# A REPORT ON SOIL INVESTIGATIONS AT THE SITES OF SIREN SYSTEM (EWANS) IN JAMAICA

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#### 1.1. Authority

NHL Engineering Ltd. submitted a proposal for soil investigations for the investigation of the sites for the Emergency Siren Development Project throughout parts of the island. Our proposal was accepted and a package of 3 distributed areas located across the island was issued. This report is specific to the sites in St. Catherine and Portland.

The field investigation commenced on April 21 and was completed on May 1, 2016.

This report contains the results of the work done; the conclusions drawn; and the recommendations made regarding the main areas of engineering concerns as defined by the scope of this investigation.

#### 1.2. Scope of Work

NHL Engineering Limited was to arrange:

i) The field exploration based on the proposed test location point and

ii) The laboratory testing programme, which in our judgment, was necessary to provide a satisfactory basis for evaluating the site for the design of the steel tower foundations and other infrastructural elements on site.

On completion, a report presenting the results obtained, together with our recommendations for the appropriate design parameters should be submitted to the Client.

#### 1.3. Project Description

1. <u>SITES LOCATION:</u>

#### **Old Harbour Bay**

The general location of the four (4) locations can be seen in the report Appendices. The sites are located in Narine Lane, Old Harbour Bay Fishing Village, Black Wood Gardens and New Old Harbour Village in Old Harbour Bay, St. Catherine. The area is two fold in deposition history; it forms part of an alluvium along with intrusions of the white limestone deposits in the hilly regions. Insitu subsoil materials in the area were therefore likely to be a mixture of Clays, Sands and Gravels in varying mixed proportion as well as the Newport Formation which comprises mainly of white Limestone Group. This group is generally fractured, fossilerous and are usually overlain by residual soils typically silts and clays.



PLATE 1 – Picture showing the existing topography in the vicinity of borehole **#SIR 001** 



PLATE 2 – Picture showing the existing topography in the vicinity of borehole **#SIR 002** 



PLATE 3 – Picture showing the existing topography in the vicinity of borehole **#SIR 003** 



PLATE 4 – Picture showing the existing topography in the vicinity of borehole #SIR 004

# **Bog Walk**

The general location of the five (5) locations can be seen in the report Appendices. The sites are located in Bog Walk, Kent Village, Steep Slope, Dam Head Tower and Angel's Round-A-Bout in Bog Walk, St. Catherine. Due to access issues at the Steep Slope Site, this location will not undergo a field investigated. The site generally forms part of the Newport, Formation which comprises mainly of white Limestone Group. This group is generally fractured, fossilerous and are usually overlain by residual soils typically silts and clays.

Alluvial soils such as clays, silts sands and gravels are also quite prevalent in the areas in close proximity to past and present river systems.



PLATE 5 – Picture showing the existing topography in the vicinity of borehole **#SIR 005** 



PLATE 6 – Picture showing the existing topography in the vicinity of borehole **#SIR 006** 



PLATE 7 – Picture showing the existing topography in the vicinity of borehole **#SIR 007** 



PLATE 8 – Picture showing the existing topography in the vicinity of borehole **#SIR 008** 



PLATE 9 – Picture showing the existing topography in the vicinity of borehole **#SIR 009** 

#### Port Maria

The general location of the six (6) sites can be seen in the report Appendices. The sites are located in Castel Gardens, the Parish Council, in the Town Center, RADA Office, Clembhards Park and Trinity in Port Maria, Portland. Due to access issues with the RADA Office Site no field investigation will be done at this site, a desk study is proposed.

The general area is also characterized by the Walderston- Brown's Town Formation, which entails a mixture of Shales and Sandstones. The upper soils are likely to be alluvial, consisting of a mixture of Clays, Sands and Gravels in varying mixed proportion.



PLATE 10 – Picture showing the existing topography in the vicinity of borehole **#SIR 010** 



PLATE 11 – Picture showing the existing topography in the vicinity of borehole **#SIR 011** 



PLATE 12 – Picture showing the existing topography in the vicinity of borehole **#SIR 012** 



PLATE 13 – Picture showing the existing topography in the vicinity of borehole **#SIR** 013



PLATE 14 – Picture showing the existing topography in the vicinity of borehole **#SIR 014** 



PLATE 15 – Picture showing the existing topography in the vicinity of borehole **#SIR 015** 

#### 2. Superstructures:

According to the information obtained from the client, it is proposed to construct poles housing the sirens for the sites comprising of reinforced steel framed/tubular or reinforced precast concrete conical column. The investigation will seek therefore to consider foundation requirements for both types based on the anticipated critical lateral or vertical design loads.

#### 2.1. Proposed Programme

The proposed investigation will seek to establish the following;

- i) The insitu density of the soils on site.
- ii) Soil stratification and distribution across the site including depth to bedrock (if necessary).
- iii) The design parameters relevant to the design of the anticipated structural and infrastructural elements required on site.

The field investigation entailed the drilling of one (1) borehole at each of the thirteen (13) locations. The Boreholes were to be taken to a maximum depth of 35ft (10.7m).

The methods of drilling and sampling were in accordance with the Standard Penetration Testing specifications, using the Split Spoon Sampling technique. The boreholes were to be used to recover representative samples of the soil for examination by the Soils Engineer and for the carrying out of the laboratory testing programme. These results were to be use along with site deductions during the sampling exercise and intuitive knowledge of the deposition history of the area, to arrive at a reasonable presumptive profile and subsequently a design profile across the site.

It was envisaged that laboratory testing would not include more than the conventional Classification and Index Tests, if however the information was insufficient to predict fairly accurately the required designed parameters, other tests would be specified (one dimensional consolidation).

#### 2.2. Anticipated Design Approach

Given the nature of the proposed structures and projected uses, the pertinent loading conditions to be considered at all 15 locations are:

- i) Uplifting and overturning due to hurricane design wind speed and
- ii) Settlement of the foundation (mass concrete mat) in the upper clayey strata

The adjustment to depth and type of foundation should account for (i) and (ii) above, And will depend on soil type and structure/loading type at the specific location

In general shallow foundation should be appropriate for all sites under steady load condition. Macro instability should however be analyzed under seismic loading conditions for shallow foundations.

## 2.3. Soil Boring & Sampling

#### 1. <u>Methodology</u>:

The borings were made by NHL Drillers using a truck mounted CME Drill Rig, with a 160 mm hollow stem auger string. Sampling was done with a Split Spoon in accordance with Standard Penetration Testing specifications, using a Cathead Hammer ( $N_{55}$  values). In general, S.S samples were taken at 0.76 metre intervals of depth to the first 3 metres and thereafter at 1.5 metre interval to the maximum depth. The field logs are shown in the (Appendix II).

## 2. Discussion of results:

The results of the field and laboratory tests are shown in the appendix.

#### Old Harbour:

The soils encountered across the Old Harbour Bay were predominantly Very Stiff Clays. Insitu densities were generally in the Firm/Very Loose to Very Stiff/Dense range. No Refusal on the auger was encountered in any of the boreholes.

Water table was only encountered in one hole at approximately 2m below existing ground level in one of the Old Harbour Bay sites.

#### Bog Walk:

The soils encountered across the Bog Walk Sites were predominantly Very Dense Sands Cobbles & Boulders. Insitu densities were generally in the Compact/Firm to Very Dense/Hard range. Refusal was encountered on the auger in two (2) of the boreholes.

No water table was encountered below existing ground level at any of the Bog Walk sites.

#### Port Maria:

The soils encountered across the Port Maria Sites were predominantly Firm Clays. Insitu densities were generally in the Very Soft/Compact to Very Stiff/Very Dense range. No Refusal on the auger was encountered in any of the boreholes.

Water table was encountered at variable depths, about 2+m below existing ground level at the Port Maria sites.

The soils encountered were predominantly of the cohesive fraction. Forty one (41) samples were selected for testing; seventeen (17) Grainsize Distribution Tests and twenty four (24) Index Testings were done on the samples recovered. The chosen samples are, to the best of the engineer's judgment, representative of the samples recovered from the boreholes.

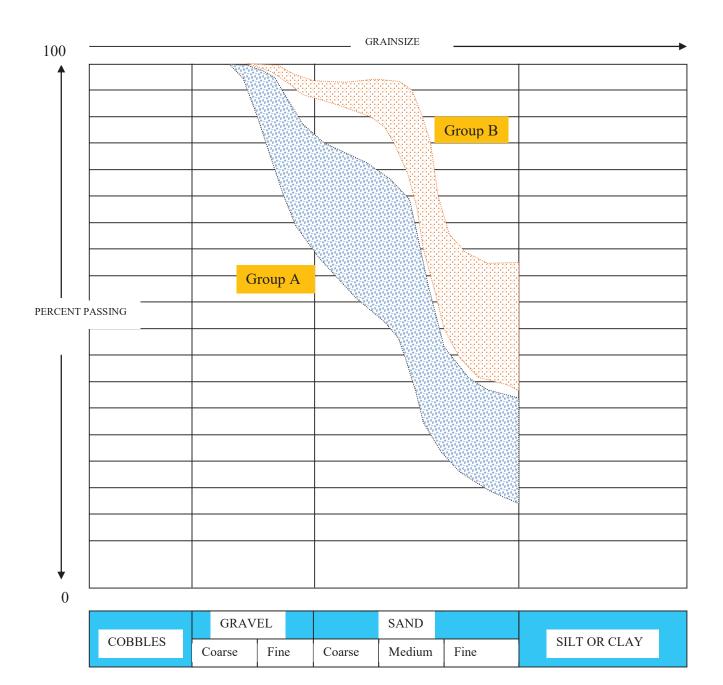
#### 3.1. Classification & Index Testing:

1. Grainsize Distribution:

Figures 3.1 shows the grainsize distribution envelopes of the samples tested. The figure indicates that the samples have gradation that falls essentially into two significant groups. The following is the group descriptions:

- 1) Group A the Graded Coarse to Fine Sands plus some Gravels & Clays
- 2) Group B the Clays and Sands plus little Gravels
  - 2. Soil Plasticity:

Appendix II gives a listing of the Atterberg Limits for the samples tested. The results indicate that the soils classified as Inorganic Clays of Medium to High Plasticity; the Liquid Limits ranged between 50.0% and 84.8%; the Plastic Limits between 23.6% and 30.5%; and the Moisture Contents between 9.0% and 24.0%. Based on these results, it is expected that the majority of these soils will exhibit moderate to high swell/shrinkage and compressibility. Given however their frequency of occurrence within the depths explored, it is expected that they will not have a significant impact on the design of the foundation soils and other infrastructural elements on site.



# FIGURE 3.1 - GRADATION ENVELOPE – IMPROVEMENT OF EMERGENCY COMMUNICATION SYSTEMS IN JAMAICA (OLD HARBOUR BAY)

#### 4.1. Presumptive Soil Profile

The Presumptive profiles shown are an extrapolation of the borehole information along with an understanding of the deposition history of the soils in the area. The profile boundaries shown are presumptive and should be viewed only as approximate representations of the insitu soil condition on site.

#### Old Harbour Bay

The subsoil layers applicable for evaluating engineering behavior and construction concerns can be characterized as five (5) distinct types found on the different sites in this area (see typical site profiles below). The type is as follows:

#### A) <u>TYPE 1</u>

 Loose - Compact SANDS + Some Gravels Depth Range; Variable 0-10.7+m Average N<sub>55</sub> = 6 Borehole - # 002, 003 & 004

#### B) <u>TYPE 2</u>

2) Very Stiff CLAYS Depth Range; Variable 2.3-10.7+m Average  $N_{55} = 15$ Borehole - # 002, 003 & 004

C) <u>TYPE 3</u>

 3) Firm – Stiff CLAYS Depth Range; Variable 0-10.7+m Average N<sub>55</sub> = 9 Borehole - # 001 & 003

#### D) <u>TYPE 4</u>

 4) Very Loose SANDS Depth Range; Variable 1.5-6m Average N<sub>55</sub> = 2 Borehole - # 002 E) <u>TYPE 5</u>

5) Very Soft CLAYS Depth Range; Variable 3-5m Average N<sub>55</sub> = 1 Borehole - # 002

#### BogWalk

The subsoil layers applicable for evaluating engineering behavior and construction concerns can be characterized as five (5) distinct types found on the different sites in this area (see typical site profiles below). The type is as follows:

#### A) <u>TYPE 6</u>

- Very Dense Calcareous COBBLES & BOULDERS + Some Sands Depth Range; Variable 0-2.1m Average N<sub>55</sub> = 40 Borehole - # 006, 008 & 009
- B) <u>TYPE 3</u>
- 2) Firm Stiff CLAYS Depth Range; Variable 0-10.7+m Average N<sub>55</sub> = 15 Borehole - # 0005 & 009
- C) <u>TYPE 2</u>
- 3) Very Stiff Hard CLAYS Depth Range; Variable 0-10.7+m Average N<sub>55</sub> = 40 Borehole - # 006 & 009

D) <u>TYPE 7</u>

- 4) Medium Hard Porous Limestone Rock Depth Range; Variable 1.5-3.7+m Borehole - # 006 & 008
- E) <u>TYPE 1</u>
- 5) Compact SANDS Depth Range; Variable 2.3-9.1m Average  $N_{55} = 10$ Borehole - # 009

#### Port Maria

The subsoil layers applicable for evaluating engineering behavior and construction concerns can be characterized as five (5) distinct types found on the different sites in this area (see typical site profiles below). The type is as follows:

#### A) <u>TYPE 3</u>

1) Firm – Stiff CLAYS Depth Range; Variable 0-10.7+m Average  $N_{55} = 5$ Borehole - # 011, 014 & 015

B) <u>TYPE 5</u>

2) Very Soft - Soft CLAYS Depth Range; Variable 0-10.7+m Average N<sub>55</sub> = 15 Borehole - # 011, 012, 014 & 015

C) <u>TYPE 2</u>

- 3) Very Stiff CLAYS Depth Range; Variable 7.6-10.7+m Average N<sub>55</sub> = 15 Borehole - # 012 & 014
- D) <u>TYPE 1</u>
- 4) Compact Calcareous SANDS + Some Gravels Depth Range; Variable 0-10m Average N<sub>55</sub> = 12 Borehole - # 010 & 011

E) <u>TYPE 6</u>

 5) Very Dense Calcareous Gravelly SANDS + Some Gravels Depth Range; Variable 4.6-7.6m Average N<sub>55</sub> = 50 Borehole - # 010 & 011

#### **Old Harbour Site:**

Generally the Types 5 and 4 soils will exhibit significant settlement especially the Type 5 Soils. These soils will require modification or replacement. The Type 4 soils can be modified with mechanical compaction when they are close to the surface. The Type 4 soils however will need to be replacing part and or reinforced using geogrid to mitigate settlement.

In the case of the Types 3 and 2 soils, seasonal swell shrinkage could be problematic; deepening the footings and or soil replacement should mitigate the problems.

#### **Port Maria Site:**

Boreholes 12 and 14 show significant presence of the Type 5 soils (very soft clays). These soils will need replacement and reinforcement with geogrid. Passive resistance of these soils will be very low and lateral stability could be a major problem. The use of short bored piles is an option.

