September 2012

FOUNDATION INVESTIGATION REPORT

Culvert Replacement At Station 18+515
Highway 400 Northbound Rehabilitation
Highway 11 to Highway 93
Simcoe County, Ontario, GWP 2179-10-00

Submitted to:
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GEOCRES No.: 31D-548

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Distribution:

1 Copy - Morrison Hershfield Limited

REPORT

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PART A

FOUNDATION INVESTIGATION REPORT
CULVERT REPLACEMENT AT STATION 18+515
HIGHWAY 400 NORTHBOUND REHABILITATION
HIGHWAY 11 TO HIGHWAY 93
SIMCOE COUNTY, ONTARIO, G.W.P. 2039-06-00

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 foundation engineering services in support of the Highway 400 northbound rehabilitation from Highway 11 to Highway 93 in Simcoe County, Ontario.

The terms of reference and scope of work for the foundation investigation are outlined in MTO‟s Request for Proposal (RFP) dated May 2008; in Section 6.8 of MH‟s *Technical Proposal* for this assignment and in Golder‟s scope change letter of May 10, 2011.

This report provides factual data on the subsurface conditions encountered at the site (Highway 400 Northbound, Station 18+515) where a new culvert will be installed to replace the existing skewed corrugated steel pipe (CSP) culvert located at Station 18+508.

2.0 SITE DESCRIPTION

The site is located at the Highway 400 and Highway 11 split at Station 18+515 on Highway 400 Northbound. Highway 400 NBL in this area is a two lane freeway that rises up on an embankment and crosses above the Highway 11 freeway.

The topography across the site adjacent to the Highway 400 and Highway 11 split slopes gently to the west towards Little Lake. Vegetation within the right of way is sparse consisting of grass and small shrubs with densely treed areas further beyond. The Highway 400 NBL embankment is about 3.5 m high and its side slope geometry is approximately 2 horizontal to 1 vertical (2H:1V). The ground surface at the embankment toe varies from approximately Elevation 230.5 m to 231.5 m, referenced to Geodetic datum.

There is an existing skewed CSP culvert located under the embankment at approximately Station 18+508 that facilitates drainage of the Hwy 11/Hwy 400 median to the east property line.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on December 20 and 21, 2011, and consisted of drilling and sampling a total of three (3) boreholes to depths ranging from 11.1 m to 15.8 m below ground surface. The boreholes were numbered 11-C1-01, 11-C1-02 and 11-C1-03 and their locations are shown on Drawing 1.

The field investigation was carried out using a track mounted D50 drill rig supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The boreholes were advanced through the overburden using 108 mm inside diameter (I.D.) hollow-stem augers. Soil samples were obtained at intervals of depth of 0.75 m and 1.5 m, using a 50 mm outside diameter split-spoon sampler driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedures, as specified in ASTM D1586 (Standard Test Method for Standard Penetration Test).

In addition to the testing outlined above, Dynamic Cone Penetration Tests (DCPT) were conducted in Borehole 11-C1-01. This test consists of continuously driving into undisturbed ground a 50 mm diameter cone (60°vertex angle) attached to a drill rod, with a driving energy of 475 J per blow (63.5 kg hammer dropping freely a vertical distance of 0.76 m). The number of blows for each 300 mm of penetration is recorded and this provides an indication of the relative changes in the soil density/consistency with depth.

Groundwater conditions were observed in the open boreholes during and immediately following the drilling operations. All boreholes were backfilled to ground surface using bentonite pellets in accordance with Ontario Regulation 903 (as amended).

The field work was supervised on a full-time basis by a member of Golder‟s staff who located the boreholes in the field, directed the drilling, sampling and in situ testing operations, and logged the boreholes. At this site the embankment slopes are relatively steep and it was necessary to undertake the field investigations with minimal traffic disruptions. Therefore, the borehole locations were selected to be as close as feasible to the desired location while allowing for safe operation of the drill rig and minimal traffic disruptions.

The recovered soil samples were subjected to Visual Identification (VI) and select samples were also subjected to a laboratory testing programme consisting of natural moisture content and grain size distribution analyses in accordance with MTO and/or ASTM Standards as appropriate. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and the laboratory figures in Appendix B.

The borehole locations were staked in the field by Golder personnel relative to the on-site features shown on the digital terrain model provided by MH. The ground surface elevations at the borehole locations were also determined from this digital terrain model. The borehole locations in MTM NAD83 northing and easting coordinates, the ground surface elevations referenced to geodetic datum and the depths drilled, are summarized below.

Culvert Location Station	Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
Hwy. 400 NBL Station 18+515	11-C1-01	4920690.3	292743.7	231.0	15.8 m
	11-C1-02	4920671.2	292762.0	233.8	14.2 m
	11-C1-03	4920650.2	292772.6	230.9	11.1 m

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 400 is located within the physiographic region known as the Simcoe Uplands (Chapman and Putnam 1984). The general topography within the Simcoe Uplands consists of broad, gently rolling till or moraine plains divided by deep valleys. The till within the Uplands is often overlain by glaciofluvial deposits consisting of sandy silt to sand and gravel. These deposits can present a wide range of grain sizes including large boulders, till lenses and silt.

Surficial deposits of glaciolacustrine materials formed by the wave action at the shores of glacial lakes or along glacial melt water streams are also commonly found within the site area overlaying the till. These deposits consist primarily of coarse-grained sediments of fine to medium grained sand or silt and minor clay deposits (Ontario Geological Survey, 1994). Surficial deposits of clayey silt to silty clay are also present adjacent to current and former streams.

