REPORT

November 17, 2011

FOUNDATION INVESTIGATION REPORT

HIGHWAY 11 NBL CULVERT REPLACEMENT AT STATION 27+340
TOWNSHIP OF SOUTH HIMSWORTH, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5416-00

Submitted to:
URS Canada Inc.
75 Commerce Valley Drive East
Markham, ON L3T 7N9

GEOCRES NO. 31L-146

Report Number: 09-1191-0042-R04

Distribution:

1 e-copy: Ministry of Transportation, Ontario, North Bay, Ontario (Northeastern Region)
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1 e-copy: URS Canada Inc., Markham, Ontario
1 Copy: Golder Associates Ltd., Sudbury, Ontario

Golder Associates

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed rehabilitation of the Highway 11 Northbound Lanes (NBL), including the culvert replacement at Station 27+340. This project is part of the detail design for the rehabilitation of Highway 11 Northbound Lanes (NBL) and Southbound Lanes (SBL) from 1.5 km south of Highway 534, northerly 3.5 km and NBL only from 2.0 km north of Highway 534 northerly 9.5 km to 1.5 km south of Highway 654 in the Township of North Himsworth. The general location of this section of the Highway 11 alignment is shown on the Key Plan on Drawing 1 following the text of this report.

This report addresses the investigation carried out for the replacement of the culvert on Highway 11 NBL at Station 27+340 only. Separate reports will be submitted detailing the foundation investigations for other culverts for this project, as well as for the wildlife crossing. The drawing for the culvert alignment was provided to Golder by URS on June 4, 2010 and cross-sections showing invert information were provided on August 25, 2010.

Based on the information from URS, the culvert at Station 27+340 will be concrete and will have an opening of about 1.2 m. The invert at both ends of the culvert will be Elevation 251.4 m. The embankment in the culvert area is about 3 m high and we understand that a 1 m grade raise and associated embankment widening (i.e. about 2 m on each side) will be required at this culvert location.

The purpose of this investigation is to establish the subsurface conditions at the location of the proposed culvert replacement by borehole drilling, in situ testing and laboratory testing on selected samples.

The culvert alignment was located in the field by Golder relative to stakes installed by Callon Dietz Inc. (Callon Dietz), a professional surveying company retained by URS, and referencing plan drawings provided by URS. The investigated area is shown in plan on Drawing 1 following the text of this report.

2.0 SITE DESCRIPTION

The replacement culvert will be located on the same alignment as the existing culvert in the Township of South Himsworth on Highway 11 approximately 0.9 km north of McCharles Line and Lindquist Line. In general, the topography in the area of the overall project limits is flat with numerous bedrock outcrops separated by swamps in low-lying areas or creeks.

The Preliminary Design Report (PDR) dated July 2009 indicates that the existing culvert at Station 27+340 is a 1,220 mm diameter and 25 m long Corrugated Steel Pipe (CSP) culvert and that the condition of the culvert is poor to fair.

The ground surface of the shoulder of the embankment is at Elevation 255 m and the creek water surface at the time of the investigation was about Elevation 251.9 m and Elevation 251.8 m on the east and west sides of the embankment, respectively.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation associated with the culvert replacement at Station 27+340 was carried out on May 3, 4, 10 and 11, 2010, during which time a total of four (4) Boreholes (BH09-01 and BH09-07 to BH09-09) and four (4) Dynamic Cone Penetration Tests (DCPTs) were advanced at the culvert location. The field investigation was carried out using a Track Mounted D-50 drilling rig supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The location of the boreholes is shown on Drawing 1 following the text of this report.

The boreholes were advanced through the overburden using 108 mm inside diameter hollow-stem augers. Soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-08a). The DCPTs were driven about 1 m north or south of each borehole, except at BH09-01 where the DCPT was advanced 6 m north of the borehole, to determine the depth to refusal. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903 (as amended by Ontario Regulation 372).

The boreholes were advanced to depths ranging between 7.2 m and 11.5 m below existing ground surface. The boreholes and DCPTs were terminated on refusal to further auger/casing advancement and cone penetration, respectively. These depths to refusal do not confirm bedrock surface elevations but may be inferred to indicate potential proximity to the bedrock surface.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets in Appendix A. It should be noted that groundwater elevations as encountered in the boreholes may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. Furthermore, groundwater elevations will vary depending on seasonal fluctuations, precipitation and local soil permeability.

The fieldwork was supervised throughout by a member of our technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury geotechnical laboratory where the 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, Atterberg limits and grain size distribution) was carried out on selected soil samples. The results of the laboratory testing are included in Appendix B.

A sample of the creek water was obtained during the field investigation using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters. The results of the analytical testing are summarized in Table B-1 in Appendix B.

Survey stakes were installed near the NBL embankment east toe by Callon Dietz prior to drilling. The as-drilled borehole locations, in stations and offsets, were measured in reference to the stakes and were subsequently converted into MTM NAD 83 coordinates in AutoCAD. Borehole elevations were surveyed by a member of our technical staff in reference to the ground surface elevations at the horizontal control points along Highway 11. The borehole locations given on the Record of Borehole sheets and shown on Drawing 1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum.

The as-drilled borehole locations, ground surface elevations at the drilled locations and borehole depths are summarized below.

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
09-01	5107941.1	315195.8	254.7	11.5
09-07	5107951.7	315182.2	254.9	11.0
09-08	5107954.7	315174.2	251.8	7.2
09-09	5107945.1	315204.3	252.0	7.7

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in The Physiography of Southern Ontario (Chapman and Putnam, 1984)[1], this section of Highway 11 lies within the physiographic region known as the Number 11 Strip, which extends along Highway 11 from Gravenhurst to North Bay. This part of the Number 11 Strip physiographic region is near the southwest shoreline of glacial Lake Algonquin. As a result, the streams entering Lake Algonquin deposited sand as delta features and silt and clay settled in deeper offshore water. Sand and gravel was also deposited as an esker which follows the strip from Bondfield to Gravenhurst.