The soils at Location 13 (inaccessible) appear subjectively to be calcareous sands and gravels and are therefore likely to be similar in properties to the Type 1 soils summarized below. The assumption in that location is that lateral restraint is offered by the retaining wall along the slope in the vicinity of the proposed location.

#### **BogWalk Site:**

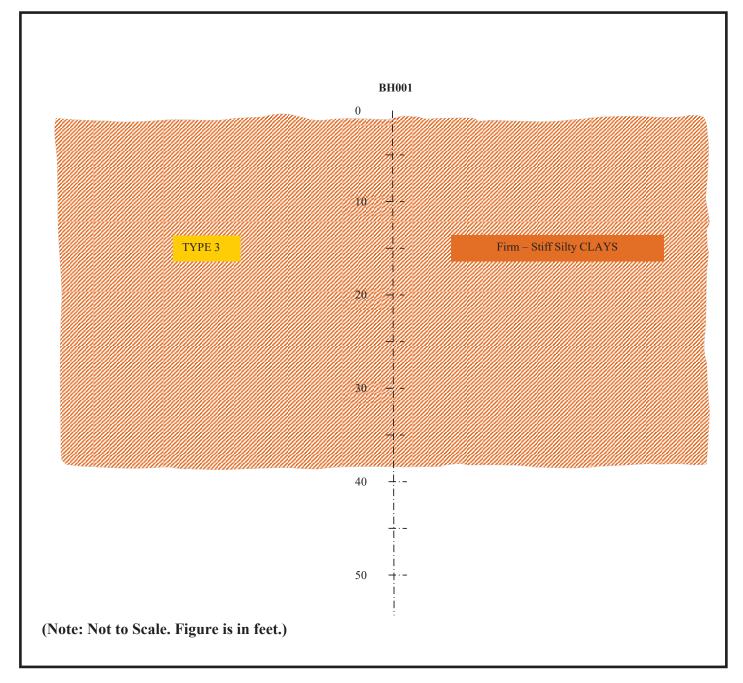
The soils in this area are generally good foundation soils and are not anticipated to present any significant problems. In areas where the Type 3 soils were encountered foundation deepening could be sufficient. To satisfy the requirements for lateral loading, the required depth of the foundation could mitigate swell shrinkage issues.

The site at Location 7 was inaccessible by our testing equipment. Based on our visual assessment the area is comprised of predominantly limestone rock. The outcroppings appear quite fractured and the RQDs are likely to be fairly low. The properties are therefore similar to that of the Type 7 soils summarized below and are recommended for foundation design purposes.

In general for all 3 locations, overturning will however govern the design of the footing. The passive resistance of the soil and the weight of the foundation and the soil above it will be the stabilizing forces in this design. Both problems will have to be accounted for in design.

For locations requiring soil replacement, it is recommended that a compact granular layer of soil placed below the footing to dissipate pore pressure development during saturated conditions. In addition use a stiff mat for the tower to mitigate settlement problems. The depth and size of the mat shall be chosen to ensure macro stability of the tower.

# **Old Harbour Bay**





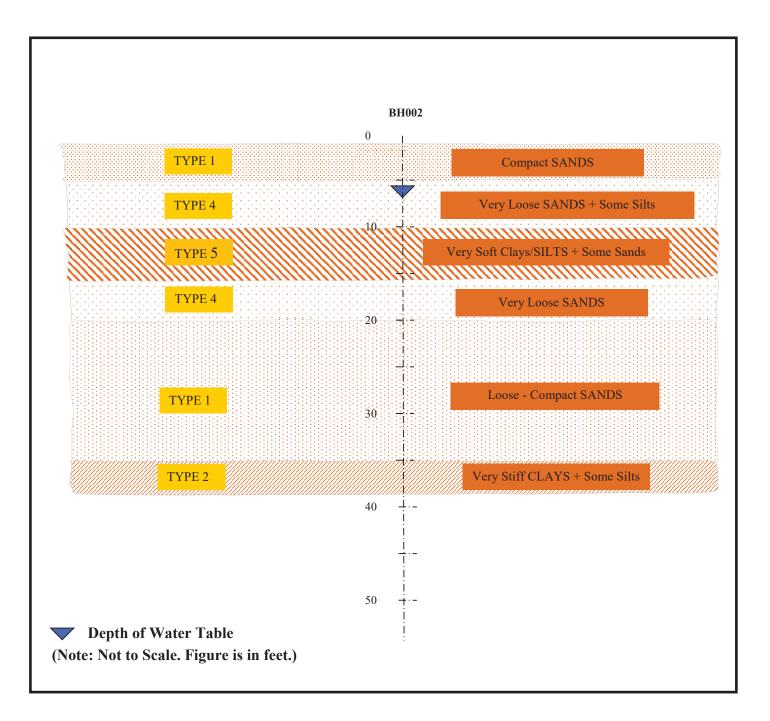


FIGURE 4.2 - Presumptive Profile – BOREHOLES #002

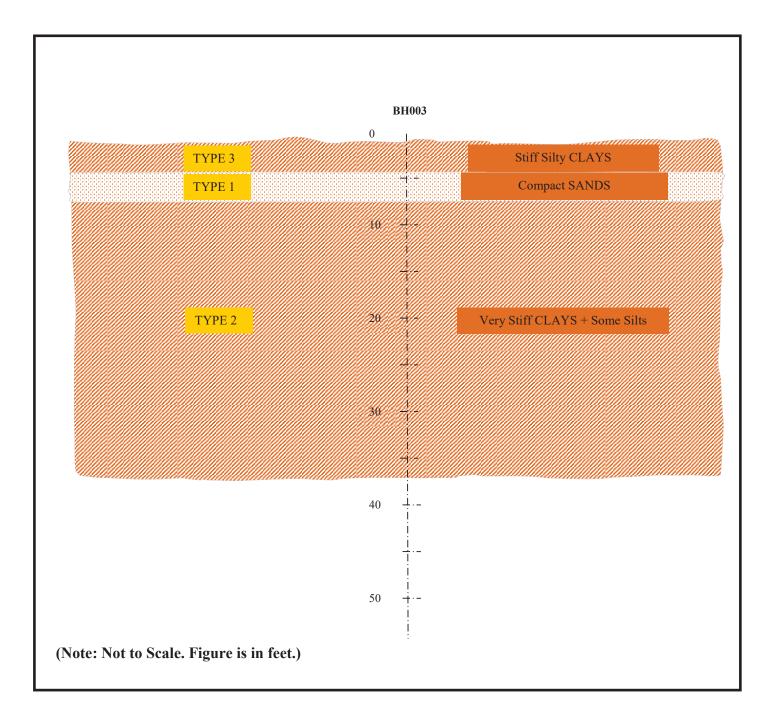


FIGURE 4.3 - Presumptive Profile – BOREHOLES #003

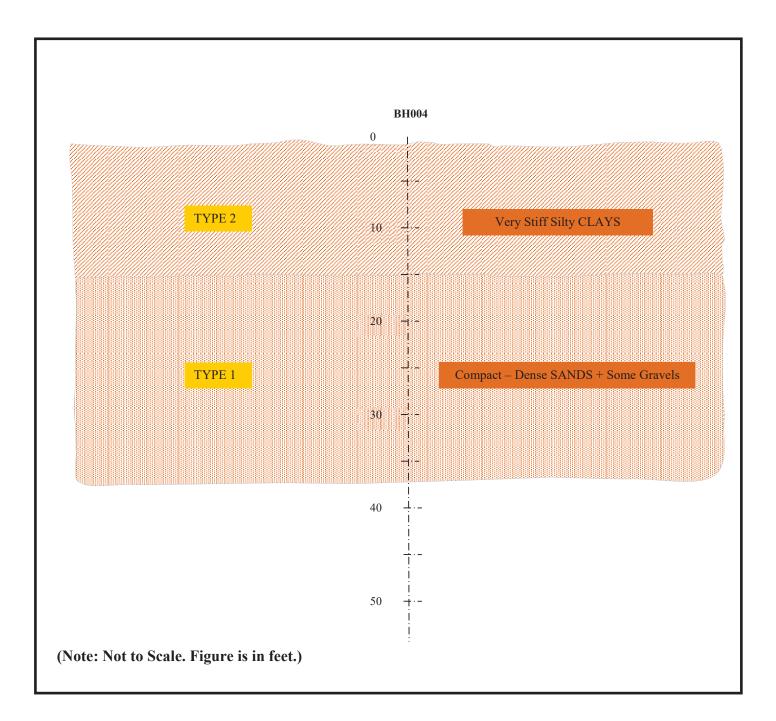


FIGURE 4.4 - Presumptive Profile – BOREHOLES #004

# **Bog Walk**

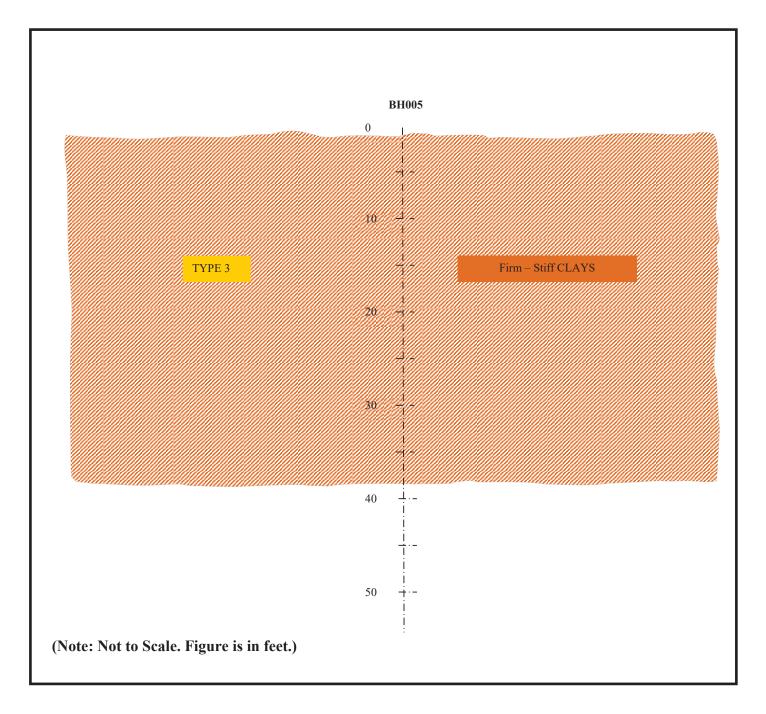
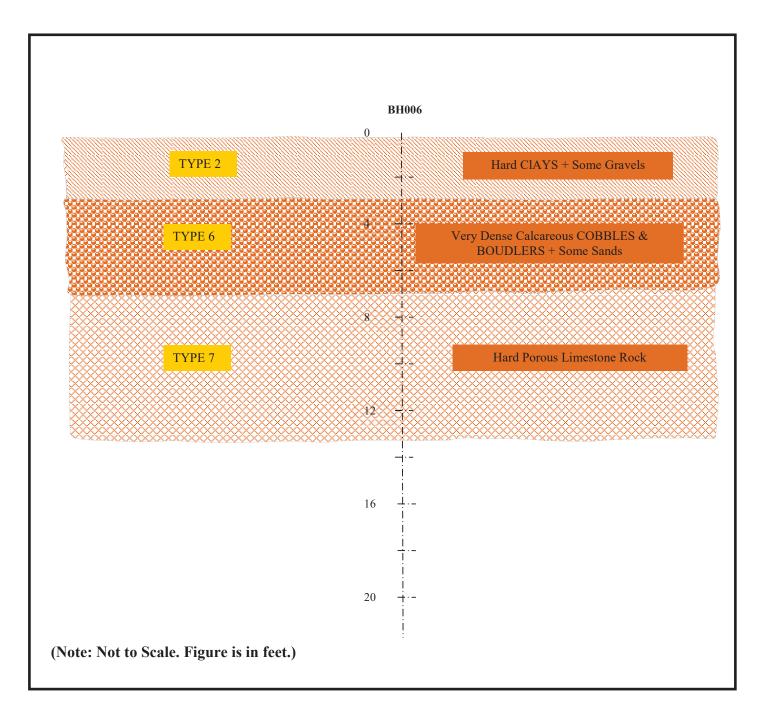


