



April 18, 2012

FOUNDATION INVESTIGATION REPORT

**CULVERT 34 - STA 20+287, PECK TOWNSHIP
HIGHWAY 60 FROM WEST GATE
EASTERLY 24.5 KM TO STATION ROAD
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5551-04-00**

Submitted to:

HDR Corporation
100 York Boulevard, Suite 300
Richmond Hill, Ontario
L4B 1J8

REPORT

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by HDR Corporation (HDR), on behalf of the Ministry of Transportation, Ontario (MTO), to provide foundation engineering services for the replacement of a culvert at STA 20+287 on Highway 60 in Peck Township, Ontario. The Key Plan showing the general location of this section of Highway 60 and the location of the investigated area are shown on Drawing 1. The purpose of this investigation is to establish the subsurface conditions at the location of the proposed culvert by borehole drilling, rock coring, in situ testing and laboratory testing on selected samples.

2.0 SITE DESCRIPTION

The replacement culvert (Culvert 34) will be located at the same station and on the same alignment as the existing culvert at STA 20+287 in Peck Township, approximately 15 km east of the west gate to Algonquin Park. The existing highway grade at the culvert location is at about Elevation 425.6 m, up to about 7.3 m above the surrounding terrain which is at Elevation 418.2 m and 420.4 m at the south and north toe of slope, respectively. The south side slope of the existing embankment is formed at about 2 Horizontal to 1 Vertical (2H:1V) to the top of the culvert and then steeper to the toe of the slope, resulting in an overall local side slope of about 1.7H:1V. The north side slope of the existing embankment is formed at about (2.7H:1V).

In general, the topography in the area of the overall project limits consists of rolling terrain, including densely treed areas, numerous bedrock outcrops and steep valleys. Open water is present beyond the culvert outlet south of Highway 60, discharging into nearby Smoke Lake. At the time of our investigation, the culvert did not have water flowing through it.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation associated with the replacement of the culvert at STA 20+287 was carried out on August 25 and September 6 to 12, 2011, during which time a total of three (3) Boreholes (C34-1 to C34-3) were advanced along the culvert alignment. In addition, seven (7) probe holes were advanced in the immediate vicinity of C34-2 and C34-3 to confirm the depth to refusal, as noted in the Record of Borehole sheets. The locations of, and ground surface elevations at, the boreholes are shown on Drawing 1.

Borehole C34-1, located on the existing highway embankment, was advanced using a track-mounted CME 55 drill rig outfitted with 108 mm inside diameter continuous flight hollow-stem augers, NW casing with wash boring and NQ size core barrel. Boreholes C34-2 and C34-3, located at the south and north toe of slope, respectively, were advanced using portable equipment outfitted with BW casing and thin-wall NQ coring equipment. All equipment was supplied and operated by Landcore Drilling Inc. of Sudbury, Ontario. The boreholes were advanced through the overburden using primarily wash boring methods and through cobbles/boulders using rock coring techniques. Soil samples in Borehole C34-1 were obtained continuously, or at intervals of depths of about 0.75 m and 1.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler (driven by an automatic hammer), performed in accordance with Standard Penetration Test (SPT) procedure (ASTM D1586) or using a thin-wall NQ core barrel. Boreholes C34-2 and C34-3 were advanced using portable equipment, and the split-spoon sampler was driven by a ½ weight hammer that was lifted manually to the SPT height. The number of blows per 0.3 m of penetration was converted to 'N'-values for the lower energy drive. Samples of the bedrock were obtained using a thin-wall NQ core barrel which fits inside NW or BW casing. All boreholes were backfilled with bentonite upon completion of drilling and coring in accordance with Ontario Reg. 903 (as amended).



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As requested by the Ministry of Natural Resources (MNR), both the track-mounted and portable drill rigs were washed and sterilized with a 10 per cent bleach solution prior to being mobilized to site. The drill rigs were subsequently re-sterilized upon every re-entry to the site. These sterilization methods were completed in accordance with our Environmental Protection Plan.

Traffic protection was implemented for the boreholes drilled within the roadway in accordance with the Traffic Protection Plan for this project and MTO Book 7 "Temporary Conditions Manual of the Ontario Traffic Manual" (2001).

The boreholes were advanced to depths ranging between 3.6 m and 12.9 m below the ground surface, which includes coring of bedrock for depths ranging from about 1.7 m to 3.3 m below the surface of the bedrock. 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.

The fieldwork was supervised throughout by members 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 and bedrock core 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 and grain size distribution) was carried out on selected soil samples. Strength testing (uniaxial compression) was also carried out on selected specimens of the bedrock core. The results of the laboratory testing are presented on the Record of Borehole and Drillhole sheets in Appendix A and are also included in Appendix B.

The highway was surveyed for station location and the stationing was painted on the asphalt surface by exp (formerly Trow), sub-consultant to HDR, prior to drilling. The as-drilled borehole locations and ground surface elevations were measured and surveyed by members of our technical staff, referenced to the painted stations on the highway. The MTM NAD 83 northing and easting coordinates, ground surface elevations referenced to Geodetic datum and borehole depth at each borehole are presented on the Record of Borehole sheets in Appendix A and are summarized below.

