td><td>by bybyby bybybyby10.01&lt;</br></br></br></br></br></br></td></td></tha<>	UNCONFINED COMPRESSION TEST (UC           0 <td>UNCONFINED COMPRESSION TEST (UCS)-ROCC           no         no</td> <td>by bybyby bybybyby10.01&lt;</br></br></br></br></br></br></td>	UNCONFINED COMPRESSION TEST (UCS)-ROCC           no         no	by byby byby byby byby byby byby byby byby byby byby byby byby byby byby byby byby byby byby 
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# Appendix 8– Summary of classification results.

												LA	TE	ST R	ESU	LTS	SUM	MA	RY-	ROC	L/SO	IL												L		
CLIENT			AB H	ARAA	MBE (	CONST	RUC	TION																		1							DF	ECO-	MAT	TS
PROJEC	T:		JUB/	A CITY	COUN	NCIL S	ANIT	ARY A	ND EN	VIRON	IMENT	fal n	UILT-	PURP	OSE B	UILDI	NG															Co	Drill	ing, Eng	ineering hnical S	g &
LOCATI	NC		JUB/	A CITY	; Rep	UBLIC	OF S	outh	SUDA	N																					12/2/2	2021				
														Soil In	dex Pro	perties	ă.											So	oil Density			Shea	r strengt	hs		
BH/TP no	Dep	oth(m)		,					3	% Pass	ing Sie	ve (mm	i.							GM	NM			Plastic	city		MDD	OMC	Bulk Density	SG	ę	c	Bulk density	Remolded	Comr	ments
		_	75.0	50.0	37.5	28.0	20.0	14.0	10.0	6.3	5.0	4.0	2.0	1.18	0.600	0.425	0.300	0.150	0.075		COMPLEX.	u	PL	Pl	LS	PM	Kg/m3	%	Kg/m3		C	Kg/m2	Kg/m3	%		
1 BH1	0.00	1.00					100	97.7	96.6	94.9	94.1	90.1	89.6	75.2	59.5	46.7	33	8.9	0.4		16.8	NP	NP	NP	NILL	0	1930	15.3	2225.29	2.595	27	0.02	1712	77		
2 BH1	1.00	2.00			_	1		100	99.7	99.1	89.7	97.4	95.3	84.1	67.2	51	36.3	12.1	1.8		9.4	NP	NP	NP	NILL	0				2.500						
3 BH1	2.00	3.00							100	99.7	98.1	96.3	94.8	84.3	67.9	51.5	36.7	12.1	0.9		6.7	NP	NP	NP	NILL	0				2.595						
4 BH1	3.00	4.00							100	99.3	98.9	96.9	95.7	85	68.6	51.9	36.2	10.1	0.3		2.0	NP	NP	NP	NILL	0				2.660						
s BH1	4.00	5.00							100	99.5	99.2	97.5	96.6	86.4	69.0	52.2	36.8	9.3	02		1.8	NP	NP	NP	NILL	0				2.660						
6 BH1	5.00	6.00								100	99.5	97.6	96.8	86.8	69.9	53.2	37.8	10.4	0.6		2.2	NP	NP	NP	NILL	0				2,569						
7 BH2	0.00	1.00				100	96.7	95.7	94,1	91.2	89.0	82.3	79.3	68.8	57.2	46.8	35.1	14.1	8.1		13.0	28.7	23.12	5.58	2.79	261.14				2.605						
B BH2	1.00	1.50												100	96.6	89.0	83.1	75.7	56.5		6.7	NP	NP	NP	NILL	0	1930	15.3	2225.29	2.500	25	0.13	1680	75		
9 BH2	1.50	2.30							100	99.8	99.5	97.6	96.5	86.5	69.4	52.8	37.1	15.0	0.3		15.5	27.40	14.29	13.11	6.555	692.21				2.625						
10 BH2	2.30	3.50							100	99.8	99.7	97.9	97.1	86.7	67.4	58.8	37.3	10.2	0.7		2.3	NP	NP	0	NILL	NILL	8			2.76						
11 BH3	0.00	1.00					100	96.5	54.4	54.5	91.2	89.3	82.6	86.6	69.3	58	47.2	35.2	14.6		2.00	34.6	25	9.6	4.8	556.80	1930	15.3	2225.29	2.47	26	0.03	1565	70		
12 BH3	1.00	2.00							100	98.7	95.4	93.8	95.9	89.9	70.8	57.9	46.2	33.5	10		1.7	NP	NP	0	NILL	NILL				2.625						
13 BH3	2.00	3.00								100	97.1	95.6	88	88	71.5	56.8	44.9	31.7	8.8		22	NP	NP	0	NILL	NILL				2,66						
14 BH3	12.20	12.50				_				100	98.7	96.4	86.5	89.5	72.6	57.7	46.8	32.6	9.1		1.4	NP	NP	0	NILL	NILL				2,715						
15 BH4	0.00	1.00				100	92.1	92	90.4	86.6	83.9	73.1	68.9	63.7	51.9	41.4	31.6	14.6	9		4.3	31.3	19,3	12	6	496.80	1680	11.9	1937.04	2.50	25	0.09	1580	82		
16 BH4	1.00	2.00						100	98.7	94.7	90.9	76.8	72	66.4	52.4	30.3	27.4	6.6	0.4		0.3	NP	NP	0	NILL	NILL				2.565						
17 EP1	0.00	1.00						100	98.6	94	84.5	79.4	65.8	61,4	48.5	39.6	33.2	27	18.4		9.4	31.2	18.97	12.23	NILL	NILL	1930	15.3	2225.29	2.595	23	0.12	1599	72		
18 EP1	1.00	2.00					100	96.6	96.6	95.4	87.5	82.3	68.6	64	50.1	40.8	34.3	28	19.4	75	5.6	NP	NP	0	NILL	NILL				2.625						
19 EP2	0.00	1.00					100	93.5	87.4	82.2	77.2	69.4	61.6	58.6	50.5	44.9	40.6	35.9	26.9		19.5	NP	NP	0	NILL	NILL	1680	11.9	1937.04	2.53	20	0.16	1723	89		
20 EP2	1.00	2.00					100	94	91.9	87.1	82.7	80	72.1	69.4	61.4	54.6	49.3	44	34.4		10.3	NP	NP	0	NILL	NILL				2.53						
Keys																																				
L	Liquid	Limit	LS	Linear	Shrinka	ge	6		0.105	USCS	Unified	Soil Cl	assifica	tion Sys	tem		MH	Elastic	Silt (Hi	gh plast	icity)					CH	Fat Clay	(High pla	sticity)		NA	Not App	blicable			
PL PI	Plastic	: Limit sity Index	PM PI=	Plastic	ity Mool	uius (pro	oduct o	r Passin	g U.425 i	GM	Gradin	ig moau Ne	IUS				ML.	Olean	Clav (h	n <i>u</i> nlast	icityl					SU	Silty San	and d			N5 Ø	Angle o	finternal	friction		
NP	Non-P	Nastic	MV	Silts of	verv his	oh olast	icity			NM	Natura	il Moistu	re				UL	Ologin	oldy (D	on hoa	wiy/					SP	Poorly or	u aded San	d		(*)	Degree	5	EN-EUT		
SG	Specif	fc gravity	CV	Clays	of very h	high plas	sticity			CE	Clays	of extra	nely hig	h plasti	city											LS	Linear sh	ninkage	1.97 1.97		UCS	Unconfi	ned com	pressive streng	th	
Vince Labor Dreco	nt Kime atory M matts L	eu lanager .imited			3				12		-				(j) (j)			2	2	×—:				8 <u>-</u> 9				2247		·	8					

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### **Appendix 9– Grading results.**

#### BH1 0.0 - 1.0m



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BH1 1.0 - 2.0m



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BH1 2.0 - 3.0m



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### BH1 3.0 - 4.0m

				SO Sieve	e Ana	CI lysis	LAS	SIFI ory Test	CA Result	TIC -BSS	<b>DN</b> 1377				DRECO Drilling, En Construction Te	-MATTS gineering & chnical Suppor
CLIENT		AB HA	ARAMBE C	ONSTRU	CTION									Date		7/2/2021
PROJEC	ст	PROP	OSED JUE	BA CITY E	BUILD	NG AN	ID GARAG	ε								
ocatio	n		BH 1			Depth	(m)	3.0	)-4.00m				sample	e no		
CLA	Y		SI	LT			S	AND			GI	RAVEL				Cobble
		Fine	Medium	Coarse	% Silt	Fine	Medium	Coarse	% Sand	Fine	Medium	Coarse	% Gravel	0		0
	0.0	0.0	0.0	0.3	0	35.9	32.4	27.11	95	3.636	0.66	0	4	0		
		% pas	sing 0.425	sieve				52								
		% pa	ssing 0 075	sieve				0								
50 37.5 28 20 14 10 6.3 5 4 2 1 0.6 0.425 0.3 0.15 0.075	100 100 100 100 100 99.34 96.86 95.7 84.96 68.6 51.9 36.2 10.08 0.331		90 80 70 60 50 50 30 20 10 0													
	Descr	iption	;-	Grey FI	NE-ME	DIUM	SAND -M	NON PLAS	TIC	article	Size mm	n				

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BH1 4.0 -5.0m



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BH1 5.0 -6.0m



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### BH 2 0.0-1.0m

	-			Siev	e Ana	lysis	Laborar	Ory Test	Result	-BSS	31377			c	DRECO-M Drilling, Engine onstruction Techn	ATTS sering & ical Suppor
CLIENT		AB HA	ARAMBEC	ONSTRU	CTION						4			Date	7/2	2/2021
PROJE	ст	PROP	OSED JUE	BA CITY I	BUILDI	NG AN	ID GARAG	iΕ								
Locatio	n		BH 2			Depth	(m)	0.	0-1.0m				sampl	e no		
CL	AY		SI	LT			S	AND			GI	RAVEL				Cobble
		Fine	Medium	Coarse	% Silt	Fine	Medium	Coarse	% Sand	Fine	Medium	Coarse	% Gravel	0		0
	0.0	0.0	0.0	8.1	8	27.0	22.2	22.03	71	11.88	4.49	3	20	0		
		% pa:	ssing 0.425	sieve				47								
		% pas	ssing 0.075	sieve				8	grav	elly	1	-	-			
37.5 28 20 14 10 6.3 5 4 2 1 0.6 0.425 0.3 0.15 0.075	100 100 96.7 95.7 94.1 91.2 89.0 82.3 79.3 68.8 57.2 46.8 35.1 14.1 8.1		90 80 70 50 40 30 20 10 10													
	Descr	iption	0.	Light bro	own /y	ellowis	h FINE N	IEDIUM S/	0.1 Pa	ION PL	Size mr	n n		10		00
			<i>2</i>													