FIGURE 4.5 - Presumptive Profile – BOREHOLES #005



 $FIGURE \ 4.6 \ - \ Presumptive \ Profile - \ Boreholes \ \#006$ 

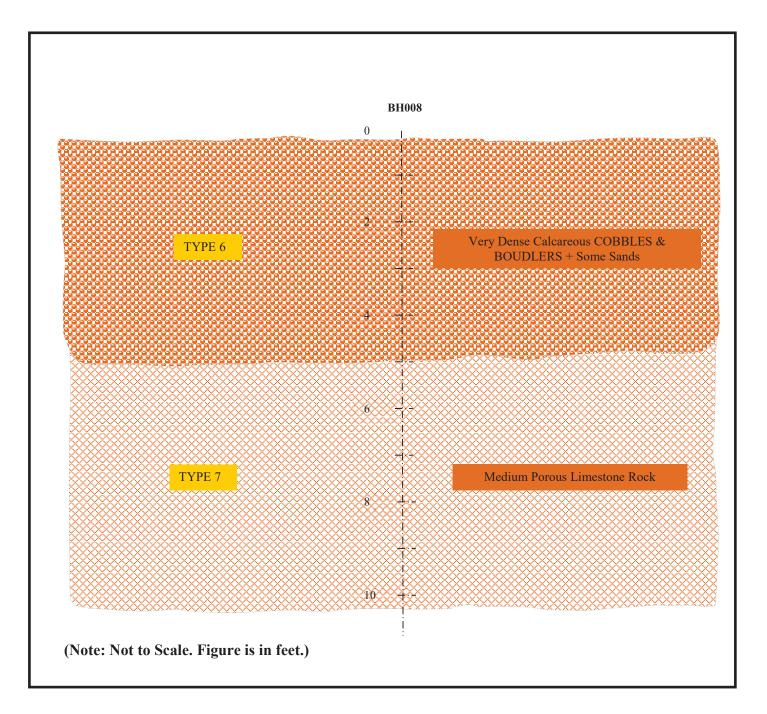


FIGURE 4.7 - Presumptive Profile – BOREHOLES #008

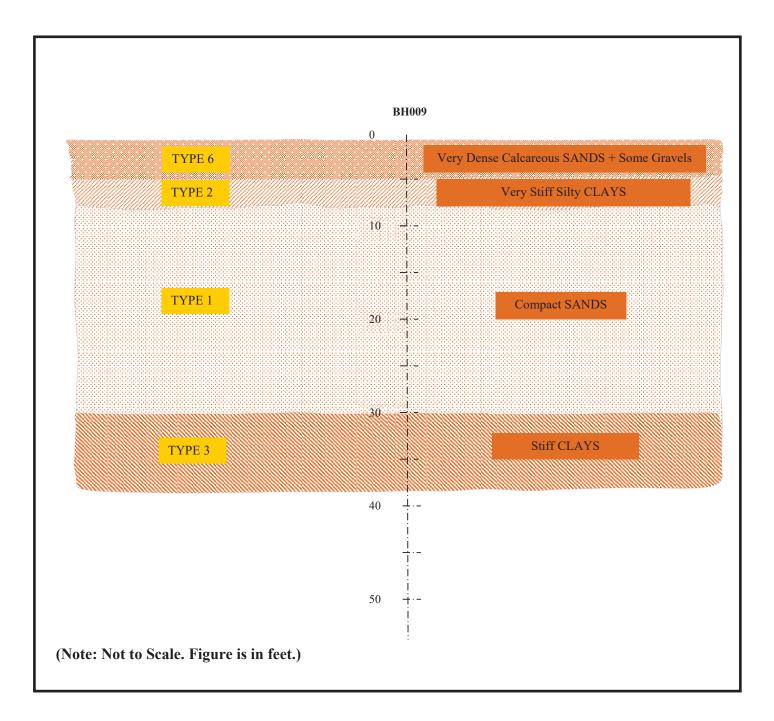


FIGURE 4.8 - Presumptive Profile – BOREHOLES #009

# <u>Port Maria</u>

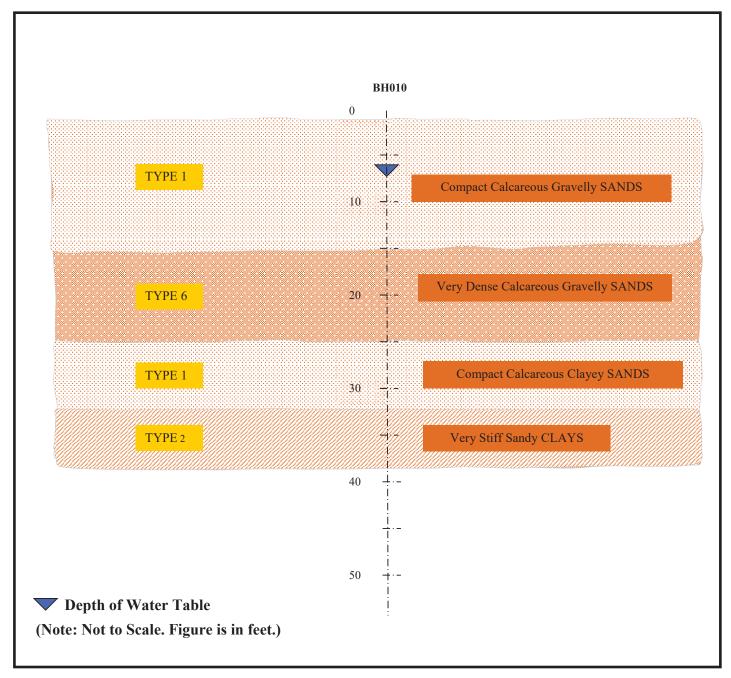


FIGURE 4.9 - Presumptive Profile – BOREHOLES #010

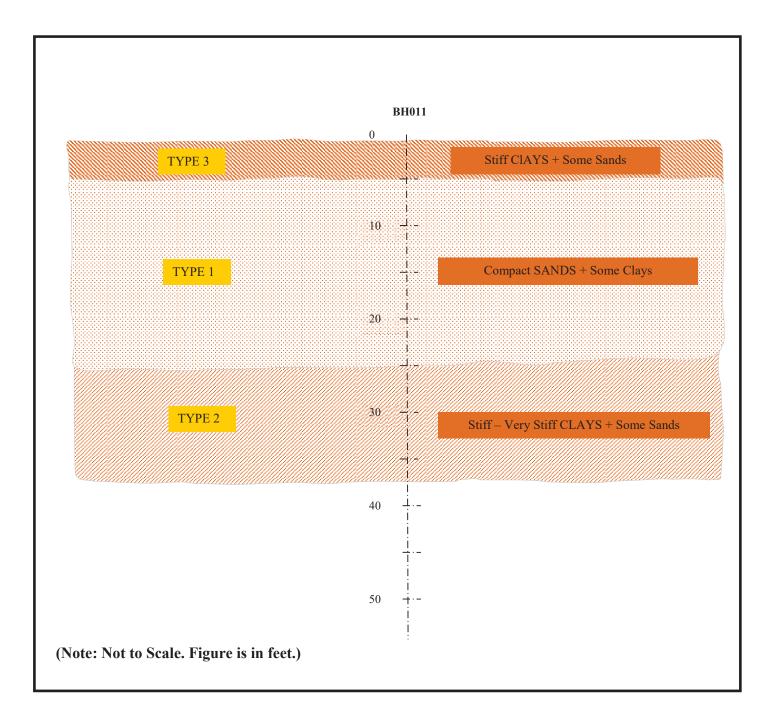


FIGURE 4.10 - Presumptive Profile – BOREHOLES #011

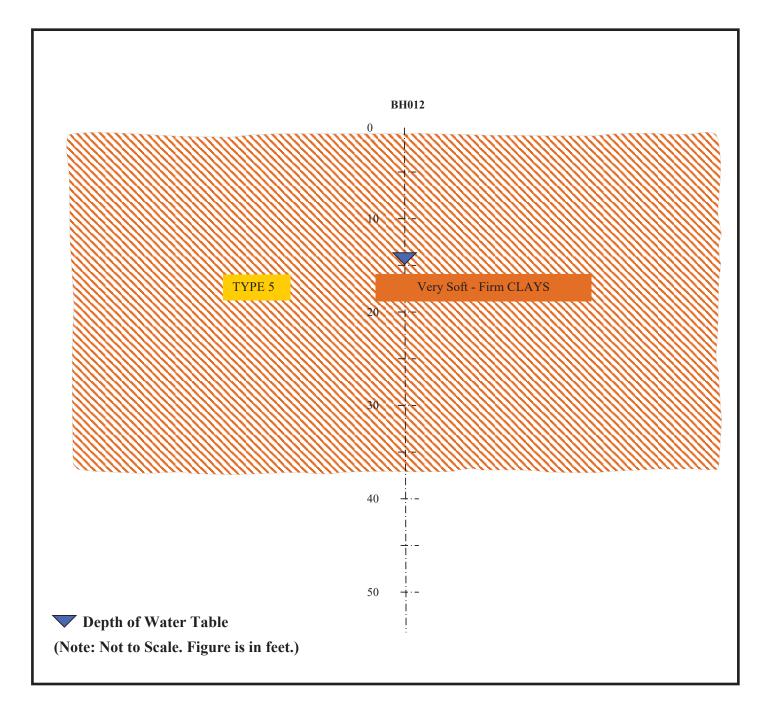
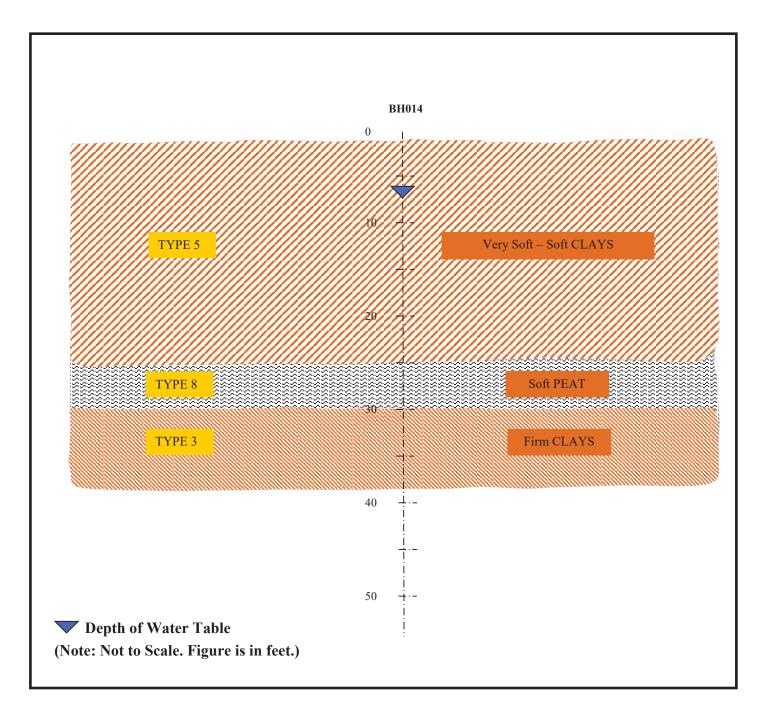
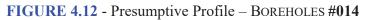


FIGURE 4.11 - Presumptive Profile – BOREHOLES #012





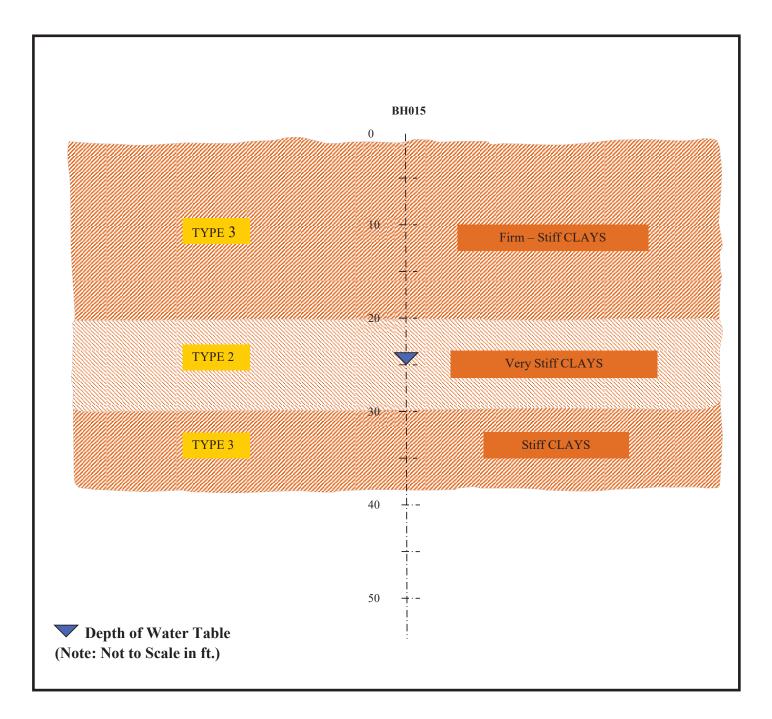


FIGURE 4.13 - Presumptive Profile – BOREHOLES #015

4.2. Bearing Capacity

4.2.1. Shear Considerations:

Note, if soil modification is chosen and the densities are verified; apply a multiplying factor of 1.25 to relevant bearing values.

Also note that Ultimate values are given for the insitu soils. A Factor Of Safety of 3 for maximum safe load capacity is recommended based on the high variability and compressibility of the soils on site.

TYPE 1 SOILS – Compact SANDS

The Modulus of Subgrade Reaction (Ks) is the parameter of relevance for raft design. Using the Design Profiles shown below, the recommended value for this parameter is:

i) Ks = 
$$7974*(1-0.4*B/L)*B$$
 kN/m<sup>3</sup>

The Ultimate Bearing Capacity and other relevant parameters recommended on these soils are:

i)  $Q_{ult.} = 395.09*(1+0.34*B/L)*(1+0.18*D/B)$  kPa

### **TYPE 2 SOILS** – Very Stiff CLAYS

The Modulus of Subgrade Reaction (Ks) is the parameter of relevance for raft design. Using the Design Profile shown in Figure 4.1 - 4.13, the recommended value for this parameter is:

i) Ks = 12483\*(1+0.2\*B/L) kN/m<sup>3</sup>

The ultimate bearing capacity and other relevant parameters recommended for these soils are:

i) 
$$Q_{ult.} = 312.07*(1+0.20*B/L)*(1+0.2*D/B) + 15.45$$
 kPa

#### TYPE 3 SOILS – Firm – Stiff CLAYS

The Modulus of Subgrade Reaction (Ks) is the parameter of relevance for raft design. Using the Design Profile shown in Figure 4.1 - 4.13, the recommended value for this parameter is:

i) Ks = 
$$8399*(1+0.2*B/L)$$
 kN/m<sup>3</sup>

The ultimate bearing capacity and other relevant parameters recommended for these soils are:

i) 
$$Q_{ult.} = 209.96*(1+0.20*B/L)*(1+0.2*D/B) + 15.45$$
 kPa

TYPE 4 SOILS – Very Loose SANDS

The Modulus of Subgrade Reaction (Ks) is the parameter of relevance for raft design. Using the Design Profiles shown in Figures 4.1 - 4.13, the recommended value for this parameter is:

i) Ks = 
$$4198*(1-0.4*B/L)*B$$
 kN/m<sup>3</sup>

1The Ultimate Bearing Capacity and other relevant parameters recommended on these soils are:

i) 
$$Q_{ult.} = 251.23*(1+0.30*B/L)*(1+0.17*D/B)$$
 kPa

**TYPE 5 SOILS** – Soft – Very Soft CLAYS

The Modulus of Subgrade Reaction (Ks) is the parameter of relevance for raft design. Using the Design Profile shown in Figure 4.1 - 4.13, the recommended value for this parameter is:

i) Ks = 
$$4104*(1+0.2*B/L)$$
 kN/m<sup>3</sup>

The ultimate bearing capacity and other relevant parameters recommended for these soils are:

i) 
$$Q_{ult.} = 102.6*(1+0.20*B/L)*(1+0.2*D/B) + 15.45$$
 kPa

TYPE 6 SOILS – Very Dense SANDS/COBBLES & BOULDER + Some Gravels

The Modulus of Subgrade Reaction (Ks) is the parameter of relevance for raft design. Using the Design Profiles shown in Figures 4.1 - 4.13, the recommended value for this parameter is:

i) Ks = 
$$12351*(1-0.4*B/L)*B$$
 kN/m<sup>3</sup>

The Ultimate Bearing Capacity and other relevant parameters recommended on these soils are:

i) 
$$Q_{ult.} = 541.27*(1+0.38*B/L)*(1+0.19*D/B)$$
 kPa

**TYPE 7 SOILS** – Highly fractured Medium Limestone Rock Modeled As Very Dense Gravels and Sands

a) Mat/Raft Footing

The Modulus of Subgrade Reaction (Ks) is the parameter of relevance for raft design. Using the Design Profiles shown in Figures 4.1 - 4.13, the recommended value for this parameter is:

- i)  $Ks = 40936*(1-0.4*B/L)*B kNm^3$
- b) <u>Raft Pad/Beam Footing</u>

The Ultimate Bearing Capacity and other relevant parameters recommended on this site are:

i)  $Q_{ult.} = 1291.77*(1+0.49*B/L)*(1+0.22*D/B)$  kPa

#### TYPE 8 SOILS – PEATY SOILS

Ignore Soil Contribution

Where,

 $Q_{ult}$  is the Ultimate Bearing Capacity, kPa Ks is the Modulus of Subgrade Reaction, kN/m<sup>3</sup> D is the Depth of footing, m B is the Width of footing, m L is the Length of footing, m

### **TABLE 4.1 - SUMMARY OF SOIL BEARING CAPACITIES**

LOCATION	ULTIMATE BEARING CAPACITY 1mx1m; D=0.5	ULTIMATE BEARING CAPACITY 1mx1m;D=1	Allowable Bearing Capacity 1mX1m; D=0.5	Allowable Bearing Capacity 1mX1m; D=1
BOREHOLE	KPa	KPa	KPa	KPa
001	292.6	317.8	97.5	105.9
002	354.4	382.1	118.1	127.4
003	292.6	317.8	97.5	105.9
004	427.4	464.8	142.5	154.9
006	817.9	888.9	272.6	296.3
007	817.9	888.9	272.6	296.3
008	817.9	888.9	272.6	296.3
009	427.4	464.8	142.5	154.9
010	577.7	624.7	192.6	208.2
011	292.6	317.8	97.5	105.9
012	150.9	163.2	50.3	54.4
013	817.9	888.9	272.6	296.3
014	150.9	163.2	50.3	54.4
015	292.6	317.8	97.5	105.9

Bearing Capacity at No. 005 and No.013 sites are presumed to be following. \*1 No.005 date is not described in this table. Each bearing capacity is presumed the same as No.003 that hall be calculated from same soil type. \*2 Boring is machine cannot enter into No.13. This site presumed to have minimum bearing capacity in this table from sight.

