



December 23, 2013

FOUNDATION INVESTIGATION REPORT

**LITTLE EAST RIVER BRIDGE NO. 4, SITE NO. 44-177
HIGHWAY 592 - REPLACEMENT OF SIX STRUCTURES
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5265-07-00 WP 5268-07-01**

Submitted to:

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GEOCREs No: 31E-333

Report Number: 11-1111-0149-4

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REPORT



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PART A

FOUNDATION INVESTIGATION REPORT

LITTLE EAST RIVER BRIDGE NO. 4 – Site No. 44-177

HIGHWAY 592 – REPLACEMENT OF SIX STRUCTURES

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 5265-07-00; WP 5268-07-01



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the replacement of Little East River Bridge No. 4 (site No. 44-177) over Highway 592 in Huntsville, Ontario. The proposed work is part of the replacement of six bridge structures along Highway 592. The Little East River Bridge No. 4 is located approximately 1.5 km south of Bay Lake Road and approximately 4.5 km north of the Highway 11/Novar Road interchange, in between Emsdale and Novar, Ontario. The location of the existing bridge structure along Highway 592 is shown on the Key Map on Drawing 1.

The Terms of Reference (TOR) for the foundation investigation are outlined in MTO's Request for Proposal dated October 2011. Golder's proposal (Scope of Work) for foundation engineering services associated with the Little East River Bridge 4 structure is contained in Section 6.8 of MH's Technical Proposal of this assignment. The work was carried out in accordance with Golder's Project Specific Supplementary Specialty Plan for foundation engineering services, dated March 21, 2012.

This report addresses the investigation carried out for the Little East River Bridge No. 4 structure and the associated approach embankments only.

The purpose of this investigation is to establish the subsurface conditions at the replacement bridge structure location, including the associated approach embankments, by borehole drilling, in situ testing and laboratory testing on selected soil samples. The borehole locations for this investigation were surveyed by Tulloch Geomatics Inc. (Tulloch), a professional surveying company retained by MH. The investigation area is shown in plan on Drawing 2.

2.0 SITE DESCRIPTION

The existing Highway 592 alignment within the project limits is oriented generally in a south-north direction.

In general, the topography along Highway 592 consists of rolling terrain, including lakes, low-lying swamps containing areas of standing water, sparsely to densely populated tree covered areas. Land use in some areas consists of residential/recreational communities. The existing bridge is a single-span rigid frame structure with a span length of 6.1 m. The bridge structure and associated approach embankments are situated on a relatively flat, sparsely treed area and standing water, with Little East River flowing westerly at this location. Residential/recreational properties are located north of the proposed bridge structure. The existing ground surface within the limits of the proposed structure and approach embankments is at about Elevations 328.0 m and 327.7 m, at borehole locations, referenced to Geodetic datum. The Highway 592 south and north approach embankments along the centreline are at about Elevations 327.7 m and 327.9 m, respectively.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

The field work for the proposed bridge structure was carried out between May 22 and 28, 2013 during which time a total of four boreholes and one Dynamic Cone Penetration Test (DCPT) were advanced at the location of the structure foundation footprints and approach embankments. In addition, Dynamic Cone Penetration Tests were carried out from the bottom of Boreholes B4-01 to B4-03 to determine depth to refusal at these locations.



FOUNDATION REPORT - LITTLE EAST RIVER BRIDGE NO.4 - HIGHWAY 592 GWP 5265-07-00; WP 5268-07-01

A summary of the respective boreholes advanced at each foundation element and approach embankment is presented below.

Foundation Unit	Borehole
South Approach Embankment	B4-01
South Abutment	B4-02
North Abutment	B4-03 and B4-DC03
North Approach Embankment	B4-04

The results of the borehole investigation and dynamic cone penetration test are presented on the Record of Borehole sheets in Appendix A. The boreholes and DCPT were advanced at the locations shown in plan on Drawing 2.

The field borehole investigation was carried out using a truck-mounted CME 55 drill rig supplied and operated by Landcore Drilling of Chelmsford, Ontario. The boreholes were advanced through the overburden using 120 mm outside diameter (O.D.) continuous flight hollow-stem augers and 'NW' casing. Soil samples were obtained at intervals of depth of about 0.75 m and 3.0 m, using a 50 mm O.D. split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586 – Standard Test Method for Standard Penetration Test). Where cobbles and boulders were encountered, samples were recovered using an 'NQ' size rock core barrel. The boreholes and DCPTs were advanced to depths of up to about 31.1 m and 38.0 m below existing ground surface, respectively.

The groundwater conditions in the open boreholes were observed during and upon completion of drilling operations, and a standpipe piezometer was installed in a borehole advanced immediately adjacent to Borehole B4-02 to permit monitoring of the water level at this locations. The piezometer consists of 38 mm diameter PVC pipe, with a slotted screen surrounded with sand sealed at a select depth within the borehole. The borehole and annulus surrounding the piezometer pipe above the screen and sand pack were backfilled to the surface with bentonite pellets/grout. Piezometer installation details and water level readings are described on the Record of Borehole sheets in Appendix A. All open boreholes were backfilled with cement grout by tremie technique upon completion and the piezometer was also abandoned with cement grout by tremie technique on June 26, 2013, in accordance with Ontario Regulation 903, Wells (as amended).

The field work was observed by a member of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling and sampling operations, logged the boreholes, and examined and cared for the soil samples. The soil samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, organic content, grain size distribution and Atterberg limits) was carried out on selected soil samples. The results of the laboratory testing are included in Appendix B.

The as-drilled borehole locations and ground surface elevations were surveyed by Tulloch. The locations given in the Record of Borehole/DCPT sheets and shown on Drawing 2 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are summarized below.