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#### BH 2 1.0-1.5m



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#### BH 2 1.5-2.3m



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#### BH 2 2.3-3.5m



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### BH 3 0.0-1.0m



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BH 3 1.0-2.0m



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### BH 3 2.0-3.0m



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BH 3 12.2-12.5m



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#### BH 4 0.0-1.0m



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#### BH 4 1.0-2.0m



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#### EP1 00.0-1.0m



#### **AB Harambe Engineering and Construction**

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#### EP1 1.0-2.0m



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#### EP2 0.0-1.0m



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#### EP2 1.0-2.0m



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### **Appendix 10– Plasticity Index results.**

BH1 0.0-1.0m

												DRECO-	MATTS	
				Atterberg	s Limit La	borarory Test Result	-BSS 1377 pa	rt 2			l	Drilling, Eng Construction Tee	glocoring & choical Support	
Lient		AB HARAM	be cons	TRUCTION					Date	e	8/2/2	021		
ROJECT		PROPOSED	JUBA CI	TY BUILDING A	ND GARAGE	E								
Ĺ	ocation		В	H 1	Dep	pth (m)	ð	0.0-1.0M						
reparation;-Ai	r dried, pas	sing 0.042	5 85 Siev	ve					116		4			
TEST			U	IQUID LIMIT			PLASTIC	LIMIT		PLASTICITY IN	IDEX		DEC	DUCTIONS
			LL				Р	L		LL-PL		0-5	Ĵ	None Plastic
ENETRATION	15.0	17.0	19.4	21.0	LL n at	ead from the graph penetration of 20.	-1	2				,6-10		Low
											-	,11-18	2	Moderate
C %	NP	NP	NP	NP	NON	IE PLASTIC	Av.		in the second seco		-	>19	-12	High
M	75 74 73 72 71 70													
M o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 63 64 63 62 61													
M o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 64 63 62 61 62 61	0	160			18.0	190	200	210	220		230		24.0 2
M o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 15	.0	16.0		17.0	18.0	19.0 e n e t	20.0 ratio	210	22.0		23.0		24.0 2
M o i s t u r e	75 74 73 72 71 70 69 68 67 66 63 64 63 62 61 62 61 60 15	0	15.0		17.0	18.0	19.0 e n e t	20.0 ratio	210	22.0		23.0		24.0 2
M O i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 15	.0	16.0	Checked b	17.0.	18.0 P Esther Githiga	19.0 e n e t	20.0 ratio	21.0	22.0 GK Wambugu		23.0		24.0 2
M o i s t u r e e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 15	.0 A Bulemi	16.0	Checked b	17.0	18.0 Esther Githiga	19.0 e n e t	20.0 ratio	210 D ector(Technica	22.0 GK Wambugu a)		23.0	Sta	24.0 2 24.0 2

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#### BH1 1.0-2.0m

					SOIL PLASTIC	ITY			DEFCOMAT	75
				Atterberg	ps Limit Laborarory Test Result	-BSS 1377 pa	urt 2		Brilling, Engineerin Construction Technical	ing A Support
.IENT		AB HARAN	IBE CONS	TRUCTION				Date	8/2/2021	
OJECT		PROPOSEI	) JUBA CI	ity Building /	ND GARAGE					
Ļ	ocation		B	3H 1	Depth (m)		1.0-2.0M	_		
paration;-Ai	r dried, pas	sing 0.042	5 BS Sie	ve				ΩP.	~	
TEST			81	IQUID LIMIT		PLASTIC		PLASTICITY INDEX		DEDUCTIONS
			LL			P	L	LL-PL	0-5	None Plastic
NETRATION	15.0	17.0	19.4	21.0	LL read from the graph at penetration of 20.	1	2	5.000 10 Mol	,6-10	Low
									,11-18	Moderate
С%	NP	NP	NP	NP	NONE PLASTIC	Av.			>19	High
N	75 74 73 72 71 20									
N o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 65 64 63 62 62 62									
N o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 61 63 55 64 55 64 55 64 55 64 55 64 55 64 55 64 55 64 55 64 55 64 55 64 55 64 55 64 55 64 55 64 55 64 55 64 55 64 64 65 65 65 65 65 65 65 65 65 65 65 65 65	0	35.0		17.0 18.0	19.0	20.0	210 220	25.0	24.0 250
N o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 62 61 62 51 55	0	35.0		17.0 18.0 P	190 e n e t	200 ratio	210 220	23.0	24.0 25.0
N O i s t u r e	75 74 73 72 71 70 69 68 65 64 65 64 63 62 61 60 15	o A Bulemi	35.0	Checked	17.0 180	190 enet	20.0 ratio	210 220 n	25.0	24.0 25.0
N O i s t u r e s t e s t e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 15	0 A Bulemi fechnitian	35.0	Checked	by Esther Githiga	190 enet	20.0 ratio	21.0 22.0 n GK Wambugu ector(Technical)	23.0	240 250

BPC5 Engineering Services Ltd Ptol 4 School Grove OFF School Lane P.O. 80% 20598-00100 Nairabi Tel:+254 721394530 www.tapcongineering.co.te

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### BH1 2.0-3.0m

				1	SUIL PLASTICI	II Y			DRECO-MAT	ITS
				Atterberg	s Limit Laborarory Test Result	-BSS 1377 part 2			Drilling, Engineeri Construction Technical	ing A I Support
LIENT		AB HARAN	MBE CONS	TRUCTION			Date	Į a	8/2/2021	
ROJECT		PROPOSE	D JUBA C	ity building a	ND GARAGE					
i	Location		E	3H 1	Depth (m)	2.0-3.0M				
reparation;-A	ir dried, pas	sing 0.043	<b>:5 8</b> 5 Sie	ve					2	
TEST			ì			PLASTIC LIMIT	PLA	STICITY INDEX		DEDUCTIONS
			LL		7	PL		LL-PL	0-5	None Plastic
ENETRATION	15.0	17.0	19.4	21.0	LL read from the graph at penetration of 20.	1 2		120012242044	,6-10	Low
									,11-18	Moderate
10%	NP	NP	NP	NP	NONE PLASTIC	Av.			>19	High
N	75 74 73 72 71 70									
N o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 65 64 63 62 61 60									
N o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 65 64 63 62 61 60 11		15.0		17.0 18.0 <b>P</b>	19.0 20.0 e n e t rat	210 i o n	220	28.0	24.0 250
N o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 65 64 63 62 61 60 15		16.0		17.0 18.0 P	19.0 20.0 enetrat	210 i o n	22.0	23.0	24.0 25.0
esteed By	75 74 73 72 71 70 69 68 67 66 65 64 65 64 63 62 61 60 15	5.0	15.0	Checked b	y Esther Githiga	19.0 20.0 e n e t r a t	210 i o n GKV	22.0 Vambugu	23.0	24.0 250
N o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 11	A Bulemi Technitian	15.0	Checked E	y Esther Githiga	19.0 20.0 e n e t r a t	210 i o n GK V Director(Technical)	22.0	23.0	24.0 250

### **AB Harambe Engineering and Construction**

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### BH1 3.0-4.0m

										DRECO-MA	ITS
				Atterber	rgs Lin	nit Laborarory Test Result	-BSS 1377 pa	art 2		Orilling, Engineer Construction Technica	ing A I Support
CLIENT	5	AB HARAN	BE CONS	TRUCTION					Date	8/2/2021	
PROJECT		PROPOSE	) JUBA C	ity building	AND G	ARAGE				STATUTE I	
i	Location		E	IH 1		Depth (m)	0000	3.0-4.0M			
Preparation;-A	ir dried, pas:	sing 0.042	5 BS Sie	ve		li.				di	
TEST			1		ş		PLASTI	сциит	PLASTICITY INDEX		DEDUCTIONS
1201			LL -			2	P	L.	LL-PL	0-5	None Plastic
PENETRATION	15.0	17.0	10.4	21.0		LL read from the graph at penetration of 20.	1	2		,6-10	Low
										,11-18	Moderate
MC%	NP	NP	NP	NP		NONE PLASTIC	Av.		5	>19	High
N	75 74 73 72 71 70										
N o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 63 63 63 63 63										
N o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 15	0	16.0		17.0	18.0	19.0	20.0	210 220	23.0	24.0 250
N o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 15	0	15.0		17.0	18.0	19.0 e n e t	20.0 <b>ratio</b>	210 220	23.0	24.0 250
N o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 15	0 A Bulemi	16.0	Checked	17.0	18.0 P Esther Githiga	19.0 e n e t	20.0 ratio	210 220 R GK Wambugu	23.0	24.0 25.0

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BH1 4.0-5.0m

					SOIL PLASTIC	ITY			
				Atterberg	s Limit Laborarory Test Result	-BSS 1377 part 2		DRECO-MAT Drilling, Engineerin Construction Technical	TS ng & Support
.IENT		AB HARAN	IBE CONS	TRUCTION			Date	8/2/2021	
ROJECT		PROPOSE	) JUBA C	ity building ai	ND GARAGE				
Ģ	ocation		E	ян 1	Depth (m)	4.0-5.0M		-	
eparation;-Ai	r dried, pas	sing 0.042	5 BS Sie	ve					
TEST		105	E	iquid limit		PLASTIC LIMIT	PLASTICITY INDEX		DEDUCTIONS
			LL	0		PL	LL-PL	0-5	None Plastic
NETRATION	15.0	17.0	19.4	21.0	LL read from the graph at penetration of 20.	1 2		,6-10	Low
			1		·	<u></u>		,11-18	Moderate
:%	NP	NP	NP	NP	NONE PLASTIC	Av.	State 1	>19	nign
M	75 74 73 72 71								
M o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 65 64 63 62 62 61								
M o i s t u r e	75 74 73 72 71 70 69 68 65 64 65 64 63 62 62 61 15	0	16.0		17.0 18.0	19.0 20.0	21.0 22.0	23.0	24.0 25.0
M o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 15	0	15.0		17.0 18.0 <b>P</b>	19.0 20.0 e n e t ratio	210 220	23.0	24.0 25.0
M o i s t u r e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 15	0 A Bulemi	16.0	Checked b	y Esther Githiga	15.0 20.0 e n e t r a t i o	210 220 B GK Wambugu	23.0	24.0 250
teed By e	75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 15	o A Bulemi echnitian	16.0	Checked by	y Esther Githiga	15.0 20.0 e n e t r a t i o Approved by Dir	210 220 D GK Wambugu ector(Technical)	23.0	24.0 250