## TABLE 4.2 - SUMMARY OF SOIL PARAMETERS

LAYER	TYPE 1	TYPE 2	TYPE 3	TYPE 4
IDENTIFICATION	SOILS	SOILS	SOILS	SOILS
Bulk Unit Weight KN/m3	16.1	19.3	19.3	15.3
Submerged Unit Weight	9.2	9.5	9.5	8.7
Compression Index				
Void Ratio				
Undrained Cohesion (KPa)		60.7	40.8	
Drained Cohesion (KPa)				
Effective PHI/PHI	33.1	18	15	29.7
Relative Density	49.9			19.0
Ка	0.293	0.691	0.741	0.338
Кр	3.409	1.447	1.349	2.957
Permeability Coef. (k)				

## TABLE 4.3 - SUMMARY OF SOIL PARAMETERS

	TYPE 5 SOILS	TYPE 6 SOILS	TYPE 7 SOILS	TYPE 8 SOILS
				IGNORE
Bulk Unit Weight KN/m3	19.3	16.6	18.5	
Submerged Unit Weight	9.5	9.5	10.0	
Compression Index				
Void Ratio				
Undrained Cohesion (KPa)	20.0			
Drained Cohesion (KPa)				
Effective PHI/PHI	6	35.6	41.5	
Relative Density		69.5	100	
Ка	0.895	0.266	0.203	
Кр	1.117	3.756	4.923	
Permeability Coef. (k)				

### 4.3. Seismic Considerations

Information obtained from available seismic risk map for Jamaica indicates that the spectral acceleration for short periods/two second periods with 5% damped acceleration response spectrum for the maximum considered earthquake with a 2% probability of exceedance in 50 years, was deduced as  $S_1 = 0.3g$ . According to the IBC code (2003) and the UBC (1997) code, the sites vary in classifications from Classes C to E from the fractured limestones to the soft Clays respectively.

### 4.4. Liquefaction Considerations

In a seismic event, the stresses developed on an element of soil are usually cyclic in nature. The manner in which soils response to these stresses is dependent on a number of factors, including but not limited to, insitu density (relative density), water table conditions, grainsize distribution and shape. For example, loose saturated sands having a contractive structure and subjected to shear deformation might develop very high pore water pressures and lose virtually all their resistance to deformation. This condition where a static (peak) or cyclic load leads to high pore or residual pressures that reduces the effective confining pressures to very low values or where the confining pressures becomes equal to the effective pore pressures leading to large deformation is called liquefaction.

The potential for a soil to liquefy has been determined to be dependent on the cyclic stress ratio  $\tau_h/\sigma'$ , where  $\tau_h$  is the average horizontal shear stress induced by an earthquake and  $\sigma'$  is the initial effective overburden pressure on the soil layer involved.

The Type 1 soils (encountered below the water table at Location 2, in Old Harbour) appear susceptible to liquefaction based only on its relative density, its grainsize distribution however shows fines content (retained #200 sieve size) of over 35%. Typically soils with over 20% fines content, rarely liquefies.

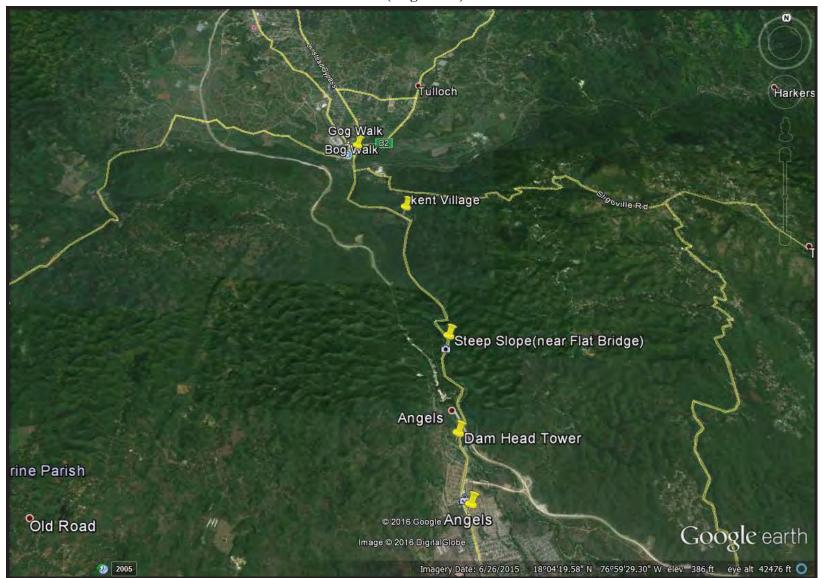


PhD., M.Sc. M.A.S.C.E. Registered Professional Engineer (PE) Geotechnical Engineering

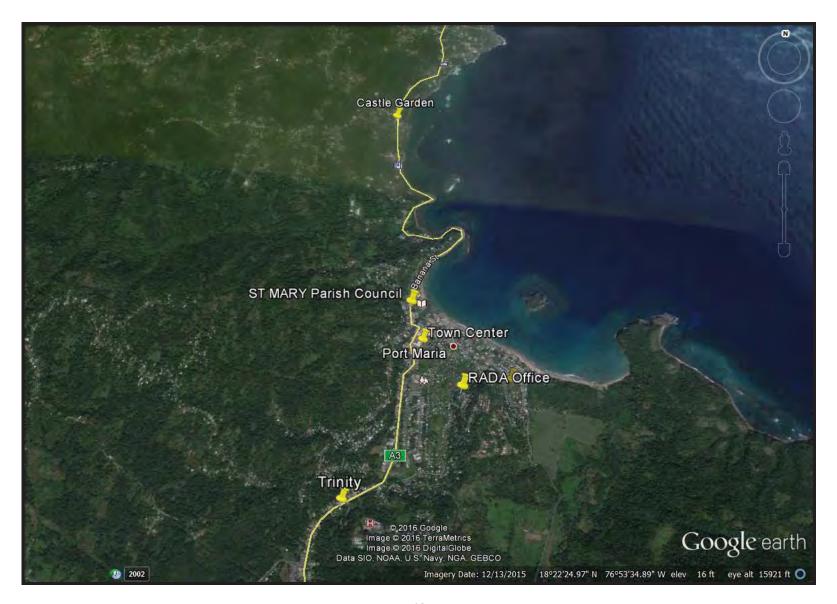
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Appendix I - Site Location Plan and Test Location Plan (Old Harbour Bay)





Site Location Plan and Test Location Plan (Bog Walk)



Site Location Plan and Test Location Plan (Port Maria)

# Appendix II - Soil Boring Log

	ENT: C/O ODPEM DJECT: Soil Investigation	Eastings:		Loca	ation	Re	eference Northings:			Тур	e/Size	
	DRESS: 2 - 4 Haining Road,		y Sire	n Pro			larine Lane, St. Catherine	9			5" Diameter Au	
	Kingston 5					atui					140 lbs Cathe mer for SPT.	ead
Sam	Jamiaca ple Types Wash		Grat		Elev		on: Split Spoon					
~		12		-	amp	_			Tube		R. Core	
t (tt	dealer and a	Plk	Con Con	2	_		20	80	20	otanu	ard Penetration (Blows/ft.)	100
Depth (IL)	Soil Description	Strata Plea	SPT River Count	Type	ID Mark	Recevery	Wet Unit We (kip/cu.ft)	ight d 13	Un 10 C	drained L omp. Tes	Inconfined She (kip/sq.ft) t + Vane Shea	ear Strength
0	Sliff Brown Clayey Silt & Medium - Fine S	Sand		455	a.	18						
5	Firm Brown Silty Clay				2	18						
	Firm Brown Silty Clay		3	345	3	18						
10	Stiff Brown Clay with some Sift & Traces Sand	of	100	6 7	4	18						
15	Stiff Brown Clay with some Silt & Traces of Sand	of s		6 7 8	5	18						
0	Stiff Brown Clay with some Silt & Traces of Sand	s	5 8 8	IXI:	6 1	18						
5	Sliff Brown Clay with some Silt & Trace of Sand	s	7 6 7	X	7 1	18						
1 1	**note 51 represent refusal on spoon		1			-						
	ENGINEERING LTD ULTING ENGINEERS					1		Dat	les	Job No.		
	nroe Road on 6, Jamaica						Start	28.04.16		E	3.H. No.	Sht. 1 of
FFIC	E BOREHOLE RECORD		-	_	_	0	Completion	28.04.16			1# Sir001	
						Ţ,	Final W. L.	N/A		1 5	On our	

	NT: C/O ODPEM IECT: Soil Investigation	Eastings:					Nothin	105				Туре/	Size	
ADDF	RESS: 2 - 4 Haining Road,	Emerg	ency	Siren	Proje	ct - N Datur	arine La	ane, St. Catherin	e	Hollov 3 25	v Ster	n 6.25" Stern 1	Diameter A 40 lbs Cath	uger,
	Kingston 5 Jamiaca												at for SPT.	eau
Sample	e Types Wash	P	10	Brab	E	evatio		lit Spoon	T.W.	Tube	-	-	R. Con	
(f.)		1	51	III	sam			Plasticity			S		Penetratio	
Da	Soil Description			W COJ	14	12	20	0	80	20		(	Blows/ft.)	100
Lepin (IL.)	oon beschpiton		IN COLO	SPT Blow Count	ID Mark	Recovery	.07	Wet Unit We (kip/cu.ft)	eight 🗆 ) 13	10 0	ndrair	Test +	onfined She (kip/sq.ft) Vane Shear	ear Strength
30				1 80	7	1 <b>2</b>	1	1 1 1 1	13	1.0 0	-omp.	1 cot 1	vane onear	5,0
-				7	8	18								
-	Stiff Brown Clay with some Silt & San	d			1									
-														
-														
35	Stiff Brown Silty Clay with some Sand	d		8										
	(BH Ends @ 35Ft.)			8	9	18								
2														
-														
-														
-														
5														
-														
-														
-														
-														
4														
-														
-														
1														
	**note 51 represent refusal on spoon													
L EN	GINEERING LTD TING ENGINEERS		-	-	-		-		Dat	es	Job	No		
Monro	e Road 6, Jamaica					Sta	art		28.04.16		0.00		-	Sht. 2 of 2
						Co	mpletic	n	28.04.16		1	B.H.	No.	1 Carrier
FICE	BOREHOLE RECORD					Fir	al W. L				-	BH# S	Sir001	
						Fil	idi VV. L		N/A					1

	NT: C/O ODPEM JECT: Soil Investigation	Easting			Loca	atio	n R	eference			Ту	pe/Size	
110.	acon our investigation	Eastings: Emergence	cy Si	ren P	roie		Old	Northings: Harbour Bay, Fishing Villag		Heller	Clar C	06" Dia 1	
ADD	RESS: 2 - 4 Haining Road,	- Bank		.+10	1.590		atu			3.25"	I.D. Ster	25" Diameter A n, 140 lbs Cath	uger, ead
-	Kingston 5 Jamiaca					Fle	vati	0.0.				mmer for SPT	
Samp	le Types Wash		1	Grab		-10		Split Spoon	T. W.	Tube	Г	R Core	3
1		1	510	- and	1 5	amp	ples			1		dard Penetratio	
Depth (ft.)	0-10-11	14	IS O IO	SPT Blow Count	6			00	80	20		(Blows/ft.)	100
spt	Soil Description	1	ALD V	Blow	JYNS .	1D Mark	Recovery	Wet Unit We (kip/cu.ft)	ight 🗆	Un	drained	Unconfined Sh	ear Strength
ă		10	17	Tas	1	g	Rec	07	13	1.0 C	omp. Te	(kip/sq.ft) st + Vane Shea	ar 5.0
0		(S)	3	-	T	-	-	111111		1-1-1	1.7	1.1.1.	
-					H								
-					5	1	18						
-	Compact Brown Medium - Fine Sand	1		12	64								
		100											
5													
-	Very Loose Brown Madium Pice					2	18						
	Very Loose Brown Medium - Fine Sand some Silt	with		1	14	-	10						
			V										
	Varial page Press - Press - Press			1	M	3	18						
	Very Loose Brown Sandy Silt with Clay			1									
10					Ц								
			10.00	1	X	4	18						
	the state of the s			3	P								
-	Very Soft Brown Clayey Silt with some S	Sand											
-			1										
-		199											
15				HW			1						
_	Soft Brown Clayey Silt with some Sand			HW		5	18						
		il.	1										
	Very Loose Grey Coarse - Fine Sand with Traces of Silt	縣											
20													
		藤		2 2 2	M	6	10						
-				2	Δ	0	18						
-	Loose Grey Coarse - Fine Sand with Traces of Silt & Shells												
-													
				2	-								
		No.		32	X	7	18						
	Loose Grey Coerce - Fine Can doubt		8	3	-								
-	Loose Grey Coarse - Fine Sand with Traces of Silt												
-													
0													
	**note 51 represent refusal on spoon NGINEERING LTD	1989			-		-						
ONSU	LTING ENGINEERS						+		Date	es	Job No		
	oe Road						40	Start	28.04.16				Sht. 1 of 2
ingstor	n 6, Jamaica						+	Dirit est	12.2.2.4	-		B.H. No.	
FFICE	BOREHOLE RECORD		-	_	-	_	-	Completion	28.04.16		P	H# Sir002	
CONS.								ingl W/ 1	-74		1 0	- IF 511002	
							F	inal W. L	7'				