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Borehole	Location (MTM NAD 83)		Ground Surface Elevation	Borehole / DCPT Depth
	Northing	Easting		
B4-01	5038289.2	324225.6	327.7 m	17.4 m / 21.3 m
B4-02	5038309.5	324223.1	328.0 m	31.1 m / 37.2 m
B4-03	5038318.8	324215.8	327.9 m	31.1 m / 38.0 m
B4-DC03	5038320.2	324214.6	327.9 m	15.9 m
B4-04	5038339.1	324212.7	327.9 m	9.8 m

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario*¹, this section of Highway 592 lies within the physiographic region known as the “Number 11 Strip”, with portions of Highway 592 in contact with the “Georgian Bay Fringe” region. The Number 11 Strip is a narrow belt that extends from Gravenhurst to North Bay and is characterized by deposits of sand, silt and clay, together with more recent swamp deposits between rock knobs and ridges. The bedrock in the area is typically highly deformed gneiss of the Moon River Domain of the Central Gneiss Belt, a subdivision of the Grenville Structural Province (Geology of Ontario, 1991)².

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation together with the results of the laboratory tests carried out on selected soil samples, are provided in Appendix A and B, respectively. The results of the in situ field tests (i.e. SPT ‘N’-values) as presented on the Record of Borehole sheets and in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the profile on Drawing 2 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Test (SPTs). These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. It should be noted that the interpreted stratigraphy shown on Drawing 2 is a simplification of the subsurface conditions.

In general, the subsurface conditions in the area of the proposed bridge structure consist of a surficial layer of asphalt/asphalt fragments over a deposit of fill associated with the Highway 592 embankments. The fill is underlain by a deposit of organic silt and/or silt to sand, which is in turn underlain by a deposit of sand and gravel.

A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

¹ Chapman, L.J. and D. F. Putnam, 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P. 2715, Scale 1:600,000.

²Ontario Geological Society. 1991. *Geology of Ontario*, Special Volume 4, Part 2. Eds. P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott. Ministry of Northern Development and Mines, Ontario.



4.2.1 Asphalt

A 25 mm to 460 mm thick layer of asphalt/asphalt fragments was encountered at the ground surface in all boreholes.

4.2.2 Sand and Gravel to Sand Fill

A deposit of non-cohesive fill comprised of sand and gravel to sand, trace gravel was encountered below the asphalt layer in all boreholes. The top of the fill deposit is at between Elevations 327.7 m and 327.4 m and the thickness of the deposit ranges from 0.9 m to 1.5 m.

The SPT 'N'-values measured within the non-cohesive fill deposit range from 7 blows to 19 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The natural water content measured on one sample of the fill is about 7 per cent.

4.2.3 Organic Silt

A 1.6 m thick pocket of dark grey organic silt, trace to some sand was encountered underlying the fill deposit in Borehole B4-03. Top of the deposit was encountered at Elevation 326.5 m.

The SPT 'N'-values measured within the organic silt pockets range from 2 blows to 3 blows per 0.3 m of penetration, indicating a very loose relative density.

The natural water content and organic content measured on one sample of the organic silt is about 83 per cent and 10 per cent, respectively.

4.2.4 Silt to Sand

A non-cohesive deposit of silt to sand was encountered underlying the fill deposit in Boreholes B4-01, B4-02 and B4-04 and below the organic silt in Borehole B4-03. The overall silt to sand deposit is comprised of an upper portion of silt and sand to silty sand and a lower portion of silt to sandy silt. The deposit contains trace to some clay and trace organics to a depth of about 11.3 m. In addition, a 6.1 m thick stratum of organic silt and sand in Borehole B4-01. The top of the overall silt to sand deposit ranges from Elevations 326.5 m to 324.9 m and the thickness of the deposit ranges between 8.4 m and 21.7 m, including the thickness of the organic silt and sand in Borehole B4-01. Boreholes B4-01 and B4-04 were terminated within this deposit.

The SPT 'N'-values measured within the overall silt to sand deposit range from 0 blows (weight of hammer) to 26 blows per 0.3 m of penetration, indicating a very loose to compact relative density. The silty sand to silt and sand upper portion of the deposit may be described as very loose to loose, the silt to sandy silt lower portion of the deposit may be described as very loose to compact and the sand pockets are compact in relative density.

The natural water content measured on twenty six samples of the overall deposit ranges from about 20 per cent to 77 per cent, but is generally lower than 36 per cent.

The organic content measured on four samples of the deposit ranges from about 2 per cent to 4 per cent.

The results of grain size distribution tests completed on fourteen samples of the overall silt to sand deposit are shown on Figures B1 in Appendix B, presented for the silt and sand to silty sand upper portion of the deposit on



Figures B1A and B1B, for the sand pockets on Figure B1C and for the silt to sandy silt lower portion of the deposit on Figure B1D.

Atterberg limits test carried out on one sample of the silt and sand portion of this deposit in Borehole B4-04 indicates the fine material to be non-plastic.

Atterberg limits tests were carried out on two upper samples of the silt and sand deposit that contains organics. The limits test carried out on Sample 3 from Borehole B4-04 indicates the fine material to be non-plastic while the test carried out on Sample 7 from Borehole B4-03 measured a liquid limit of about 43 per cent, a plastic limit of about 40 per cent and a plastic index of about 3 per cent. The result of the Atterberg limits test from Borehole B4-03 is presented on Figure B2 and indicates that the fines material of this upper portion of the deposit is classified as silt and sand of medium plasticity.