The bedrock in the area consists typically of crystalline granite gneisses of the Powassan Domain of the Central Gneiss Belt, a subdivision of the Grenville Structural Province, as described in Geology of Ontario, OGS Special Volume 4[2].

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced for this investigation, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets in Appendix A. The results of the laboratory testing are provided in Appendix B. The inferred stratigraphy as encountered in the boreholes is shown on Drawing 1. The stratigraphic boundaries shown on the Record of Borehole sheets and in profile on Drawing 1 are inferred from non continuous sampling, observations of drilling progress and the results of SPTs and in situ testing. 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.

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

[2] Geology of Ontario, 1991. Ontario Geological Society Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.

It should be noted that the orientation (i.e. north, south, east and west) stated in the text of the report is typically referenced to project north (along the Highway 11 alignment) and therefore may differ from that shown on the drawing which represents magnetic north.

In general, the subsurface stratigraphy along the culvert alignment consists of a layer of fill at ground surface, underlain by a stratum of clayey silt and a deposit of sand to sand and silt. Refusal to further penetration on inferred bedrock was encountered at the bottom of the sand to sand and silt deposit.

The bottom of the creek was probed using a steel bar from the edge of the creek at the time of the field investigation and the depth to firm creek bottom was measured at 0.3 m below water surface on both sides of the existing embankment.

4.2.1 Fill

Boreholes BH09-01 and BH09-7 were advanced from the granular shoulder surface and penetrated through fill consisting of brown sand and gravel, trace to some silt. The fill contains cobbles and boulders in Borehole BH09-01. The thickness of the granular fill is 2.6 m in Borehole BH09-01 and 2.1 m in Borehole BH09-07. In Boreholes BH09-8 and BH09-09, advanced near the toes of the embankment, about 0.1 m and 0.15 m of organics was encountered at ground surface underlain by about 0.4 m and 0.15 m of sand and gravel fill, respectively.

The SPT ‘N’-values measured within the sand and gravel fill are between 4 blows and 30 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The grain size distributions of two samples of the deposit are shown on Figure B-1 in Appendix B.

The measured water content on samples of this deposit varies between about 1 percent and 5 percent.

4.2.2 Clayey Silt

A deposit of grey and/or brown clayey silt, trace to some sand, was encountered underlying the fill in each of the boreholes. Trace to some organics was noted in the upper portion of the samples within the layer. The thickness of the stratum ranges from 0.9 m to 3.5 m and the top of the deposit was encountered between Elevation 252.8 m and 251.3 m.

The SPT ‘N’-values measured within this deposit range from 2 blows to 17 blows per 0.3 m of penetration suggesting a soft to very stiff consistency.

Atterberg limits tests were carried out on four samples of the deposit and the test results indicate liquid limits ranging from 21 percent to 27 percent, plastic limits ranging from 14 percent and 16 percent and plasticity indices ranging from about 6 percent to 12 percent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B-2 in Appendix B and indicate that the material is classified as a clayey silt of low plasticity.

The grain size distributions of four samples of the clayey silt deposit are shown on Figure B-3 in Appendix B.

The natural water content measured on samples of the deposit ranges between 19 percent and 48 percent.

An organic content test on one sample of the clayey silt deposit indicates about 6 percent organics corresponding to the highest water content of the samples tested.

4.2.3 Sand to Sand and Silt

A deposit of grey sand to sand and silt, trace to some gravel and trace clay, was encountered underlying the clayey silt stratum in each of the boreholes. The top of the deposit was encountered between Elevation 250.9 m and 248.9 m and the thickness of the deposit ranges from 4.3 m to 7.7 m. The bottom of this deposit is defined by auger or casing refusal in each of the boreholes.

The SPT 'N'-values measured within this deposit range between 5 blows and 24 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The grain size distributions of seven samples of this deposit are shown on Figure B-4 in Appendix B.

The natural water content measured on samples of this deposit varies between 11 percent and 28 percent.

4.2.4 Bedrock/ Refusal

In each of the boreholes and DCPTs, advanced 1 m to 6 m away from the boreholes, refusal to further auger or casing advancement or cone penetration was encountered at depths ranging between 7.2 m and 11.5 m below ground surface, between Elevation 244.6 m and 243.2 m. These depths to refusal, while they do not confirm bedrock elevations, may be inferred to indicate potential proximity to the bedrock interface.

4.2.5 Groundwater Conditions

In general, the samples taken in the boreholes were wet with free water noted in some samples of cohesionless material. Water levels observed in the boreholes upon completion of drilling range from 0.2 m to 7.6 m below existing ground surface, ranging between Elevation 253.2 m and 247.1 m. Groundwater/surface water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

5.0 CLOSURE

The field personnel supervising the drilling program were Mr. Ed Savard and Mr. Indulis Dumpis. This report was prepared by Mr. André Bom, P.Eng. The technical aspects were reviewed by Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project, who also carried out a quality control review of the report.

Report Signature Page

GOLDER ASSOCIATES LTD.

André Bom, P.Eng.
Geotechnical Engineer

Jorge M. A. Costa, P.Eng.
Designated MTO Contact, Principal

AB/JMAC/lb

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Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, Fourth Edition.

Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA-S6-06. 2006. CSA Special Publication, S6.1-06. Canadian Standard Association.

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

Geology of Ontario. 1991. Ontario Geological Society, 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.

Kulhawy, F.H. and Mayne, P.W. 1990. Manual on Estimating Soil Properties for Foundation Design. EL 6800, Research Project 1493 6. Prepared for Electric Power Research Institute, Palo Alto, California.

Rutledge, P.C. and Gould, J.P. 1973. Movements of Articulated Conduits Under Earth Dams on Compressible Foundations, In: Embankment Dam Engineering – Casagramde Volume. Eds. Hirschfeld, R.C. and Poulos, S.J. John Wiley & Sons, New York.