	ENT: C/O ODPEM DJECT: Soil Investigation	Eastings:		Lo	catic		ference Nothin				Тур	e/Size	
		Emergenc	y Si	en Proj	ect -	Old H	larbour	gs. Bay, Fishing Village	-	Hollow	Stem 6.2	5" Diameter Aug	er;
ADD	DRESS: 2 - 4 Haining Road, Kineston 5					Datun				3.25"	D. Stem	, 140 lbs Cathea	
	Kingston 5 Jamiaca				Ele	evatio	on:			D	rop Ham	mer for SPT	
Sam	ple Types Wash		] G	irab				lit Spoon	T. W.	Tube		R. Core	
3		ot	ń	MIRK	samp	les	-	Plasticity			Stand	ard Penetration	
Uepun (IIL.)	Soil Description	Strata Plot	ROL	SPT Blow Count	12	8	20	10/-11-0 10/-10	80	20		(Blows/ft.)	100
chi	Con Description	trat	3	SPT Blow	ID Mark	Keroven		Wet Unit Weig (kip/cu.ft)		Un	arained C	Inconfined Shea (kip/sq.ft) + Vane Shear	
2		Ø	R	1	8	Sec.	.07		.13	1.0 00	mp. Test	+ Vane Shear	5.0
30				4V					TT		TT		
-				5	8	18							
-	Compact Brown Medium - Fine San												
-	with some Silt												
_													
_													
35	Very Stiff Brown Clay with some Silt & Trad of Sand	ces		4	9	18							
	(BH Ends @ 35Ft.)			8	U	10							
-		1											
-													
-													
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45													
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2	**note 51 represent refusal on spoor												
	ENGINEERING LTD SULTING ENGINEERS								Da	ates	Job No		
M	onroe Road					S	Start		28.04.16				Sht. 2 of
	ton θ, Jamaica					C	Comple	tion	28.04.16			B.H. No.	
FFI	CE BOREHOLE RECORD					-			1.200		В	H# Sir002	
						F	inal W	. L.	7'				

PRO	ENT: C/O ODPEM DJECT: Soil Investigation DRESS: 2 - 4 Haining Road, Kingston 5	Eastings: Emergency S			- Bla	Reference Northings: ackwood Gardens, St. Catherin turn	ne	3.25"	Stem 6.2 I.D. Sterr	e/Size 25" Diameter Au 1, 140 Ibs Cathe	iger; aad
	Jamiaca			E	Eleva	ation:			Drop Ham	imer for SPT.	
Sam	ple Types Wash		Grab		G	Split Spoon	T. W.	Tube	E	R. Core	
Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count		Reconceru aldu	20	80	20 Un	idrained L	ard Penetration (Blows/ft.) Jnconfined She (kip/sq.ft) t + Vane Sheai	100 ar Strenoth
Q	Shiff Brown Siles Class with Tarray of			T	T			111		Ì	
-	Stiff Brown Silty Clay with Traces of S	sand	6 6 7	Χ,	1	10					
-	Compact Brown Coarse - Fine Sand										
5 -	Stiff Brown Silty Clay with Traces of S	Sand	8		2 8	B					
0	Compact Brown Coarse - Fine Sand		9/								
	Very Stiff Brown Silly Clay with Traces of S	Sand	10 8 7	3	18	8					
10	Very Sliff Brown Silty Clay with Traces Sand	of	5 8 7	4	18	8					
15	Very Stiff Brown Clay with some Silt & Tra of Sand	of aces	6 7 9	5	18	R.					
0	Very Stiff Brown Clay with some Silt & Trac of Sand	ces	888	6	18						
5	Very Stiff Brown Clay with some Silt & Trax of Sand		5 7 9	7	18						
HL E	**note 51 represent refusal on spoon ENGINEERING LTD										
Mon	ULTING ENGINEERS					Start	Date 29.04.16	es	Job No.		Chi 4 . ch
ngsto	on 6, Jamaica					Completion	29.04.16	-	8	B.H. No.	Sht. 1 of 2
FFICE	E BOREHOLE RECORD					Final W. L.	N/A	-	BH	l# Sir003	

PROJE	T: C/O ODPEM ECT: Soil Investigation	Eastings	S:		Local	uon t	Reference Nothin				Type/S	ize	
				en Pr	oject		kwood G	ardens, St. Catherin	ie	Hollow	Stem 6.25" D	liameter Aug	ier;
ADDRE	ESS: 2 - 4 Haining Road, Kingston 5					Date	ım				I.D. Stem, 14		nd
_	Jamiaca				E	Eleva	tion:			L	)rop Hammer	IOF SPIL	
Sample	Types Wash	L		Grab				lit Spoon	T. W. T	ube		R. Core	
(F)			lot	CULDI	san	nples		Plasticity			Standard	Penetration * Blows/ft.)	
Depth (ft.)	Soil Description		Strata Plot	SPT Blow Count	2 1	ALK.	20	Wet Unit Weig	ant D	20 1 Und	drained Unco	onfined Shea	100 Ir Strength
Jep			iura.	PLB	T'>pod %T	Recovery	.07	Wet Unit Weig (kip/cu.ft)		10 00	(Homp. Test + V	tip/sq.ft)	5.0
-					F F	12	1		.13	1 00		and onedi	1
30				78	XE	3 18							
	Very Oth Dame of the			9	4	1	11						
	Very Stiff Brown Clay with some Sil Traces of Sand	ιă											
35	Very Stiff Dark Brown Clay with som	10		8	7								
	Silt & Sand (BH Ends @ 35FL)			8 9	N :	9 18							
-	ALC: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			3	1								
-													
_													
-													
40						1							
-					1								
45													
50													
_													
5													
				1	1								
		8											
				1									
0	**note 51 represent refusal on spoor	,											
HL EN	IGINEERING LTD			-1-	-	-	1			1	Job 11		
	TING ENGINEERS						Stad		Date	<b>1</b> 0	Job No.		
9 Monro ingston (	e Road 6, Jamaica						Start		29.04.16	_	B.H	. No.	Sht. 2 of 2
				_			Comple	lion	29.04.16				
FFICE	BOREHOLE RECORD								Contraction of the local sectors of the		101111	Sir003	

	ENT: C/O ODPEM DJECT: Soil Investigation	Eastings:				Reference Northin						Type/			
ADD	RESS: 2 - 4 Haining Road,	Emergency Si	ren Pro		- New Datu		lage, St. Cathe	erine			25" I.D.	Stem, 1	" Diameter Au 140 lbs Cathe		
	Kingston 5 Jamiaca			E	Elevat	tion:					Drop	Hamm	ner for SPT.		
Samp	ple Types Wash		Grab				it Spoon		T.W	V. Tube			R. Core	,	
(T)		let	oret	sar	mples	- Provention	Plastic	city	-	20			rd Penetration (Blows/ft.)		_
a l	Soil Description	d an	O MO	Care .	Nat.	20	Wet Unit V	Weigh	80. It 10	20		1	(Blows/ft.)	100 J	noth
Depth (tt.)	The set for your a	Strata Plot	SPT Blow Count	T MAN	ID. Mark Recovery	.07	(kip/cu	J.ft)	.13	1.0			(kip/sq.ft) + Vane Shear		
0			100		-1-			-	1 1 1		1 1	_			-
0			12										6111		
-	Statute T	aces of Sand	12 15 14	5 X 1	1 1	10									
-	Very Stiff Brown Silty Clay with Tra of Sand	aces	1.4	f1											
-															
5			9	K7											
	Very Stiff Brown Silty Clay with Traces of	of Sand	12		2 18	8									
T			10		3 18										
	Very Stiff Brown Silty Clay with Traces of	Sand	11 18	X 3	16										
10			10	6											
1			10 13 21	X 4	4 18	3									
	Very Olly Dealer City Olay with Part		1	A.											
	Very Stiff Brown Silty Clay with some	e Sand		1											
15				4											
H			14		5 6										
-	Compact Brown Medium - Fine Sand	1233	15/	4											
-	with some Gravel														
-															
-		*		-											
20	n		16	X 6	5 5										
-			18		0										
-	Dense Brown Medium - Fine Sand some Silty Clay	with													
_															
-								1							
25			14	V z	7										
-		2623	13 15		1										
-	Compact Brown Medium - Fine San with some Gravel	nd	11												
-															
30															
HL E	"note 51 represent refusal on spoor ENGINEERING LTD	n 💹		1	1			4			4			11	
CONSU	SULTING ENGINEERS							-	1.000	Dates	J	Job No.		1	
	onroe Road ton 6, Jamaica					Start			29.04.16	5		в	8.H. No.	Sht.	1 of
_	ND 05 12/0715					Completi	ion		29.04.16	3					
SEEIO-	CE BOREHOLE RECORD							-+			_	BH	1# Sir004		

	C/O ODPEM T: Soil Investigation	Eastings:		LO	cauc	a) Re	Nothin				Type/Size	
	IS: 2 - 4 Haining Road,		cy Sir	en Proje		Vew H Datu	larbour '	ys. Village, St. Catherine	-		Stem 6.25" Diameter D. Stem, 140 lbs Ca	
	Kingston 5										op Hammer for SPT	
Sample Ty	Jamiaca /pes Wash		7 G	rab		evati		it Spoon	T.W.	Tube	R.C	ore
		18	-	2.11	amp	-		Plasticity		1	Standard Penetrat	ion Test
II) (III	1000	id	A	W Con	1	1	20	0	80	20	(Blows/ft.)	100
Depth (IL)	Soil Description		IN CO D	SPT Blow Count	<b>ID Mark</b>	Recovery	.07	Wet Unit Weigh (kip/cu.ft)	13	Und 1.0 Con	rained Unconfined S (kip/sq.ft) np. Test + Vane She	hear Strength
30		8	1	16	-	-			TIT	TIT		TIT
-				17	8	18						
-	Dense Brown Medium - Fine Sand	vith										
_	some Gravel											
		vith										
35	Dense Brown Medium - Fine Sand with some Gravel			12	9	18						
	(BH Ends @ 35Ft.)			22								
		1										
0												
							12					
45												
-												
1												
50												
-												
5												
-												
-												
-												
-												
	*note 51 represent refusal on spoo SINEERING LTD	n L			-	-						
ONSULT	ING ENGINEERS								2.2.1.1.2.2	ates	Job No.	1
9 Monroe lingston 6	Road Jamaica						Start		29.04.16		B.H. No.	Sht. 2 of 2
OFFICE B	OREHOLE RECORD			_	-	-	Comple	tion	29.04.16		BH# Sir004	4
							Final W	11	N/A		1.000	

	NT: C/O ODPEM ECT: Soil Investigation	Eastings:	L	ocatio	on R	Reference Northings				Ту	/pe/Size		
1000			Siren			Bog Walk, S	s: St. Catherine		Hollow	Stem 6.	.25" Diameter /	Auger:	
AUUR	ESS: 2 - 4 Haining Road, Kingston 5		-		Datu				3.25"	I.D. Ster	m, 140 lbs Cat	lhead	
Same	Jamiaca	-	_	Ele	evati					огор На	mmer for SPT.		
-	e Types Wash		Grab			Split 8		T. W.	Tube		R. Co		
(H)		Not	Jano		nples	00	Plasticity		-	Stan	dard Penetrati (Blows/ft.)		
Depth (ft.)	Soil Description	Strata Plot 1< <> 10	SPT Blow Count	art.	VIEW	1	Wet Unit We (kip/cu.ft)	eight 🗆	20       	Idrained	Unconfined St	100 L hear Str	
De		SIL	SPTE	T Norb	Recovery	07	(kip/cu.ft)	.13	1.0 0	omp. Te	(kip/sq.ft) est + Vane She	ar 5	
0				1		1 1	1		11		1		_
			1	-	1							T	1
-			4 4	1	18	8							
	Firm Light Brown Clay with some Sil	t 📗	54	1									
_				1	1								
												11	
5	******		1	7	1							11	
1	Stiff Light Brown Clay with Traces of Si		3	2	18							11	
	Sources of S		5	1	1								
	*********		3	7	D								
-	Stiff Light Brown Clay		3 5 8	3	18								
10				11	10								
			3	1	18								
-	and the second second		5	7 4	10								
-	Firm Light Brown Clay			T									
				1									
-								111					
15			3	7									
			5	5	18			TIN					11
	Stiff Light Brown Clay		T	11				TIN		11			
1				11									
0	······································			11				1111		11			
			4	6	18								
1	Stiff Light Brown Clay		8	Y									
	a second			11									
1													
5								111					
			67	7	18								
-			7		10			1111		11			
-	Stiff Light Brown Clay			1									
				11									
										11			
HL EN	**note 51 represent refusal on spoon												
ONSUL	IGINEERING LTD TING ENGINEERS				L			Date	es	Job No	».		
Monroe	e Road				4	Start		30.04.16				She	t. 1 of 2
ngston	6, Jamaica				-				_	-	B.H. No.	an	
			_		- "	Completion		30.04.16		1		1	
FICE	BOREHOLE RECORD									11.1	3H# Sir005		

	C/O ODPEM	Eastings:					eferenc Nothir	ds:			T	ype/Size	
ADDRESS	2 - 4 Haining Road, Kingston 5	Emerg	gency	y Sirei	Pro	ject - Datu	Bog Wa	lk, St. Catherine	-	3.25"	I.D. Ste	3.25" Diameter A em, 140 lbs Cath	
	Jamiaca				E	levati	on:				Drop Ha	ammer for SPT.	
Sample Typ	es Wash		10	Grab				lit Spoon	T. W.	Tube	E	R. Cor	e
(11)	1000000		101	Ceunt	sam		-	Plasticity		1	Star	ndard Penetratio (Blows/ft.)	
Depth (ft.)	Soil Description		E O	low (	ark	Kaa	20	Wet Unit Wei	BO ight D	20 Ur	ndrained	Unconfined Shi	100 ear Strength
Del			ISCIDE FION	SPT Blow Count	1D Mark	Recovery	.07	Wet Unit Wei (kip/cu.ft)	.13	1.0 C	omp. Te	(kip/sq.ft) est + Vane Shear	5.0
30			-	201	7	1-				11		1	
30				8	8	18							
-	Stiff Light Brown Clay			8/									
-													
-													
35	Stiff Light Brown Clay			7									
	(BH Ends @ 35Ft.)		2	8	9	18							
-		1											
-													
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0													
15													
0													
_													
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-													
-													
HL ENGIN	te 51 represent refusal on spo EERING LTD	on											
ONSULTIN	G ENGINEERS					+			Dat	es	Job N	0.	_
Monroe Ringston 6, Ja	pad Imaica					s	tart		30.04.16			B.H. No.	Sht. 2 of 2
-	EHOLE RECORD		_	_	_	C	omplet	on	30.04.16			BH# Sir005	
FFICE BOR													