Within the silt to sand in Borehole B4-01, an approximately 6.1 m thick stratum of organic silt and sand, trace clay, containing fibrous peat layers was encountered at Elevation 322.1 m. The SPT 'N'-values measured within the organic silt and sand ranges from 3 blows to 6 blows per 0.3 m of penetration, indicating a very loose to loose relative density. The natural water content measured on four samples of the organic stratum ranges from about 66 per cent to 110 per cent, while the organic content measured on one sample is about 13 percent. The result of grain size distribution tests completed on a sample of the organic stratum is shown on Figure B3 in Appendix B.

4.2.5 Sand and Gravel

A non-cohesive deposit of grey sand and gravel was encountered below the silt to sand deposit in Boreholes B4-02 and B4-03. Cobbles were encountered in Borehole B4-02 at about Elevation 301.5 m and a 0.9 m long core sample was recovered. The top of this deposit was encountered at Elevations 304.8 m and 304.1 m and the thickness of deposit is 7.9 m and 7.3 m in Boreholes B4-02 and B4-03, respectively, and potentially up to about 14.2 m thick as inferred from the DCPT driven from the bottom of Borehole B4-03. The DCPT advanced from the bottom of these boreholes were inferred to be terminated within this deposit at depths of 37.2 m and 38.0 m below ground surface, corresponding to Elevations 290.8 m and 290.0 m. The SPT 'N'-values measured within the deposit range from about 12 blows to 34 blows per 0.3 m of penetration, indicating a compact to dense relative density.

The natural water content measured on two samples of the deposit is about 11 per cent and 24 per cent.

4.3 Groundwater Conditions

In general, the soil samples taken in the boreholes were moist to wet. The groundwater levels measured in the open boreholes upon completion of drilling range from Elevations 327.0 m to 326.4 m measured at depths of between 0.9 m and 1.6 m below ground surface.

A standpipe piezometer was installed in a borehole advanced immediately adjacent to Borehole B4-02 to allow monitoring of the groundwater level at the site. Details of the piezometer installation are shown on the Record of Borehole No. B4-02 in Appendix A and the groundwater level measured in the piezometer is summarized below.



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Borehole	Ground Surface Elevation	Depth to Water Level	Groundwater Elevation	Date of Measurement
B4-02	328.0 m	1.6 m	326.4 m	May 24, 2013
		1.5 m	326.5 m	May 27, 2013
		1.5 m	326.5 m	May 31, 2013
		2.2 m	325.8 m	June 26, 2013

It should be noted that groundwater levels in the area are subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

5.0 CLOSURE

Mr. Indulis Dumpis, a senior technician with Golder, directed the drilling program. This report was prepared by Mr. Al Varshoi, M.E.Sc., and reviewed by Mr. Christopher Ng, P.Eng., a geotechnical engineer and Associate with Golder. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project and Principal with Golder, conducted an independent quality control review of the report.



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HIGHWAY 592 GWP 5265-07-00; WP 5268-07-01

Report Signature Page

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DRAWINGS

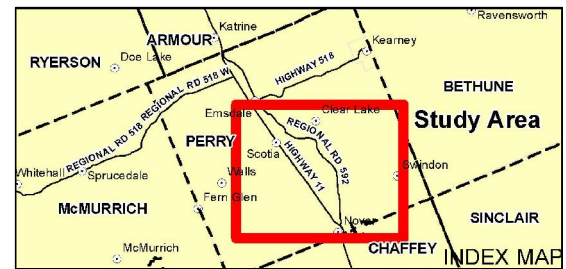


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No. WP No. 5268-07-01		
HIGHWAY 592 REPLACEMENT OF SIX STRUCTURES KEY MAP		



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



N.T.S

REFERENCE

Base data - MNR NRVIS, obtained 2004, CANMAP v2006.4 Produced by Golder Associates Ltd. under licence from Ontario Ministry of Natural Resources



NO.	DATE	BY	REVISION	
Geocres No. 31E-333				
HWY. 592		PROJECT NO. 11-1111-0149		DIST.
SUBM'D. AV		CHKD. CN	DATE: Dec. 2013	SITE:
DRAWN: JFC		CHKD.	APPD.	DWG. 1



APPENDIX A

Record of Borehole/DCPT Sheets



LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a)	Index Properties
$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
shear strength = (compressive strength)/2



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	c_u, s_u	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w _p	plastic limit
w _l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D _R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



PROJECT <u>11-1111-0149</u>		RECORD OF BOREHOLE No B4-01		SHEET 1 OF 2		METRIC	
W.P. <u>5268-07-01</u>		LOCATION <u>N 5038289.2 ;E 324225.6</u>		ORIGINATED BY <u>ID</u>			
DIST <u> </u> HWY <u>592</u>		BOREHOLE TYPE <u>120 mm O.D. Hollow Stem Augers and NW Casing</u>		COMPILED BY <u>GRL/AV</u>			
DATUM <u>Geodetic</u>		DATE <u>May 22, 2013</u>		CHECKED BY <u>TVA</u>			

[illegible]

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

GTA-MTO 001 11-1111-0149.GPJ GAL-GTA.GDT 12/20/13

PROJECT 11-1111-0149				RECORD OF BOREHOLE No B4-01				SHEET 2 OF 2				METRIC					
W.P. 5268-07-01				LOCATION N 5038289.2 ; E 324225.6				ORIGINATED BY ID									
DIST HWY 592				BOREHOLE TYPE 120 mm O.D. Hollow Stem Augers and NW Casing				COMPILED BY GRL/AV									
DATUM Geodetic				DATE May 22, 2013				CHECKED BY TVA									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100	W _p	W	W _L		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED									
								20	40	60	80	100	20	40	60		
310.3	SILT, trace to some sand, trace to some clay, trace organics Very loose to compact Grey Wet		14	SS	10		312										
							311										
17.4	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)		15	SS	18		310										
							309										
							308										
							307										
306.4	END OF DCPT																
21.3	NOTES: 1. Water level in open borehole at a depth of 1.3 m below ground surface (Elev. 326.4 m) upon completion of drilling. 2. Borehole caved at a depth of 11.6 m (Elev. 316.1 m) below ground surface upon completion of drilling.																