Borehole	Borehole Location		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
C34-1	5044664.9	367267.9	425.6	12.9
C34-2	5044647.5	367276.9	418.2	3.6
C34-3	5044678.9	367251.0	420.4	4.9



4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Published literature indicates that the site is located in the McClintock Domain of the Algonquin Terrane, which is located in the Grenville Province (Geology of Ontario; OGS Special Volume 4)¹. The bedrock of this domain generally consists of metasedimentary gneiss in granulite facies.

Based on terrain mapping (Ontario Geological Survey²), the site is located with a bedrock ridge below a ground moraine veneer with a ridged moderate local relief and a dry surface condition.

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 and bedrock core samples, are given on the attached Record of Borehole and Drillhole sheets in Appendix A. Detailed results of the laboratory testing of the soil samples are provided in Appendix B. The stratigraphic boundaries shown on the Record of Borehole and Drillhole sheets 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 and rock types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

The inferred stratigraphy as encountered in the boreholes is shown on Drawing 1. It should be noted that the orientation (i.e. north, south, east, west) stated in the text of the report is typically referenced to project north (i.e. Highway 60 is oriented east - west) and therefore may differ from that shown on the drawings which represents magnetic north.

In general, the subsurface stratigraphy along the culvert alignment consists of topsoil or embankment fill, underlain by a deposit of sand and silt to silt underlain by a deposit of cobbles and boulders, overlying gneiss bedrock.

4.2.1 Topsoil

Approximately 0.1 m of topsoil was encountered at the ground surface at Elevation 418.2 m and 420.4 m in Boreholes C34-2 and C34-3, respectively.

4.2.2 Fill

Borehole C34-1 was advanced through the existing Highway 60 embankment and penetrated a layer of asphalt 60 mm thick, underlain by an approximately 75 m thick layer of granular fill which, in turn, is underlain by another layer of asphalt 320 mm thick. Underlying the asphalt in Borehole C34-1 and underlying the topsoil in

¹ Geology of Ontario, 1991. Ontario Geological Survey, Special Volume 04, Part 1. Eds. P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott. Ministry of Northern Development and Mines, Ontario.

² Southern Ontario Engineering Geology Terrain Study, 1980. Ontario Geological Survey.



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Boreholes C34-2 and C34-3, the boreholes penetrated a deposit of fill consisting of sand to sand and gravel, trace to some silt, trace organics and/or blast rock, with a thickness between 0.3 m and 5.6 m, respectively. In Borehole C34-1, the fill deposit is comprised of a 0.9 m thick layer of sand, underlain by a 3.5 m thick layer of blast rock in a sand and gravel matrix, and a 1.2 m thick layer of sand. The top of the fill was encountered at Elevation 425.0 m (below the lower layer of asphalt) in Borehole C34-1 and at Elevation 418.1 m and 420.3 m in Boreholes C34-2 and C34-3, respectively.

The SPT 'N'-values measured within the fill range between 9 blows and 37 blows per 0.3 m of penetration, indicating a loose to dense relative density. When coring through the blast rock fill between a depth of 2.1 m and 4.0 m, a Total Core Recovery (TCR) of 40 per cent was recorded. In Boreholes C34-2 and C34-3, the split-spoon was noted to bounce upon penetrating the SPT sample depth.

The grain size distribution of one sample of the sand fill is shown on Figure B1 in Appendix B.

The measured water content on two samples of the fill is about 4 per cent and 13 per cent.

4.2.3 Sand and Silt to Silt

A 2.9 m thick deposit of grey sand and silt to silt containing trace to some clay and trace gravel was encountered underlying the fill in Borehole C34-1. The top of the deposit was encountered at a depth of about 6.1 m below the top of the embankment, at Elevation 419.5 m.

The SPT 'N'-values measured within this deposit range between 13 blows and 63 blows per 0.3 m of penetration, indicating a compact to very dense relative density. The split-spoon was noted to be bouncing at the bottom of the lowest sample taken.

The grain size distributions of two samples of this deposit are shown on Figure B2 in Appendix B.

The measured water content on two samples of this deposit is about 17 per cent and 19 per cent.

4.2.4 Cobbles and Boulders

A layer of cobbles and boulders between 0.8 m and 1.2 m thick was encountered underlying the fill or sand and silt to silt deposit in all the boreholes. The top of the cobbles and boulders layer was encountered between the depths of 0.4 m and 9.0 m below ground/pavement surface, at between Elevation 420.0 m and 416.6 m, respectively.

Rock coring techniques were used to advance the boreholes through the layer of cobbles and boulders. In Borehole C34-1, a TCR of 46 per cent was achieved between the depths of 9.0 m and 9.8 m. Split-spoon samples were taken at depths of 1.7 m and 0.8 m in Boreholes C34-2 and C34-3, respectively, and the split-spoon was noted to be bouncing with no sample being recovered. Boulders were penetrated in Borehole C34-2, between the depths of 0.7 m and 1.2 m and between 1.2 m and 1.9 m, with a TCR of 100 per cent and 0 per cent, respectively. Similarly, in Borehole C34-3, a boulder was penetrated between a depth of 0.4 m and 1.6 m with a TCR of 0 per cent. A total of seven probe holes were advanced by hand methods at both the north and the south sides of the embankment near the ends of the existing culvert to depths ranging from 0.1 m to 1.0 m below ground surface at which depths the split-spoon encountered refusal conditions (i.e. bouncing) on inferred cobbles and boulders.



