



April 4, 2018

FOUNDATION INVESTIGATION REPORT

**REPLACEMENT OF HORNEPAYNE CREEK CULVERT - SITE NO. 38N-004/C
HIGHWAY 631, TOWNSHIP OF WICKSTEED, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5569-09-00, WP 5165-13-01**

Submitted to:

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REPORT



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PART A

**FOUNDATION INVESTIGATION REPORT
REPLACEMENT OF HORNEPAYNE CREEK CULVERT – SITE NO. 38N-004/C
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GWP 5569-09-00, WP 5165-13-01**



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by LEA Consulting Ltd. (LEA), on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the replacement of the Hornepayne Creek Culvert (Site No. 38N-004/C), located in on Highway 631 about 97 km north of Highway 17 in Wicksteed Township, Ontario. The key plan showing the general location of this section of Highway 631 and the location of the investigated area are shown on Drawing 1.

The purpose of this investigation is to establish the subsurface soil conditions at the existing culvert location by borehole drilling and laboratory testing on selected soil samples.

The Terms of Reference and Scope of Work for the Foundation Investigation are outlined in MTO's Request for Proposal dated April 2016. Golder's proposal for foundation engineering services associated with replacement of this structure is contained in Section 17.8 of LEA's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundations engineering services for this project, dated January 11, 2017.

2.0 SITE DESCRIPTION

The existing Hornepayne Creek Culvert consists of a twin 29 m long ellipse corrugated steel culverts, each 3.5 m wide. The approximate invert of the culvert is Elevation 320.5 m. In general, the topography of the site and surrounding area is relatively flat with dense tree cover beyond the highway right-of-way. The existing approach embankments are about 3 m to 4 m high relative to the creek. The water level in Hornepayne Creek was measured at the culvert site at Elevation 320.9 m in November 2016 and June 2017.

Photographs at the culvert area are shown on Photographs 1 to 4, following the text of this report.

3.0 INVESTIGATION PROCEDURE

The field work was carried out between June 7 and June 9, 2017, during which time six boreholes (HP-1 to HP-6) were advanced at the locations shown on Drawing 1. The borehole records are presented in Appendix A. The field investigation was carried out using the following drilling equipment:

- Boreholes HP-1 and HP-2 were advanced using a CME-55 truck-mounted drill rig supplied and operated by Landcore Drilling Inc. (Landcore) of Sudbury, Ontario.
- Boreholes HP-3 to HP-5 were advanced using a portable tripod drilling equipment supplied and operated by Downing. A dynamic cone penetration test (DCPT) was advanced adjacent to each of these three boreholes.
- Borehole HP-6 was advanced using a CME-55 track-mounted drill rig supplied and operated by Downing Drilling Inc. (Downing) of Grenville-sur-la-Rouge, Quebec.

The boreholes were advanced using 108 mm inner diameter hollow stem augers and/or NW casing and wash boring. Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer on the drill rigs in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586) and a manual half-weight hammer (Acker) on the portable drill rigs dropped from the SPT height and the blow counts were prorated to the inferred values that would be obtained with a standard weight hammer. A dynamic cone penetration test (DCPT) was carried out from ground surface adjacent to Boreholes HP-3 to HP-5. The groundwater level in the open boreholes was observed during and



FOUNDATION REPORT, REPLACEMENT OF HORNEPAYNE CREEK CULVERT, HIGHWAY 631, SITE 38N-004/C

immediately following the drilling operations as described on the borehole records in Appendix A. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (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, cleared the site for buried services, directed the drilling and sampling operations and logged the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's Sudbury Laboratory for further examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Index and classification tests consisting of water content, Atterberg limits and grain size distribution were carried out on selected soil samples. The results of the laboratory testing on samples from the boreholes are presented on the borehole records in Appendix A, and on the grain size distribution figures in Appendix B.

A soil sample was obtained on June 8, 2017, from Borehole HP-2, using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters including pH, resistivity, conductivity, sulphates and chlorides. The results of the analytical testing are presented in Table B1 in Appendix B.

The borehole locations and elevations were measured in the field by Golder personnel, relative to existing site features and surveyed to point HCP-101. The borehole locations (referenced to the MTM NAD83 Zone 12 co-ordinate system), ground surface elevations (referenced to Geodetic datum) and borehole depths at refusal, except for Borehole HP-6, are presented on the borehole records in Appendix A, and are summarized below.

Borehole	Location (MTM NAD 83, Zone12)		Location (WGS84)		Ground Surface Elevation (m)	Borehole Depth (m)	DCPT Depth (m)
	Northing	Easting	Latitude	Longitude			
HP-1	5451566.6	247796.2	49.199525	-84.782251	323.8	12.5	-
HP-2	5451591.8	247798.2	49.199752	-84.782227	324.0	13.9	-
HP-3	5451599.5	247812.8	49.199822	-84.782020	321.2	5.3	8.8
HP-4	5451588.3	247817.7	49.199722	-84.781959	321.2	5.5	5.5
HP-5	5451582.2	247777.8	49.199664	-84.782506	321.7	5.2	7.1
HP-6	5451564.7	247785.8	49.199507	-84.782393	321.4	9.8	-

4.0 SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)¹ mapping, the Hornpayne Creek Culvert is located within an outwash plain, consisting primarily of sands and silts, bordered by bedrock knobs.