4.2 Subsurface Conditions

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered subsurface conditions and the results of in-situ and laboratory tests are presented in this appendix and on the "Borehole Locations and Soil Strata" drawing. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions.

The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic section (Drawing 1) are inferred from non-continuous sampling and therefore represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In general, the subsurface soils at this site consist of a surficial layer of topsoil and loose to compact silty sand to sand and silt embankment fill material. These soils are further underlain by very loose to compact sand and silt to silt deposits, a loose surficial layer of sand and very loose to very dense sand to silty sand soils.

4.2.1 Topsoil

A 700 mm thick surficial layer of topsoil was encountered below the existing ground surface in Boreholes 11-C1-01 and 11-C1-03. Topsoil thickness may vary between and beyond the boreholes.

4.2.2 Asphalt

Borehole 11-C1-02 was drilled through the paved shoulder of Highway 400 NBL. An approximately 100 mm thick layer of asphalt was encountered at this location.

4.2.3 Silty Sand to Sand and Silt (Fill)

Fill material ranging in composition from silty sand to sand and silt; trace to some clay, trace to some gravel with occasional cobbles was encountered below the asphalt layer in Borehole 11-C1-02. The fill material is approximately 3.6 m thick and extends to a depth of 3.7 m below ground surface (Elevation 230.1 m).

The measured SPT „N" values within the fill material range from 9 blows to 29 blows per 0.3 m of penetration, indicating a loose to compact relative density.

Two (2) samples of the silty sand to sand and silt fill were subjected to a grain size distribution test and the results are shown on Figure B1 in Appendix B. These results show a grain size distribution consisting of 6 % and 11 % gravel, 39 % and 54 % sand, 23 % and 41 % silt and 12 % and 14 % clay sized particles. The presence of cobbles is also inferred from increased resistance to augering during the drilling operations.

The natural water content measured on two (2) samples of the fill material is 9% and 27 %. The higher moisture content was recorded where occasional topsoil inclusions were found within the fill.

4.2.4 Sand

An approximately 700 mm thick sand layer was encountered below the topsoil in Borehole 11-C1-03. The sand deposit extends to a depth of 1.4 m below ground surface corresponding to Elevation 229.5 m.

One SPT „N" value measured in the sand layer is 8 blows per 0.3 m of penetration, indicating a loose relative density.

4.2.5 Sand and Silt to Silt

A native granular deposit ranging in composition from sand and silt to sandy silt to silt and containing trace to some clay and trace gravel was encountered in all three boreholes. The sand and silt to silt deposit is 3.0 m to 3.8 m thick, and extends to depths ranging from 4.2 m to 7.5 m below ground surface (Elevations 226.8 m to 226.3 m).

The SPT „N" values measured within this deposit range from 2 blows to 22 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

Grain size distribution tests were conducted on three (3) samples of the sand and silt portion of this deposit and on two (2) samples of the sandy silt to silt portion of this deposit. The results are shown on Figures B2 and B3, respectively, in Appendix B. These results show a grain size distribution consisting of 0 % to 4 % gravel, 10 % to 59 % sand, 35 % to 82 % silt and 2 % to 10 % clay sized particles.

The natural water content measured on seven (7) samples of this deposit ranges from about 18% to 25 %.

4.2.6 Sand to Silty Sand

A granular deposit consisting of sand to silty sand, trace to some silt, trace clay, trace to some gravel was encountered in all three boreholes extending to borehole termination depths ranging from 11.1 m to 14.2 m below ground surface (Elevation 219.8 m to 218.4 m).

The SPT „N" values measured within this deposit range from 3 blows to 66 blows per 0.3 m of penetration. Based on these values the relative density of the deposit is described as very loose to very dense.

In Borehole 11-C1-01 DCPT tests were performed from 14.2 m to 15.8 m below ground surface corresponding to Elevations 218.4 m to 215.2 m. Based on these results, the subsurface soils below the sand to silty sand are inferred to have a very loose to compact relative density.

Two (2) samples of the sand to silty sand deposit were subjected to a grain size distribution test and the results are shown on Figure B4 in Appendix B. These results show a grain size distribution consisting of 0 % gravel, 66 % and 86 % sand, 9 % and 29 % silt and 5 % clay sized particles.

The natural water content measured on nine (9) samples of this deposit ranges from about 17% to 27 %.

4.3 Groundwater Conditions

The recorded depths to the groundwater level and corresponding elevations upon completion of drilling are summarized as follows:

Borehole No.	Date	Groundwater Level	
		Depth (m)	Elevation (m)
11-C1-01	December 21, 2011	4.6	226.4[1]
11-C1-02	December 20, 2011	3.7	230.1[1]
11-C1-03	December 21, 2011	3.0	227.9[1]

1. Recorded unstabilized water level.

In Borehole 11-C1-02, hydrostatic uplift was encountered at a depth of 7.6 m when drilling in the sand deposit, suggesting that excess hydrostatic pressure exists in this water bearing and relatively permeable deposit.

The groundwater level elevation at this site has been estimated based on the unstabilized water levels observed during and following completion of drilling, soil moisture conditions, and changes in soil colour from brown to grey. Based on these observations, the estimated groundwater level at this site is approximately 230.3± m. All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and are expected to rise during wet periods of the year.