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BH1 5.0-6.0m

											DRECO-MAT	TS
				Atterbe	rgs Lin	nit Laborarory Test Result	-BSS 1377 pa	rt 2		Can	Brilling, Englements struction Technical	ig & Support
IENT		AB HARA	MBE CONS	TRUCTION					Date	8/2/2021		
OJECT		PROPOSE	d Juba C	ity building	AND G	ARAGE						
	Location		E	IH 1		Depth (m)	8	5.0-6.0M				
paration;-J	Air dried, p	essing 0.04	25 BS Sie	ve		2h				2		
TEST	1	09465	ī				PLASTIC			FX		DEDUCTIONS
TEOT		<i>a</i> 3	ш			1 551 1000m 05 100	P	L	LL-PL		0-5	None Plastic
VETRATION	15.0	17.0	19.4	21.0		LL read from the graph at penetration of 20.	1	2			,6-10	Low
	2265	209.2	12,514	12-02.0							,11-18	Moderate
%	NP	NP	NP	NP		NONE PLASTIC	Av.				>19	High
	7 7 7 8 7 8 7 9 7											
               	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7		16.0		17.0	18.0	15.0 <b>e n e t</b>	20.0	210 220		23.0	24.0 25
steed By	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	A Bulemi	16.0	Checked	17.0 by	18.0 P Esther Githiga	19.0 e n e t	20.0 ratio	210 220 n		23.0	24.0 25
iteed By	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	A Bulemi Technitian	16.0	Checked	17.0	18.0 P Esther Githiga er (Geotech&Materials)	15.0 e n e t	20.0 ratio	210 220 CK Wambugu ector(Technical)		23.0	24.0 25

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### BH2 0.0-1.0m

					SO	IL PLASTICI	IY		DRECO-MAT	TS
				Atterbe	rgs Lin	nit Laborarory Test Result	-BSS 1377 part 2		Drilling, Englocerin Construction Technical	ng & Support
IENT		AB HARAM	be const	RUCTION				Date 80	2/2021	
OJECT		PROPOSED	ЈИВА СП	y Building	GAND GA	ARAGE				
j.	ocation		BH	2		Depth (m)	0.0-1.0M		15	
eparation;-A	ir dried, pass	ine 0.042	BS Siev							
		<u> </u>	11			(* 1) 1 1 1 1			1	DEDUCTIONS
TEST			LL		6		PLASIC LIMIT		0.5	None Plastic
						LL read from the graph at penetration of 20.	1 2	5.6	,6-10	Low
NETRATION	15.9	17.2	19.8	21.4			20.5 25.735	6	,11-18	Moderate
:%	24.6231156	26.3158	28.2609	30		28.7	Av. 23.118	5.5°	>19	High
Noi	30 29 28									
N o i s t u r e	30 29 28 27 26 25 25 24 15	0	16.0		17.0	180 P	19.0 20.0 e n e t ratior	210 220	23.0	24.0 25
N o i s t u r e	30 29 28 27 26 25 24 15	D A Bulemi	15.0	Checker	17.0 I by	18.0 P Esther Githiga	15.0 20.0 e n e t r a t i o r	210 220 GK Wambugu	23.0	24.0 25
N o i s t u r e s t ed By je	30 29 28 27 26 25 24 15.	D A Bulemi echnitian	16.0	Checker	17.0 d by Engineer	18.0 P Esther Githiga	19.0 20.0 e n e t r a t i o r Approved by	210 220 CK Wambugu	23.0	24.0 25.

AB	Harambe	Engineering	and Constructio	n
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BH2 1.5-2.3m

					SOIL PLASTIC	IIY				-	
				Atterbergs	Limit Laborarory Test Result	t -BSS 1377 pa	art 2		6	DRECO-MAI Drilling, Engineeris onstruction Technical	TS ng & Sappart
LIENT		AB HARAME	e constr	NCTION				Date	8/2/202	H	
ROJECT	1	PROPOSED	JUBA CITY	BUILDING AN	D GARAGE					Alt - L	
Loc	ation		BH	2	Depth (m)		1.5-2.3M		_		
reparation;-Air o	dried, pass	ing <b>0.042</b> 5	BS Sieve								
TEST			LIQ	UID LIMIT		PLASTIC	С ЦМІТ	PLASTICITY IN	DEX		DEDUCTIONS
			LL			Р	'L	LL-PL		0-5	None Plastic
ENETRATION	15.60	17.57	19.46	21.45	LL read from the graph at penetration of 20.	1	2	13.1		,6-10	Low
	2.5557					14.2857	14.286	13		,11-18	Moderate
С%	21.60	24.14	26.92	27.78	27.4	Av.	14.286	even even		>19	High
M	30.00 29.00 28.00 27.00										
M o i s t u r e	30.00       -         24.00       -         27.00       -         25.00       -         24.00       -         25.00       -         24.00       -         23.00       -         24.00       -         21.00       -         21.00       -										
M o i s t u r e	20.00 29.00 27.00 25.00 24.00 23.00 21.00 21.00 15.0	o	15.00	17 Checked by	00 18:00 P	19.00 e n e t	20.00 20.00 20.00 20.00 20.00	21.00 22.00 n			24.00 25.00

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### BH2 2.3-3.5m

					SO	IL PLASTIC	ITY				
				Atterber	rgs Lim	iit Laborarory Test Result	-BSS 1377 p	art 2		DRECO-MA Drilling, English Construction Technic	TTS (ing A al Support)
LIENT	2	AB HARAM	BE CONSTR	RUCTION					Date	8/2/2021	
ROJECT		PROPOSED	JUBA CITY	r Building	AND GA	NRAGE					
Lo	ation		BH	2		Depth (m)		2.3-3.5M			
eparation;-Air	dried, pass	ing 0.0425	BS Sieve	0		A264					
TEST			LIG	UID LIMIT			PLAST	IC LIMIT	PLASTICITY INDE	EX	DEDUCTIONS
			LL			195 552 ¥199 828	1	PL	LL-PL	0-5	None Plastic
ENETRATION	15.60	17.57	19.46	21.45		LL read from the graph at penetration of 20.	1	2	#VALUEI	,6-10	Low
							NP	NP		,11-18	Moderate
С%	NP	NP	NP	NP		NONE PLASTIC	Av.		0	>19	High
M	30.00 29.00 28.00 27.00										
M o i s t u r	30.00 - 29.00 - 28.00 - 27.00 - 26.00 - 26.00 - 24.00 - 23.00 -										
M o i s t u r e	30.00 - 29.00 - 27.00 - 25.00 - 25.00 - 23.00 - 23.00 - 23.00 -										
M o i s t u r e	30.00 - 29.00 - 27.00 - 25.00 - 25.00 - 23.00 - 23.00 - 21.00 - 30.00 -										
M o i s t u r e	30.00 29.00 27.00 25.00 24.00 23.00 21.00 21.00 30.00 15.0	0	16.00		17.00	18.00	19.00 enet	20.00 tratio	21.00 22.00	23.00	24.00 25.00
M o i s t u r e s	30.00 29.00 27.00 25.00 24.00 23.00 21.00 21.00 30.00 15.0	o A Bulemi	16.00	Checked	17.00 by	18.00 P	19.00 enet	20.00 tratio	21.00 22.00 n	23.00	24.00 25.00
M o i s t u r e s t e	30.00 29.00 27.00 25.00 25.00 23.00 21.00 30.00 15.000	0. A Bulemi ectnitian	36.00	Checked	17.00 by Engineer	18.00 P Esther Githiga	19.00 enet	20.00 tratio	21.00 22.00 D GK Wambugu ector(Technical)	23:00	24.00 25.00

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### BH 3 0.0-1.0m

				22	SOIL	PLASTIC	III			DRI	ECO-MATTS	
				Atterberg	s Limit L	Laborarory Test Result	t -BSS 1377 pa	irt 2		Deillin Constructi	ng, Engliseering A fun Technical Supp	port
ENT		AB HARAMB	e constr						Date	8/2/2021		
DJECT		PROPOSED	ЈИВА СПТҮ	BUILDING A	ND GARA	GE						
Loc	ation		BH3		80	Depth (m)	(	0.0-1.0M				
eparation:-Air	ried, pas	sine 0.0425	BS Sieve			-1						
	orient free						DI A OTTA			-	D	EDUCTIONS
TEST					1	1	PLASIC			EX	-	None Plastic
<u>.</u>					— u	read from the graph	1	2	9.6	0- c	-5	Low
IETRATION	16.32	18.52	20.83	22.90			25.00	25.00	1322	.10-	-18	Moderate
%	31.82	32.73	35.48	37.04		34.6	Av.	25	10	>1	19	High
Moi	40.00 39.00 38.00 37.00 36.00									~		
M o i s t u	40 00 39 00 38 00 37 00 36 00 35 00 34 00											
M o i s t u r	40.00 39.00 38.00 37.00 35.00 35.00 34.00 33.00											
M o i s t u r	40.00 39.00 38.00 37.00 36.00 35.00 34.00 33.00 33.00 33.00											
M o i s t u r	40.00 39.00 37.00 36.00 35.00 34.00 33.00 33.00 31.00 30.00	00	16.00			1800	1900	200		23.00		24.00 25.0
M o i s t u r e	40.00 39.00 37.00 36.00 34.00 33.00 31.00 30.00 15	00 A Bulemi	16.00		2,00	18.00 P	19.00 e n e t	20.00 ration	21.00 22.00	.23.00		24.00 25.0
M o i s t u r e	40.00 39.00 37.00 35.00 34.00 33.00 31.00 30.00 15.	00 A Bulemi	16.00		2.00	18.00 P Esther Githiga	19.00 e n e t	20.00 ration	21.00 22.00 GK Wambugu	23.00	SI	24.00 25.0
eed By	40.00 39.00 36.00 35.00 34.00 31.00 30.00 15.	00 A Bulemi Fechnitian	16.00	Checked b	7.00	18:00 P Esther Githiga Geotech&Materials)	19.00 e n e t	20.00 ration	21.00 22.00 GK Wambugu ctor(Technical)	.23.00	SI	24.00 25.0