4.2.5 Bedrock

Bedrock was encountered in all of the boreholes at depths ranging from 1.6 m to 9.8 m below the ground/pavement surface, corresponding to between Elevation 418.8 m and 415.8 m.

Based on a review of the bedrock core samples, the bedrock generally consists of fine to coarse grained, fresh to highly weathered, pinkish grey gneiss, as presented in the Record of Drillhole sheets in Appendix A. Photographs of the retrieved bedrock core samples are shown on Figure B3.

The TCR for the bedrock core samples ranges from about 51 per cent to 100 per cent. For the core samples obtained from Boreholes C34-1 and C34-3, the Solid Core Recovery (SCR) ranges from about 37 per cent to 85 per cent and the Rock Quality Designation (RQD) ranges from about 37 per cent to 100 per cent, indicating that generally the rock is of poor to excellent quality according to Table 3.10 in the Canadian Foundation Engineering Manual (CFEM, 2006). In Borehole C34-2, the SCR and RQD is 0 per cent.

Laboratory Unconfined Compression Strength (UCS) testing was carried out on two core samples of the bedrock. The UCS values which are presented on the Record of Drillhole Sheets in Appendix A and summarized below, indicate that the bedrock is very strong ($R5, 100 \text{ MPa} < \text{UCS} < 250 \text{ MPa}$) as per Table 3.5 of CFEM (2006).

Borehole	Elevation (m)	UCS (MPa)
C34-1	414.3	134
C34-3	416.8	140

4.2.6 Groundwater Conditions

The unstabilized water level in Boreholes C34-1 and C34-3 was measured at depths of 6.1 m and 0.2 m below pavement/ground surface, corresponding to Elevation 419.5 m and 420.2 m, respectively. Borehole C34-2 was dry upon completion of drilling. The groundwater level in the area is subject to seasonal fluctuations and variations due to precipitation events.

5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Ed Savard and Mr. Matt Thibeault EIT, under the overall direction of Mr. Evan Childerhose, P.Eng. This report was prepared by Mr. Evan Childerhose, P.Eng, and the technical aspects were reviewed by Ms. Sarah E. M. Coyne, P.Eng., a senior 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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Report Signature Page

GOLDER ASSOCIATES LTD.