5.0 CLOSURE

Mr. Daniel Demmings supervised the drilling, sampling and in situ testing operations, logged the boreholes and processed the recovered soil samples for transport to Golder"s laboratory in Whitby for further examination and laboratory testing.

This Foundation Investigation Report was prepared by Ms. T. Veronica Ayetan, P.Eng., a geotechnical engineer, under the technical direction of Mr. Rehman Abdul, P.Eng., a senior geotechnical engineer. Mr. Fintan J. Heffernan, P.Eng., Golder"s MTO"s Designated Contact for this project conducted an independent quality control review and audit of the report.

Report Signature Page

GOLDER ASSOCIATES LTD.

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n:\active\2009\1111\09-1111-0022 mh - hwy 400 nbl - vespra twp\6 - reports\7 - culvert at crown hill ramp\final report\fir\09-1111-0022 rpt07 2012september27 trenchless culvert installation.docx

REFERENCES

Chapman, L.J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.

Ontario Geological Survey 1994. *Aggregate Resources Inventory of Ting, Tay and Medonte Townships, Simcoe County*. Paper 79, Ontario Geological Survey.

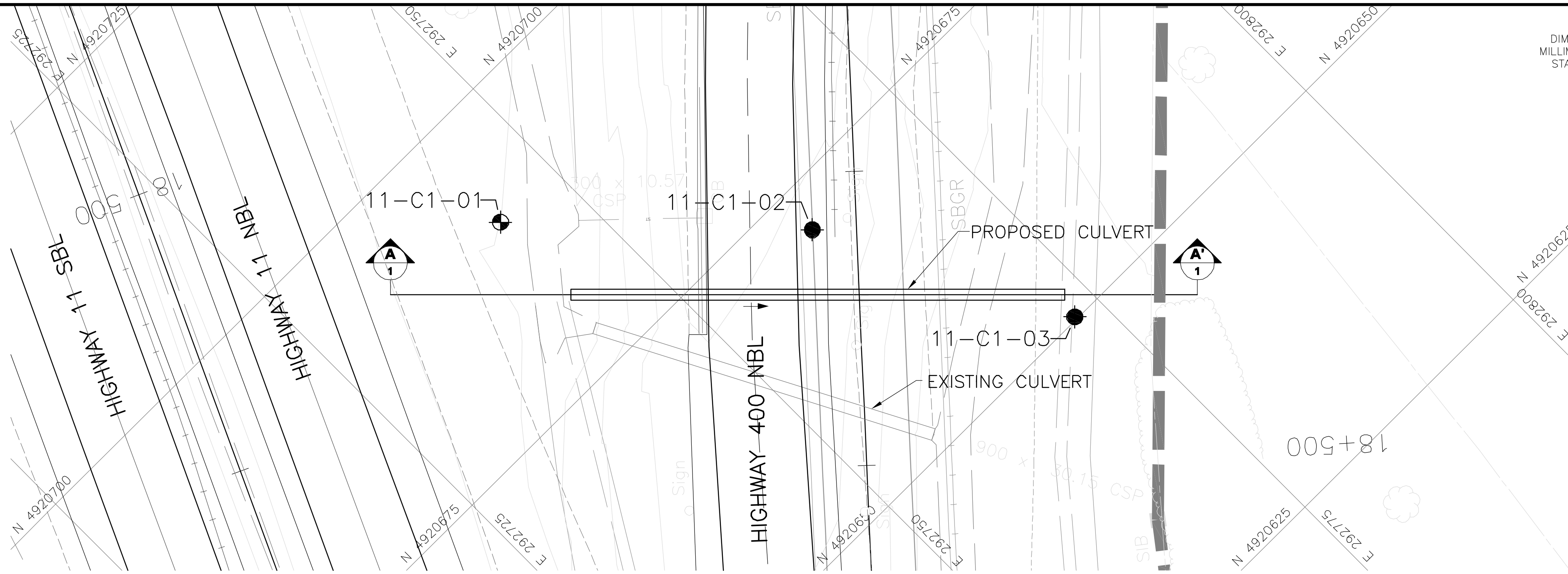
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. 2012–2034
GWP No. 2179–10–00