PROJECT 11-1111-0149		RECORD OF BOREHOLE No B4-02		SHEET 1 OF 3		METRIC	
W.P. 5268-07-01		LOCATION N 5038309.5 ; E 324223.1		ORIGINATED BY ID			
DIST _____ HWY 592		BOREHOLE TYPE 120 mm O.D. Hollow Stem Augers and NW Casing		COMPILED BY GRL/AV			
DATUM Geodetic		DATE May 23 and 24, 2013		CHECKED BY TVA			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)							
								20	40	60	80	100	W _p	W	W _L					
328.0	GROUND SURFACE																			
0.0	Asphalt fragments (300 mm)		1A	AS	-															
327.7			1B																	
0.3	Sand, trace gravel, trace silt (FILL) Compact Brown Moist		2	SS	9															
326.5																				
1.5	Silty SAND, trace organics Very loose to loose Dark brown Moist		3	SS	5															
			4	SS	2															
			5	SS	1															
324.2																				
3.8	SAND, some silt, trace to some clay, trace organics Very loose Dark grey Wet		6	SS	2															
			7	SS	3															
			8	SS	2															
320.8																				
7.2	Sandy SILT, trace clay, trace organics to a depth of 11.3 m Very loose to compact Dark grey becoming brown below a depth of 11.3 m Moist to wet		9	SS	2															
			10	SS	1															
			11	SS	1															
			12	SS	12															
			13	SS	12															
313.2																				
14.8																				

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT 11-1111-0149		RECORD OF BOREHOLE No B4-02		SHEET 2 OF 3		METRIC						
W.P. 5268-07-01		LOCATION N 5038309.5 ; E 324223.1		ORIGINATED BY ID								
DIST HWY 592		BOREHOLE TYPE 120 mm O.D. Hollow Stem Augers and NW Casing		COMPILED BY GRL/AV								
DATUM Geodetic		DATE May 23 and 24, 2013		CHECKED BY TVA								
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES					
	--- CONTINUED FROM PREVIOUS PAGE ---											
	SAND, some silt, trace clay Compact Grey Wet		14	SS	13							0 85 14 1
						312						
						311						
						310						
			15	SS	18							
						309						
307.9						308						
20.1	SILT, trace to some sand, trace clay Compact Grey Wet					307						
			16	SS	22							0 8 88 4
						306						
304.8						305						
23.2	SAND and GRAVEL Compact Grey Wet					304						
			17	SS	23							
						303						
						302						
	Cobbles encountered between depths of 26.5 m and 27.4 m.		1	RC	REC 30%	301						
			18	SS	12							
						300						
						299						

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 11-1111-0149.GPJ GAL-GTA.GDT 12/20/13



+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

GTA-MTO 001 11-1111-0149.GPJ GAL-GTA.GDT 12/20/13

GTA-MTO 001 11-1111-0149.GPJ GAL-GTA.GDT 12/20/13

+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE



GTA-MTO 001 11-1111-0149.GPJ GAL-GTA.GDT 12/20/13

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>11-1111-0149</u>		RECORD OF BOREHOLE No B4-03		SHEET 3 OF 3		METRIC	
W.P. <u>5268-07-01</u>		LOCATION <u>N 5038318.8 ; E 324215.2</u>		ORIGINATED BY <u>ID</u>			
DIST <u> </u> HWY <u>592</u>		BOREHOLE TYPE <u>120 mm O.D. Hollow Stem Augers and NW Casing</u>		COMPILED BY <u>GRL/AV</u>			
DATUM <u>Geodetic</u>		DATE <u>May 27 and 28, 2013</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE	w _p w w _L						
						● QUICK TRIAXIAL × REMOULDED									
						20 40 60 80 100									
	--- CONTINUED FROM PREVIOUS PAGE ---														
296.8	SAND and GRAVEL Compact to dense Grey Wet		19	SS	21		297								
31.1	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)						296								
							295								
							294								
							293								
							292								
							291								
290.0	END OF DCPT Refusal to Further Penetration (85 Blows / 0.15 m)						290								
38.0	NOTE: 1. Water level in open borehole at a depth of 1.2 m below ground surface (Elev. 326.7 m) upon completion of drilling.														