Evan Childerhose, P.Eng.
Geotechnical Engineer

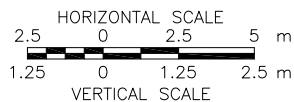
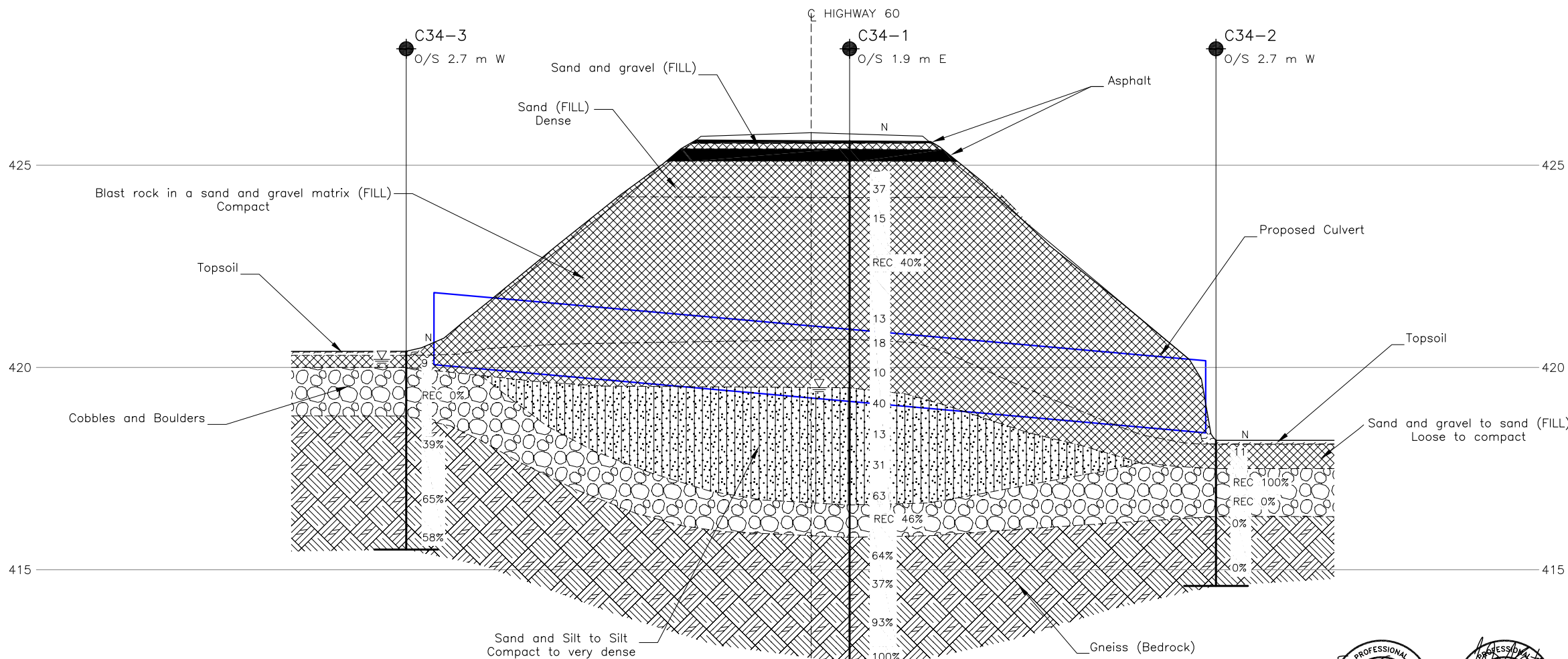
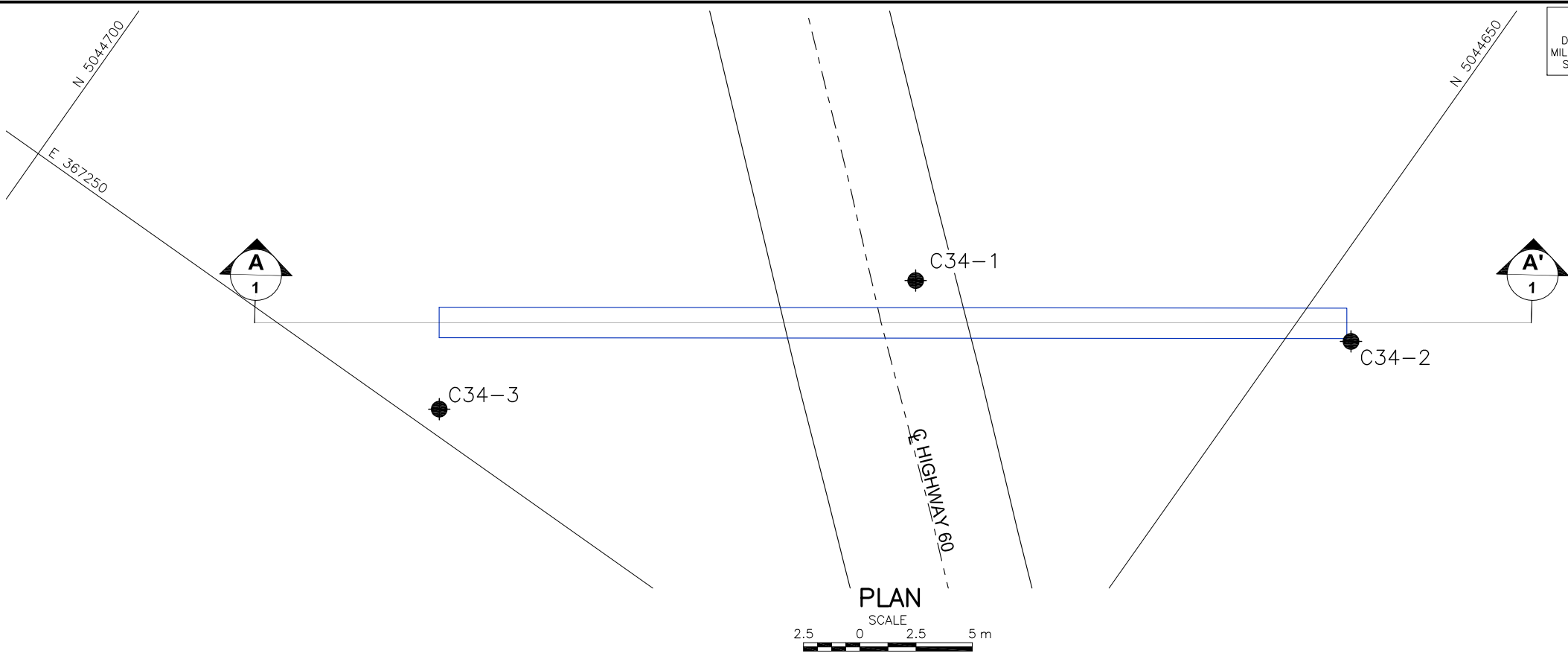
Sarah E. M. Coyne, P.Eng.
Associate, Senior Geotechnical Engineer



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

EC/SEMC/JMAC/lb/cl

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

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WP No. 5551-04-00

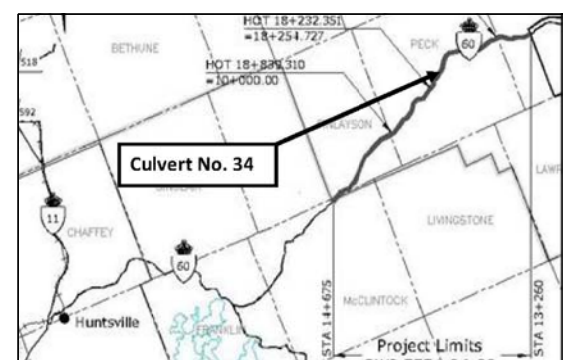
HIGHWAY 60
CULVERT AT STA. 20+287
BOREHOLE LOCATIONS AND
SOIL STRATA



SHEET



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- REC Recovery
- WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C34-1	425.6	5044664.9	367267.9
C34-2	418.2	5044647.5	367276.9
C34-3	420.4	5044678.9	367251.0