STANDARDS:

ASTM International:

ASTM D1586-08a	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

Contract Design Estimating and Documentation (CDED):

Special Provision 110S13	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material.

Ontario Occupational Health and Safety Act:

Ontario Regulation 213/91	Construction Projects
Ontario Regulation 443/09	Amendment to Ontario Regulation 213

Ontario Provincial Standard Drawing:

OPSD 203.010	Embankments Over Swamp – New Construction.
OPSD 803.010	Backfill and Cover for Concrete Culverts With Spans less than or equal to 3.0 m.
OPSD 810.010	Rip-Rap Treatment for Sewer and Culvert Outlets.

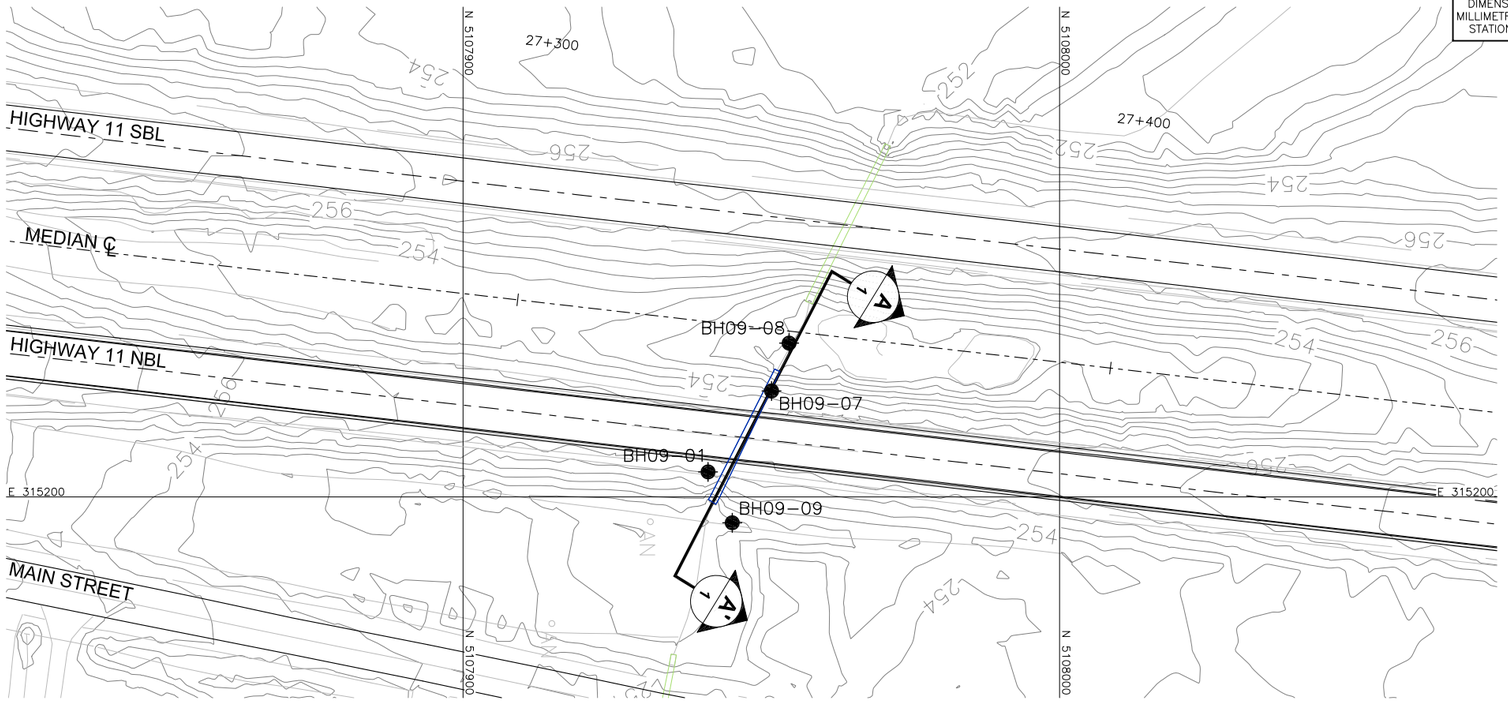
Ontario Provincial Standard Specification:

OPSS 209	Construction Specification for Embankments Over Swamps and Compressible Soils.
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut.
OPSS 501	Construction Specification for Compacting.
OPSS 539	Construction Specification for Temporary Protection Systems.
OPSS 1002	Material Specification for Aggregates – Concrete.
OPSS 1205	Material Specification for Clay Seal.

Ontario Water Resources Act:

Ontario Regulation 372/97	Amendment to Ontario Regulation 903

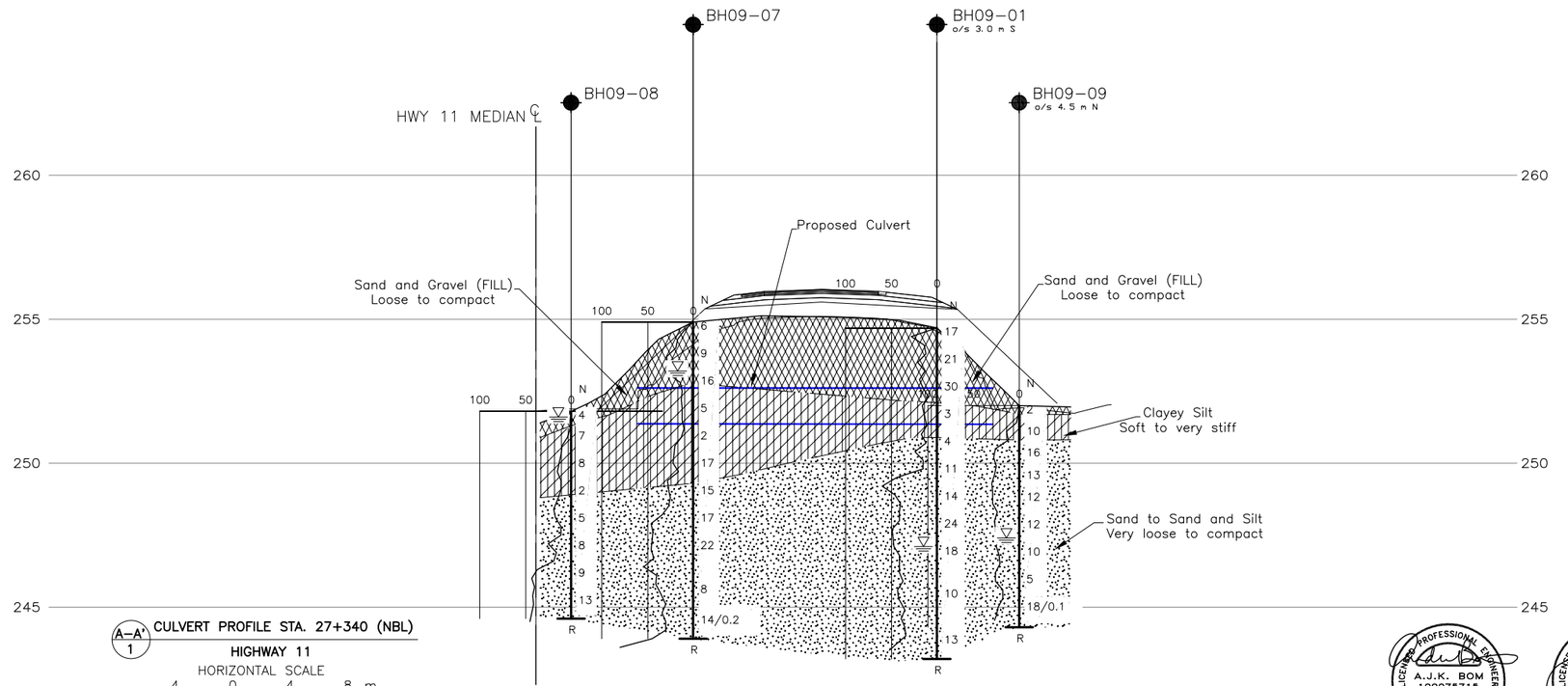
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

SCALE

10 0 10 20 m



A-A' / 1 CULVERT PROFILE STA. 27+340 (NBL)

HIGHWAY 11

HORIZONTAL SCALE

4 0 4 8 m

2 0 2 4 m

VERTICAL SCALE

METRIC

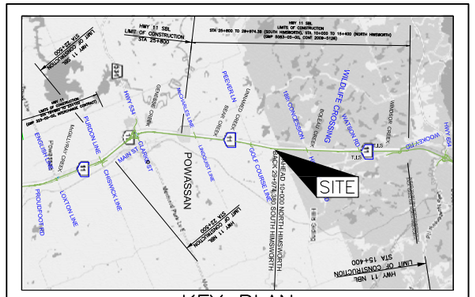
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5416-06-00

SHEET

HIGHWAY 11
CULVERT AT STA 27+340 NBL
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



KEY PLAN

SCALE

2.5 0 2.5 km

LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
BH09-01	254.7	5107941.1	315195.8
BH09-07	254.9	5107951.7	315182.2
BH09-08	251.8	5107954.7	315174.2
BH09-09	252.0	5107945.1	315204.3

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 URS, drawing file nos. BasePlan HWY 11.dwg received June 04, 2010, Keyplan received June 03, 2011.

LICENCED PROFESSIONAL ENGINEER A.J.K. BOM 100075715 NOV 17, 2011 PROVINCE OF ONTARIO

LICENCED PROFESSIONAL ENGINEER J.M.A.COSTA NOV 17, 2011 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 31L-146

HWY. 11		PROJECT NO. 09-1191-0042	DIST.
SUBM'D. LG	CHKD. AB	DATE: NOV 2011	SITE:
DRAWN: JJL	CHKD.	APPD. JMAC	DWG. 1

PLOT DATE: November 16, 2011
FILENAME: \\Vaut1-S-CADD01\Golder\CAD\Projects\2009\09-1191-0042 Hwy 11 Culverts\091910042 Culvert 27340.dwg

APPENDIX A

Record of Boreholes

LIST OF SYMBOLS

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

1. GENERAL

π	3.1416
in 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
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
v	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

* 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	liquid limit
w_p	plastic limit
I_p	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_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
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

Notes:
1 $\tau = c' + \sigma' \tan\phi'$
2 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
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	c_u, s_u 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	Sand and Gravel
	With (cohesive)	Silty Clay with sand / Clayey Silt with sand

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RECORD OF BOREHOLE No BH09-01

1 OF 1 **METRIC**

PROJECT 09-1191-0042 | W.P. 5416-06-00 | DIST ____ HWY 11 | DATUM Geodetic

LOCATION N 5107941.1; E 315195.8 | BOREHOLE TYPE 108 mm I.D. Continous Flight, Hollow Stem Augers, NW Casing, Wash Boring | DATE May 3 and 4, 2010

ORIGINATED BY EHS | COMPILED BY AMW | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
254.7	GROUND SURFACE										
0.0	Sand and gravel, trace silt, containing cobbles and boulders (FILL) Compact Brown Moist		1	SS	17		254		○		
			2	SS	21				○		55 39 (6)
	Auger refusal at 1.8 m depth. Switched to NW casing.		3	SS	30		253		○		
252.1			4	SS	3		252				
2.6	CLAYEY SILT, some sand, trace to some organics Firm Brown to black Wet		5	SS	4				○		0 15 70 15
250.9							251				
3.8	SAND to SAND and SILT, trace to some gravel Compact Grey Wet		6	SS	11				○		
			7	SS	14		250		○		0 93 (7)
			8	SS	24		249		○		
			9	SS	18	▽	248		○		
			10	SS	10		247				
							246				
							245				
			11	SS	13		244		○		22 43 (35)
243.2											
11.5	END OF BOREHOLE CASING REFUSAL										