Based on geological mapping by the Ontario Ministry of Northern Development and Mines (MNDM)², the site is underlain by bedrock from the metasedimentary suite of rocks comprised of wacke, arkose, argillite, slate, marble, chert, iron formation, minor metavolcanic rock.

¹ Ontario Ministry of Natural Resources and Forestry. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 42FNE

² Ontario Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2543



4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes together with the results of the laboratory tests carried out on selected soil samples, are presented on the borehole records in Appendix A, and the laboratory test sheets in Appendix B. The results of the in situ field tests (i.e., SPT 'N' values) as presented on the borehole records and in Section 4 are uncorrected, except for those obtained by use of the half weight hammer as noted in Section 3.0. The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic profile on 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. A summary of the subsurface conditions as encountered in Boreholes HP-1 and HP-6 is presented below.

4.2.1 Subsoil Conditions

A description of the soil deposits encountered in the boreholes is provided below.

Deposit/Layer Description	Boreholes	Deposit Surface Elevation (m)	Deposit Thickness (m)	N Values (blows)	Laboratory Testing
				Relative Density	
Asphalt	HP-1, HP-2	324.0, 323.8	0.1	n/a	n/a
(FILL) Silty SAND to Sand to Gravelly Sand	HP-1, HP-2, HP-5 and HP-6	323.9 - 321.3	0.3-2.6	N = 3 – 47	w = 3% – 6% 2 – M (Fig. B1)
				Very loose to Dense	
PEAT and Silty Topsoil	HP-3 to HP-6	321.7 - 321.2	0.1-1.4	N = 1 – 3	w = 58% and 139%
				Very soft to soft	
SILT to SILT and SAND	HP-1, HP-2, HP-5 and HP-6	321.7 - 320.2	2.5 – 6.1	N = WH (0) – 31	w = 18% – 40% 8 – MH (Fig. B2) 2 – AL (NP)
				Very loose to Dense	
SAND to Gravelly SAND	HP-2, HP-3, HP-4 and HP-6	320.9 - 315.3	0.7 - 4.5	N = 1 – 16	w = 15% – 22% 6 – MH (Fig. B3)
				Very loose to Compact	
Boulder	HP-2	317.7	0.9	N/A	N/A
(TILL) Gravelly Silty Sand to Sand and Gravel and cobbles	HP-1, HP-2 and HP-6	316.8 - 313.8	> 2.2 – 6.7	N = 18 – 50/0.08	w = 10% – 20% 3 – MH (Fig. B4)
				Compact to Very dense	

Where:

N = SPT 'N' values; number of blows for 0.3 m of penetration
w = Natural moisture content (%)
M = Sieve analysis
MH = Combined sieve and hydrometer analysis
AL = Atterberg Limits

¹A 0.1 m thick layer of peat and silty topsoil was encountered over the granular fill in Boreholes HP-5 and HP-6, respectively.



4.2.2 Groundwater Conditions

The depths to/elevations of unstabilized groundwater levels measured in the open boreholes upon completion of drilling are presented below. Water levels should be expected to vary depending on the time of year and precipitation events.

Borehole No.	Depth to Unstabilized Groundwater Level (m)	Approximate Groundwater Elevation (m)
HP-1	2.3	321.5
HP-2	3.0	321.0
HP-3	0.0	321.2
HP-4	0.0	321.2
HP-5	0.5	321.2
HP-6	0.6	320.8

The creek water level was surveyed by others at Elevation 320.9 m in November 2016 and June 2017.

5.0 CLOSURE

The field drilling program was supervised by Mr. Shane Albert and Mr. Mathew Riopelle. This Foundation Investigation Report was prepared by Ms. Aronne-Kay De Souza, EIT, and the technical aspects were reviewed by Mr. André Bom, P.Eng., a geotechnical engineer and Associate of Golder. Mr. Jorge M.A. Costa, P.Eng., a Designated MTO Foundations Contact and Senior Consultant of Golder, conducted an independent quality control review and technical audit of this report.

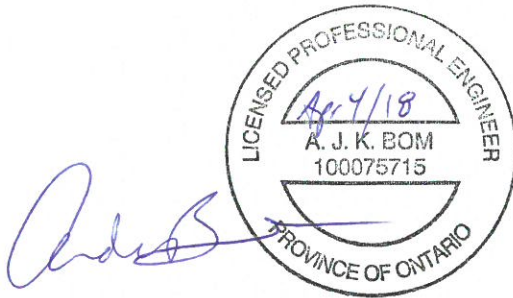


Report Signature Page

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Geotechnical Engineering Intern