	IT: C/O ODPEM ECT: Soil Investigation	Eastings:		Lo	catio	n Re	ference Northings:				Туре	/Size		
	ESS: 2 - 4 Haining Road,		cy s	Siren F		t - K	ent Village, St. Cath	erine	-			" Diameter Aug 140 lbs Cathea		-
	Kingston 5											ner for SPT.		
Sample	Jamiaca Types Wash		1 0	Srab	Ele	vatio	on: Split Spoon	F	T. W. T	ube		R. Core		_
_		13			sam	ples		sticity		1		rd Penetration	Test	_
E	Station Manharen	Pik	N.	/ Cou			20		80	20		(Blows/ft.)	100	
the purchase	Soil Description	Strata Blou	CI CO NI	SPT Blow Count	ID Mark	Recovery	Wet Uni (kip/	it Weig cu.ft)	ht a	Une	drained U	(kip/sq.ft)	r Streng	th
Ť		Ū.	1	SP	- 9	Rea	07		.13	1.0 Co	omp. Test	(kip/sq.ft) + Vane Shear	5.0	_
0				TT	T	1			TH	TT	T		TT	
				4	7.									
				19 21	1	12								
	Brown Silty Clay with some Gravel													
5	17117-1-1117-11-11-11-11-11-11-11-11-11-													
-	(Refusal @ 9')	8		40	2	6								
-	Very Dense Cream Calcareous Cobbl Boulders with some Sand	es &		F	1									
			the second		-									
-			80	%	3	60								
-	Hard Cream Porous Limestone													
0														
-	(BH Ends @ 12')				1									
-	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1													
5														
-														
-														
-														
-														
0														
-														
-														
-														
-														
5														
-														
-														
-														
	Service Concernance													
HL E	**note 51 represent refusal on spoon NGINEERING LTD		-			_								
ONSU	LTING ENGINEERS							-	Dat	es	Job No.		1	-
	roe Road n 6, Jamaica						Start		30.04.16		1	B.H. No.	Sht. 1	of
FEICE	BOREHOLE RECORD		_	_	_	-	Completion		30.04.16		В	H# Sir006		
						- 14		-					1	

1115	OJECT: Soil Investigation	Eastings						erence Northing	S:					Type/s	Size			
AD	DRESS: 2 - 4 Haining Road,	Emergen	cy Sir	en Pr	oje	ct - D	am l	Head Tow	er, St. Catheri	ne		Hollov	v Sten	6.25"	Diameter	Auger	1	
	Kingston 5					Da	tum					3.25	Drop I	Stem, 1 Hamme	40 lbs Cat r for SPT	thead		
Sam	Jamiaca nple Types Wash	-	~	Seels	-	Elev							and all a		6.000			
	The second secon			Grab	-	_	_	Split			T. W.	Tube			R. Co			
Depth (ft.)			Strata Plot	SPT Blow/Count	1.17	sampl		20	Plasticity	-	80	20	S	tandard (	Penetrati Blows/ft.)		st 00	
pth	Soil Description		ata Pk	Blow	net	dark	Kiow		Wet Unit Wei		-	U	ndrain	ed Unc	onfined S	hear S		h
De			Sur	SPT	PSING.	ID Mark	Recovery	.07	(kip/cu.ft)	.13	3	1.0	Comp.	Test +	kip/sq.ft) Vane She	ear	5.0	
0			8	-		_		TT	111	1			-	1 1		1		_
-																		1
-	Cream Calcareous Sand & Gravel/Cob	bles	•															
-	(Refusal @ 3")			50														
-	Very Dense Cream Calcareous Boulde	rs &	0	50	X	1	3											
-	Cobbles with some Sand																	
5	Very Dense Cream Calcareous Boulders & C	Cobbles	-	50	X	2	23											
			10	*		3	40											
	Medium Cream Porous Limestone																	
	mount cream Porous Limestone																	
			3															
10	(BH Ends @ 10')		2															
	fen cina @ rej																	1
15																		
0																		
-																		
-																		
-																		
5																		
-																		
1																		
-																		
5	Manala 51 represent of and																	
HL	**note 51 represent refusal on spoon ENGINEERING LTD	-	1	-	1	-	+				11		-					
	SULTING ENGINEERS						-	14		-	Date	es	Job	No,		-	-	-
	onroe Road ton 6, Jamaica						St	art		01.0	5.16			B.H	I. No.	S	ht. 1 o	of 1
	CE BOREHOLE RECORD		_			-	C	ompletion		01.0	5.16							
	JE DURERULE RELURI						-			-				BH#	Sir008			

	NT: C/O ODPEM JECT: Soil Investigation	Eastings:	Lo	catio	n R	eference Northings:			Type/S	lize	
	RESS: 2 - 4 Haining Road, Kingston 5		ren Proje	D	atu	s Round About, St. Catherine m		25"1.0		Diameter Aug 10 lbs Cathea r for SPT.	
Sample	Jamiaca le Types Wash		Grab	Ele	evati	on:	T. W. Tube	6		R. Core	_
(H.)		10	E	samp	oles	Plasticity	_			Penetration	
Depth (f	Soil Description	Strata Plot	SPT Blow Count	ID Mark	Recovery	- 20 Wet Unit Weigl (kip/cu.ft)	80 21 ht = .13 1	Undr	ained Unc	Blows/ft.) onfined Shea kip/sq.ft) Vane Shear	100 ar Strength 5.0
0	(Refusal @4") Very Dense Cream Coarse - Fine San with some Gravel		50	,	2						
5	Very Stiff Brown Sandy Clay		589	2	12						
	Compact Compact Brown Coarse - Fine Sa		10 11 12	3	14						
10	Compact Brown Coarse - Fine Sand		8 13 10	4	15						
15	Compact Brown Coarse - Fine Sand		7 10 12	5	10						
20	Compact Brown Coarse - Fine Sand		11 13 14	6	10						
25	Compact Brown Coarse - Fine Sand		10 12 15	7	B						
30	**note 51 represent refusal on spoon										
	ENGINEERING LTD ULTING ENGINEERS						Dates	-	Job No.		
	nroe Road on 6, Jamaica					Start	01.05.16		В.	H. No.	Sht. 1 of 2
OFFIC	E BOREHOLE RECORD		_	_	-	Completion	01.05.16		BH	# Sir009	
51110	and a second reason of the second sec					Final W. L.	N/A			a decome to	

1100	NT: C/O ODPEM JECT: Soil Investigation	Eastings					eference Nothin	gs:			Type/S	nze	
		Emerger	icy Sire	en Pro			is Round	About, St. Catherine	1			Diameter Aug	
ADDF	RESS: 2 - 4 Haining Road, Kingston 5					Datu	m					40 lbs Cathea	bd
	Jamiaca				E	levat	ion:			Dr	op Hamme	FIOT SP1	
Sampl	le Types Wash	P		Grab				lit Spoon	T. W. 1	lube		R. Core	
Put			Strata Plot	County	sam	ples	-	Plasticity	-		Standard	Penetration Blows/ft.)	Test 100
u) indan	Soll Description		Strata Ploi	SPT Blow Count	i a	ALCO N	20	Wet Unit Weig	bt 🗆	20 Und	1	onfined Shea	1
da.			tra	W BI	ID Mark	Recovery	.07	Wet Unit Weig (kip/cu.ft)	.13	10 Cor	mp Test + \	kip/sq.ft) Vane Shear	5.0
-		_	00 14	33		12	1	I.	1	10 00	1		
30				11	X	6							
	2013 000 0000 000 000 000 000			17	1								
	Dense Brown Coarse - Fine Sand												
-													
1	Dense Brown Coarse - Fine Sand			13	1								
15				16	( 9	6							
	(BH Ends @ 35Ft.)			181									
0													
-													
5													
-													
-													
					1								
50													
0													
Q													
8													
0													
5	**note 51 represent refusal on spoor	0											
5 5 HL 1	**note 51 represent refusal on spoor ENGINEERING LTD ULTING ENGINEERS	n							Da	les	Job No.		
5 HL TONS	ENGINEERING LTD ULTING ENGINEERS	n					Start		Da 01.05.16	tes			Sht. 2 o
5 D HL I ONS E Moi	ENGINEERING LTD	0							01.05.16	tes		Н. No.	Sht. 2 o
5 0 HL I ONS 9 Mot	ENGINEERING LTD ULTING ENGINEERS nroe Road	2					Start	tion		les	В,	H. No. # Sir009	Sht. 2 o

	NT: C/O ODPEM DECT: Soil Investigation	Eastings:						eference Northing	5.					ype/Siz	ze		
ADD	RESS: 2 - 4 Haining Road,	Emerge	ncy	Sire	n Pr		ct - I		len, St. Mary						ameter Au		
nee	Kingston 5					U	atur	m							bs Cather for SPT.	ad	
Same	Jamiaca ble Types Wash		-	1.5.1	_	Ele	vati						-	-		_	_
Janit	ble Types Wash		-	Grab	_		-	Split :	5 m )=		.W.1	ube			R. Core		
(11)		Ploi	0	Count		amp			Plasticity	80		20	Sta		Penetration lows/ft.)	Test 100	
riepun (III.	Soil Description	Ita	0	(Rio)	196	lark	Xax	20	Wet Unit Wei		-	U	ndraine	d Uncor	nfined Shea	ar Stren	gth
nel		Strata Plot	14 CO E	SPT Blow Count	Type	ID Mark	Recovery	.07	(kip/cu.ft)	13		1.0 0	comp. T	est + V	p/sq.ft) ane Shear	5.0	
0		1	1	1		-				1	-		1	1	1 1 1	1	-
÷.		BAA	8	9	H					13							
-		bus		10	XI	1	12			11							
_	Compact Cream - Brown Calcared Fine - Medium Gravelly Sand	bus	-	10	M												
_																	
5																	
	Compact Cream Fine - Medium Calca	reous		11 11	X	2	13										
-	Gravelly Sand	reous		11	-												
	1999)			8													
-	Compact Cream Fine - Medium Calcare		1	12	X	3	12										
-	Sand with some Fine Gravel																
o				11	V	4	16										
-				10	$\wedge$	4	10										
	Compact Cream Fine - Medium																
	Calcareous Sand & Gravel																
5	(Refusal @ 5")			50		1											
	Lucinova (8) or V				X	5	5										
	Very Dense Cream Fine - Medium Calcar				-												
	Gravelly Sand	eous															
												11					
-	(Refusal @6")			50	V	6	5										
-	Very Dears Course The Law				4												
-	Very Dense Cream Fine - Medium Calcareous Sand with some Gravels																
-																	
-																	
-				7	7												
-		, 8		7	1	7	8										
1	Compact Dark Brown Fine - Medium	n 🕅															
1	Clayey Sand																
	**note 51 represent refusal on spoon																
	ENGINEERING LTD ULTING ENGINEERS						1				Date	s	Job	No.			
	nroe Road							Start		23.04	.16					Sht.	1 of
	on 6, Jamaica						+						-	B.H.	No.	ont.	
FEIC	E BOREHOLE RECORD			_	_	_	-	Completion	1	23.04	.16			RH# 9	Sir010		
1110	- Constructs DECORD						t	Final W. L.		N/A		_		Di la s			

	C/O ODPEM CT: Soil Investigation	Eastings:		Loca	ation		ference Nothing								Ty	pe/Si	ze			
	SS: 2 - 4 Haining Road,	Emergen	cy Si	ren Pi			Castel G		, St. Mar	у				25" 1.1	). Ster	m, 140	amete Ibs Ci	athead		
	Kingston 5 Jamiaca				Elev	vatio	n:							Dro	ор на	mmer	for SP	1.		
Sample 1			Grab				< Spl	it Spoo	n	E	T	W. T	ube				R. 0	Core		
3		of		Sa	mple	es	_		Plastici	ty		-		-	Stan		enetra			-
E	Dell Deservicion	Id Y	N Co	5	×	ġ	20 1			Interna	80	-	20	11-2		1	lows/ft.		100	
ncha (III.	Soil Description	Strata Plot	SPT Blow Count	octXL.	ID Mark	Recovery	07	vv	et Unit W (kip/cu.)	ft)	.13		1.0	Con	np. Te	(k st + V	nfined ip/sq.ft ane Sh	) lear	5.0	ığın
30		ie th			8	18		Τ			T	T		1				T	11	
	Very Sliff Dark Brown Clay with som	. 1	1	вĄ																
	Sand & Traces of Gravel																			
35	Very Stiff Dark Brown Sandy Clay wit	th		N																
	Traces of Fine Gravels (BH Ends @ 35Ft.)	14		Å	9	18														
-																				
-																				
-																				
-																				
0																				
-																				
45																				
				H																
50				1																
-																				
-																				
_																				
5																				
50	"note 51 represent refusal on spoor	n																		
HL EN	GINEERING LTD TING ENGINEERS											Da	tes		Job	No.				
ONSUL							Start				23.04	4.16				в.н	ł. No.		Sht	. 2 of
9 Monro						110				-		_			1					
29 Monro Kingston	6, Jamaica BOREHOLE RECORD				_	-	Comple	etion			23.04	4.16				BH#	Sir01	0		

PRC	ENT: C/O ODPEM DJECT: Soil Investigation DRESS: 2 - 4 Haining Road, Kingston 5 Jamiaca ple Types	Eastings: Emerger		ren P	noje D Ele	ct - atu	lion:		3.25"	Stem 6. I D. Ster	be/Size 25" Diameter A n, 140 lbs Cath nmer for SPT.		
-	ple Types Wash		Grab		1		Split Spoon	T. W. 1	Tube		R. Core		-
(1)	the second se	lot	1	Si	ampl	les	Plasticity			Stand	dard Penetratio	n Test	
Depth (ft.)	Soil Description	Strata Plot	SPT Blow Count	5	쇧	8	20	80	20	-	(Blows/ft.)	100	
6	our beschpildt	Sut	V Ba	Delega	ID Mark	Recovery	Wet Unit Wei (kip/cu.ft)	ght 🗆	Un	drained	Unconfined Sh	ear Strer	ngth
9		No.	A Las	2	m	Rec	.07	13	1.0 Co	omp. Tes	(kip/sq.ft) t + Vane Shea	r 5.0	
0		8//2	T	11	-	-		1 1 1	1 1				
-				Ц	-1								
				5	,	10							
	Stiff Dark Brown Clay with some S	and		5	1	10							
-	en e			11									
-													
_													
5													
	Compact Dark Press Press a	K			2	10							
-	Compact Dark Brown Sand & Clay					1							
		and											
			1		3	18							
	Compact Dark Brown Fine - Medium Sa With some Clay	and	è			.0							
10	and some only	and											
-			7		4 4	8							
-			5			9							
_	Compact Dark Brown Fine - Medium	1222											
	Sand with some Clay												
15			- 4	M									
-			8		5 1	18							
	Compact Dark Brown Fine - Medium												
	Sand with some Clay												
-													
-		883											
20			5										
		2	5	XD	5 1	8							
	0		9	-									
-	Compact Brown Fine - Medium San with Traces of Fine Gravels & Clay	a A											
-													
_		d .											
5			6	-									
			5	X	7 1	6							
1			7	4									
-	Stiff Brown Clay with some Sand												
-													
-													
0	**note 51 represent refusal on spoon												
	ENGINEERING LTD		-	-1		1						11	_
	ULTING ENGINEERS					F	20.0	Date	25	Job No.		1	-
9 Mon	nroe Road on 6, Jamaica					1	Start	23.04.16				Sht.	1 of 2
gott							Completion		-		B.H. No.	-	-
FFIC	E BOREHOLE RECORD			-	-	-1	Completion	23.04.16		B	H# Sir011		
							Final W 1	N/A		1	an on other		
						F	Final W. L.	N/A				_	