Notes:

1. Water level at a depth of 7.6 m below ground surface (Elev. 247.1 m) upon completion of drilling.

2. Advanced DCPT 6.0 m north of Borehole BH09-01. Refusal at a depth of 11.3 m (Elev. 243.4 m) (hammer bouncing).

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

SUD-MTO 001 09-1191-0042-4000.GPJ GAL-MISS.GDT 16/11/11 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH09-07

1 OF 1 **METRIC**

PROJECT 09-1191-0042 | W.P. 5416-06-00 | DIST ____ HWY 11 | DATUM Geodetic

LOCATION N 5107951.7; E 315182.2 | BOREHOLE TYPE 108 mm I.D. Continous Flight, Hollow Stem Augers | DATE May 10, 2010

ORIGINATED BY ID | COMPILED BY AMW | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
254.9	GROUND SURFACE										
0.0	Sand and gravel, trace to some silt (FILL) Loose to compact Brown Moist		1	SS	6		254		○		
			2	SS	9						
252.8			3	SS	16	▽	253		○		57 36 (7)
2.1	CLAYEY SILT, trace sand, trace to some organics in upper 1.5 m Soft to very stiff Grey Wet		4	SS	5		252				
			5	SS	2				○	OC=5.9%	
			6	SS	17		251				
249.3			7	SS	15		250		⊢○⊣		0 24 50 26
5.6	SAND to SAND and SILT, trace gravel, trace clay Loose to compact Grey Wet		8	SS	17		249				
			9	SS	22		248				
			10	SS	8		247		○		
243.9			11	SS	14/0.2		246				3 36 58 3
11.0	END OF BOREHOLE SPOON AND AUGER REFUSAL						245				
	Notes: 1. Water level at a depth of 1.7 m below ground surface (Elev. 253.2 m) upon completion of drilling. 2. Advanced DCPT 1.0 m north of Borehole BH09-07. Refusal at a depth of 11.3 m (Elev. 243.6 m) (hammer bouncing).						244				

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

SUD-MTO 001 09-1191-0042-4000.GPJ GAL-MISS.GDT 16/11/11 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH09-08

1 OF 1 **METRIC**

PROJECT 09-1191-0042 | W.P. 5416-06-00 | DIST ____ HWY 11 | DATUM Geodetic

LOCATION N 5107954.7; E 315174.2 | BOREHOLE TYPE 108 mm I.D. Continous Flight, Hollow Stem Augers | DATE May 11, 2010

ORIGINATED BY ID | COMPILED BY AMW | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
251.8	GROUND SURFACE										
0.0 / 251.3	Organics (0.1 m) over sand and gravel (FILL) Loose Brown Wet		1	SS	4	▽	251				
0.5	CLAYEY SILT, trace to some organics Soft to firm Grey Wet		2	SS	7						
			3	SS	8		250				
248.9			4	SS	2		249				0 13 60 27
2.9	Sandy SILT, trace clay Loose to compact Grey Wet		5	SS	5						
			6	SS	8		248				0 23 69 8
			7	SS	9		247				
							246				
			8	SS	13						
244.6							245				
7.2	END OF BOREHOLE AUGER REFUSAL										

Notes:

1. Water level at a depth of 0.2 m below ground surface (Elev. 251.6 m) upon completion of drilling.

2. Advanced DCPT 1.5 m north of Borehole BH09-08. Refusal at a depth of 7.3 m (Elev. 244.5 m) (hammer bouncing).

3. Borehole advanced on south side of creek; water surface at Elev. 251.8 m. Creek bed measured at about 0.2 m below water surface and probed to fim bottom at about 0.3 m below water surface.

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

Golder Associates

RECORD OF BOREHOLE No BH09-09

1 OF 1 **METRIC**

PROJECT 09-1191-0042 | W.P. 5416-06-00 | LOCATION N 5107945.1; E 315204.3 | ORIGINATED BY ID

DIST _____ HWY 11 | BOREHOLE TYPE 108 mm I.D. Continous Flight, Hollow Stem Augers | COMPILED BY AMW

DATUM Geodetic | DATE May 11, 2010 | CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
252.0	GROUND SURFACE										
0.0 251.7	Organics (0.15 m) over sand and gravel (FILL)		1	SS	2						
0.3	Brown Moist										
	CLAYEY SILT, some sand Soft to stiff Grey and brown		2	SS	10		251		○		0 17 61 22
250.8 1.2	Moist										
	SAND to SAND and SILT, trace clay Loost to compact Grey Wet		3	SS	16		250		○		
			4	SS	13				○		0 80 16 4
			5	SS	12		249		○		
			6	SS	12		248				
			7	SS	10	▽	247		○		0 95 (5)
			8	SS	5		246		○		0 34 64 2
244.3			9	SS	18/0.1		245		○		
7.7	END OF BOREHOLE SPOON AND AUGER REFUSAL										

Notes:

1. Water level at a depth of 4.6 m below ground surface (Elev. 247.4 m) upon completion of drilling.

2. Advanced DCPT 1.0 m south of Borehole BH09-09. Refusal at a depth of 7.5 m (Elev. 244.5 m) (hammer bouncing).

3. Borehole advanced on north side of creek; water surface at Elev. 251.9 m. Creek bed measured at about 0.2 m below water surface and probed to fim bottom at about 0.3 m below water surface.