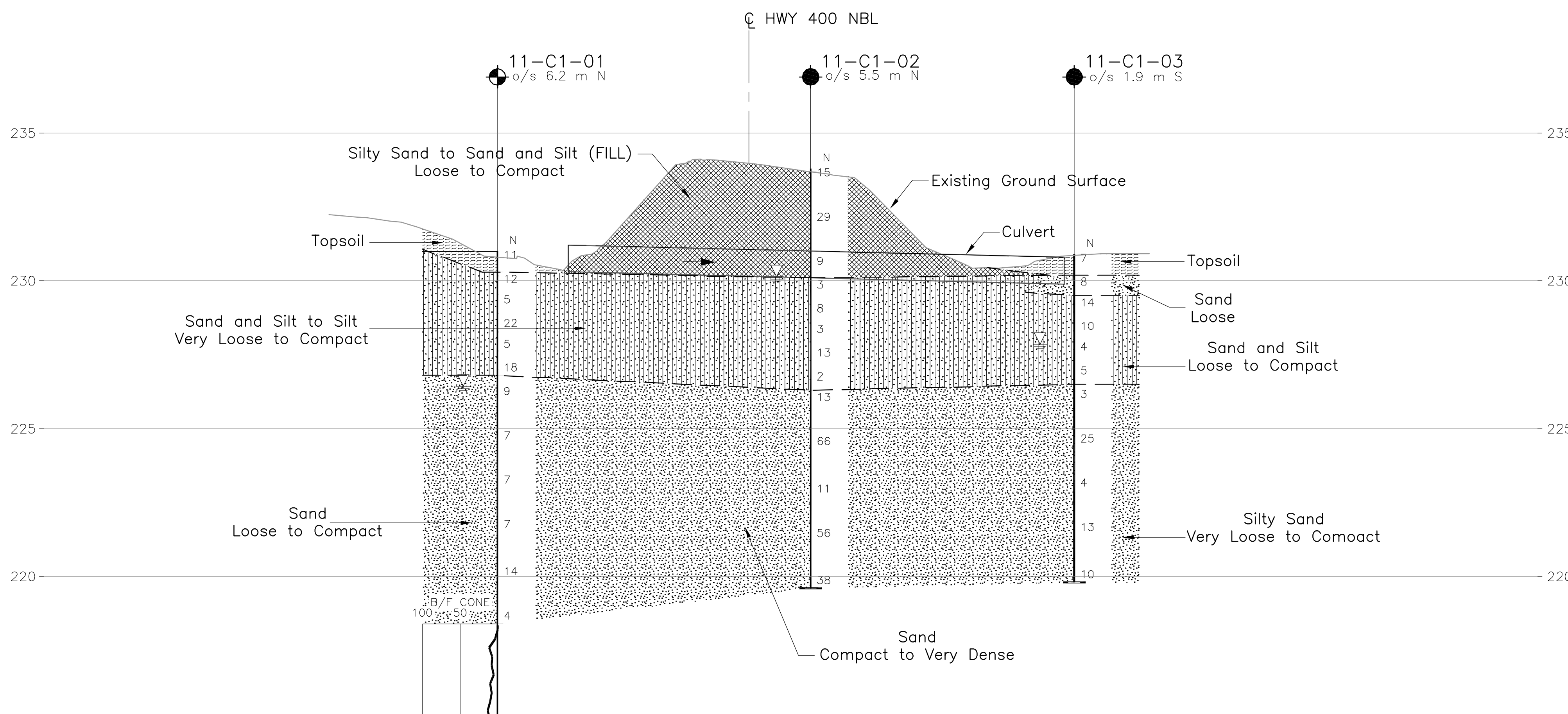
CULVERT REPLACEMENT
STATION 18+515
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 62

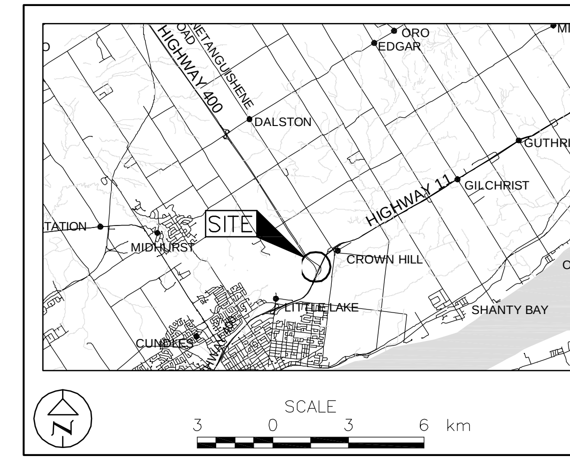
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN
SCALE 5 0 5 10 m



SECTION A–A' CULVERT AT STATION 18+515
HIGHWAY 400 (NBL)
HORIZ. SCALE 5 0 5 10 m
VERT. SCALE 2 0 2 4 m



LEGEND

- Borehole – Current Investigation (Golder, 2011)
- Borehole and DCPT – Current Investigation (Golder,2011)
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling
- Flow direction

BOREHOLE CO–ORDINATES

No.	ELEVATION	NORTHING	EASTING
11–C1–01	231.0	4920690.3	292743.7
11–C1–02	233.8	4920671.2	292762.0
11–C1–03	230.9	4920650.2	292772.6

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by MH, drawing files x84117Align.dwg, x84117Base.dwg and x84117design.dwg received May 24, 2012 and X094197Contours.dwg, received July 18, 2011. Culvert section obtained from drawing file no. 60% Sections May 2 2012.dwg, received June 4, 2012.

F. J. HEFFERNAN — Sept. 27, 2012 — REGISTERED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO
R. A. ABDUL — Sept. 27, 2012 — LICENSED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 31D–548
HWY. 400 | PROJECT NO. 09–1111–0022 | DIST.
SUBM'D. TVA | CHKD. RAA | DATE: 9/27/2012 | SITE:
DRAWN: CD | CHKD. | APPD. FJH | DWG. 1

PLOT DATE: September 27, 2012
FILENAME: T:\Projects\2009\09-1111-0022 (MH, Vaspro)\--MA-- (Crown Hill Culvert Replacement)\09111100022MA001.dwg

APPENDIX A

Record of Borehole Sheets

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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
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, 60º 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 cm^2 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) Cohesionless Soils

Density Index Relative Density	N 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

Percent 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 (cohesionless) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

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

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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma$ - u)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_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

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

(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 δ
c'	effective cohesion
c_u, s_u	undrained shear strength (ϕ = 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

Notes:

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

Foundation Design

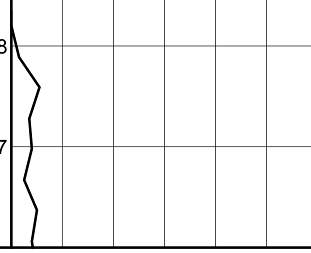
Golder Associates

RECORD OF BOREHOLE No 11-C1-01 SHEET 1 OF 2 METRIC

PROJECT 09-1111-0022
G.W.P. 2079-10-00 LOCATION N 4920690.3 ;E 292743.7 ORIGINATED BY DD
DIST Central HWY 400 BOREHOLE TYPE D-50 Track-Mount, 108 mm Diameter Hollow Stem Auger COMPILED BY NLP
DATUM Geodetic DATE December 21, 2011 CHECKED BY TVA/RA

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
231.0	GROUND SURFACE											
0.0	TOPSOIL Brown	1	SS	11								
230.3 0.7	SAND and SILT to Sandy SILT, trace to some clay, trace gravel Loose to compact Grey Wet	2	SS	12		230						
		3	SS	5		229	o		4	45	41	10
		4	SS	22		228						
		5	SS	5			o		0	27	63	10
		6	SS	18		227						
226.8 4.2	SAND, trace to some silt, trace clay Loose Brown to grey Wet				∇							
		7	SS	9		226	o					
		8	SS	7		225	o		0	86	9	5
		9	SS	7		224, 223						
		10	SS	7		222	o					
	- - - - - - - - - - - - - - - - silty loose to compact	11	SS	14		221, 220						
		12	SS	4		219	o					
218.4 12.6	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)					218, 217						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
REMARKS & GRAIN SIZE DISTRIBUTION (%)



Continued Next Page

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

RECORD OF BOREHOLE No 11-C1-01 SHEET 2 OF 2 METRIC

PROJECT 09-1111-0022			
G.W.P. 2079-10-00	LOCATION N 4920690.3 ;E 292743.7		ORIGINATED BY DD
DIST Central HWY 400	BOREHOLE TYPE D-50 Track-Mount, 108 mm Diameter Hollow Stem Auger		COMPILED BY NLP
DATUM Geodetic	DATE December 21, 2011		CHECKED BY TVA/RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED) 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
215.2											
15.8	END OF DCPT NOTES: 1. Unstabilized water level measured at a depth of 4.6 m (Elev. 226.4 m) below ground surface upon completion of drilling.										

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 11-C1-02

METRIC

PROJECT 09-1111-0022

G.W.P. 2079-10-00 | LOCATION N 4920671.2 ;E 292762.0 | ORIGINATED BY DD

DIST Central HWY 400 | BOREHOLE TYPE D-50 Track-Mount, 108 mm Diameter Hollow Stem Auger | COMPILED BY NLP

DATUM Geodetic | DATE December 20, 2011 | CHECKED BY TVA/RA

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	GR	SA	SI	CL
233.8	GROUND SURFACE									
0.0 / 0.1	ASPHALT (100 mm)									
	Silty sand to sand and silt, trace to some clay, trace to some gravel, occasional cobbles (FILL) Loose to compact Brown Moist to wet	1	SS	15						
		2	SS	29		○	11	54	23	12
	---------------- with topsoil dark brown to black	3	SS	9		○	6	39	41	14
230.1 / 3.7	SAND and SILT to SILT, trace to some clay Very loose to compact Grey Wet				∇ (approx. El. 230.3)					
		4	SS	3		○	0	59	35	6
		5	SS	8						
		6	SS	3		○	0	10	82	8
		7	SS	13						
		8	SS	2		○				
226.3 / 7.5	SAND, trace silt, trace to some gravel Compact to very dense Brown Wet	9	SS	13						
		10	SS	66		○				
		11	SS	11		○				
		12	SS	56						
	---------------- silty, trace gravel	13	SS	38						
219.6 / 14.2	END OF BOREHOLE									

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (233 to 220); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

RECORD OF BOREHOLE No 11-C1-02 SHEET 2 OF 2 METRIC

PROJECT 09-1111-0022

G.W.P. 2079-10-00 LOCATION N 4920671.2 ;E 292762.0 ORIGINATED BY DD

DIST Central HWY 400 BOREHOLE TYPE D-50 Track-Mount, 108 mm Diameter Hollow Stem Auger COMPILED BY NLP

DATUM Geodetic DATE December 20, 2011 CHECKED BY TVA/RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION --- CONTINUED FROM PREVIOUS PAGE ---	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	NOTES: 1. Unstabilized water level measured at a depth of 3.7 m (Elev. 230.1 m) below ground surface upon completion of drilling. 2. Increased resistance to augering probably on cobbles/boulders from a depth of 2.0 m to 2.9 m (Elev. 231.8 m to 230.9 m) below ground surface. 3. Hydrostatic uplift encountered at a depth of 7.6 m; sand rose 2.1 m in augers. Auger retracted to 7.6 m and borehole redrilled from 7.6 to 9.1 m.										