### **AB Harambe Engineering and Construction**

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### BH 3 1.0-2.0m

					SC	DIL PLASTIC	ITY			DRECOM	TIS
				Atterbe	ergs Lii	mit Laborarory Test Result	-BSS 1377 p	art 2		Drilling, Engineer Construction Technics	rtny & al Support
LIENT		AB HARAM	be consti	RUCTION					Date	8/2/2021	
ROJECT		PROPOSED	JUBA CIT	y Building	g and g	ARAGE					
Lo	cation		BH	13		Depth (m)		1.0-2.0M			
reparation;-Air	dried, pas	sing 0.042	5 BS Sieve	•	1						
TEST	09900	392	LIC			전	PLAST		PLASTICITY INDE	x	DEDUCTIONS
1201			LL				1	PL	LL-PL	0-5	None Plastic
ENETRATION	18.22	10.52	20.02	22.00		LL read from the graph at penetration of 20.	1	2	#VALUE!	,6-9	Low
STERNIN	10.52	10.02	20.03	22.80			NP	NP		,10-18	Moderate
C %	NP	NP	NP	NP		none plastic				>19	High
i s t u r e	36.00 35.00 34.00 33.00 32.00										
	31.00										
	15	00	16.00		17.00	1800 P	19.00 enet	20.00 tration	21.00. 22.00 N	23.00	24.00 25.0
esteed By		A Bulemi		Checke	d by	Esther Githiga		Approved by	GK Wambugu		
isteed By	2	A Bulemi Fechnitian		Checke	d by Engine	Esther Githiga		Approved by Dire	GK Wambugu		Stamp
steed By	16	A Bulemi Fechnitian		Checke	d by Engine	Esther Githiga eer (Geotech&Materials)		Approved by Dire	GK Wambugu		Stamp

### **AB Harambe Engineering and Construction**

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BH 3 2.0-3.0m

				5	SOIL PLASTIC	ITY			DRECOMO	
				Atterbergs	Limit Laborarory Test Result	-BSS 1377 p	art 2		Drilling, Engineeri Construction Technical	ing & Support
LIENT		AB HARAM	be const	RUCTION	-			Date	8/2/2021	
ROJECT		PROPOSED	JUBA CIT	Y BUILDING AN	ID GARAGE					
Lo	ocation		BH	13	Depth (m)		2.0-3.0M			
reparation:-Air	rdried, pas	sing <b>0.042</b> !	5 BS Sieve	e					99 	
		2			57	DIACT	C LINET			DEDUCTIONS
TESI					16 L-1	PLASI	<u>CLIMII</u> L		0.5	None Plastic
n antissi e e e	00005	10000	00000	68556	LL read from the graph at penetration of 20.	1	2	#VALUE!	.6-9	Low
NETRATION	16.32	18.52	20.83	22.90		NP	NP		,10-18	Moderate
c %	NP	NP	NP	NP	none plastic				>19	High
M	38.00 \$7.00								-	-
M o i s t u r	38.00 37.00 36.00 35.00 34.00 33.00 32.00									
M o i s t u r e	88.00 37.00 36.00 35.00 34.00 33.00 32.00 31.00									
M o i s t u r e	38.00 37.00 35.00 34.00 33.00 31.00 30.00 15		15.00	1	7.00 18:00 P	19.00 enet	20.00 20.00	21.00 22.00	23.00	24.00 25.0
M o i s t u r e s s t e	38.00 37.00 35.00 34.00 33.00 31.00 30.00 15	00 A Bulemi	16.00	1. Checked by	/ Esther Githiga	19.00 enet	20.00 ratio	21.00 22.00 n	23.00	24.00 25.0
M o i s t u r e s teed By tle	38.00 37.00 36.00 395.00 33.00 31.00 30.00 15	00 A Bulemi	16.00	Li Checked by El	/ Esther Githiga	19.00 enet	20.00 ratio	21.00 22.00 21.00 22.00 CGK Wambugu ector(Technical)	23.00	24.00 25.0 Stamp

	AB	Harambe	Engineering	and	Construction
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### BH 3 12.2-12.5m

										DRECO-MAT	TS
				Atterbergs	Limit Laborarory Test Resu	t -BSS 1377	part 2			Drilling, Engleveria Construction Technical S	HE A
LIENT		AB HARAME	be constr	RUCTION				Date	8/2/2	2021	
ROJECT		PROPOSED	JUBA CITY	Y BUILDING AN	ID GARAGE						
Lo	cation		вн	3	Depth (m)		12.2-12.5M			·	
reparation;-Air	dried, pass	ing 0.0425	BS Sieve	2							
TEST	500-7-		LIQ			PLAST	TIC LIMIT	PLASTICITY I	NDEX		DEDUCTIONS
174 	1.1	LIQUID LIMIT				PL	LL-PL		0-5	None Plastic	
PENETRATION	16.32	18.52	20.83	22.90	LL read from the graph at penetration of 20.	1	2	#VALUE!		,6-9	Low
	7/522/3	10.255	4000000000 0000	1-17/07 1	1	NP	NP		8	,10-18	Moderate
С%	NP	NP	NP	NP	none plastic					>19	High
M	40.00 39.00 38.00 37.00										
M o i s t u r e	40.00 39.00 36.00 35.00 35.00 35.00 35.00 35.00 35.00 35.00										
M o i s t u r e	40.00 39.00 36.00 37.00 36.00 36.00 34.00 34.00 34.00 31.00 30.00 15.1	0	16.00	1		19.00	20.00	21.00 22.00		23.00	24.00 25.00
M o i s t u r e s t e	40.00 38.00 37.00 36.00 35.00 34.00 33.00 32.00 31.00 30.00 154	0 A Bulemi	16:00	13 Checked by	1.00 18.00	19.00 ene	20.00 tration	21.00 22.00 D		23.00	24.00 25.00
M O i S t u r e s teed By tle	40.00 38.00 36.00 36.00 36.00 36.00 36.00 36.00 36.00 36.00 31.00 30.00 15.0	0 A Bulemi echnitian	16.00	1 Checked by	2.00 18:00	19.00 e n e	20.00 tration	21.00 22.00 D GK Wambugu		23.00	24.00 25.00

### **AB Harambe Engineering and Construction**

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### BH 4 0.0-0.1m

				10121-012				1 DAY		DRECO-N	TATTS
				Atterberg	is Limi	it Laborarory Test Result -	-BSS 1377 pa	art 2		Construction Tech	nical Support
LIENT		AB HARAME	E CONSTR	UCTION					Date	8/2/2021	
ROJECT		PROPOSED	JUBA CITY	BUILDING #	ND GA	RAGE					
Loc	ation		BH4	(		Depth (m)	1	0.0-1.0 <b>M</b>			
reparation:-Air	dried, pas	sine 0.0425	BS Sieve			17				20	
		-					DI ACTIV	C LIMIT			DEDUCTIONS
TESI						2	PLASII		PLASTICITY INDE	x	None Plastic
			115		-	LL read from the graph	1	2	12.0	0-5	Low
PENETRATION	16.27	18.23	20.52	22.86		at penetration of 20.	18.63	20.00	-	,6-9	Moderate
10.9	27.69	29.29	32.14	34.29		24.2	10.05	49.242	12	>10	High
M o	37.00 36.00 35.00 34.00 33.00 32.00										
M o i s t u r	37.00 36.00 35.00 34.00 33.00 32.00 31.00 30.00 29.00 28.00										
M o i s t u r e	37.00 36.00 35.00 34.00 33.00 32.00 31.00 30.00 29.00 29.00 29.00 27.00 26.00										
M o i s t u r e	37.00 36.00 35.00 34.00 33.00 32.00 30.00 29.00 28.00 27.00 26.00										
M o i s t u r e	37.00 36.00 35.00 34.00 33.00 31.00 30.00 29.00 27.00 26.00 25.00 24.00 25.00	20	16.00		17.00	38.00 P	19:00 e n e t	20.00	21.00 22.00	23.00	24.00 25
M o i s t u r e e	37.00 36.00 35.00 33.00 30.00 29.00 28.00 27.00 26.00 25.00 24.00 15.	20 A Bulenti	16.00	Checked	17.00	18.00 P	19.00 e n e t	20.00 ratior	21.00 22.00 D	23.00	24.00 25
esteed By	37.00 36.00 35.00 34.00 31.00 30.00 29.00 20.000	20 A Bulemi echnitian	15.00	Checked I	17.00 17.00	18.00 P Esther Githiga	19.00 e n e t	20.00 ration	21.00 22.00 GK Wambugu ctor(Technical)	23.00	24.00 25

### **AB Harambe Engineering and Construction**

February 2021

### BH 4 1.0-2.0m

				10		2 2 4 2 B				DRECO-MA	TTS	
				Atterberg	s Limit Laborarory Test Res	ult -BSS 1377 p	oart 2		Dr	rilling, Engineer truction Technica	ring & al Sapport	
LIENT		AB HARAM	be const	RUCTION				Date	8/2/2021			
ROJECT		PROPOSED	JUBA CIT	y Building A	ND GARAGE					-		
	Location		BH	14	Depth (m)		1.0-2.0M		25			
Preparation;-A	ir dried, pas	sing 0.042!	S BS Sieve	e .					5			
			110		12	DIACT					DEDUCTION	s
TEST	р. 					PLASI	PL			0.5	None	Plastic
	18.27	10.22	20.52	22.08	LL read from the graph at penetration of 20.	1	2	#VALUE!		,6-9	I	low
CNETIVATION	10.27	10.23	20.52	22.00		np	np	2		10-18	Mo	derate
10%	NP	NP	NP	NP	NONE PLASTIC	Av.				>19	н	ligh
N	37.00 36.00 35.00 34.00 33.00											
M co i s t u r e	37.00 36.00 35.00 34.00 33.00 32.00 31.00 29.00 29.00 29.00 29.00 29.00											
M a i s t u r e	37.00 36.00 35.00 34.00 33.00 32.00 31.00 29.00 29.00 27.00 25.00											
M co i s t u r e	37.00 36.00 35.00 34.00 33.00 32.00 30.00 29.00 29.00 28.00 25.00 25.00 24.00											
N a i s t u r e	37.00 36.00 35.00 34.00 33.00 32.00 31.00 29.00 29.00 29.00 25.00 25.00 24.00 15	00	16.00		2.00 18:00	19.00 Penef	20.00 t ratio	21.00 22.00	23		24.00	25.00
esteed By	37.00 35.00 35.00 31.00 30.00 29.00 27.00 25.00 25.00 25.00 25.00 25.00	000 A Bulemi	16.00	Checked b	y Esther Githiga	19.00 Penet	20.00 t ratio	21.00 22.00 CK Wambugu	23	3.00	24.00	25.00
esteed By Ittle	37.00 36.00 35.00 34.00 32.00 30.00 29.00 20.000	00 A Bulemi	16.00	L Checked b E	y Esther Githiga		20.00 tration	21.00 22.00 R GK Wambugu ector(Technical)	23	3.00	24.00	25.00
AB	Harambe	Engineering	and Construction									
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EP1 0.0-1.0m