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

APPENDIX B

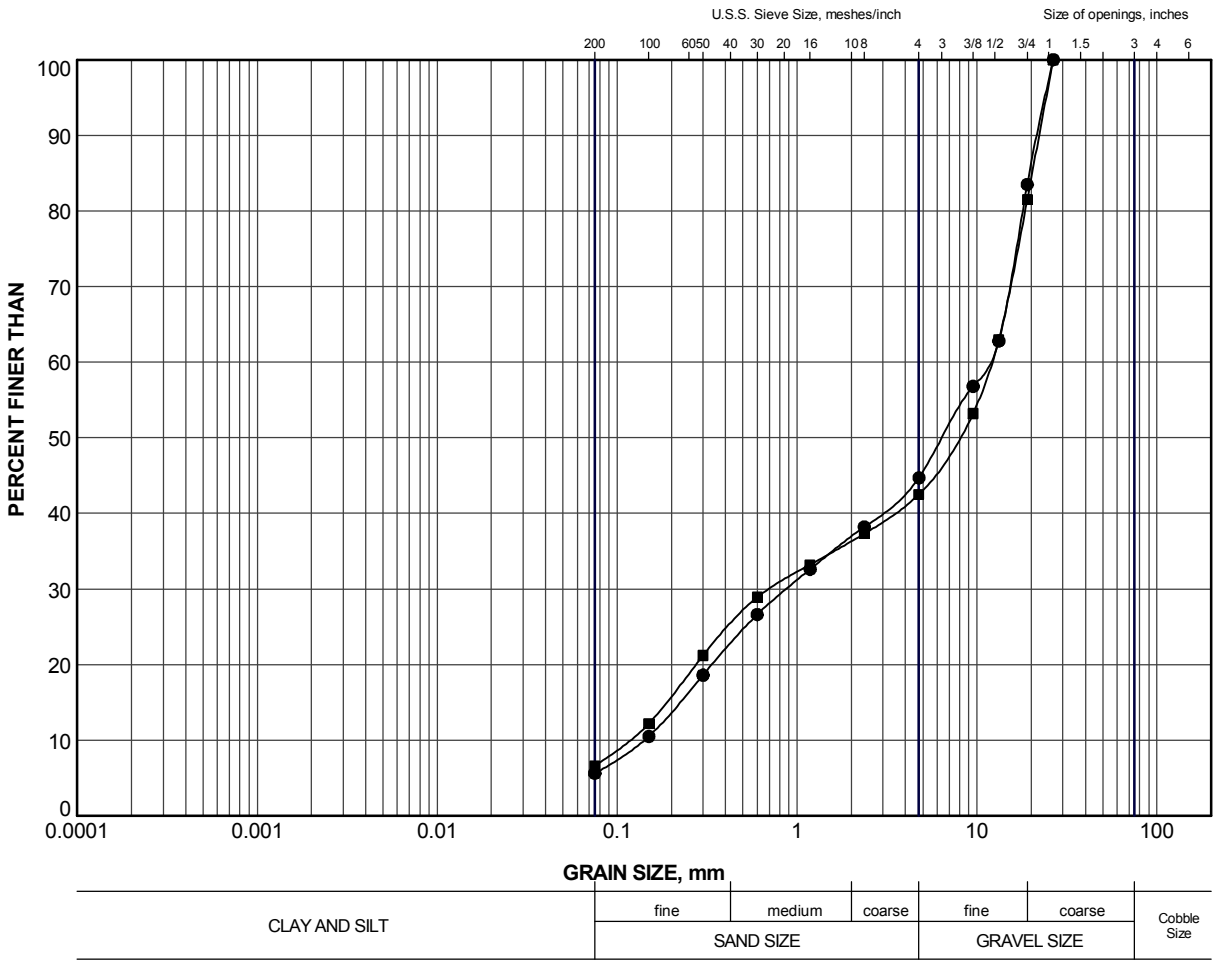
Laboratory Test Results

Table B-1 - Summary of Analytical Testing of Creek Water

Parameter	Units	Method Detection Limit	Result
Chloride	mg/L	0.2	6.53
Sulphate	mg/L	1	4.9
Conductivity	µS/cm	1	135
Resistivity	Mohm-cm	n/a	0.0074
pH	n/a	n/a	7.07

Notes: 1. Samples obtained May 17, 2010.
2. Analytical testing carried out by Testmark Laboratory Ltd.

Compiled by: AB
Checked by: LG



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH09-01	2	253.6
■	BH09-07	3	253.1