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No 11-C1-03

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-0022
G.W.P. 2079-10-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4920650.2 ;E 292772.6
BOREHOLE TYPE D-50 Track-Mount, 108 mm Diameter Hollow Stem Auger
DATE December 21, 2011
ORIGINATED BY DD
COMPILED BY NLP
CHECKED BY TVA/RA

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%) (w)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
230.9	GROUND SURFACE						
0.0	TOPSOIL	1	SS	7			
230.2 / 0.7	SAND, trace to some silt, containing rootlets; Loose; Brown; Moist	2	SS	8			
229.5 / 1.4	SAND and SILT, trace clay; Loose to compact; Brown, grey below 2.1 m; Wet	3	SS	14		~22	0 57 41 2
		4	SS	10			
					∇ (approx. Elev. 227.9)		
		5	SS	4		~25	
		6	SS	5			
226.5 / 4.4	Silty SAND, trace clay; Very loose to compact; Brown to grey; Wet	7	SS	3		~18	0 66 29 5
		8	SS	25			
		9	SS	4		~18	
		10	SS	13			
219.8		11	SS	10		~23	
11.1	END OF BOREHOLE						

Elevation scale: 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

NOTES:

1. Unstabilized water level measured at a depth of 3.0 m (Elev. 227.9 m) below ground surface upon completion of drilling.

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

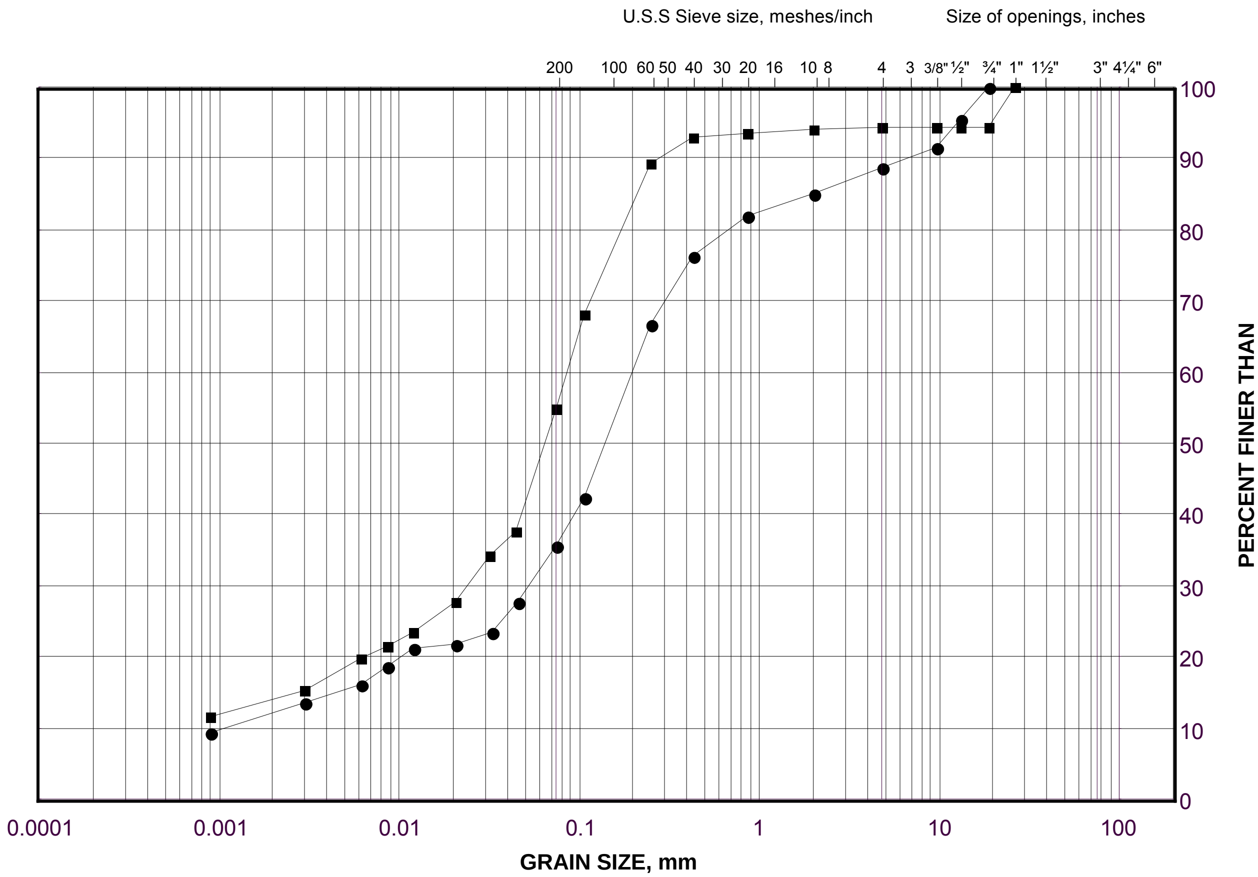
APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Silty Sand to Sand and Silt (Fill)

FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	11-C1-02	2	232.0
■	11-C1-02	3	230.5