+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE



+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



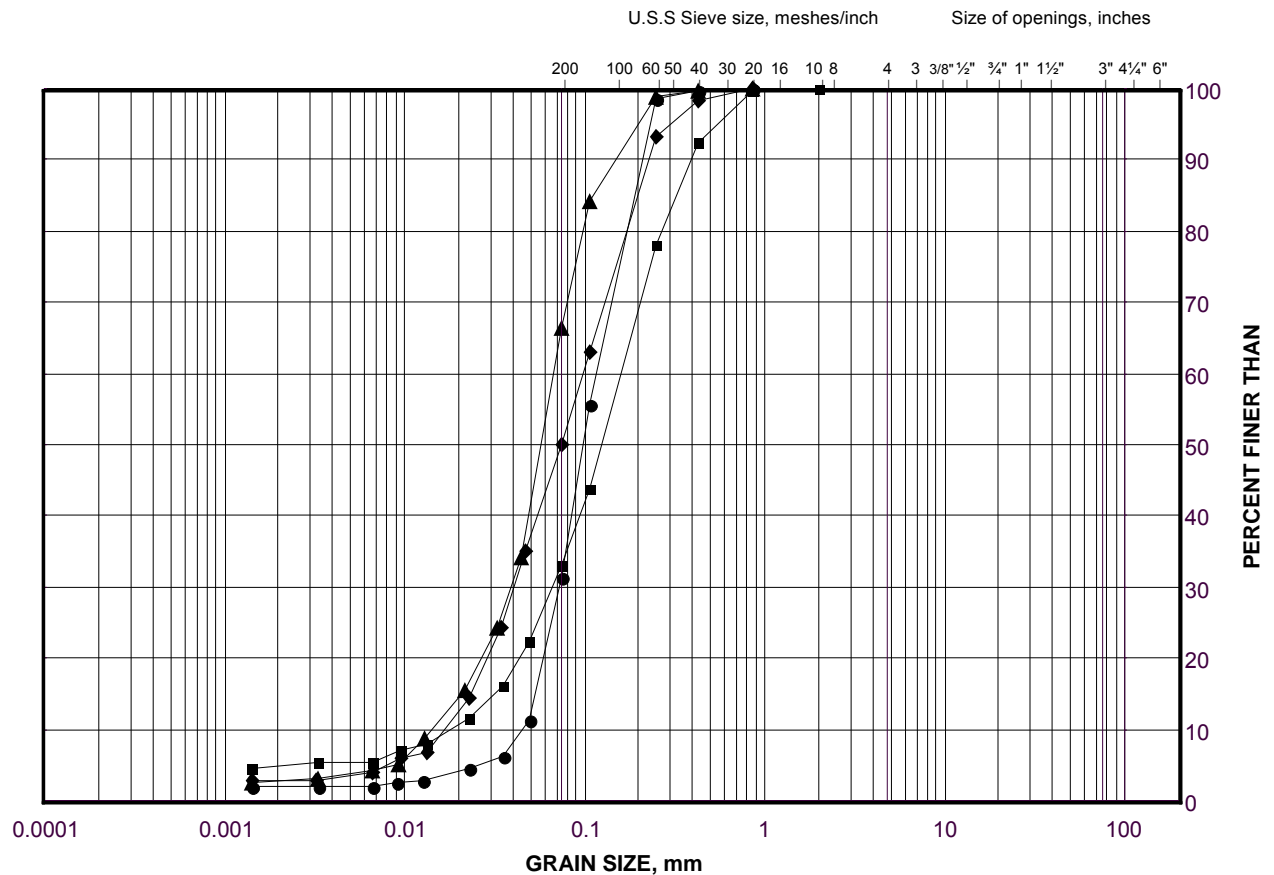
APPENDIX B

Laboratory Test Results and Bedrock Core Photographs

GRAIN SIZE DISTRIBUTION

Silt and Sand to Silty Sand

FIGURE B1A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B4-03	11	316.9
■	B4-03	5	324.5
◆	B4-03	7	323.0
▲	B4-03	9	319.9