	ENT: C/O O DJECT: So	I Investigation	Easting	IS:				Nothin	IS:					Type/S	Size		
	DRESS: 2 - 4	4 Haining Road,	Em	ergency	/ Siren	Proj	ect - I Datur	Parish C	ouncil, St. N	lary	-	Holk 3.2	5" I.D. S	Stem, 14	Diameter Au 10 lbs Cathe	ger; ad	
	Jar	ngston 5 miaca				El	evati	on:							r for SPT.		
Sam	ple Types	Wash	P		Grab			<_ Spl	t Spoon	1	T.V	V. Tube			R. Core	6	-
(~)				lot	SALES .	samp	ples	-	Plas	ticity			St	landard	Penetration		-
(P)		Soil Description		a b	0.80	iek	Sie	20	Wet Unit	Maia	80	20	Indette		Blows/ft.)	100	_
Lepun (III.)				Strata Plot	SPT Blow Count	ID Mack	Recovery	07	(kip/c	cu.ft)	.13	1.0	Comp.	eo Unci Test + \	onfined She kip/sq.ft) /ane Shear	5.0	h
30					8	8	12		TT				TT	TT		T	1
	Very St	iff Brown Clay with Traces of F Gravels	ine		7												
35	Very Stiff Bro	own Clay with Traces of Fine G	Gravels		7	9	14										
_		(BH Ends @ 35FL)		1	вД		14										
_																	
-																	
0																	
-																	
-																	
-															111		
-																	
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5																	
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D																	
1																	
1																	
1																	
	ENGINEERIN	represent refusal on spoon					+						1				
HL	SULTING ENG	INEERS					s	tart	-		23.04.1	ates	Job	No.		Sht. 2 d	
HL	nroe Road						1							P H	. No.	011. 20	
HL ONS	nroe Road on 6, Jamaica	r					C	ompleti	on		23 04 4	3	-	D.H	. NO.	-	of 2
ONS Mo ngst						_	-	ompleti			23.04.10 N/A	5			Sir011		of 2

	ENT: C/O ODPEM DJECT: Soll Investigation	Eastings:		1	oca	tion	R	eference Northings:					Тур	e/Size			
	DRESS: 2 - 4 Haining Road,	Emerg	geno	cy Sin	en Pi	roje	ct	- Town Center, St. Mary		-					neter Aug s Cathea		-
	Kingston 5						-							mer for		10	
Sam	Jamiaca ple Types Wash		] 0	Grab	- 1			ion:	E	T.W	Tube	_			R. Core	-	_
2		10	_	-	sar	mple		Plasticit			1	-		ard Per	etration	Test	-
U.C.		Strata Plot	ROD	SPT Blow Count	5 4	w]	8	20		80	20			(Blow	/s/ft.)	100	
Depth	Soil Description	ranta	V	Blev	Server 1	UU Mark	Recovery	Wet Unit W (kip/cu.ft	eigh t)	t. =		Undra	ined L	Inconfir (kip/s	ned Shea sq.ft) e Shear		gth
ā		8	4	SP	6	3	Ko	.07		.13	1.0	Comp	). Test	+ Vane	e Shear	5.0	
0					1	Т	-				TT		1	TT	TT		
-				2	V .									11			
	Firm Dark Brown Sandy Clays wth some G	avels		2	41		14										
-																	
-																	
5				4	V.	2 1											
_	Firm Brown Clays			4	4	-	14										
-																	
_	Firm Brown Clays			2 2 2	3	1	15										
-				24	-												
10				2 2 2	X 4		10										
-				2	4.	T											
-	Firm Brown - Grey Clays																
-																	
-																	
15			y	1	7												
		avols		2	× :		9										
_	Firm Brown - Grey Clays with Traces of Gra	ivels															
20				2	7												
				222	6	1	5										
	Firm Grey - Brown Clays				1												
25				HW	1												
				HW	(7	1	14										
_	Very Soft Dark Grey Clays																
_	Tary our pain biey oldys																
30	**note 51 represent refusal on spoon		-														
CON	ENGINEERING LTD SULTING ENGINEERS									D	ates	J	ob No			-	
29 Ma	onroe Road							Start		22.04,16						Sht.	1 of 2
Kings	iton 6, Jamaica							Completion		22.04.40		-		B.H. 1	No.	-	-
OFFI	CE BOREHOLE RECORD				-	-	-	Completion	_	22.04.16	2		в	H# Sir	012		
								Final W. L.		15'							

	NT: C/O ODPEM JECT: Soil Investigation	Eastings:					ference Nothings				Тур	pe/Size		
	RESS: 2 - 4 Haining Road,	Eme	rgenc	y Sirer		ject - Datum	Town Cer	nter, St Mary	-	3.25"	D. Sten	25" Diameter A n, 140 lbs Cath		
	Kingston 5 Jamiaca				FIE	evatio	n:					nmer for SPT.		
Sampl	le Types Wash		] G	irab				Spoon	T. W.	Tube		R. Cor	e	
EL.)			1 of	ount	samp	les	20	Plasticity			_	dard Penetratic (Blows/ft.)	on Test	
Depth (It.)	Soil Description		Strata Pl	low (	ark	Kiet	20	Wet Unit Wei	80 1 ght 0	20 Un	drained	Unconfined Sh	10 near Stre	
Incl			Strata Plot	SPT Blow Count	1D Mark	Recovery	.07	(kip/cu.ft)	13	1.0 Co	mp. Tes	(kip/sq.ft) st + Vane Shea	ir 5.	
30				11/7	-				111	111	11	1 1 1	1	11
-				1	8	18								
-	Soft Dark Grey Clays			T										
-														
35	Firm Brown - Grey Clays with Traces of Gra	vels		2										11
+	(BH Ends @ 35Ft.)			3	9	12								
	100000000													
		1											11	
40														
1														
45														
1														
_														
1														
50														
-														
1							11							
-														
5														
-														
-														
0														
HL E	**note 51 represent refusal on spoon ENGINEERING LTD			1	1	-			+11					
ONSL	ULTING ENGINEERS					-	art		A STREET, STRE	ates	Job No	o,		
	nroe Road on 6, Jamaica					-	tart		22.04.16		-	B.H. No.	Sh	it. 2 of 2
FFICE	E BOREHOLE RECORD		_	_	-	C	ompletio	1	22.04.16			BH# Sir012		
						E	nal W. L.		15'		1		1	

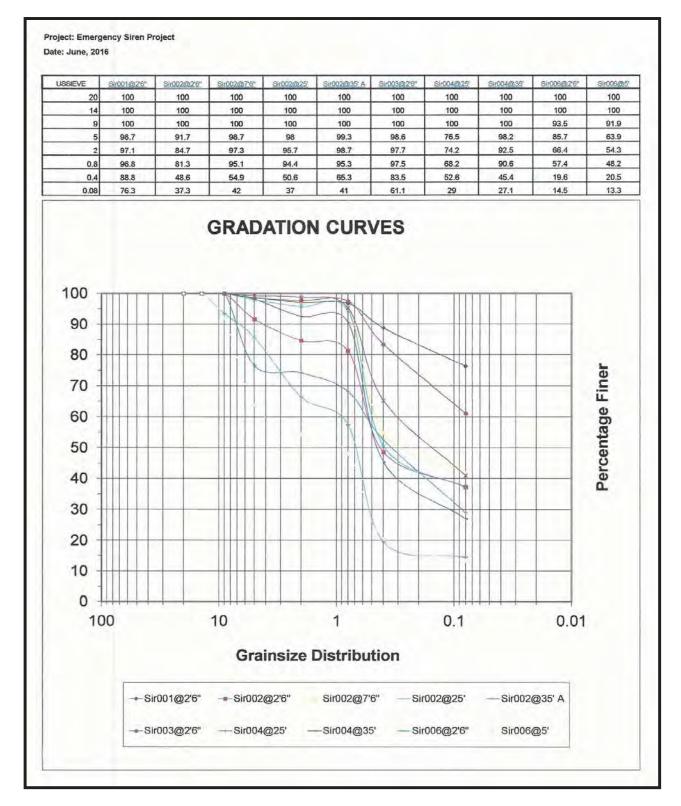
ADDRESS	Soil Investigation : 2 - 4 Haining Road, Kingston 5 Jamiaca	Eastings: Emergend		iren	Proj	Da	- Cl	n on:	ds Park					3	llow S .25" I. Dr	item ( D. Str op Ha	em, 1- amme	Diame 40 lbs er for \$	Cath SPT.	ead	-	
Sample Typ	es Wash		G	ab		C	>	Spli			-	=1	W. 1	Tube					Core			
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Depth (ft.)	Soil Description	Strata Plot	ROD	SPT Blow Count	SONT.	SUE	きる	20	We	t Unit V	Veiah	80 1		20		raine	I				trengt	th
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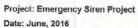
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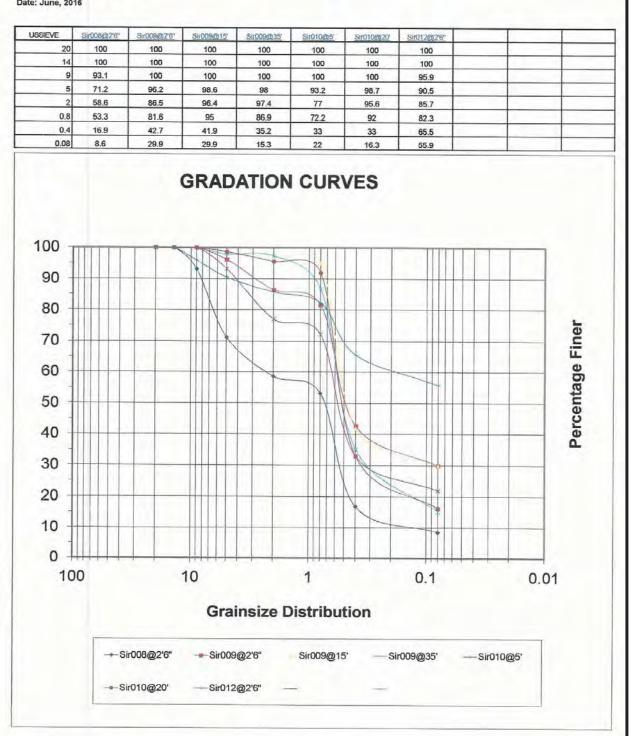
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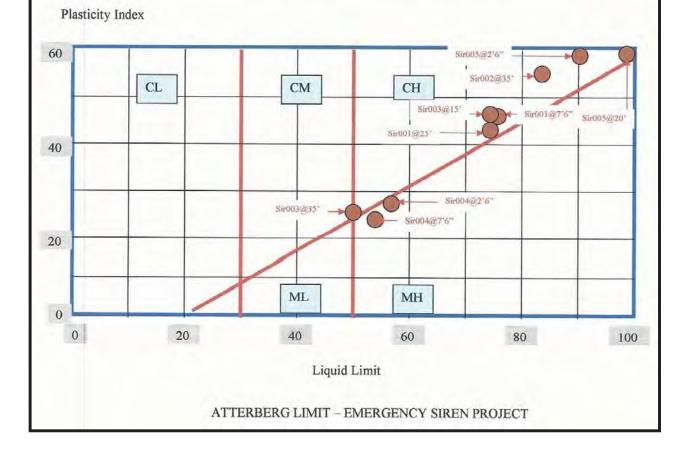
### **Appendix III**





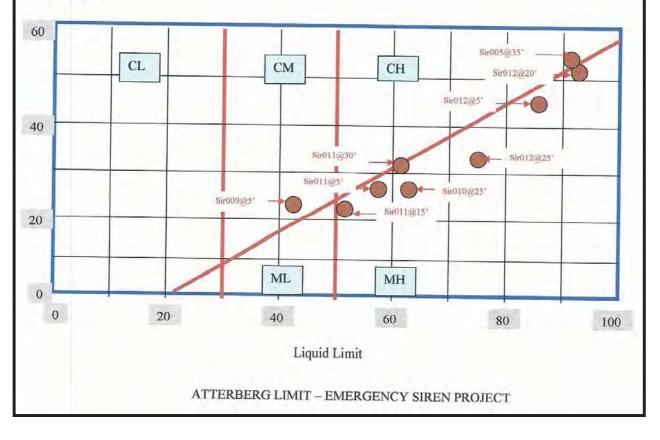


BH #	Sample Dept	Liquid Limit	Plastic Limit	Moisture Content	% Passing #40
Sir001	7'6"	75.0	27.3	24.02	85.5
Sir001	25'	73.0	29.4	23.02	85.1
Sir002	35'	84.8	28.6	18.08	83.6
Sir003	15'	73.7	25.6	16.07	84.3
Sir003	35'	50.0	23.6	19.04	85.3
Sir004	2'6"	57.4	30.0	09.01	85.1
Sir004	7'6"	54.4	30.5	22.07	87.0
Sir005	2'6"	90.7	30.1	26.04	84.7
Sir005	20'	101.6	38.1	30.02	84.9



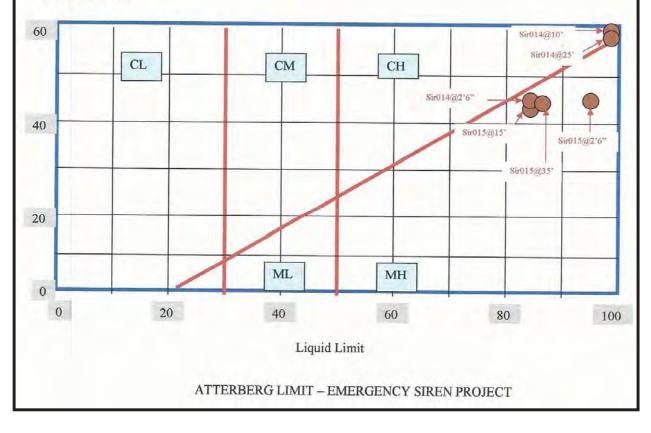
BH #	Sample Dept	Liquid Limit	Plastic Limit	Moisture Content	% Passing #40
Sir005	35'	91.4	91.4	25.06	85.9
Sir009	5'	42.3	19.8	13.01	84.4
Sir010	25'	62.8	35.4	19.09	85.6
Sir011	5*	58.2	30.3	15.03	87.0
Sir011	15'	51.2	29.1	21.05	85.3
Sir011	30'	61.6	30.4	21.03	84.2
Sir012	5'	85.4	40.9	27.03	86.0
Sir012	20'	92.1	40.6	37.05	85.6
Sir012	25'	76.2	42.7	47.01	87.3

Plasticity Index



BH #	Sample Dept	Liquid Limit	Plastic Limit	Moisture Content	% Passing #40
Sir014	2'6"	85.4	39.0	35.09	86.7
Sir014	10'	137.6	47.4	50.00	95.7
Sir014	25'	161.0	87.7	116.01	94.7
Sir015	2'6"	96.0	49.6	28.04	87.0
Sir015	15'	83.1	41.1	29.06	85.6
Sir015	35'	86.3	41.6	33.03	88.4

Plasticity Index



## A-10-3 無線中継局既設建屋(Rep006) コンクリート基礎コア抜き試験報告書

Yachiyo Engineering Co. Ltd- Concrete testing at Shotover, Portland- June\_2016.