Project Number: 09-1111-0022

Checked By: ______________________

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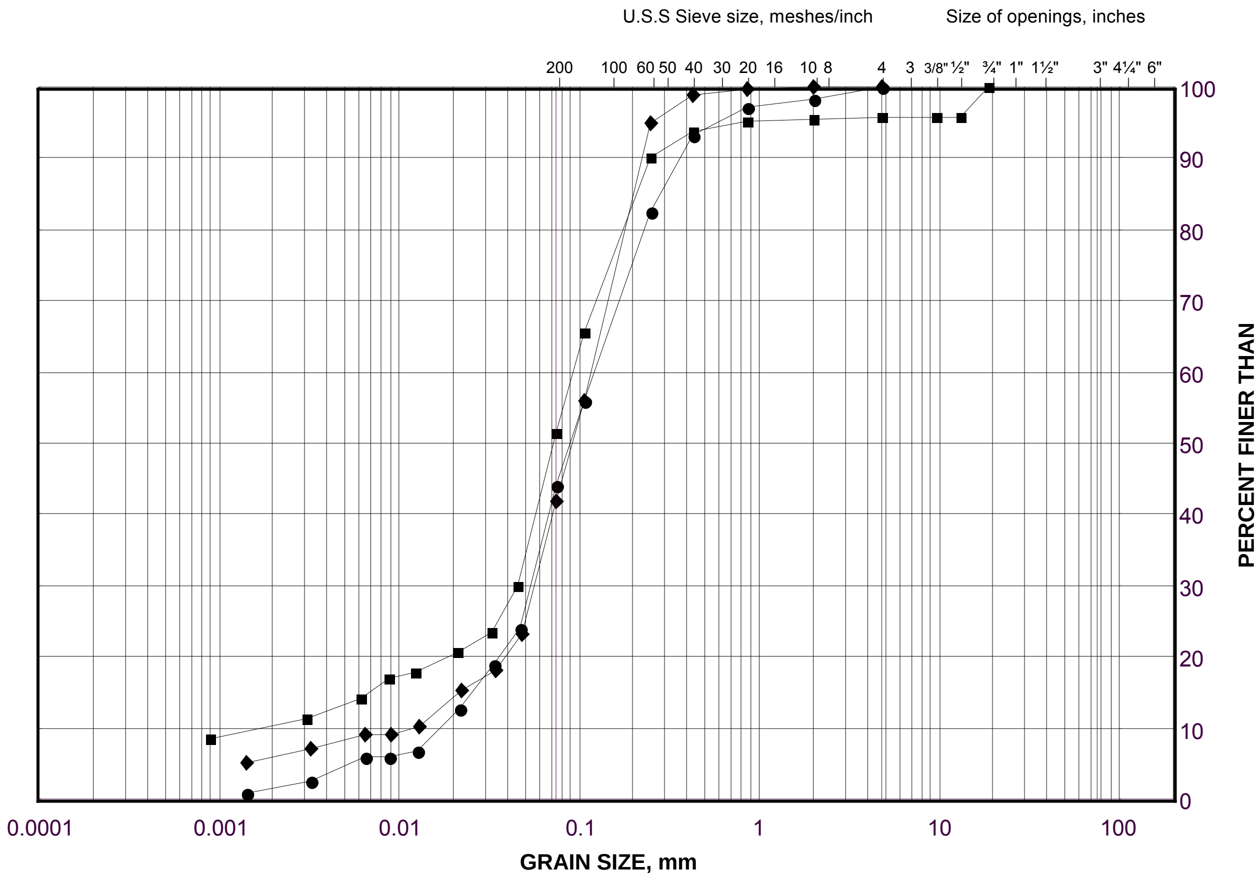
Date: 05-Jun-12

GRAIN SIZE DISTRIBUTION

Sand and Silt

FIGURE B2



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	11-C1-03	3	229.1
■	11-C1-01	3	229.2
◆	11-C1-02	4	229.7

Project Number: 09-1111-0022

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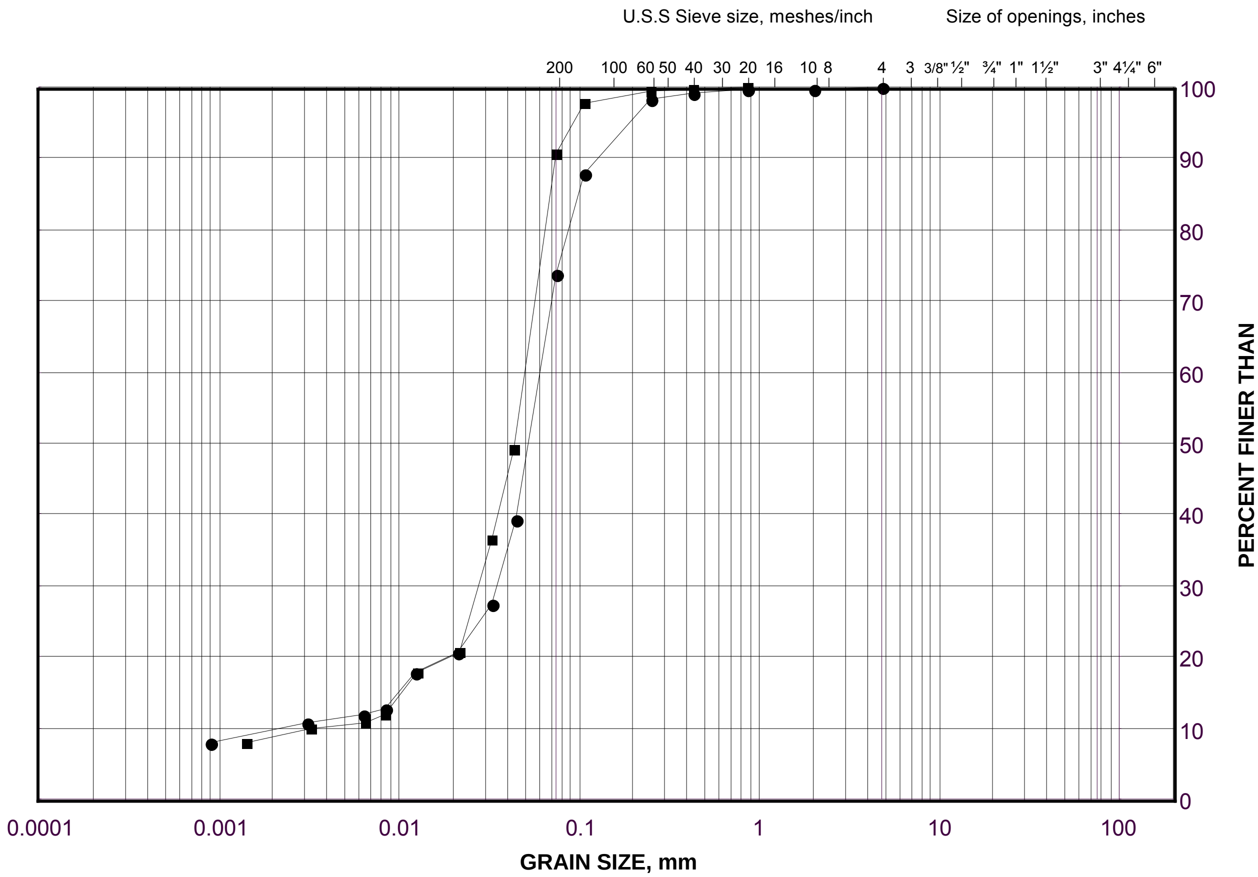
Date: 05-Jun-12