Project Number: 11-1111-0149

Checked By: AV

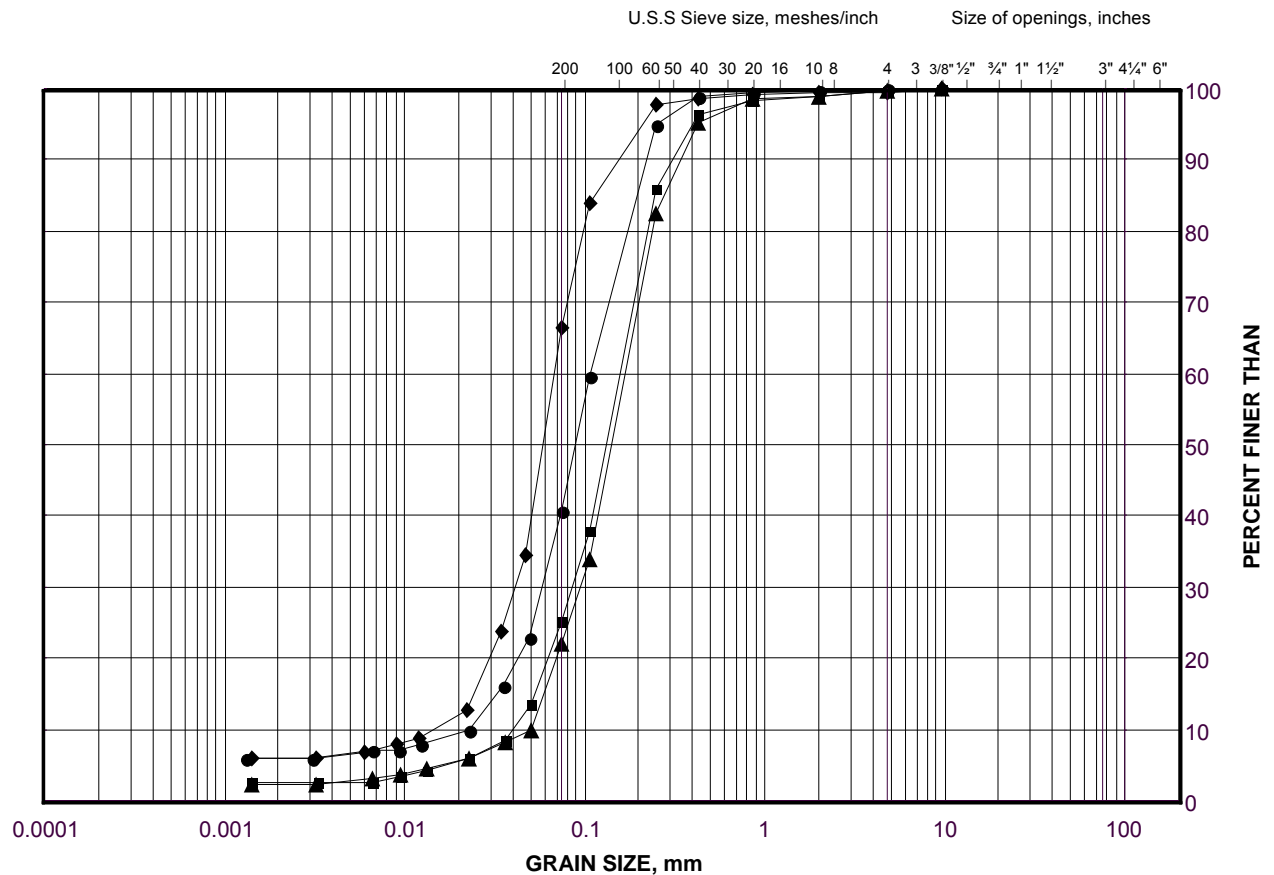
Golder Associates

Date: 27-Nov-13

GRAIN SIZE DISTRIBUTION

Silt and Sand to Silty Sand

FIGURE B1B



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B4-04	3	326.1
■	B4-01	4	325.1
◆	B4-04	7	323.1
▲	B4-01	7	322.8

Project Number: 11-1111-0149

Checked By: AV

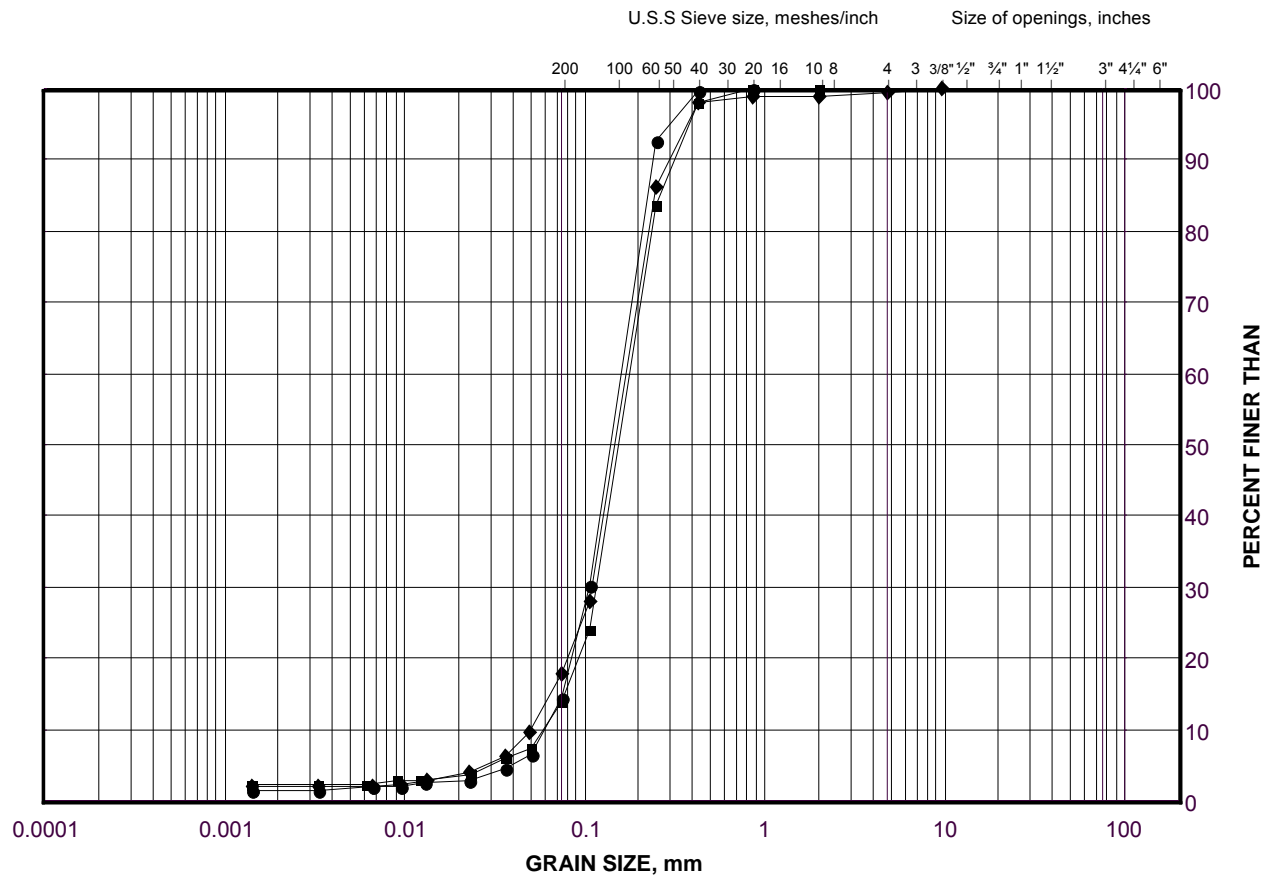
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GRAIN SIZE DISTRIBUTION

Sand (Pockets)

FIGURE B1C



SILT AND CLAY SIZES				FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED				SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B4-02	14	312.5
■	B4-02	6	323.9
◆	B4-02	8	321.7