				5	SOIL PLASTIC	YIIY			DRECO-MA	TTS-
				Atterbergs	Limit Laborarory Test Resu	llt -BSS 1377 part	2		Drilling, Engineer Construction Technics	ring A al Support
LIENT		AB HAR AM	be constr	UCTION				Date	8/2/2021	
ROJECT		PROPOSED	JUBA CITY	BUILDING AN	D GARAGE					
Lo	cation		EP1		Depth (m)	0.0-	1.0M			
reparation:-Air	dried. a.z	sine 0.0429	BS Sieve				3			
	9000	200			÷.	2				DEDUCTIONS
TEST				JID LIMIT		PLASTIC L	IMIT	PLASTICITY INDE	EX	None Plastic
		Î		1	LL read from the graph		2	LL-PL	0-5	Low
ENETRATION	15.20	17.48	20.24	22.93	at penetration of 20.	18.12	19.82		,6-9	Moderate
c %	28.21	30.77	29.63	34.15	30.2	Av. 1	8 966	n	>19	High
M	35.00 34.00 33.00 32.00								2	
M o i s t u r e	35.00 34.00 33.00 32.00 31.00 30.00 29.00 28.00 27.00									
M o i s t u r e	35.00 34.00 33.00 32.00 31.00 30.00 29.00 27.00 25.00 25.00 25.00									
M o i s t u r e	35.00 34.00 33.00 32.00 30.00 29.00 29.00 29.00 29.00 29.00 25.00 25.00 24.00 15	00	16.00	17.			20.00 ation	21.00 22.00	23.00	24.00 25.0
M o i s t u r e	35.00 34.00 33.00 32.00 30.00 29.00 20.000	00 A Bulemi	16.00	17. Checked by	00 18.00		20.00 ation	21.00 22.00 GK Wambugu	23.00	24.00 25.0
M o i s t u r e e teed By i e	35.00 34.00 33.00 32.00 30.00 29.00 29.00 29.00 29.00 25.00 25.00 25.00 24.00 15	00 A Bulemi Fechnitian	16.00	17. Checked by En	00 18:00 Esther Githiga gineer (Geotech&Materials)	19.00 Denetr	20.00 ation	21.00 22.00 GK Wambugu ctor(Technical)	23.00	24.00 25.0 Stamp

## **AB Harambe Engineering and Construction**

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#### EP1 1.0-2.0m

					SO	IL PLASTIC	ITY			DRECOM	ITS
				Atterber	rgs Lim	it Laborarory Test Result	-BSS 1377 p	art 2		Drilling, Engineer Construction Technics	ting A d.Support
LIENT		AB HARAM	be const	RUCTION					Date	8/2/2021	
ROJECT		PROPOSED	) JUBA CIT	y Building	AND GA	RAGE				SELCC 1	
	Location	÷	EP	1		Depth (m)		1.0-2.0M		-	
reparation;	-Air dried, pa	ssin <b>a 0.042</b> !	5 BS Sieve								
		-	116				DIACT	C LIMIT			DEDUCTIONS
1551			LL				FLASI	2		0.5	None Plastic
			2000		-	LL read from the graph at penetration of 20.	1	2		.6-9	Low
ENETRATIO	N 15.20	17.48	20.24	22.93			NP	NP	2	,10-18	Moderate
С%	NP	NP	NP	NP		NONE PLASTIC	Av.			>19	High
			_	_							
	S 31.00 t 30.00 U 29.00 r 28.00 e 27.00 e 25.00										
	S 31.00 C 30.00 U 29.00 F 27.00 C 25.00 25.00 24.00 11	5.00	16.00		17.00	0.81C P	19.00 enet	20.00 <b>ratio</b> 1	21.00 22.00 N	23.00	24.00 25.00
isteed By	S 31.00 C 30.00 29.00 28.00 27.00 25.00 25.00 24.00 11	5.00 A Bulemi	16.00	Checked	17.00 by	18.00 P Esther Githiga	19.00 enet	20.00 <b>ratio</b>	21.00 22.00 n GK Wambugu	23.00	24.00 25.00
steed By tte	S 31.00 S 30.00 29.00 22.00 25.00 24.00 24.00 11	A Bulemi Technitian	16.00	Checked	17.00 by Enginee	18.00 P Esther Githiga rr (Geotech&Materials)	19.00 enet	20.00 ration pproved by Dire	21.00 22.00 n GK Wambugu	23.00	24.00 25.00 Stamp

## **AB Harambe Engineering and Construction**

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#### EP2 0.0-1.0m

					30	JIL PLASTIC	ITT			DREC	CO-MATTS
				Atterbe	ergs Li	mit Laborarory Test Result	-BSS 1377 p	art 2		Defiling, 1 Construction	Engineering A Technical Support
LIENT		AB HARAM	BE CONSTR	RUCTION					Date	8/2/2021	
ROJECT		PROPOSED	JUBA CITY	Y BUILDING	AND G	ARAGE					
Lo	cation		EP	2		Depth (m)		0.0-1.0M			
reparation;-Air	dried, past	sing 0.0425	5 BS Sieve	-	-	1			15	5	
TEST			LIG		ŕ		PLAST		PLASTICITY INDE	FX	DEDUCTIONS
			LL.			19 A.	F	۹.	LL-PL	0-5	None Plastic
PENETRATION	15 20	17.40	20.24	22.02		LL read from the graph at penetration of 20.	1	2		,6-9	Low
DICINGINA	10.20		2024	22.05			NP	NP		,10-18	8 Moderate
IC %	NP	NP	NP	NP		NONE PLASTIC	Av.			>19	High
M •	35.00 34.00 33.00 32.00										
M o i s t u r	33.00 35.00 34.00 33.00 32.00 31.00 30.00 29.00 28.00 28.00 27.00										
M o i s t u r e	33.00 35.00 34.00 33.00 32.00 31.00 30.00 29.00 28.00 27.00 25.00										
M o i s t u r e	33.00 35.00 34.00 33.00 32.00 31.00 30.00 29.00 29.00 29.00 29.00 29.00 29.00 29.00 29.00 29.00 29.00 29.00 20 20 20 20 20 20 20 20 20 20 20 20 2										
M o i s t u r e	35.00 35.00 34.00 33.00 31.00 30.00 25	200	16.00		17.00	18.00 P	19.00 enet	20.00	21.00 22.00	23.00	24.00 25
M o i s t u r e	33.00 35.00 34.00 33.00 32.00 31.00 30.00 29.00 20.000	200 A Bulemi	16.00	Checke	17.00 d by	18.00 P Esther Githiga	19.00 e n e t	20.00 ration spproved by	21.00 22.00 D GK Wambugu	23.00	24.00 25
M o i s t u r e e	35.00 35.00 34.00 33.00 30.00 29.00 28.00 27.00 25.00 25.00 25.00 25.00 25.00 25.00 25.00 25.00 25.00 25.00 25.00 25.00 25.00 25.00 25.00	00 A Bulemi	16.00	Checke	17.00 d by Engin	18.00 P Esther Githiga	19.00 enet	20.00 ration pproved by Dire	21.00 22.00 D GK Wambugu ctor(Technical)	23.00	24.00 25

## **AB Harambe Engineering and Construction**

February 2021

EP2 1.0-2.0m

					COIL						DRECO-MA	ATTS
				Atterberg	s Limit Lat	porarory Test Resul	lt -BSS 1377 p	art 2			Deilling, Englung Construction Technic	oring A nat Support
LIENT		AB HARAME	BE CONST	RUCTION					Date	8/2/2	2021	
ROJECT		PROPOSED	JUBA CITY	Y BUILDING A	ND GARAGE					-		
ı	ocation		EP	2	Dep	th (m)		1.0-2.0M				
reparation;-Ai	r eirieel, pas	sing 0.0425	BS Sieve	2		2						
TLOT			110				DIACT	C LIMIT	DIACTICITY	INDEX		DEDUCTIONS
TESI		LL				FLASH	2 <u>uwin</u>	PLASIICIT		0.5	None Plastic	
	123	1212	1000		LL re at p	ad from the graph venetration of 20.	1	2	LUT	-	.6-9	Low
ENETRATION	15.20	17,48	20.24	22.93		2	NP	NP		1	,10-18	Moderate
C%	NP	NP	NP	NP	NON	E PLASTIC	Av.				>19	High
N	37.00 36.00 35.00 34.00 33.00 32.00											
N o i s t u r	17 00 36.00 35.00 94.00 33.00 32.00 31.00 29.00 29.00 29.00											
N o i s t u r e	17.00 56.00 55.00 34.00 33.00 31.00 30.00 39.00 20.00 20											
N o i s t u r e	17.00 36.00 35.00 94.00 33.00 32.00 51.00 28.00 27.00 25.00 25.00 24.00											
N o i s t u r e	17.00 36.00 35.00 94.00 33.00 32.00 39.00 29.00 29.00 26.00 25.00 25.00 24.00 15	00	16.00		2,00	18.00	39.00 e n e t	20.00 ratio	21.00 22	.00	23.00	24.00 25
N O i S t u r e e s teed By	17.00 35.00 35.00 31.00 32.00 30.00 29.00 29.00 29.00 25.00 25.00 24.00 15	00 A Bulemi	36.00	Checked t	2,00	18:00 P	19.00 e n e t	20.00 cration	21.00 22 n GK Wambugu	.00	23.00	24.00 25
IN O I S T U F e	17.00 36.00 35.00 34.00 33.00 32.00 39.00 29.00 28.00 25.00 25.00 24.00 15	00 A Bulemi	16.00	Checked t	200.	18.00 P	19.00 9 e n e t	20.00 ratio	21:00 22 n GK Wambugu		23.00	24.00 25 Stamp