NOTES

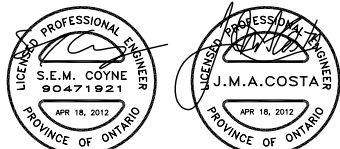
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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 HDR, PDF file no. 2011-07-14 Option G at Culvert 34.pdf, received JULY 14, 2011.
Original ground / culvert profile based on PDF received from HDR on OCT. 27, 2011.



NO.	DATE	BY	REVISION
Geocres No. 31E-314			
HWY. 60	PROJECT NO. 09-1191-0062		DIST.
SUBM'D. EC	CHKD.	DATE: APR 2012	SITE:
DRAWN: JJJ	CHKD. SEMC	APPD. JMAC	DWG. 1



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CULVERT 34 - STA 20+287, PECK TOWNSHIP**

APPENDIX A

Record of Boreholes and Drillholes



LIST OF SYMBOLS

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

1. 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
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
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

* 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 $= \sigma'_p / \sigma'_{vo}$

(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, 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) 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

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



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of Major discontinuities

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock Mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very thickly bedded	> 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	< 6 mm

JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very wide	> 3 m
Wide	1 – 3 m
Moderately close	0.3 – 1 m
Close	50 – 300 mm
Very close	< 50 mm

GRAIN SIZE

<u>Terms</u>	<u>Size*</u>
Very Coarse Grained	> 60 mm
Coarse Grained	2 – 60 mm
Medium Grained	60 microns – 2 mm
Fine Grained	2 – 60 microns
Very Fine Grained	< 2 microns

* Note: Grains > 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separation) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole, a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separation such as fractures, bedding planes and foliation planes or mechanically induced fractures caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

B - Bedding	⊥ - Perpendicular To
FO - Foliation / Schistosity	- Parallel To
CL - Cleavage	P - Polished
SH - Shear Plane / Zone	K - Slickensided
VN - Vein	SM - Smooth
F - Fault	R - Rough
CO - Contact	ST - Stepped
J - Joint	PL - Planar
FR - Fracture	U - Undulating
MF - Mechanical Fracture	C - Curved

PROJECT		09-1191-0062		RECORD OF BOREHOLE No C34-1		1 OF 1 METRIC											
W.P.		5551-04-00		LOCATION		N 5044664.9; E 367267.9											
DIST		HWY 60		BOREHOLE TYPE		108 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring (Auto Hammer)											
DATUM		Geodetic		DATE		August 25, 2011											
ORIGINATED BY		EHS		COMPILED BY		EC											
CHECKED BY		SEMC															
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60	W _p W W _L	γ	GR SA SI CL					
425.6	GROUND SURFACE																
0.0	ASPHALT (60 mm)		1	AS	-												
425.1	Sand and gravel (FILL)		2	AS	-		425										
0.5	ASPHALT (320 mm)		3	SS	37												
424.2	Sand, some gravel, trace to some silt (FILL) Dense Brown Moist		4	SS	15		424										
1.4	Blast rock, in a sand and gravel matrix (FILL) Compact Brown and grey Moist			RC	REC 40%		423										
							422										
	Spoon attempted at 4.0 m depth: No recovery.		-	SS	13		421										
420.7			5	SS	18												
4.9	Sand, some gravel, trace to some silt (FILL) Compact Brown Wet		6	SS	10		420										
419.5							419										
6.1	SAND and SILT to SILT, trace to some clay, trace gravel Compact to very dense Grey Wet		7	SS	40												
			8	SS	13		418										
			9	SS	31		417										
416.6			10	SS	63												
9.0	COBBLES and BOULDERS (as recovered in core barrel)		-	RC	REC 46%		416										
415.8							415										
9.8	GNEISS (BEDROCK) Bedrock cored from 9.8 m depth to 12.9 m depth. For coring details see Record of Drillhole C34-1.		1	RC	REC 100%												
			2	RC	REC 100%		414										
			3	RC	REC 100%		413										
412.7			4	RC	REC 100%												
12.9	END OF BOREHOLE																
	Note: 1. Water level at a depth of 6.1 m below ground surface (Elev. 419.5 m) upon completion of drilling.																

SUD-MTO 001 09-1191-0062 HWY 60 HDR.GPJ GAL-MISS.GDT 17/11/11 DATA INPUT:

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Landcore Drilling Inc.