Andre Bom, P.Eng.
Associate, Geotechnical Engineer

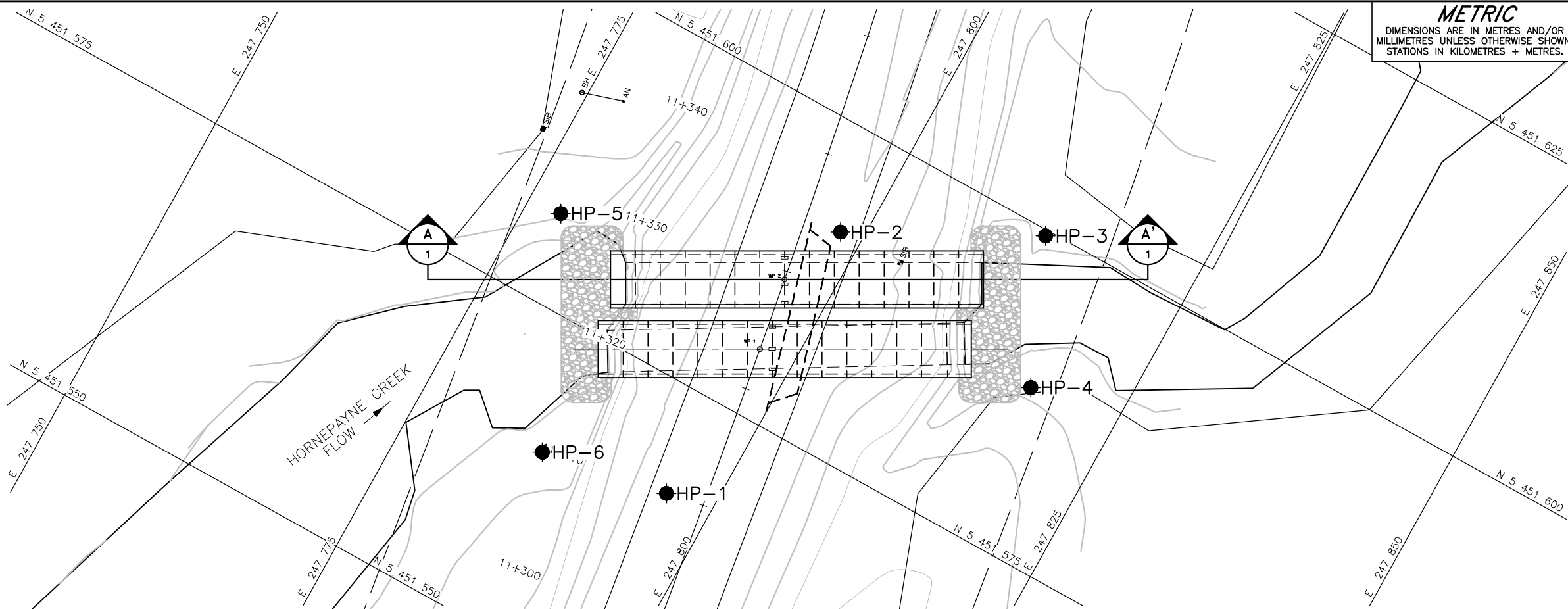


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Designated MTO Foundations Contact, Senior Consultant

AD/AB/JMAC/kp/ca

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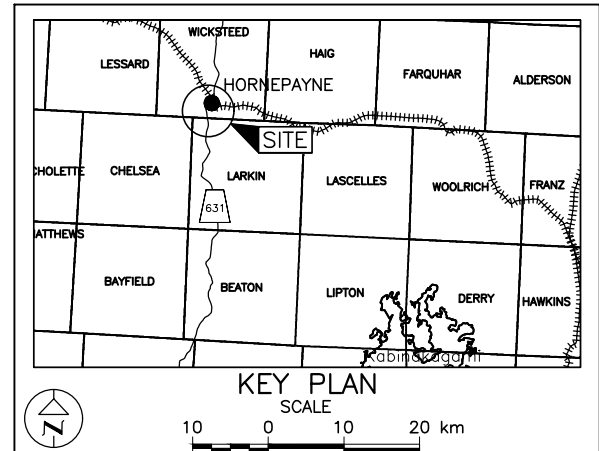


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 5569-09-00

HIGHWAY 631
HORNEPAYNE CREEK CULVERT REPLACEMENT
LAT. 49.199675, LONG. -84.782248
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



LEGEND

Borehole - Current Investigation

Standard Penetration Test Value

Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow)

WL upon completion of drilling

Refusal

BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 13)			
No.	ELEVATION	NORTHING	EASTING
HP-1	323.8	5451566.6	247796.2
HP-2	324.0	5451591.8	247798.2
HP-3	321.2	5451599.5	247812.8
HP-4	321.2	5451588.3	247817.7
HP-5	321.7	5451582.2	247777.8
HP-6	321.4	5451564.7	247785.8