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## **Appendix 11–Compaction MDD/OMC results**

BH 1 +EP1 Combined



**AB Harambe Engineering and Construction** 

February 2021

#### BH 4 +EP2 Combined



**AB Harambe Engineering and Construction** 

February 2021

## Appendix 12–TRI-AXIAL UU results

## BH1 0.0-1.0m

Client : AB Harambe Construction Company Project :Juba City Council Sanitary and Environmental Building Sample no. BH1 Depth: 0.0-1.0m Specification: According to BS 1377:1990 Direct Shear Test Loads applied weight of hanger = 4.5 kg 1st load = 32.2 kg Total = 1st load + weight of hanger = 36.7 kg 2nd load = 68.9 kg Total = 2nd load + weight of hanger = 73.4 kg 3rd load = 0.6kg Total = 2nd load + weight of hanger = 109.5 kg Buik density 1712Kg/m2 Normal stress = applied load/area of shear box Normal stress = 1.02 kg per square cm Normal stress = 2.04 kg per square cm Normal stress = 3.04 kg per square cm Shear stress = 1.58 kg per square cm Normal stress = 3.04 kg per square cm Shear stress = 1.58 kg per square cm Shear stress = 1.58 kg per square cm Normal stress = 1.58 kg per square cm		Department of Civil d	ECOMATTS LIMI	TED oil & Rock Mechanics Laboratory		DRECO-MATTS Defiling, Engineering & Construction Technical Support
Direct Shear Test.         Loads applied weight of hanger = 4.5 kg 1st load = 32.2 kg Total = 1st load + weight of hanger = 36.7 kg       Area of shear box = 36 square cm.         2nd load = 68.9 kg Total = 2nd load + weight of hanger = 73.4 kg       3rd load = 105kg Total = 3rd load + weight of hanger = 109.5 kg         3rd load = 105kg Total = 3rd load + weight of hanger = 109.5 kg       Normal stress = applied load/area of shear box         Normal stress = applied load/area of shear box       shear stress = shear force at failure/ area of shear box         Normal stress = 1.02 kg per square cm       Shear stress = 0.53 kg per square cm         Normal stress = 3.04 kg per square cm       Shear stress = 1.13 kg per square cm         Normal stress = 3.04 kg per square cm       Shear stress = 1.58 kg per square cm         Image: Stress = 3.04 kg per square cm       Shear stress = 1.58 kg per square cm         Image: Stress = 3.04 kg per square cm       Shear stress = 1.58 kg per square cm         Image: Stress = 3.04 kg per square cm       Shear stress = 1.58 kg per square cm         Image: Stress = 3.04 kg per square cm       Shear stress = 3.58 kg per square cm         Image: Stress = 3.04 kg per square cm       Shear stress = 3.58 kg per square cm	Client : AB Harambe Cons Project :Juba City Council S Sample no:BH1 Depth:0.0-1.0m Specification: According to	struction Company Sanitary and Envir <i>BS 1</i> 377:1990	onmental Building	Date: 6/02/2021		
lotal = 1st load + weight of hanger =       36.7 kg         2nd load =68.9 kg         Total = 2nd load + weight of hanger =       73.4 kg         3rd load = 105kg         Total = 3rd load + weight of hanger =       109.5 kg         Bulk density 1712Kg/m2         Normal stress = applied load/area of shear box         Normal stress =       1.02 kg per square cm         Normal stress =       2.04 kg per square cm         Normal stress =       3.04 kg per square cm         Shear stress =       1.58 kg per square cm         Normal stress =       3.04 kg per square cm         Shear stress =       1.58 kg per square cm         Vormal stress =       3.04 kg per square cm         Shear stress =       1.58 kg per square cm	Loads applied weight of hanger = 4.5 kg 1st load = 32.21	) kg	Direct Shear Test	Area of she	<b>ar box =</b> 36 square cm	
3rd load       = 105kg         Total       = 3rd load + weight of hanger =       109.5 kg         Bulk density       1712Kg/m2         Normal stress = applied load/area of shear box       shear stress = shear force at failure/ area of shear box         Normal stress =       1.02 kg per square cm       Shear stress =       0.53 kg per square cm         Normal stress =       2.04 kg per square cm       Shear stress =       1.13 kg per square cm         Normal stress =       3.04 kg per square cm       Shear stress =       1.58 kg per square cm         Stress =       3.04 kg per square cm       Shear stress =       1.58 kg per square cm         Image: Stress =       3.04 kg per square cm       Shear stress =       1.58 kg per square cm         Stress =       3.04 kg per square cm       Shear stress =       1.58 kg per square cm         Image: Stress =       3.04 kg per square cm       Shear stress =       1.58 kg per square cm         Image: Stress =       1.58 kg per square cm       Image: Stress =       Image: Stress =         Image: Stress =       1.58 kg per square cm       Image: Stress =       Image: Stress =         Image: Stress =       Image: Stress =       Image: Stress =       Image: Stress =       Image: Stress =         Image: Stress =       Image: Stress =       Image: Stress =	I otal = 1st load + weight 2nd load =68.9 kg Total = 2nd load + weight	of hanger = } of hanger =	36.7 73.4	kg		
Normal stress = applied load/area of shear box       shear stress = shear force at failure/ area of shear box         Normal stress =       1.02       kg per square cm       Shear stress =       0.53 kg per square cm         Normal stress =       2.04       kg per square cm       Shear stress =       1.13 kg per square cm         Normal stress =       3.04       kg per square cm       Shear stress =       1.58 kg per square cm         Normal stress =       3.04       kg per square cm       Shear stress =       1.58 kg per square cm	3rd load = 105kg Total = 3rd load + weight Bulk density 1712Kg	of hanger = j/m2	109.5	kg		
Normal stress = 1.02 kg per square cm Shear stress = 0.53 kg per square cm Normal stress = 2.04 kg per square cm Shear stress = 1.13 kg per square cm Normal stress = 3.04 kg per square cm Shear stress = 1.58 kg per square cm Graph of shear stress against normal stress The stress again stress against normal stress the stress against normal	Normal stress = applied l	oad/area of shear	box	shear stress = shear for	rce at failure/ area of shea	r box
Normal stress = 2.04 kg per square cm Shear stress = 1.13 kg per square cm Normal stress = 3.04 kg per square cm Shear stress = 1.58 kg per square cm Graph of shear stress against normal stress Graph of shear stress against normal stress y= 0.52x + 0.022e y= 0.52x + 0.022e y= 0.52x + 0.022e	Normal stress =	1.02	kg per square cm	Shear stress =	0.53 kg per square cm	
Normal stress = 3.04 kg per square cm Shear stress = 1.58 kg per square cm	Normal stress =	2.04	kg per square cm	Shear stress =	1.13 kg per square cm	
Graph of shear stress against normal stress	Normal stress =	3.04	kg per square cm	Shear stress =	1.58 kg per square cm	
$C = 0.02 \text{ kg/cm}^2$ $\emptyset = 27^\circ$	$C = 0.02 \text{ kg/cm}^2$ $\emptyset = 27^\circ$	Graph of shear	stress against norr	<b>nal stress</b>		

AB	Harambe	Engineering	and	Construction
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## BH2 1.0-1.50m

	Di	RECOMATTS LIM	ITED		DRECO-MATTS Drilling, Engineering &
	Department of Civ	I & Construction Engineering-	Soil & Rock Mechanics Labor	atory	Construction Technical Support
Client : AB Harambe C Project :Juba City Cour Sample no:BH 2 Depth:1.0-1.5m Specification: According	Construction Compar Incil Sanitary and Env 19 to BS 1377:1990	ny ironmental Building	Date: 10/02/2021		
1		Direct Shear Test			
Loads applied					
weight of hanger = 4.5	kg		Area	of shear box = 36 square cm	
1st load = 3	2.2 kg	26.7	la la		
Total = Ist load + wei	gnt of hanger =	30.7	кд		
2nd load =68.	9 kg				
Total = 2nd load + wei	ght of hanger =	73.4	kg		
3rd load = 105 Total = 3rd load + wei Bulk density 168	kg ight of hanger = 0Kg/m2	109.5	kg		
Normal stress = applie	ed load/area of she	ar box	shear stress = sh	near force at failure/ area of shea	r box
Normal stress =	1.02	kg per square cm	Shear stress =	0.58 kg per square cm	
Normal stress =	2.04	kg per square cm	Shear stress =	1.16 kg per square cm	
Normal stress =	3.04	kg per square cm	Shear stress =	1.53 kg per square cm	
, into annutis and Bayasards seals.	Graph of shea	Ar stress against nor y = 0.4 R <sup>2</sup> 1.5 2.5 Normal Stress (Rc per spinor cn)	mal stress		
C = 0.13 kg/cm	2				
Ø = 25°					
-					

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#### BH3 0.0-1.0m

	Department of Civi	ECOMATTS LIM	ITED Soil & Rock Mechanics Labo	oratory	DRECO-MATTS Drilling, Engineering & Construction Technical Support
Client : AB Harambe ( Project :Juba City Cour Sample no:BH 3 Depth:0.0-1.0m <i>Specification: Accordin</i>	Construction Compar ncil Sanitary and Env g to BS 1377:1990	y ronmental Building	Date: 6/02/2021		
		Direct Shear Test	3		
Loads applied weight of hanger = 4.5 1st load = 3	5 kg 2.2 kg		Area	<b>a of shear box =</b> 36 square cm	
Total = 1st load + we	ight of hanger =	36.7	kg		
2nd load =68. Total = 2nd load + we	9 kg ight of hanger =	73.4	kg		
3rd load = 105 Total = 3rd load + we Bulk density 156	ikg ight of hanger = 5Kg/m2	109.5	kg		
Normal stress = appli	ed load/area of shea	ar box	shear stress = s	hear force at failure/ area of shea	ır box
Normal stress =	1.02	kg per square cm	Shear stress =	0.51 kg per square cm	
Normal stress =	2.04	kg per square cm	Shear stress =	1.08 kg per square cm	
Normal stress =	3.04	kg per square cm	Shear stress =	1.5 kg per square cm	
(and matteries and physical stands	Graph of shea	r stress against nor	24 2 2		
C = 0.03 kg/cm	1 <sup>2</sup>				
Ø = 26°					