CHECKED: SEMC

MTOR-RCK 001 09-1191-0062 HWY 60 HDR.GPJ GAL-MISS.GDT 17/11/11 DATA INPUT:

PROJECT		RECORD OF BOREHOLE No C34-2				1 OF 1 METRIC											
W.P. 5551-04-00		LOCATION N 5044647.5; E 367276.9				ORIGINATED BY MT											
DIST HWY 60		BOREHOLE TYPE Portable Equipment, BW Casing, Wash Boring				COMPILED BY EC											
DATUM Geodetic		DATE September 6-8, 2011				CHECKED BY SEMC											
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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
418.2	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL		1	SS	11		418										
0.1	Sand and gravel, trace to some silt, trace organics (FILL)																
0.7	Compact Brown and black Wet			RC	REC 100%		417										
	Spoon bouncing at 0.4 m depth. COBBLES and BOULDERS			RC	REC 0%												
416.3	No recovery in core barrel between 1.2 m and 1.9 m depth						416										RQD = 0%
1.9	Spoon attempted at 1.7 m depth. GNEISS (BEDROCK)		1	RC	REC 100%												
	Bedrock cored from 1.9 m depth to 3.6 m depth.		2	RC	REC 51%		415										RQD = 0%
414.6	For coring details see Record of Drillhole C34-2.																
3.6	END OF BOREHOLE																
<p>Note:</p> <p>1. Borehole dry upon completion of drilling.</p> <p>2. Split Spoon sample obtained by driving with a 1/2 weight hammer. SPT 'N' value has been adjusted to the inferred value that would be obtained using a standard weight hammer.</p> <p>3. Additional three probe holes were advanced within a 1 m distance of this borehole and encountered refusal (i.e. spoon bouncing) between 0.1 m and 1.0 m depth.</p>																	

SUD-MTO 001 09-1191-0062 HWY 60 HDR.GPJ GAL-MISS.GDT 17/11/11 DATA INPUT:

PROJECT: 09-1191-0062

RECORD OF DRILLHOLE: C34-2

SHEET 1 OF 1

LOCATION: N 5044647.5 ;E 367276.9

DRILLING DATE: September 8, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SHR- Shear VN - Vein CJ - Conjugate BD- Bedding FO- Foliation CO- Contact OR- Orthogonal CL - Cleavage PL - Planar CU- Curved UN - Undulating ST - Stepped IR - Irregular PO- Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.																NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY k, cm/s			Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 ⁰	10 ¹	10 ²																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
2	BW	REFER TO PREVIOUS PAGE		416.3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													

DEPTH SCALE

1 : 50



LOGGED: MT

CHECKED: SEMC

MTO-RCK 001 09-1191-0062 HWY 60 HDR GPJ GAL-MISS GDT 17/11/11 DATA INPUT:

PROJECT		RECORD OF BOREHOLE		1 OF 1		METRIC																			
W.P.		LOCATION		ORIGINATED BY		MT/EHS																			
DIST		BOREHOLE TYPE		COMPILED BY		EC																			
DATUM		DATE		CHECKED BY		SEMC																			
09-1191-0062		N 5044678.9; E 367251.0																							
5551-04-00		Portable Equipment, BW Casing, Wash Boring																							
HWY 60		September 7, 9 and 12, 2011																							
Geodetic																									
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT			NATURAL MOISTURE CONTENT			LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa			W _p			W			W _L			γ			GR SA SI CL		
420.4	GROUND SURFACE							20 40 60 80 100			20 40 60			20 40 60			kN/m ³								
0.0	TOPSOIL		1	SS	9		420																		
420.0	Sand and gravel, trace silt, trace organics (FILL)			RC	REC 0%		419																		
0.4	Loose Brown Wet						418													RQD = 39%					
418.8	Spoon bouncing at 0.4 m depth. COBBLES and BOULDERS		1	RC	REC 93%		417													RQD = 65%					
1.6	Spoon attempted at 0.8 m depth, spoon bouncing.						416													RQD = 58%					
	No recovery in core barrel between 0.4 m and 1.6 m depth. GNEISS (BEDROCK)		2	RC	REC 100%																				
	Bedrock cored from 1.6 m depth to 4.9 m depth.		3	RC	REC 100%																				
415.5	END OF BOREHOLE																								
4.9	Note: 1. Water level at a depth of 0.2 m below ground surface (Elev. 420.2 m) upon completion of drilling. 2. Split Spoon sample obtained by driving with a 1/2 weight hammer. SPT 'N' value has been adjusted to the inferred value that would be obtained using a standard weight hammer. 3. Additional four probe holes were advanced within a 2 m distance of this borehole and encountered refusal (i.e. spoon bouncing) between 0.15 m and 0.4 m depth.																								

PROJECT: 09-1191-0062

RECORD OF DRILLHOLE: C34-3

SHEET 1 OF 1

LOCATION: N 5044678.9 ;E 367251.0

DRILLING DATE: September 12, 2011


















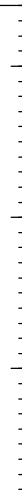

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY				Diameter Point Load Index (MPa)	RMC -Q AVG	NOTES WATER LEVELS INSTRUMENTATION
				DEPTH (m)				TOTAL CORE %	SOLID CORE %			B Angle	DIPWELL CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 ⁻⁶ k, cm/s	10 ⁻⁶ k, cm/s	10 ⁻⁶ k, cm/s				

2	BW	REFER TO PREVIOUS PAGE		418.8	1																																																																																																																																																																																																																																																																																												
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DEPTH SCALE