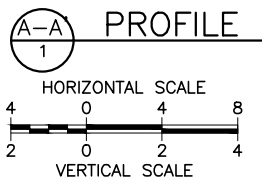
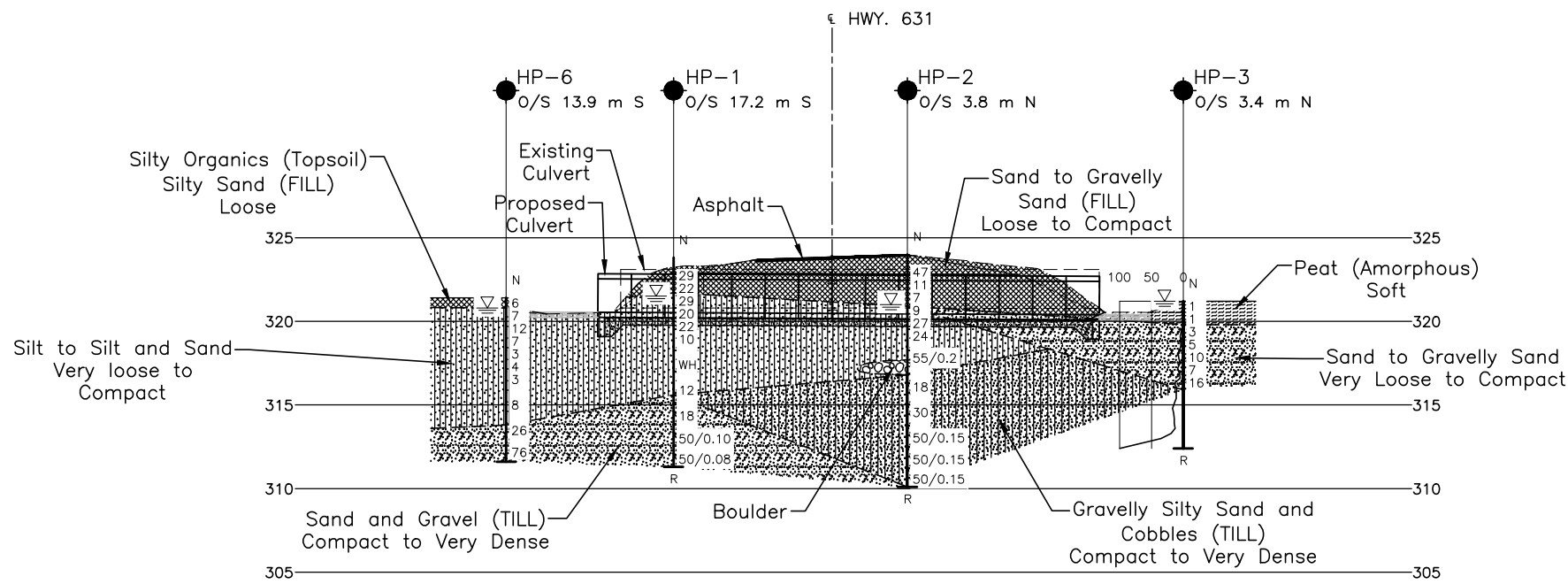
NOTES

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.

REFERENCE

Base plans provided in digital format by LEA, drawing file no. Hornepayne.dwg, received MAY 05, 2017. Hornepayne GA drawing file no. 17197-Hornepayne-S1-General Arrangement.dwg, received APR 04, 2018.



NO.	DATE	BY	REVISION
Geocres No. 42F-055			
HWY. 631	PROJECT NO. 1661607	DIST. .	
SUBM'D.	CHKD.	DATE: 4/4/2018	SITE: 38N-004/C
DRAWN: TB	CHKD. AB	APPD. JMAC	DWG. 1



PHOTOGRAPHS

**Photograph 1: Hornepayne Creek Culvert
East (Outlet) End (June 2017)**



**Photograph 2: Hornepayne Creek Culvert
West (Inlet) End (June 2017)**





PHOTOGRAPHS

**Photograph 3: Hornepayne Creek Culvert
Looking Southwest Upstream (June 2017)**



**Photograph 4: Hornepayne Creek Culvert
Looking South Along Road from North of Culvert (June 2017)**





APPENDIX A

Record of Boreholes



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

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.)

(b) Cohesive Soils Consistency

	kPa	Cu, Su	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

Dynamic Cone Penetration Resistance (DCPT); Nd:

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 (Qt), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

Per cent by Weight

Modifier

0 to 5	Trace
5 to 12	Trace to Some (or Little)
12 to 20	Some
20 to 30	(ey) or (y)
over 30	And (non-cohesive (cohesionless)) or With (cohesive)

Example

Trace sand
Trace to some sand
Some sand
Sandy
Sand and Gravel
Silty Clay with sand / Clayey Silt with sand

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MTO\1661607 LEA 5015-E-0049 NE REGION\02 DATA\GINT\1661607.GPJ GAL-MISS.GDT 11/3/17 TB/JJL

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

PROJECT 1661607		RECORD OF BOREHOLE No HP-2		1 OF 2 METRIC	
W.P. 5165-13-01		LOCATION N 5451591.8; E 247798.2 MTM ZONE 12 (LAT. 49.199752; LONG. -84.782227)		ORIGINATED BY SA	
DIST _____ HWY 631		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring		COMPILED BY AD	
DATUM GEODETIC		DATE June 8 and 9, 2017		CHECKED BY AB	



SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	w _p	w	w _L					
324.0	GROUND SURFACE																			
0.9	ASPHALT (50 mm)																			
	Gravelly sand (FILL)																			
323.5																				
0.5	Sand, trace gravel, trace silt (FILL)																			
	Loose to dense		1	SS	47															
	Brown																			
	Moist to wet																			
			2	SS	11															
			3	SS	7															
320.9																				
3.1	SAND, some gravel, trace silt		4	SS	9															
	Loose																			
	Grey																			
	Wet																			
320.2			5	SS	27															
3.8	SILT, some sand, trace gravel, trace organics		6	SS	24															
	Compact																			
	Grey																			
	Wet																			
317.7			7	SS	55/0.2															
6.3	BOULDER																			
316.8																				
7.2	Gravelly SILTY SAND and COBBLES (TILL)		8	SS	18															
	Compact to very dense																			
	Grey																			
	Wet																			
			9	SS	30															
			10	SS	50/0.15															