GRAIN SIZE DISTRIBUTION

Sandy Silt to Silt

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)
●	11-C1-01	5	227.7
■	11-C1-02	6	228.2

Project Number: 09-1111-0022

Checked By: ______________

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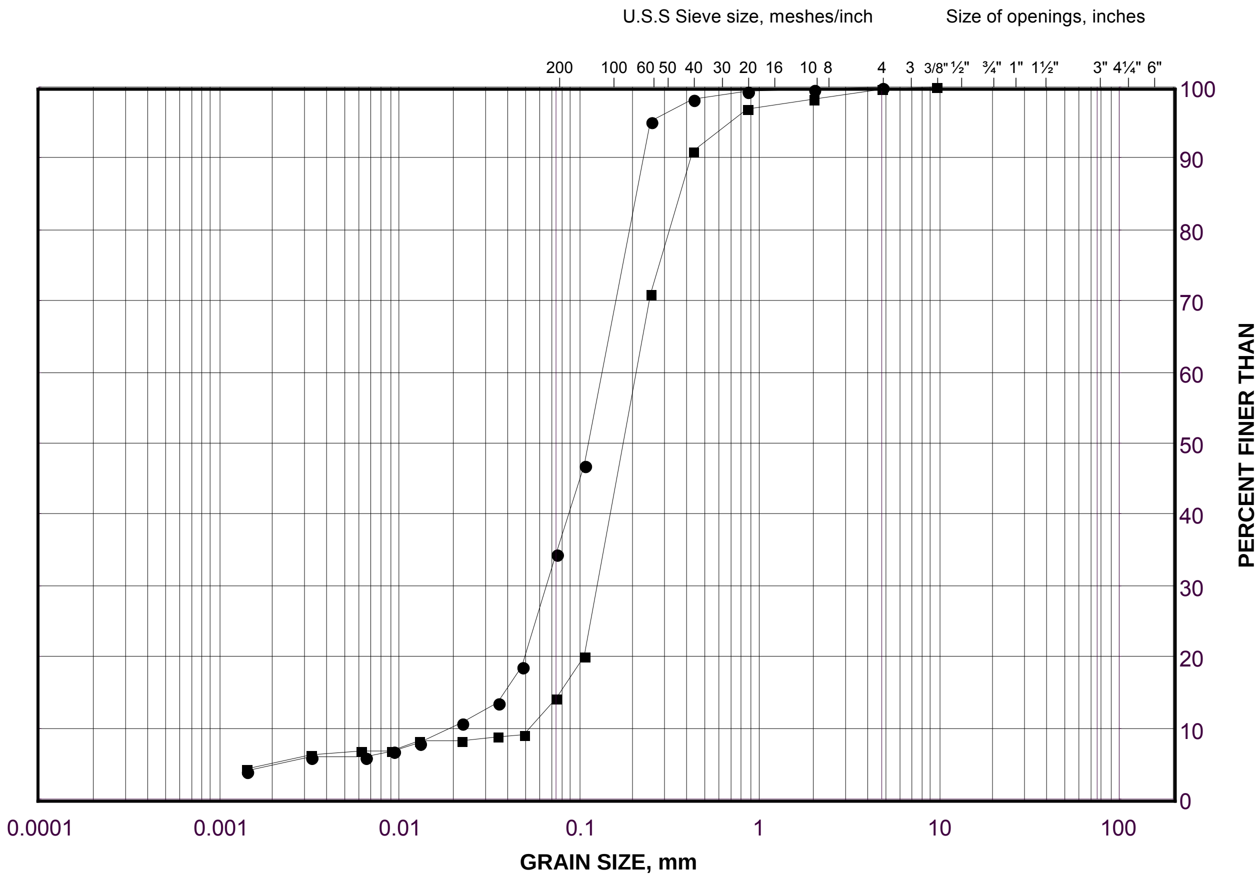
Date: 05-Jun-12

GRAIN SIZE DISTRIBUTION

Sand to Silty Sand

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	11-C1-03	7	226.1
■	11-C1-01	8	224.6

Project Number: 09-1111-0022

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Date: 05-Jun-12

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