1 : 50



LOGGED: MT/EHS

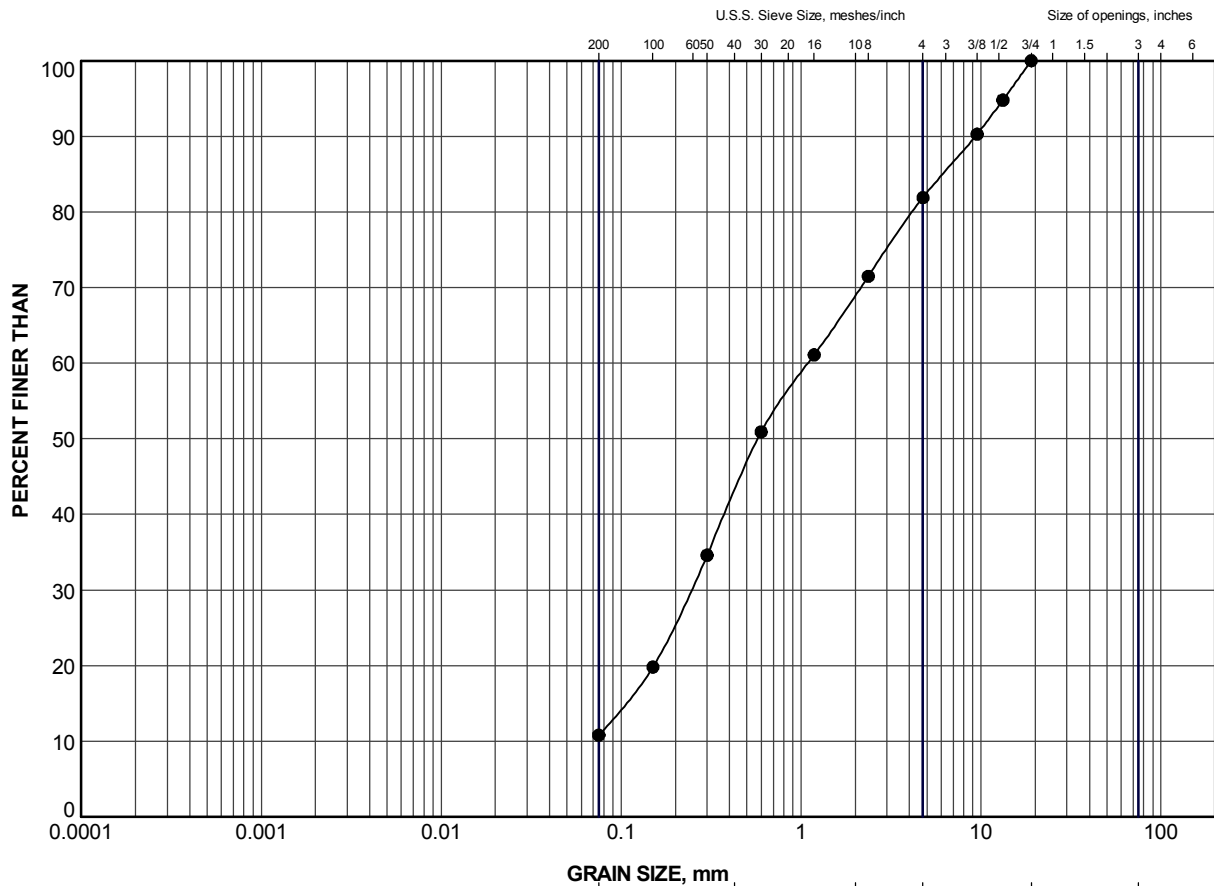
CHECKED: SEMC

MTO-RCK 001 09-1191-0062 HWY 60 HDR GFI GAL-MISS GDT 17/11/11 DATA INPUT:



APPENDIX B


Laboratory Test Results

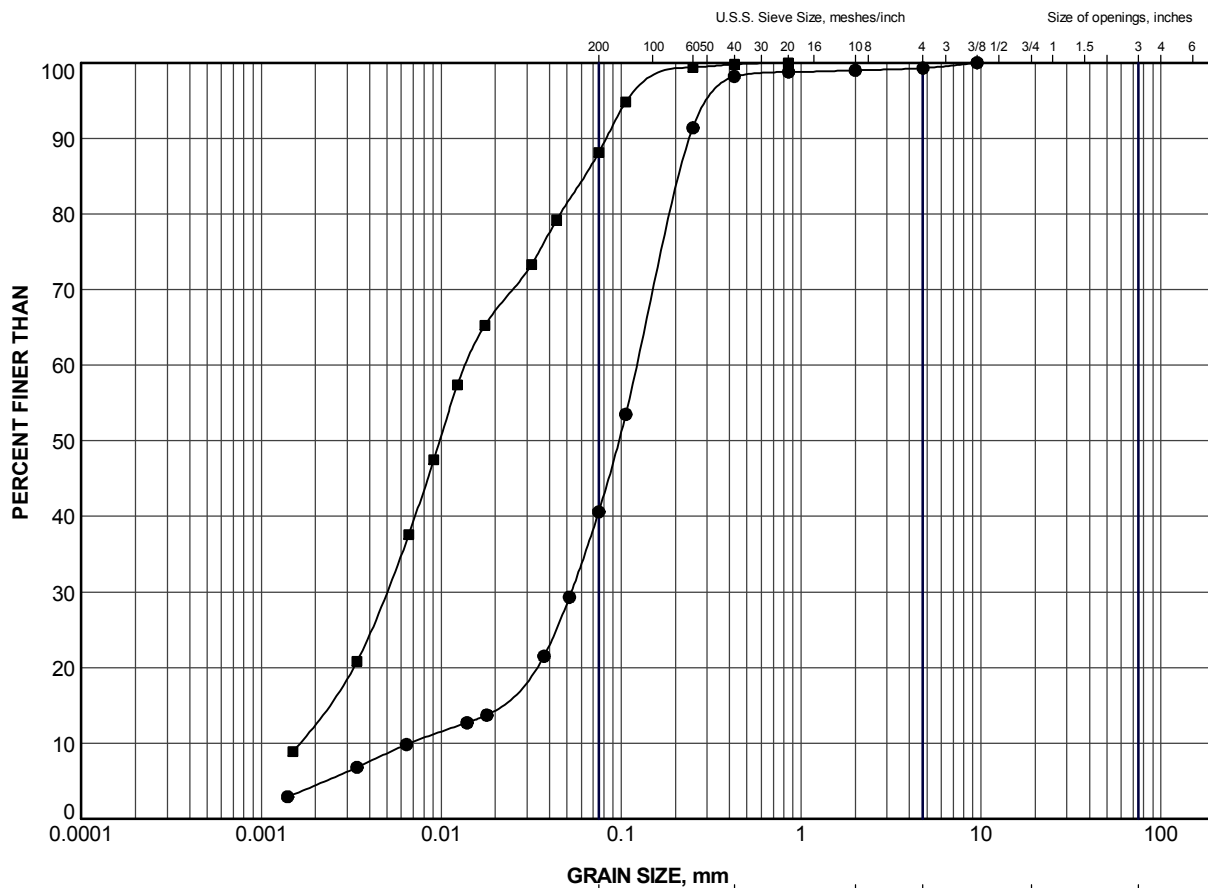


GRAVEL SIZE, mm						Cobble Size
CLAY AND SILT	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C34-1	3	424.5


PROJECT						
HIGHWAY 60 CULVERT AT STA 20+287						
TITLE						
GRAIN SIZE DISTRIBUTION SAND (FILL)						
		PROJECT No.		09-1191-0062		
		DRAWN		JJL	Nov 2011	
		CHECK		SEMC	Nov 2011	
		APPR		JMAC	Nov 2011	
		SCALE		N/A		
		REV.				
		FIGURE B1				

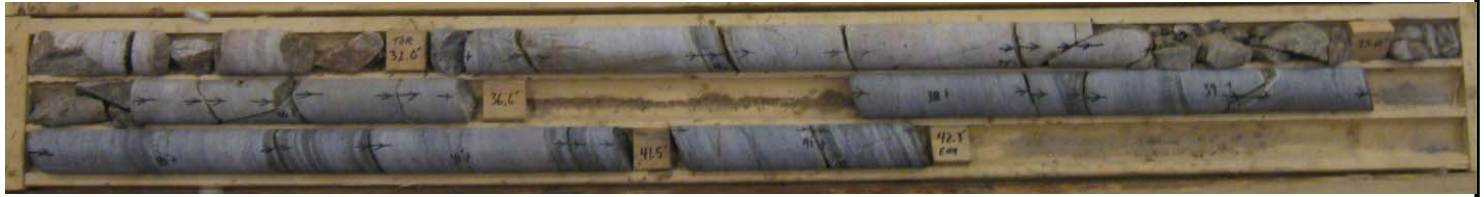


GRAVEL SIZE, mm							Cobble Size
CLAY AND SILT	fine	medium	coarse	fine	coarse		
	SAND SIZE			GRAVEL SIZE			

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C34-1	8	418.4
■	C34-1	10	416.9

PROJECT					HIGHWAY 60 CULVERT AT STA 20+287				
TITLE					GRAIN SIZE DISTRIBUTION SAND AND SILT TO SILT				
PROJECT No.		09-1191-0062		09-1191-0062 HWY 60 HDR.GPJ		SCALE		N/A	
DRAWN		JJL		Nov 2011		CHECK		SEMC	
APPR		JMAC		Nov 2011		REV.			
					FIGURE B2				




C34-1: 9.8 m – 12.9 m



C34-2: 1.9 m – 3.6 m



C34-3: 1.6 m – 4.9 m

PROJECT		CULVERT AT STA 20+287, PECK TOWNSHIP HIGHWAY 60				
TITLE		BEDROCK CORE (Boreholes C34-1 to C34-3)				
	PROJECT No.		09-1191-0062		FILE No.	----
	DESIGN	EC	APR 2012		SCALE	AS SHOWN REV.
	CADD	--			FIGURE B3	
	CHECK	SEMC	APR 2012			
	REVIEW	JMAC	APR 2012			

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solutions@golder.com
www.golder.com

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