Continued Next Page



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

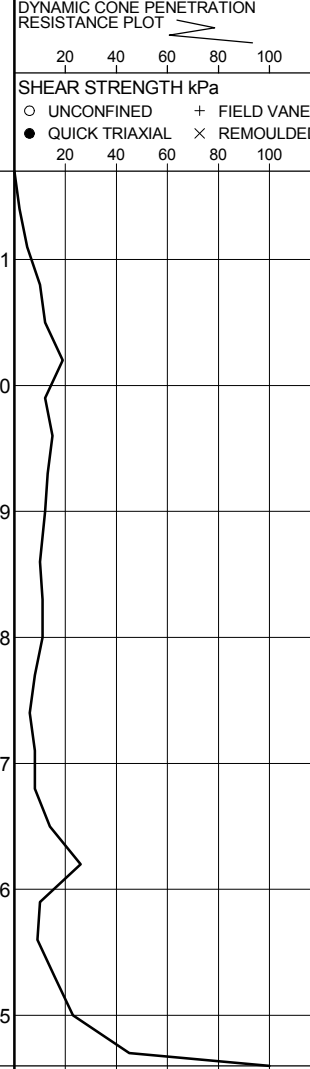
SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MTMTO1661607 LEA_5015-E-0049_NE REGION02_DATA\GINT\1661607.GPJ GAL-MISS GDT 11/3/17 TB\JUL

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

PROJECT 1661607		RECORD OF BOREHOLE No HP-3				1 OF 1 METRIC								
W.P. 5165-13-01		LOCATION N 5451599.5; E 247812.8 MTM ZONE 12 (LAT. 49.199822; LONG. -84.782020)				ORIGINATED BY MR								
DIST _____ HWY 631		BOREHOLE TYPE Portable Drill, NW Casing and Wash Boring				COMPILED BY AD								
DATUM GEODETIC		DATE June 8, 2017				CHECKED BY AB								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
321.2 0.0	GROUND SURFACE PEAT (Amorphous), trace sand, trace wood Very soft Black Wet		1	SS	1		321							
			2	SS	1		320							
319.8 1.4	SAND to Gravelly SAND, trace to some clay Very loose to compact Grey Wet		3	SS	3		319							
			4	SS	5		318							
			5	SS	10		317							
			6	SS	7		316							
			7	SS	16		315							
315.9 5.3	END OF BOREHOLE REFUSAL TO FURTHER CASING ADVANCEMENT						314							
312.4 8.8	END OF DCPT REFUSAL TO FURTHER PENETRATION Notes: 1. Water level at ground surface (Elev. 321.2 m) upon completion of drilling. 2. Split Spoon samples obtained by driving with a 1/2 weight hammer. SPT 'N' values have been adjusted to the inferred values that would be obtained using a standard weight hammer. 3. Advanced DCPT 0.6 m west of Borehole.						313							

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PROJECT 1661607		RECORD OF BOREHOLE No HP-4				1 OF 1 METRIC								
W.P. 5165-13-01		LOCATION N 5451588.3; E 247817.7 MTM ZONE 12 (LAT. 49.199722; LONG. -84.781959)				ORIGINATED BY MR								
DIST _____ HWY 631		BOREHOLE TYPE Portable Drill, NW Casing and Wash Boring				COMPILED BY AD								
DATUM GEODETIC		DATE June 9, 2017				CHECKED BY AB								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
321.2	GROUND SURFACE							20 40 60 80 100	20 40 60					
0.0	PEAT (Amorphous), trace sand Soft Black Wet		1	SS	3		321							
320.4	SAND, some gravel, trace silt, trace clay, trace organics in Samples 2 and 3 Very loose to compact Grey Wet		2	SS	1		320							9 88 (3)
0.8			3	SS	1		319							
			4	SS	2		318							17 72 7 4
			5	SS	7		317							
			6	SS	16		316							
			7	SS	21									17 75 (8)
315.9	END OF BOREHOLE REFUSAL TO FURTHER CASING ADVANCEMENT													
315.7	END OF DCPT REFUSAL TO FURTHER PENETRATION													
5.5	Notes: 1. Water level at ground surface (Elev. 321.2 m) upon completion of drilling. 2. Split Spoon samples obtained by driving with a 1/2 weight hammer. SPT 'N' values have been adjusted to the inferred values that would be obtained using a standard weight hammer. 3. Advanced DCPT 0.8 m west of Borehole.													