Geo-Edge Ltd © 2016

Page4

## A report on concrete testing at the Telecommunication Tower site at Shotover, Portland (Project for Improvement of Emergency Communication System in Jamaica

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## **1.0 INTRODUCTION**

## 1.1 **OBJECTIVES**

The aim of this geotechnical report is to:

- Conduct materials testing on concrete base (slab) of control room at selected telecommunications site
- Present findings on analysis of concrete study
- Present recommendations based on findings

## 1.2 BACKGROUND

In recent years the Japan International Cooperation Agency; JICA, and the Jamaican Government have strengthened bilateral arrangements with the aim of promoting the islands social and economic development.

A crucial component of JICA's operation is aimed at strengthening the goals and strategic objectives of the islands Comprehensive Disaster Management Framework, which partly involves the improvement of Jamaica's emergency communication infrastructure.

Hence, the objective of the project is to improve the existing emergency communication infrastructure in Jamaica. This will be accomplished by upgrading the existing communication infrastructure which will inevitably result in more efficient and effective communication island wide, and by extension a stronger emergency response mechanism in the event of natural disasters

# 1.3 PROJECT SCOPE

The scope of works provided and commissioned by Yachiyo Engineering Company Limited (YEC) and guided by an addendum to contract dated April 14<sup>th</sup> 2016 included all activities necessary to produce findings of geotechnical investigations at target sites and recommendations for construction and design. The addendum covered concrete testing of concrete base below an existing control room at the location. Testing locations were guided by YEC. Results from the material testing should then form the basis of recommendations for the use of the existing base for new or replacement Control Room

This report was prepared for the exclusive use of our client and their consultants for design of this project. In the event that any changes are made in the character, design or layout of the improvements, we must be contacted to review the conclusions and recommendations contained in this report to determine whether modifications are necessary. This document may not be reproduced in whole or in part by any means whatsoever, nor may it be quoted or excerpted without our express written consent.

# **1.4 PROJECT DESCRIPTION**

The purpose of this project is to improve the existing emergency telecommunication infrastructure in Jamaica. This involves installing the requisite wireless communication systems and relevant infrastructure.

The assessment of the structural integrity of the Control Room base serves as a component of the study, as it assesses the existing structure and its capability of supporting a new structure.

No.	Name	Parish	Longitude	Latitude	
??	Shotover	Portland	18°10'18.39"N	76°28'51.02"W	

The report hereby presents the findings of this concrete test.

Figure 1 Table showing geographic coordinate locations of Shotover, Portland tower site

## 1.5 PROJECT LOCATION

This project involves concrete testing at the Telecommunication Tower located at Shotover, in the north-central section of the parish of Portland. (See fig.2).

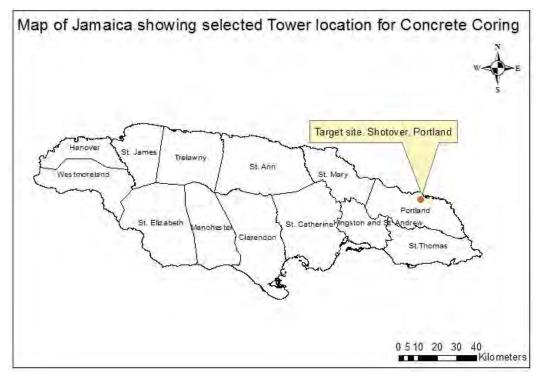


Figure 2. Map showing location of selected tower sites where soil investigations were conducted

The targeted Telecommunication Tower site is found in the rural community of Shotover, about four kilometers west southwest of the parish capital of Port Antonio. It is accessed via a parochial road that serves the District of Boundbrook leading to the rural community of Spring Bank. The site is located in highlands which rise in excess of three hundred feet above sea level, overlooking Unity Valley and Burlington which is separated by the Rio Grande, which empties at the coast, near the seaside town of St. Margret Bay. (See fig. 3)



Figure 3 Map showing location of tower site in Mount Airy, Westmoreland

# 2.0 METHODOLOGY

# 2.1 TESTING LOCATIONS

Site selection for concrete testing was guided by representative of YEC. Three locations were identified on and along existing concrete slab. Two (2) holes on western side and one (1) on eastern side of concrete. (See fig. 4)



Figure 4. Pictures showing locations of coring sites on concrete base, Shotover, Portland

Yachiyo Engineering Co. Ltd- Concrete testing at Shotover, Portland- June\_2016.

# 2.2 ACQUISITION OF SAMPLES

Sites for coring were initially identified and marked out on slab. Safety checks were conducted to ensure there were no services infront and behind the location to be cored. Wall anchor was then drilled and installed. Coring machine was then mounted, 4"diamond core bit was then affixed and centred on marked position. Water was then fed to core bit and coring occurred to a depth of eight inches (8"). At achievement of desired depth (8") machine was stopped and core removed for measurements, observations and packaging for transport to lab. Concrete mixture was then prepared and used to replace and fill cylindrical void created by coring exercise. This mixture had a ratio of 3:2:1 (cement:sand:fine gravel)



Figure 5. Pictures showing concrete preparation and infilled boring with prepared concrete mix

# 3.0 FINDINGS

Findings and results of the coring exercise at Shotover, Portland are presented below. This will be presented with respect to each coring site. All cores were drilled to a depth of eight inches (8"). Location of each target drilling position was also measured with respect to dimensions of concrete slab and its proximity to existing control room structure (metal container) siting on base. Presence of reinforcement steel bars was also noted if encountered.

# 3.1 FIRST CORE

## CORE LOCATION

At the site of the first core the container sits twelve inches (12") away from the edge of concrete base. This is located on the western side of the concrete slab. Boring was done approximately four and half inches (4  $\frac{1}{2}$ ") away from base of metal container. The boring had a diameter of four inches(4") Yachiyo Engineering Co. Ltd- Concrete testing at Shotover, Portland- June\_2016.



#### Figure 6. Location of first coring

## **CORE DESCRIPTION**

NO	ITEM DESCRIPTION	OBSERVATIONS
1	LENGTH	8″
2	DIAMETER	4"
3	PRESENCE OF REBARS	None observed
4	CORE DESCRIPTION	Core composed of a section of 6" limestone block. Limestone block space infilled with concrete mixture of alluvial aggregate. Voids seen within infilled concrete. Limestone block is composed of limestone chips and limestone dust (crusher run)

Yachiyo Engineering Co. Ltd- Concrete testing at Shotover, Portland- June\_2016.

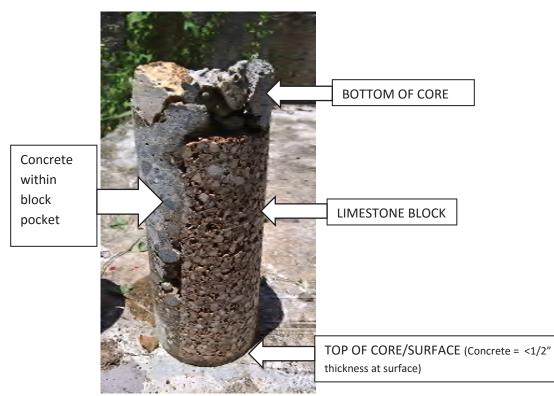


Figure 7. Picture of first core

# 3.2 SECOND CORE

## CORE LOCATION

At the site of the second core the container sits twelve inches (12") away from the edge of concrete base and is located in the southwestern corner of the concrete base. Boring was done approximately two and half inches (2 ½") away from base of metal container. The boring had a diameter of four inches(4")



Figure 8. Picture showing location of second boring in southwestern corner of concrete base

## **CORE DESCRIPTION**

NO	ITEM DESCRIPTION	OBSERVATIONS
1	LENGTH	8″
2	DIAMETER	4"
3	PRESENCE OF REBARS	None observed
4	CORE DESCRIPTION	Core composed of a section of 6" limestone block. Limestone block space is partially infilled with concrete mixture of alluvial aggregate. Concrete observed to a thickness of less than three inches (3") within block pocket. Broken pieces of limestone blocks and limestone pebbles seen in block pocket. Limestone block is composed of limestone chips and limestone dust (crusher run)

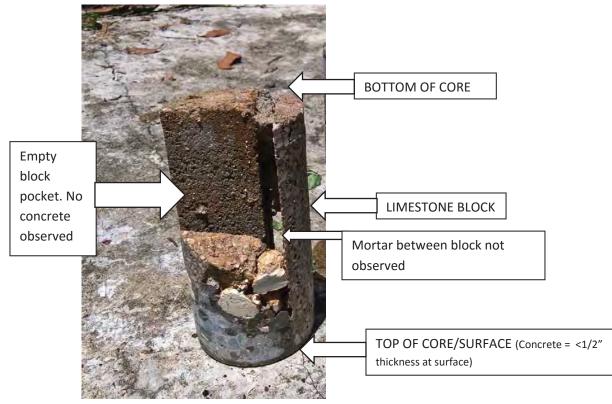


Figure 9. Picture of second core



Figure 10. Picture showing thickness of partial infilling of block pocket at location of second boring

## **MAJOR FINDING**

At the second boring site, located in the southwestern corner of the concrete base we observed a cavity within the concrete structure. This became evident three inches (3") below the surface



*Figure 11. Picture showing entrance to cavity found at second boring site* 

# 3.3 THIRD CORE

# CORE LOCATION

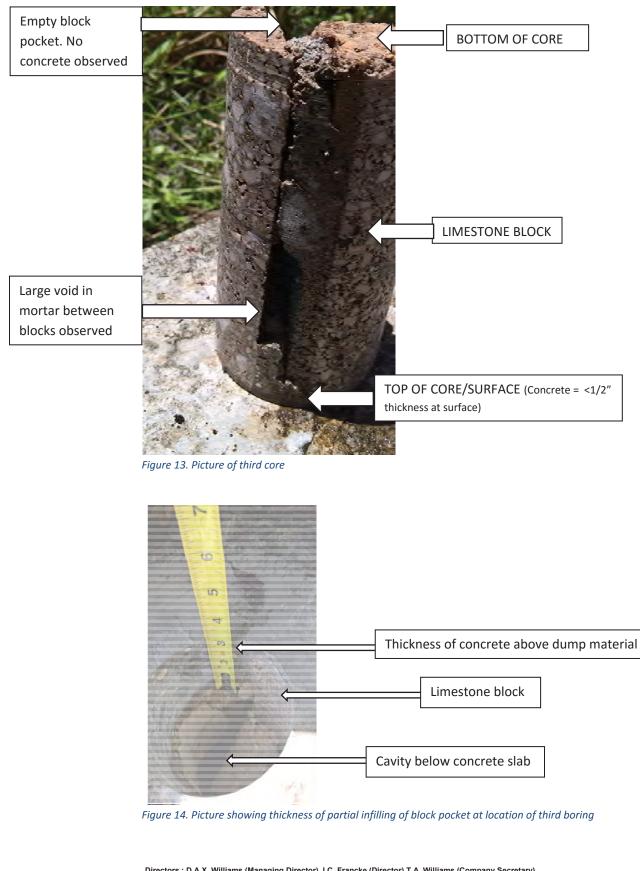
At the site of the first core the container sits fifteen and a quarter inches (15 ¼ ") away from the edge of concrete base. This is located on the southeastern corner of the concrete slab. Boring was done approximately five and quarter inches (5 ¼ ") away from base of metal container. The boring had a diameter of four inches(4")



Figure 12. Picture location of third boring in southeastern corner of concrete base

## CORE DESCRIPTION

NO	ITEM DESCRIPTION	OBSERVATIONS
1	LENGTH	8″
2	DIAMETER	4"
3	PRESENCE OF REBARS	None observed
4	CORE DESCRIPTION	Core composed of a section of 6" limestone block. Limestone block space is partially infilled with concrete mixture of alluvial aggregate. Concrete observed to a thickness of less than three inches (3") within block pocket. Broken pieces of limestone blocks and limestone pebbles seen in block pocket. Limestone block is composed of limestone chips and limestone dust (crusher run



Page 1 C

#### MAJOR FINDING

At the third boring site, located in the southeastern corner of the concrete base we again observed a cavity within the concrete structure. This became evident six inches (6") below the surface. (See fig. 14)

## 4.0 LABORATORY RESULTS OF CORE TESTING

Concrete core samples won from the coring exercise at the Telecommunication tower found at Shotover, Portland were not suitable for laboratory testing. None of the cores produced a complete cylindrical shape or core. Core recovery ranged from 35-80% due mainly to the material used in the construction of this concrete structure.

# 5.0 **RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION**

#### CONCLUSIONS

The existing concrete base at the Shotover (Portland) Telecommunication Tower site is ten feet two inches wide (10'2''), twelve feet two inches (12'2'') in length and two and a half feet high (2'6'').

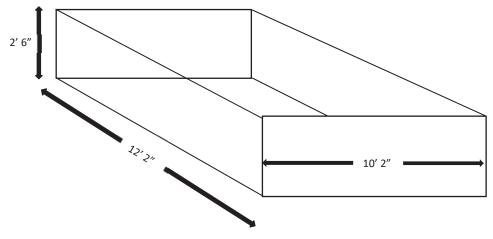


Figure 15. Schematic diagram of concrete slab

Cavities were observed in both the second and third borings which occurred on the southern side (front/entrance to container) of the concrete slab. We are unable to determine the size of the cavity but it is important to note that during the infilling of the boring it took three-four times the volume of concrete to fill space. We however stopped this seepage and siphoning of concrete by the use of limestone rocks found lying around site that was used to pack base of borings. From observation and also using stick to probe cavity, we believe that it extends beyond two feet from affected borings. This cavity was probably due to poor compaction of material used to fill this structure before the pouring of the concrete. These cavities could have also been formed post construction due to the weathering and breakdown of the inferior limestone fill used.

We did not encounter any rebars (reinforcement steel) in any of the won concrete cores. Coring done in the southwestern and southeastern corners are near the corners of the concrete structure where a stiffener (small

structural column), supported by rebars, would have normally been placed in the construction of the slab to support the anticipated weight. The cores however revealed that the construction (limestone) blocks were just tied (lapped) during the block laying process.

Coring has revealed in two instances where the block pockets were not filled with concrete. We are unable to determine how pervasive this condition is throughout the structure. These instances indicate the construction of the concrete base suffered from poor workmanship and inappropriate and insufficient use of materials.

#### RECOMMENDATIONS

Based on the findings from this study we will highly recommend that the existing concrete structure be demolished and rebuilt, engineered for the anticipated purpose. This recommendation is based on the fact the structural integrity of the concrete base is questionable and compromised. Yachiyo Engineering Company has not shared the technical specification of use for concrete base, therefore this recommendation is solely based on findings and conditions at site. This recommendation is guided by the following:

- Absence of reinforcement steel in concrete slab
- Presence of large cavity observed on southern side of concrete slab
- Presence of unfilled block pockets in more than one testing location
- Poor compaction of fill within concrete structure
- Our inability to determine how pervasive are these instances of poor workmanship, insufficient use of building materials and poor structural design.