PROJECT

HIGHWAY 11 NBL CULVERT 27+340

TITLE

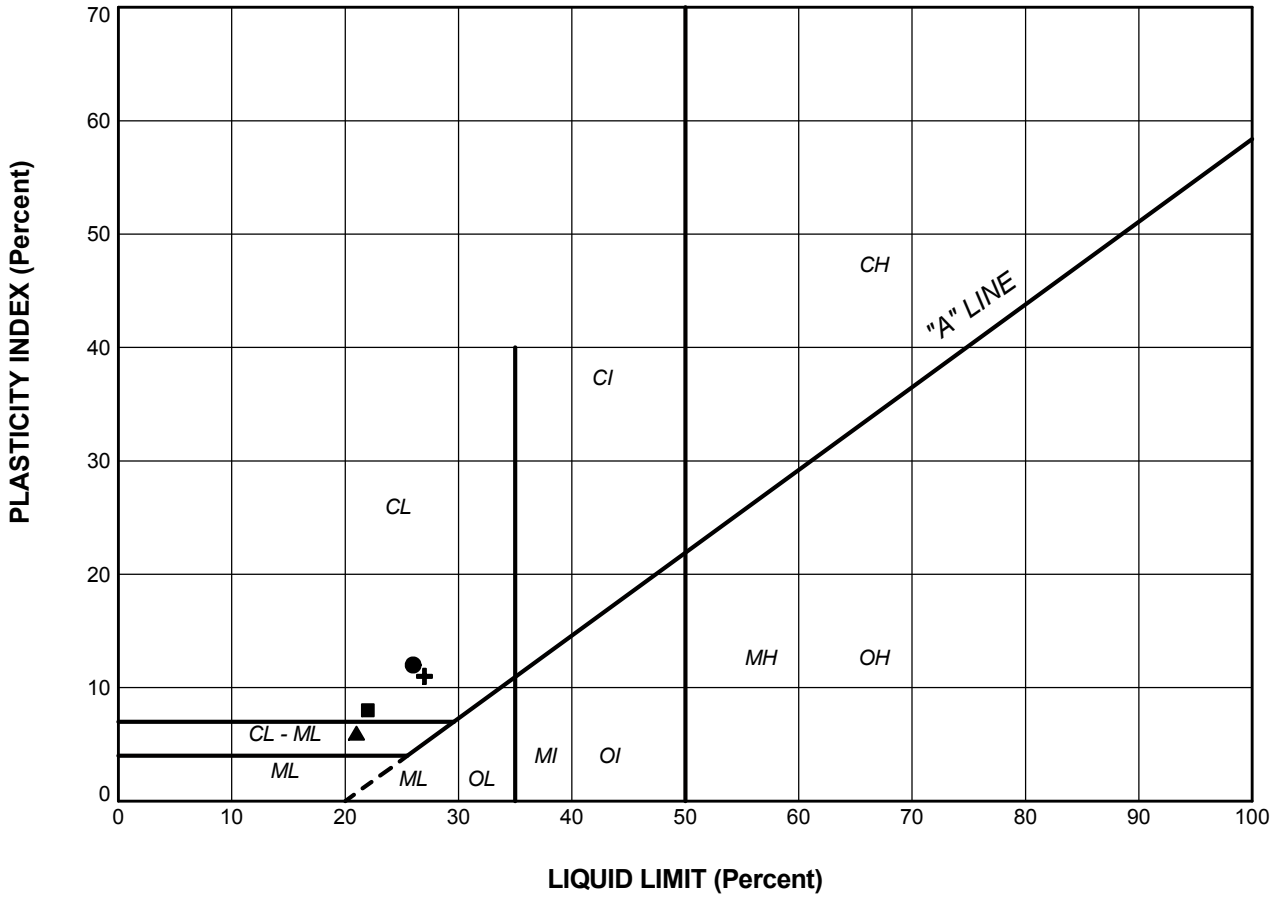
GRAIN SIZE DISTRIBUTION

SAND AND GRAVEL (FILL)

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1191-0042		FILE No. 09-1191-0042-4000.GPJ	
DRAWN	JJL	Nov 2011	SCALE N/A	REV.
CHECK	AB	Nov 2011		
APPR	JMAC	Nov 2011	**FIGURE B-1**	

LDN_MTO_NEW_GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	BH09-07	7	26.0	14.0	12.0
■	BH09-08	2	22.0	14.0	8.0
▲	BH09-08	3	21.0	15.0	6.0
✚	BH09-08	4	27.0	16.0	11.0

PROJECT

HIGHWAY 11 NBL CULVERT 27+340

TITLE

PLASTICITY CHART

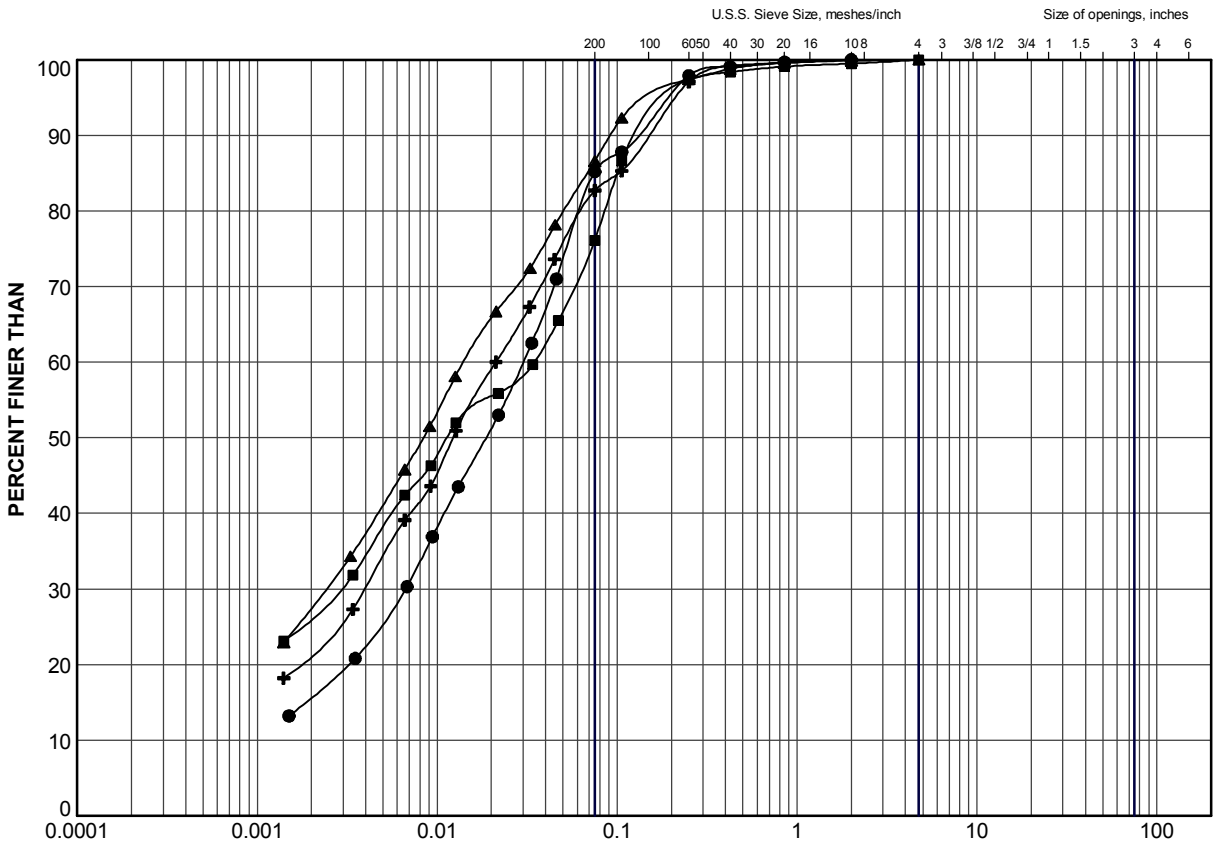
CLAYEY SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1191-0042		FILE No.	09-1191-0042-4000.GPJ
DRAWN	JJL	Nov 2011	SCALE	N/A
CHECK	AB	Nov 2011	REV.	
APPR	JMAC	Nov 2011		