PROJECT 1661607			RECORD OF BOREHOLE No HP-5				1 OF 1 METRIC				
W.P. 5165-13-01		LOCATION N 5451582.2; E 247777.8 MTM ZONE 12 (LAT. 49.199664; LONG. -84.782506)				ORIGINATED BY MR					
DIST _____ HWY 631		BOREHOLE TYPE Portable Drill, NW Casing and Wash Boring				COMPILED BY AD					
DATUM GEODETIC		DATE June 7, 2017				CHECKED BY AB					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
321.7	GROUND SURFACE										
0.0	Peat (Amorphous) (FILL) Black Wet		1	SS	3						
0.1	Sand, trace to some gravel, trace organics (FILL) Very loose to compact Brown Wet		2	SS	12						
320.6	SILT, trace sand, trace gravel, trace rootlets Loose to compact Grey Wet		3	SS	11						0 3 90 7
1.1			4	SS	8						
			5	SS	6						0 6 87 7
			6	SS	5						
317.1	SILT and SAND, trace gravel, trace clay Dense Grey Wet		7	SS	31						5 43 48 4
316.5	END OF BOREHOLE REFUSAL TO FURTHER CASING ADVANCEMENT										
5.2											
314.6	END OF DCPT REFUSAL TO FURTHER PENETRATION										
7.1	Notes: 1. Water level at a depth of 0.5 m below ground surface (Elev. 321.2 m) upon completion of drilling. 2. Split Spoon samples obtained by driving with a 1/2 weight hammer. SPT "N" values have been adjusted to the inferred values that would be obtained using a standard weight hammer. 3. Advanced DCPT 0.8 m east of Borehole.										

PROJECT <u>1661607</u>		RECORD OF BOREHOLE No HP-6		1 OF 1 METRIC	
W.P. <u>5165-13-01</u>		LOCATION <u>N 5451564.7; E 247785.8 MTM ZONE 12 (LAT. 49.199507; LONG. -84.782393)</u>		ORIGINATED BY <u>MR</u>	
DIST <u> </u> HWY <u>631</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring</u>		COMPILED BY <u>AD</u>	
DATUM <u>GEODETIC</u>		DATE <u>June 9, 2017</u>		CHECKED BY <u>AB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	W _p	W	W _L					
321.4	GROUND SURFACE																			
0.0	Silty topsoil (FILL)		1	SS	6															
0.1	Silty sand, trace organics (FILL)																			
320.8	Loose Grey Wet																			
0.6	SILT, trace sand, trace rootlets in Samples 2 to 4 Very loose to compact Grey Wet		2	SS	7															
			3	SS	12															
			4	SS	7															
			5	SS	3															
			6	SS	4															
			7	SS	3															
315.3																				
6.1	SAND, trace gravel Loose Grey Wet		8	SS	8															
313.8																				
7.6	SAND and GRAVEL, some silt, trace clay (TILL) Compact to very dense Grey Wet		9	SS	26															
			10	SS	76															
311.6																				
9.8	END OF BOREHOLE																			
	Note: 1. Water level at a depth of 0.6 m below ground surface (Elev. 320.8 m) upon completion of drilling.																			

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

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APPENDIX B

Laboratory Test Results



**FOUNDATION REPORT, REPLACEMENT OF HORNEPAYNE CREEK
CULVERT, HIGHWAY 631, SITE 38N-004/C**

Table B1 - Summary of Analytical Testing of Soil Sample

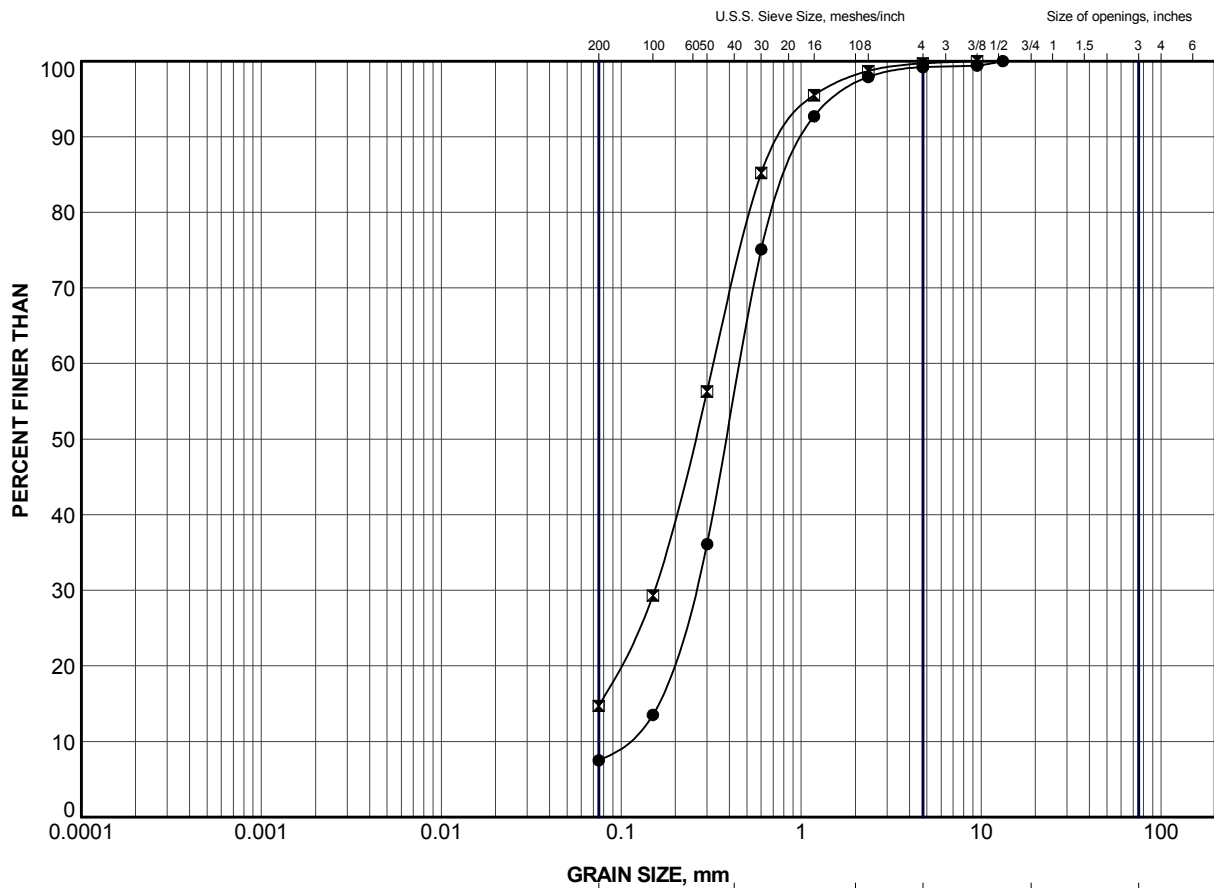
Parameter	Units	Borehole HP-2
Resistivity	ohm-cm	9800
Conductivity	µmho/cm	102
pH	pH	7.85
Sulphate	µg/g	Not Detected
Chloride	µg/g	Not Detected