Project Number: 11-1111-0149

Checked By: AV

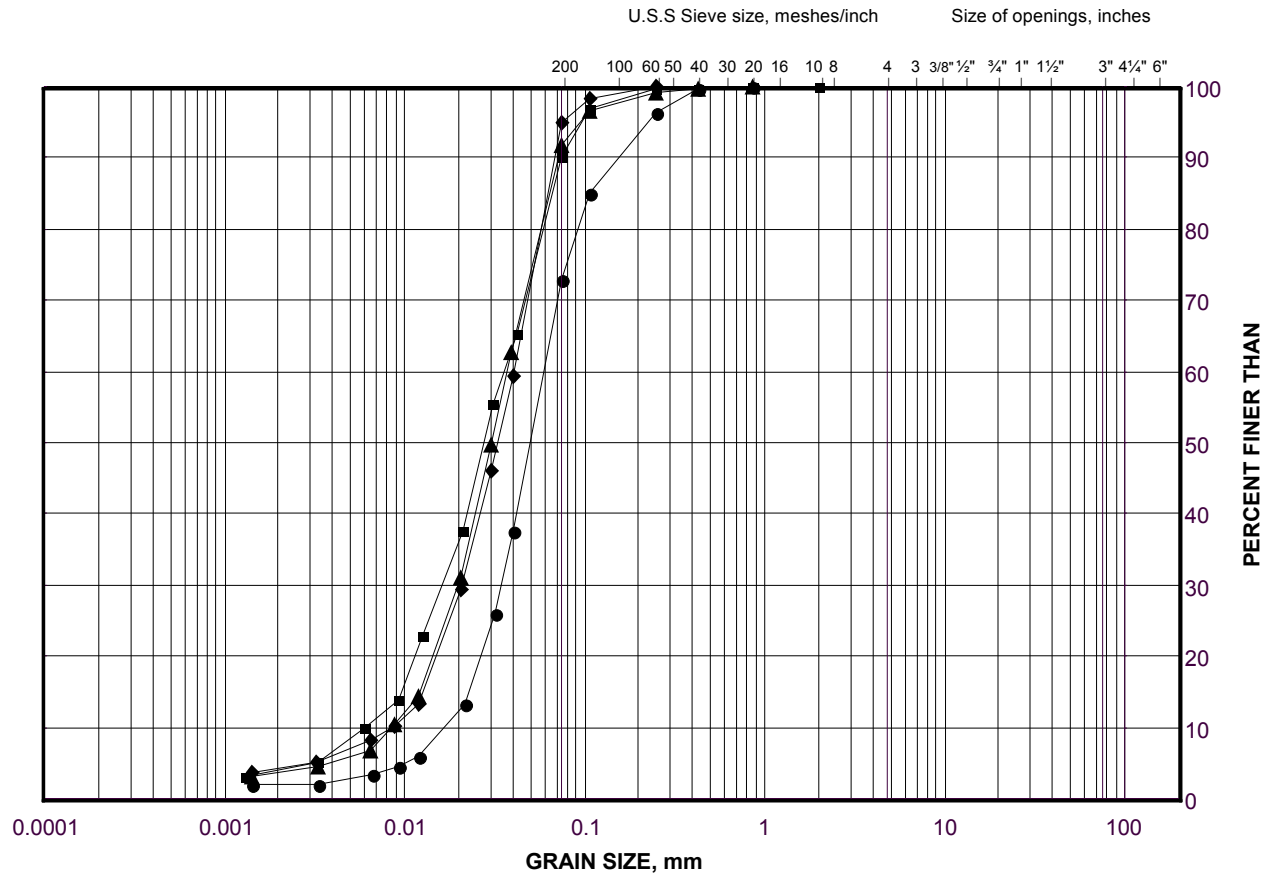
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GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt

FIGURE B1D



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

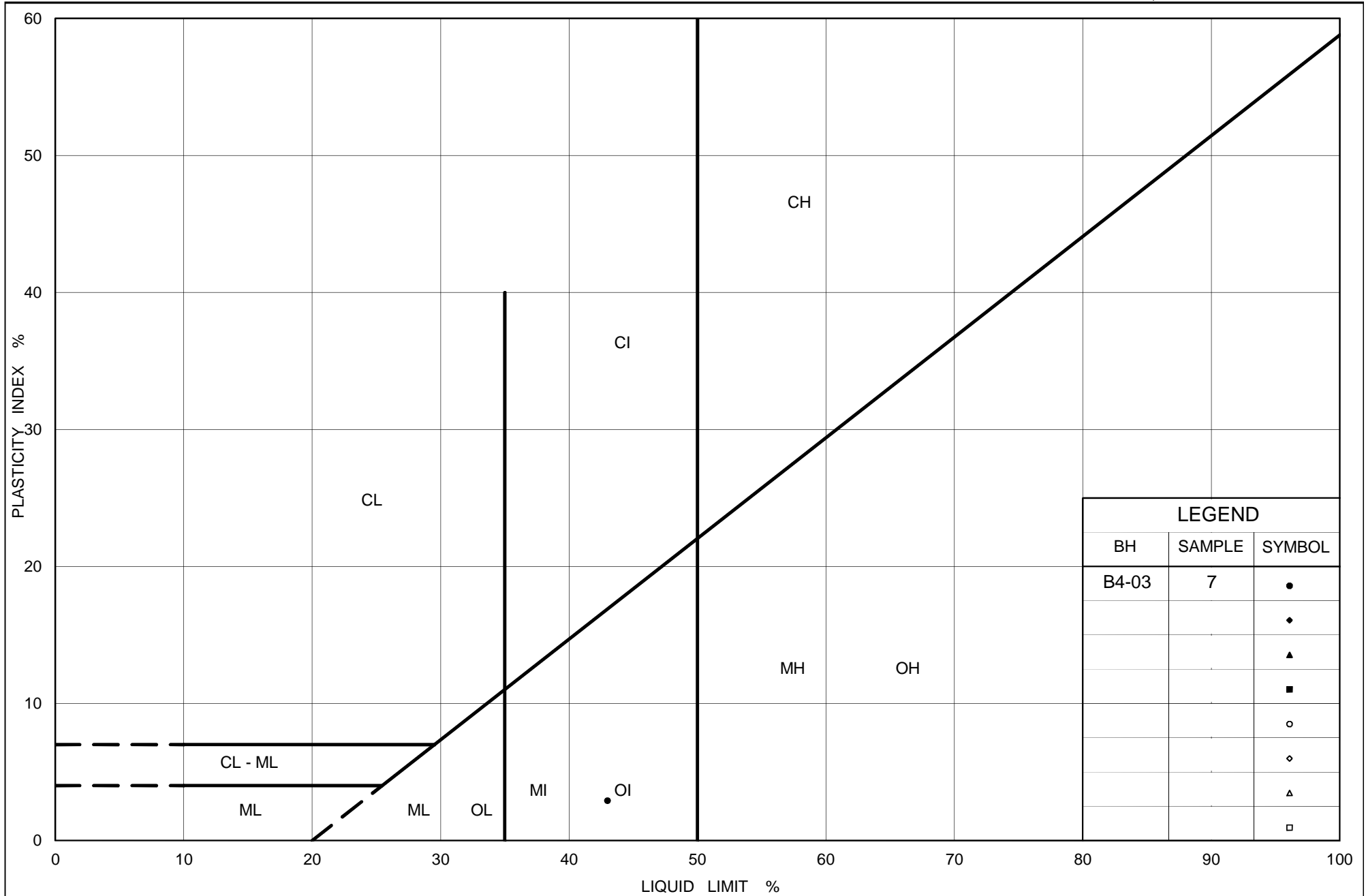
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B4-02	11	317.1
■	B4-01	13	313.6
◆	B4-03	16	306.2
▲	B4-02	16	306.4