FIGURE B-2

MTO_PI GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH09-01	5	251.3
■	BH09-07	7	250.0
▲	BH09-08	4	249.2
✚	BH09-09	2	250.9

PROJECT

HIGHWAY 11 NBL CULVERT 27+340

TITLE

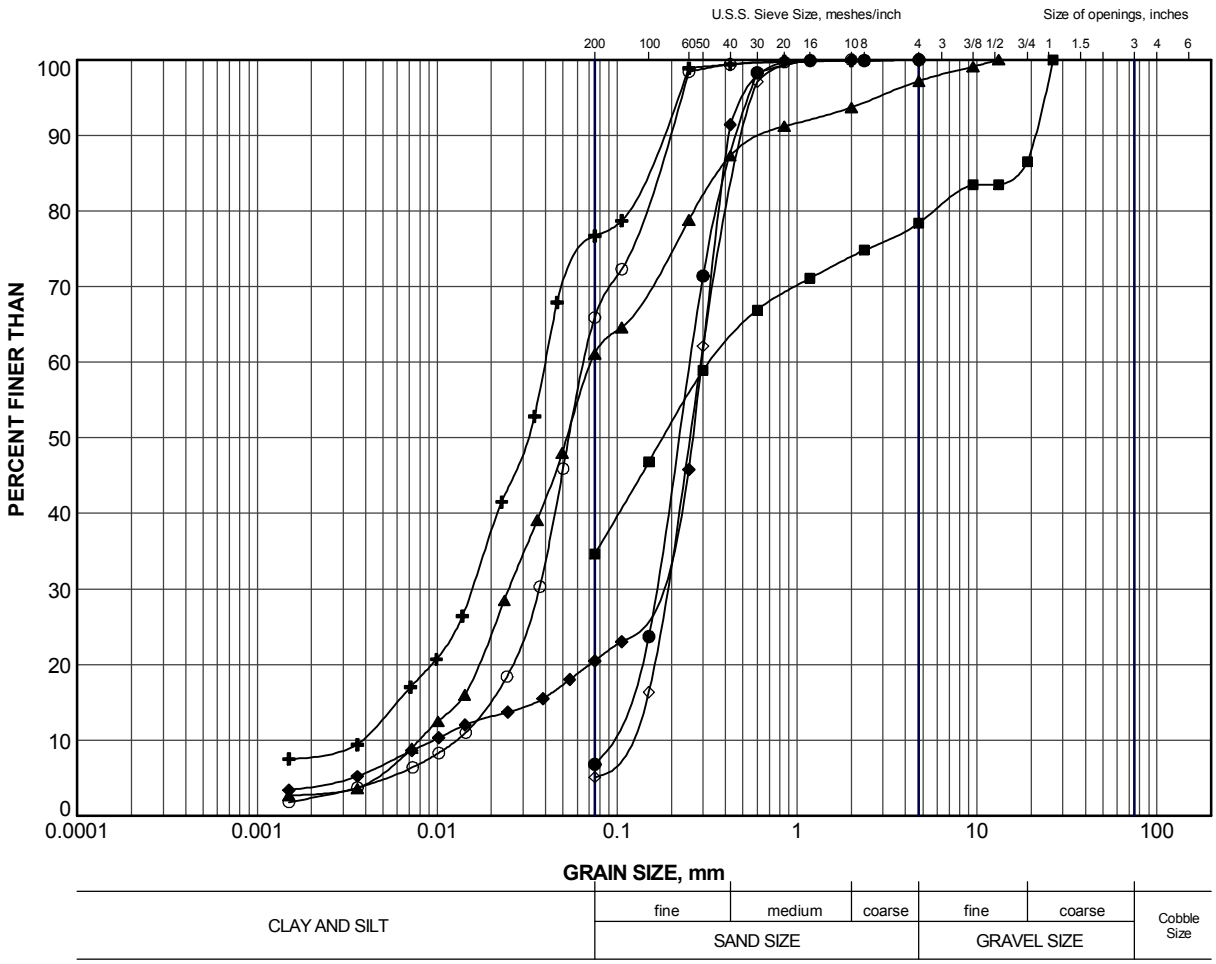
GRAIN SIZE DISTRIBUTION

CLAYEY SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1191-0042		FILE No. 09-1191-0042-4000.GPJ	
DRAWN	JJL	Nov 2011	SCALE N/A	REV.
CHECK	AB	Nov 2011		
APPR	JMAC	Nov 2011	**FIGURE B-3**	

LDN_MTO_NEW GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH09-01	7	249.8
■	BH09-01	11	243.6
▲	BH09-07	11	244.1
✚	BH09-08	6	247.7
◆	BH09-09	4	249.4
◇	BH09-09	7	247.1
○	BH09-09	8	245.6

PROJECT

HIGHWAY 11 NBL CULVERT 27+340

TITLE

GRAIN SIZE DISTRIBUTION

SAND TO SAND AND SILT

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	09-1191-0042		FILE No. 09-1191-0042-4000.GPJ	
DRAWN	JJL	Nov 2011	SCALE N/A	REV.
CHECK	AB	Nov 2011		
APPR	JMAC	Nov 2011	**FIGURE B-4**	

LDN_MTO_NEW GLDR_LDN.GDT

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1010 Lorne Street
Sudbury, Ontario, P3C 4R9
Canada
T: +1 (705) 524 6861

Golder Associates