Notes:

1. Sample obtained June 8, 2017

Prepared by: AD


Reviewed by: AB

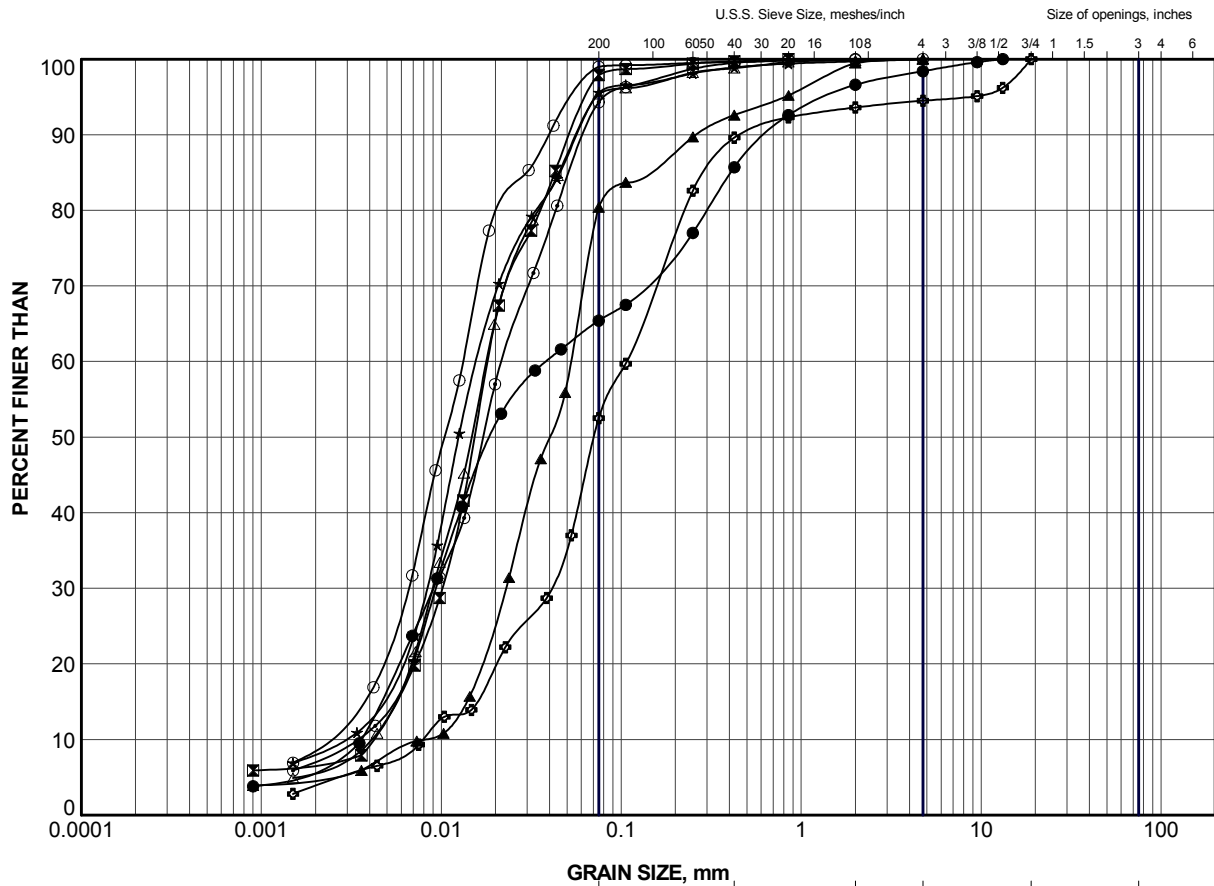


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	HP-1	1	322.7
×	HP-2	2	322.2