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PLASTICITY CHART Organic Silt and Sand

Figure No. B2

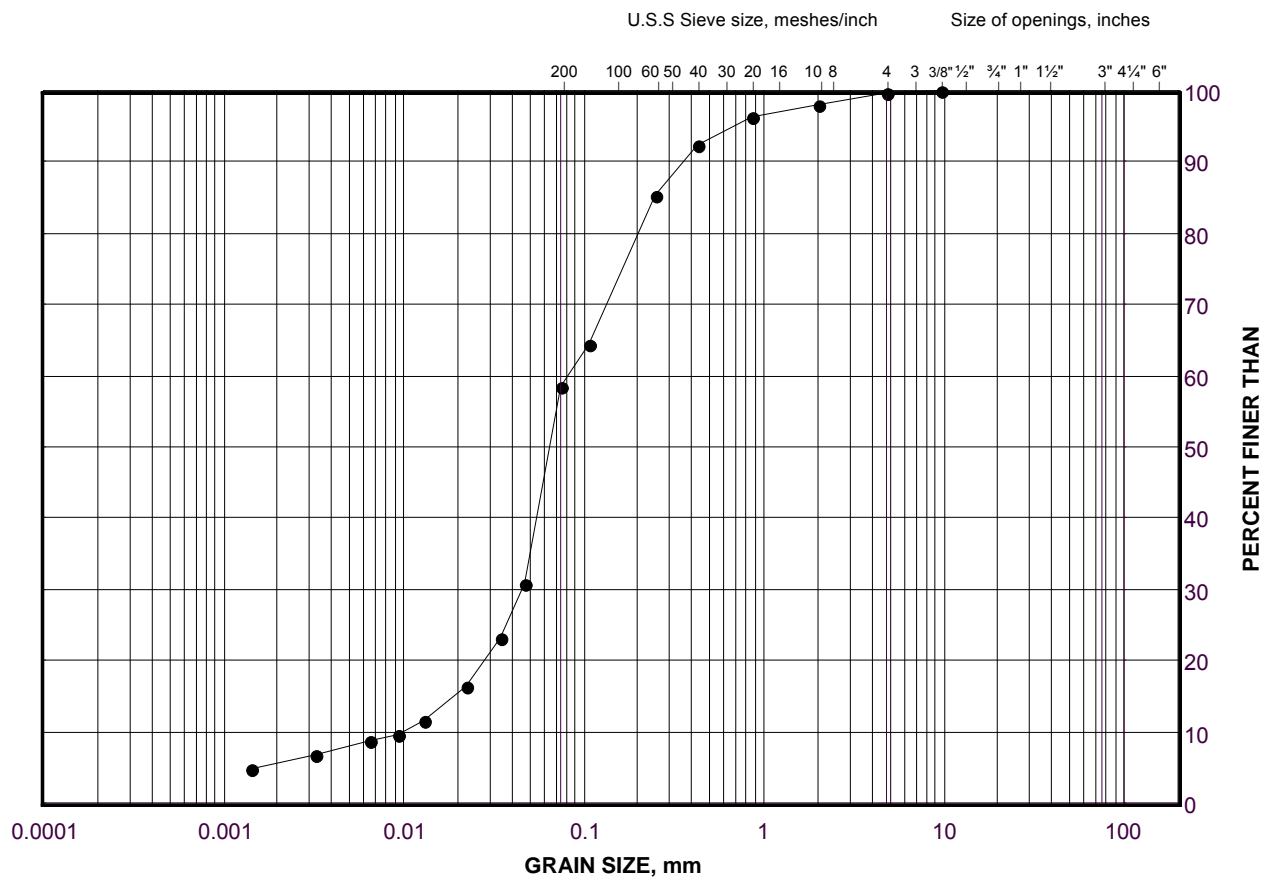
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GRAIN SIZE DISTRIBUTION

Organic Silt and Sand

FIGURE B3



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	B4-01	10	318.2

Project Number: 11-1111-0149

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Date: 28-Oct-13

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