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#### BH4 0.0-1.1m

	Department of Civil	ECOMATTS LIM	ITED oil & Rock Mechanics	Laboratory	DRECO-MATTS Drilling, Engineering & Construction Technical Support
Client : AB Harambe C Project :Juba City Counc Sample no:BH 4 Depth:0.0-1.1m Specification: According	onstruction Compan cil Sanitary and Envi to BS 1377:1990	y ronmental Building	Date: 6/02/202	21	
100		Direct Shear Test			
Loads applied weight of hanger = 4.5 1st load = 32 Total = 1st load + weig	kg ∴2 kg jht of hanger =	36.7	<b>k</b> g	Area of shear box = 36 square cm	
2nd load =68.9 Total = 2nd load + weiç	kg ht of hanger =	73.4	kg		
3rd load = 105k Total = 3rd load + weig Bulk density 1580	g ght of hanger = Kg/m2	109.5	kg		
Normal stress = applie	d load/area of shea	r box	shear stress	= shear force at failure/ area of shea	ır box
Normal stress =	1.02	kg per square cm	Shear stress	= 0.54 kg per square cm	
Normal stress =	2.04	kg per square cm	Shear stress	= 1.12 kg per square cm	
Normal stress =	3.04	kg per square cm	Shear stress	= 1.49 kg per square cm	
C = 0.09 kg/cm <sup>2</sup> Ø = 25°	Graph of shea	r stress against nori	mal stress		
Specialiat in ;-Geotechnical ,Material teat House 4, school Grove Off School Lane	ting, Geophysical,Toposurvey,Ge Westlands. P.O.Box 2050-8 004	neral Building and Engineering Serv VV GPD Natrobi Kenya - Tel: + 254 72 Bernall com - WEB	icea; NCA 4 Civil worka 8 1 394530 +254721345518	SNCA 4 Building works +254 715099361	

## **AB Harambe Engineering and Construction**

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EP1 0.0-2.0m

					D	RECOMA	TTS LAE	BS	
					Departme	ent of Civil & C (Soil Mechan	construction E	ngineering	
						27.9 to 2 minutes of the Article Lands Page			
			TR	AXI	AL TE	ST-UU			
CLIENT	AB HARAMBE C	ONST	RUCTION						
PROJECT	JUBA MUNICIP	AL CO	DUNCIL						
Depth (m)	0.0-1.0M			Test p	IT ID:	EP 1			
Test date:	26-Jan-21	1277.	1000						
opectrication	TACCOLORING TO BO	13/7.	1990		7				
SOIL TYPE				MEAN	DIAMETER	Do=			38mm
CALIBRATION FACTO	R	0.42	1kg/Div	MEAN		Lo=			76mm
WEIGHT OF SPECIME	N (c	m)	ing/bit	VOLUN	ALE Vo=/	AoLo=			86cm <sup>3</sup>
CELL PRESSURE	0.50,1.50	& 2.50	Kg/cm <sup>2</sup>	UNCO	SOLIDATED	UNDRAINED TR	IAXIAL (QUICK T	EST)	
									25
DIAL READING (in)	DIAL READING	(mm)	E=L/L	o	1-E	A=Ao/1-E	DIAL READING	LOAD P kgf	Q=P/A kgf/cm <sup>2</sup>
0	0		0		1.00	11.30	0	0	0
150	3.81		0.05		0,95	11.90	18	7.6	0.64
300	7.62		0.10		0.90	12.56	28	11.8	0.94
450	11.43		0.15		0.85	13.30	28	11.8	0.89
600	15.24		0.20	<u>.</u>	0.80	14.13		1	
750	19.05		0.25		0.75	15.08			
0	0		0		1.00	11.30	0	0	0.0
150	3.81		0.05		0.95	11.90	45	18.9	1.59
300	7.62		0.10		0.90	12.56	65	27.4	2.18
450	11.43		0.15		0.85	13.30	58	24.4	1.84
600	15.24		0.20		0.80	14.13			
750	19.05		0.25		0.75	15.08			
0	0		0		1.00	11.30	0	0	0.0
150	3.81		0.05		0.95	11.90	87	36.6	3.08
300	7.62		0.10		0.90	12.56	102	42.9	3.42
450	11.43		0.15		0.85	13.30	94	39.6	2.98
600	15.24		0.20		0.80	14.13			
750	19.05		0.25		0.75	15.08			
			Cell pres (kg/cm σ3	sure I²)	Deviator stress (kg/cm²) (σ1 - σ3)	Major Princ.stress kg/cm²) σ1			
	TEST 1		0.5		0.94	1.44			
	TEST 2		1.5		2.18	3.68			
	TEST 3		2.5		3.42	5.92			



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EP2 0.0-2.0m

					D Departm	RECOMA ent of Civil & C (Soil Mechani	ONSTRUCTION E	BS ngineering				
			TRI	AXI	AL TE	ST-UU						
CLIENT	AB HARAMBE	CONST	FRUCTION									
PROJECT	JUBA MUNIC	IPAL CO	DUNCIL			1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-						
Depth (m)	0.0-1.0M			Test p	it ID:	EP2						
Test date:	26-Jan-21	c 1077	1000									
SOIL TYPE				MEAN	DIAMETER	Do=			38mm			
PROVING RING No.	D	0.4	63171	HEIGH		Lo=			76mm			
WEIGHT OF SPECIME	N	(am)	cikg/Div	VOLUN	AREA ME Vo=	AoLo=			86cm <sup>3</sup>			
CELL PRESSURE	50,150	8 250 K	N/m²	UNCO	NSOLIDATE	UNDRAINED TRI	AXIAL (QUICK T	EST)				
			2									
DIAL READING (in)	DIAL READING	G (mm)	E=L/L	.0	1-E	A=Ao/1-E	DIAL READING	LOAD P kgf	Q=P/A kgf/cm <sup>2</sup>			
0	o		0		1.00	11.30	0	0	0			
150	3.81		0.05	ũ.	0.95	11.90	18	7.6	0.64			
300	7.62		0.10	n.	0.90	12.56	29	12.2	0.97			
450	11 43		0.15		0.95	13 30	23	0.7	0.73			
600	15.24		0.15	а. Б	0.85	14 13	25	9.7	0.75			
750	19.05		0.25		0.75	15.08						
0	0		0		1.00	11.30	0	0	0.0			
150	3.81		0.05	10	0.95	11.90	55	23.2	1.95			
300	7.62		0.10		0.90	12.56	60	25.3	2.01			
450	11.43		0.15	10	0.85	13.30	54	22.7	1.71			
600	15.24		0.20		0.80	14.13						
750	19.05		0.25	0	0.75	15.08						
0	0		0		1.00	11.30	0	0	0.0			
150	3.81		0.05	25	0.95	11.90	86	36.2	3.04			
300	7.62		0.10	oc.	0.90	12.56	94	39.6	3.15			
450	11.43		0.15	25	0.85	13.30	92	38.7	2.91			
600	15.24		0.20	CC	0.80	14.13	88	37.0	2.62			
750	19.05		0.25	6	0.75	15.08						
			Cell pres (kg/cm σ3	sure 1²)	Deviator stress (kg/cm²) (σ1 - σ3)	Major Princ.stress kg/cm²) σ1						
	TEST 1		0.5		0.97	1.47						
	TEST 2	ý.	1.5		2.01	3.51						
	TEST 3		2.5		3.15	5.65						



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## **Appendix 13–Consolidation results**

## EP1 0.0-2.0m

PROJECT:JUBA MUNICIPAL COUNCIL Sno.TP 1 0.0-2.0M													DATE:	Monda	y <mark>, Janua</mark> i	ry 25, 20	21			
Relative density of soil:- 2.65 g/cc				Dry mass of	specime	n:-	62.8 g Surface area of specimen:-				en:-	1963	.5 mm <sup>2</sup>							
Initial height of specimen:- 20 mm					Proving Rin	g Dial Rea	dings	0	0.01 mm											
Bulk Dry Density of Specimen:- 1599 kg/m			kg/m3					0.70		Co	nsolid	ation T	est							
Initial Voi	id Ratio:-		0.66						0.70											Π
Void Rati	o Reductio	on Factor	0.0829						0.60											
Vertical	Dial	Height	Void	Void	Square	CV	mv		0.00											
Pressure	Reading	Change	Change	Ratio	Root Time	m²/yr	m <sup>2</sup> /MN	0	0.00											
kPa		(mm)			sqr(min)			id Rat	0.00			*	$\downarrow$				<u> </u>			
	2300			0.66				vo	0.64						-	/				
50	2297.5	0.03	0.002	0.66	10.0	4.5	0.03		0.04							1	I			
100	2293	0.07	0.006	0.65	14.1	3.1	0.05		0.62											
100	2290.5	0.10	0.008	0.65	17.3	2.6	0.07		0.02											
200	2284	0.16	0.013	0.64	20.0	2.2	0.05		0.60											
400	2275.5	0.25	0.020	0.64	22.4	2.0	0.02		10			100		100						1000
200	2279.5	0.21	0.017	0.64	23.4	1.9	0.01					Appl	ied Pres	sure kPa						
	2288	0.12	0.010	0.65	24.4	1.8	0.02				🔶 Te	st Data			4	Initial Vo	oid Ratio			
Compress	ibility Inde	ex on last loa	iding cycle	(Cc)		0.02	}	cv:	coefficie	nt of consolida	ntion <b>m</b>	ß	modulu	is of volur	ne com	pressibi	lity			
NOTE:	Initially lo	aded withou	t water su	rround.\	Nater added	after 100	kpa had be	een aj	oplied.											