PROJECT					
HIGHWAY 631 HORNEPAYNE CREEK CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION SAND (FILL)					
PROJECT No.		1661607		FILE No.	
DRAWN		TB		Nov 2017	
CHECK		AB		Nov 2017	
APPR		JMAC		Nov 2017	
SCALE		N/A		REV.	
 Golder Associates SUDBURY, ONTARIO				FIGURE B1	



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	HP-1	4	320.4
⊠	HP-1	7	317.4
▲	HP-2	6	319.1
★	HP-5	3	319.9
⊙	HP-5	5	318.3
⊕	HP-5	7	316.8
○	HP-6	3	319.6
△	HP-6	6	317.3

PROJECT

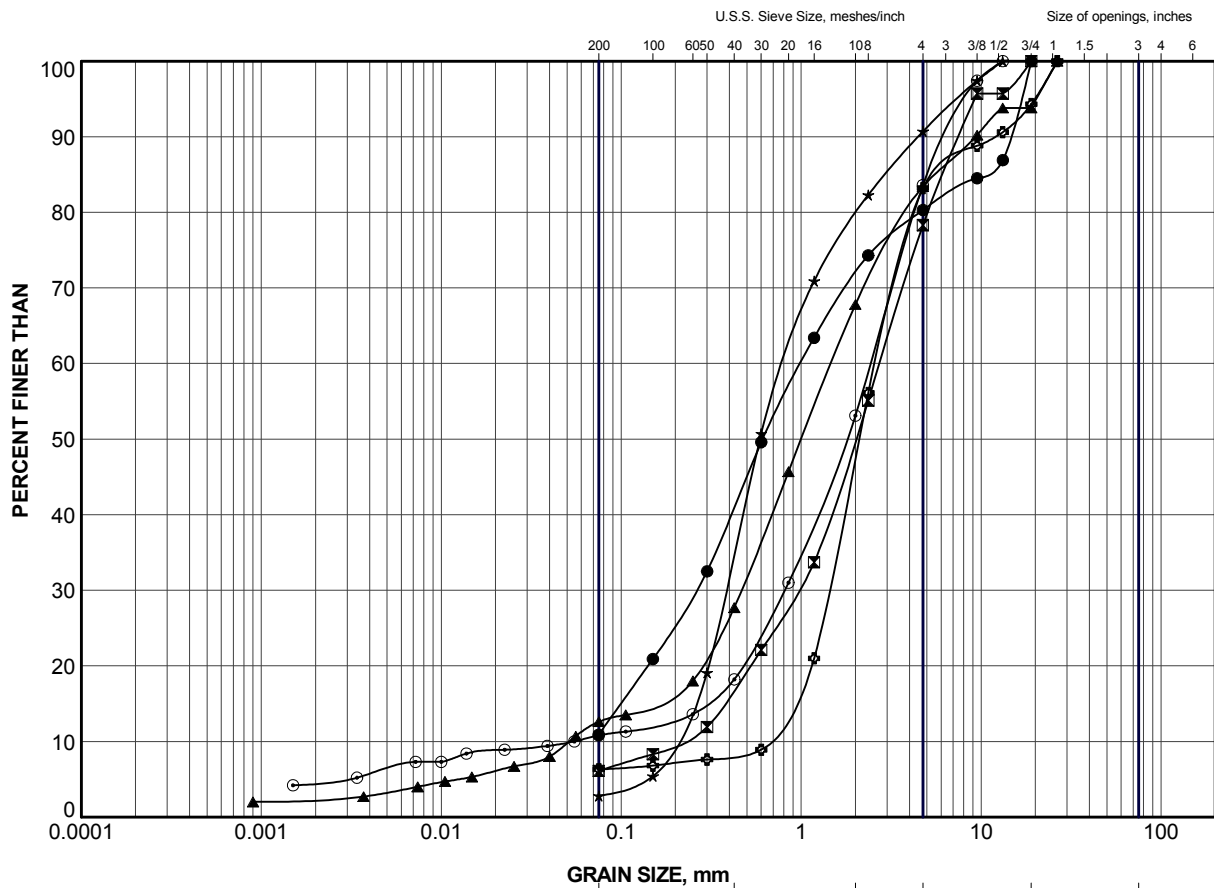
HIGHWAY 631
HORNEPAYNE CREEK CULVERT

TITLE

GRAIN SIZE DISTRIBUTION
SILT to SILT and SAND



PROJECT No. 1661607			FILE No. 1661607.GPJ		
DRAWN	TB	Nov 2017	SCALE	N/A	REV.
CHECK	AB	Nov 2017	FIGURE B2		
APPR	JMAC	Nov 2017			



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	HP-2	4	320.6
⊠	HP-3	4	318.6
▲	HP-3	6	317.1
★	HP-4	2	320.1
⊙	HP-4	4	318.6
⊕	HP-4	7	316.3

PROJECT

HIGHWAY 631
HORNEPAYNE CREEK CULVERT

TITLE

GRAIN SIZE DISTRIBUTION
SAND to GRAVELLY SAND



PROJECT No. 1661607			FILE No. 1661607.GPJ		
DRAWN	TB	Nov 2017	SCALE	N/A	REV.
CHECK	AB	Nov 2017	FIGURE B3		
APPR	JMAC	Nov 2017			

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