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#### EP2 0.00-2.0m

Relative density of soil:- 2.65 g/cc			Dry mass of	specime	1:-	148.5 g Surface area of enerimen-				453	$55 \text{ mm}^2$									
			healing	<u>.</u> 	140		our lave alle	a or specifi		JJ	<b>7</b> .2 min				8					
Initial height of specimen:- 19 mm				Proving Rin	g Dial Rea	dings	0.	0.01 mm												
Bulk Dry	Density of	Specimen:-	1723	kg/m3					0.60	4		onsolio	ation I	est				<u></u>		
Initial Vo	id Ratio:-		0.54						0.00										1 11	
Void Rati	o Reductio	on Factor	0.0810		2				0.55		2	4		4	<u> </u>		<u> </u>	2 2 1		
Vertical	Dial	Height	Void	Void	Square	CV	mv		0.50								_			-
Pressure	Reading	Change	Change	Ratio	Root Time	m²/yr	m²/MN	0	0.45 —		4	2.— 2.—		•						
kPa		(mm)			sqr(min)			id Rat	0.40											
	1500			0.54				Vo	0.40	2	8	92 5						20 6 1		
50	1458	0.42	0.034	0.50	10.0	3.9	0.44		0.35			5, 5	8 8 8		1			<u>ia</u> .e.	<u>12 1 1</u>	
100	1410	0.90	0.073	0.47	14.1	2.7	0.52		0.30		_	8 - D-			-	)	4		10-6-2	
100	1314	1.86	0.151	0.39	17.3	2.0	1.55		0.25			77	86.8						<u>15-7-</u> 3	
200	1253.5	2.47	0.200	0.34	20.0	1.6	0.86		0 20											
400	1203	2.97	0.240	0.30	22.4	1.3	0.15		10			4.00	lind Prov	100						1000
200	1205.5	2.95	0.238	0.30	23.4	1.2	0.01					мрр	ueu rre:	oure kra						
	1223	2.77	0.224	0.31	24.4	1.2	0.05				<b>+</b> T	est Data			-	Initial Vo	id Ratio			

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## **Appendix 14–Summary of Specific gravity results**

	SP	ECIFIC	GRAVITY	(SOILS)	;-BS 1377		Lab I	orm	11
LIENT	AB HARA	MBE CO	NSTRUCTION C	OMPANY			r.	ï	
ROJECT	PROPOS	ED JUBA	CITY COUNCIL	SANITARY	AND ENVIRONM	ENTAL BUILD	DATE	8/2/2021	
aterial escliption:	SOILS						12		
Locations	DEPTH (M)	BOTTLE No.	MASS OF BOTTLE + STOPPER (M1)g	MASS OF BOTTLE + STOPPER + SOIL (M2)g	MASS OF BOTTLE + STOPPER + SOIL + WATER (M3)g	MASS OF BOTTLE + STOPPER + WATER (M4)g	(M2 - M1)	S.G .	AV. S.
	0.0.1.0	1	2.00	3.05	5.40	4.75	1.05	2.50	2 505
	0.0-1.0	В	2.00	3.05	5.41	4.75	1.05	2.69	2.555
	10.20	С	2.00	3.05	5.40	4.75	1.05	2.50	2 500
BH1 EP1 BH2 BH3	1.0-2.0	4	2.00	3.05	5.40	4.75	1.05	2.50	2.500
	20-30	PS4	1.85	2.85	9.02	8.4	1.00	2.63	2 595
	2.0-0.0	PS19	1.85	2.85	9.01	8.4	1.00	2.56	2.000
	30-40	2	2.00	3.05	5.42	4.75	1.05	2.76	2 660
	0.0 4.0	96	1.85	2.85	9.01	8.4	1.00	2.56	2.000
	40-50	h	2.00	3.05	5.42	4.75	1.05	2.76	2 660
	4.0-5.0	ho.	2.05	3.05	5.36	4.75	1.00	2.56	2.000
		z	2.00	3.05	5.42	4.75	1.05	2.76	2 690
	5.0-6.0	m	2.00	2.85	5.40	8.4	0.85	2.62	2.030
	60.7	2	2.00	3.05	5.42	4.75	1.05	2.76	2 690
	8.0-7	m4	2.00	2.85	5.40	8.4	0.85	2.62	2.650
ROJECT laterial escliption: Locations BH1 EP1 BH2 BH2 BH3 EP2 BH3 EP2 BH4	0.0-1.0	2	2.05	3.05	5.37	4.75	1.00	2.63	2 595
	0.0-1.0	1Q	2.05	3.05	5.36	4.75	1.00	2.56	2.555
	1020	°1	2.00	3.05	5.39	4.75	1.05	2.56	0.005
	1.0-2.0	93	2.00	3.05	5.41	4.75	1.05	2.69	2.625
вца	0.0.1.5	W4	18.62	28.62	91.02	84.83	10.00	2.62	2 605
	0.0-1.5	W5	18.5	28.57	90.88	84.74	10.07	2.59	2.005
	15.23	2	2.00	3.05	5.41	4.75	1.05	2.69	2 6 2 5
БП2	1.5-2.5	Н	2.00	3.05	5.39	4.75	1.05	2.56	2.625
	2.3-3.5	Р	2.00	3.05	5.42	4.75	1.05	2.76	2 760
		2	2.00	3.05	5.42	4.75	1.05	2.76	2.700
	0.0-1.0	1	2.05	3.05	5.39	4.75	1.00	2.44	0.470
		F	2.05	3.05	5.4	4.75	1.00	2.50	2.470
		60P	2.05	3.05	5.39	4.75	1.00	2.56	0.005
BH2 BH3	1.0-2.0	Q	2.05	3.05	5.41	4.75	1.00	2.69	2.625
впр		0	2.00	3.05	5.41	4.75	1.05	2.70	0.000
	2.0-3.0	1	2.00	3.05	5.4	4.75	1.05	2.62	2.660
	10 0 10 5	М	2.05	3.05	5.42	4.75	1.00	2.80	0.715
	12.2-12.5	C1	2.05	3.05	5.37	4.75	1.00	2.63	2.715
	0.0.1.0	1	2.00	3.05	5.38	4.75	1.05	2.50	0.520
500	0.0-1.0	3	2.00	3.05	5.39	4.75	1.05	2.56	2.550
EF2	10.20	5	2.05	3.05	5.39	4.75	1.00	2.56	0 520
	1.0-2.0	T	2.05	3.05	5.4	4.75	1.00	2.50	2.530
	0040	D	2.05	3.05	5.40	4.75	1.00	2.50	0.500
BUA	0.0-1.0	EF	2.05	3.05	5.40	4.75	1.00	2.50	2.500
BH4	1000	C 2.05		3.05	5.41	4.75	1.00	2.69	0.505
	1.0-2.0	1	2.05	3.05	5.39	4.75	1.00	2.44	2.565
Tested by			1		Approved by				
							10	1	1
1		DRECOMA	TTS/BPC WESTLA	NDS LABORAT	ORIES		Marcola		
		House no. 4	4, School Groove C	Off School Lane	, Westlands Nairobi	P.O Box 20598-0	0100 Nairob	d.	
DBECO	MATTS	Tel +254 7	21394530 info@dr	ecomatts dre	comatts akwambugu	@amail.om info	Cencine	ering co ke	

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## Appendix 15–Summary of Moisture Content results

DRECO-MAT Drilling, Engineerin Construction Technical	TS ng & Support	MOISTURE CONTENT -BSS 1377																						
								Labo	raroi	ry Tes	st Re	sult ·	BSS	1377										
Project:		AB HA	RAME	E CO	NSTRU	JCTIO	N																	
Client:		JUBA CITY COUNCIL SANITARY AND ENVIRONMENTAL BUILDING																						
Date:		<mark>23/1/2</mark>	021																					
TECHNICAL I	DATA									10					2			v						
Location		1 BH1	2 BH1	3 BH1	BH1	BH1	6 BH1	1 EP1	2 EP1	1 BH2	2 BH2	3 BH2	4 BH2	BH2	1 BH3	2 BH3	BH3	4 BH3	EP2	2 EP2	BH4	BH4		
Depth (m)		0.0-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	0.0-1.0	1.0-2.0	0.0-1.50	1.5-2.3	2.3-3.5	1.5-2.3	2.3-3.5	0.0-1.0	1.0-20	2.0-3.0	12.2-12.5	0.0-1.0	1.0-2.0	0.0-1.0	1.0-1.5		
Tin No:		103	47	32	141	83	4A	47	8B	15	381	5B	J27	ко	MNP	63	CM	116	166	69X	24	63		
Wt. of Tin	gm.	10.00	25.50	22.00	15.50	16.50	22.50	25.50	22.00	22.50	16.50	42.50	22.00	23.50	23.00	22.50	22.50	9.50	9.50	16.50	22.50	22.50		
Wt. of Tin + Wet Soil	gm,	83.00	83.50	62.00	77.60	56.20	46.00	83.50	87.50	96.50	71.50	110.50	111.50	75.10	68.10	114.50	68.30	116.50	87.50	79.00	90.50	86.50		
Wt. of Tin + Dry Soil	gm.	72.50	78.50	59.50	76.40	55.50	45.50	78.50	84.00	88.00	64.00	109.00	110.00	74.20	67.20	113.00	67.30	115.00	83.00	77.50	82.00	80.50		
Wt. of Water	gm.	10.50	5.00	2.50	1.20	0.70	0.50	5.00	3.50	8.50	7.50	1.50	1.50	0.90	0.90	1.50	1.00	1.50	4.50	1.50	8.50	6.00		
Wt. of Dry Soil	gm.	62.50	53.00	37.50	60.90	39.00	23.00	53.00	62.00	65.50	47.50	66.50	88.00	50.70	44.20	90.50	44.80	105.50	73.50	61.00	59.50	58.00		
Water Content	%	16.8	9.4	6.7	2.0	1.8	2.2	9.4	5.6	13.0	15.8	2.3	1.7	1.8	2.0	1.7	2.2	1.4	6.1	2.5	14.3	10.3		
Tested	by			V.K	meu		Checked	by			E.Githaiga Approved by							GK.Wambugu						

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# **Appendix 16–Implementation Photographs**



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## **BH2** Implementation photographs



**AB Harambe Engineering and Construction** February 2021 MRAC 50m-1 18 1/1



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## **BH1** Implementation photographs



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**BH3** Implementation photographs



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**BH4 Implementation photographs** 



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**EP1 Implementation photographs** 



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**EP2** Implementation photographs

