



October 7, 2016

FOUNDATION INVESTIGATION REPORT

**WATSON CREEK CULVERT - SITE NO. 48E-63/C
HIGHWAY 11, DISTRICT OF THUNDER BAY
TOWNSHIP OF McCOMBER
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P 6166-04-00, WP 6167-04-01**

Submitted to:

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GEOCRES No.: 42E-25

Report Number: 1533879-R07

Distribution:

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REPORT





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PART A

DETAIL FOUNDATION INVESTIGATION REPORT
WATSON CREEK CULVERT – SITE NO. 48E-63/C
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MINISTRY OF TRANSPORTATION, ONTARIO
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Hatch Ltd. (Hatch), on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the replacement of the Watson Creek culvert (Site No. 48E-63/C). The Watson Creek culvert is located in the District of Thunder Bay in the Township of McComber, across Highway 11 at STA 18+707, approximately 9.2 km west of Highway 801 in Nezhah, Ontario. The key plan showing the general location of this section of Highway 11 and the location of the investigated area are shown on Drawing 1.

2.0 SITE DESCRIPTION

The Watson Creek culvert consists of a twin cell timber box, the details of which (i.e., width, height, length, etc.) are summarized in Table 1 following the text of the report.

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 and therefore may differ from magnetic north shown on the drawing. For the purpose of this report, Highway 11 is oriented in a west-east direction with the culvert perpendicular to the highway in a north-south orientation.

In general, the topography in the area of the culvert consists of low-lying swampy terrain on both sides of Highway 11. At the culvert location, the highway grade is at Elevation 318.3 m and the culvert invert, as provided by MTO, is at Elevation 315.0 m at the inlet (south end) and at Elevation 315.1 m at the outlet (north end). The creek ice level was surveyed by Golder in February 2016 at about Elevation 315.5 m at the inlet end. Surface conditions in the culvert inlet and outlet areas are shown on Photographs 1 to 4, attached.

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out between January 26 and February 15, 2016, during which time six boreholes (Boreholes WT-1 to WT-6) were advanced at approximately the locations shown on Drawing 1. Boreholes WT-1, WT-2, WT-5 and WT-6 were advanced at the toes of the embankment slope near the outlet/inlet ends of the culvert and Boreholes WT-3 and WT-4 were advanced from the existing highway platform. Boreholes WT-1 and WT-2 were advanced with a portable tripod using NW casing and wash boring techniques, which was supplied and operated by Landcore Drilling of Chelmsford, Ontario. Boreholes WT-3 to WT-6 were advanced using a CME 850 track mounted drill rig equipped with 108 mm inside diameter hollow stem augers, which was supplied and operated by Cartwright Drilling Inc. of Thunder Bay, Ontario.

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 or cathead hammer (for boreholes advanced using the portable tripod), in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). The groundwater level in the open boreholes was observed during the drilling operations as described on the Record of Borehole sheets 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 members of Golder's technical staff who: located the boreholes in the field; arranged for the clearance of underground services; supervised the drilling and sampling



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operations; logged the boreholes; and examined and cared for the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's geotechnical laboratory in Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content and organic content determinations, grain size distributions and Atterberg limits were carried out on selected soil samples. The geotechnical laboratory testing was completed according to MTO LS standards.

A sample of the creek water was obtained on January 27, 2016, 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 as-drilled borehole locations and ground surface elevations were measured and surveyed by members of our technical staff, referenced to the highway centerline and existing culvert and converted into northing/easting coordinates on the plan drawing. The ground surface elevation of the highway centerline was obtained from the profile drawing provided by MTO (drawing bc904113.dwg). The MTM NAD83 Zone 14 northing and easting coordinates, ground surface elevations referenced to Geodetic datum, and borehole depths at each borehole location are presented on the Record of Borehole sheets in Appendix A and summarized below.

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
WT-1	5 502 668.1	247 974.8	316.0	9.8
WT-2	5 502 670.2	247 979.0	315.6	9.8
WT-3	5 502 658.9	247 985.9	318.3	12.8
WT-4	5 502 651.0	247 972.5	318.3	12.8
WT-5	5 502 644.3	247 987.5	316.3	9.8
WT-6	5 502 643.5	247 982.7	315.6	9.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS) mapping by the Ministry of Natural Resources (MNR)¹, the Watson Creek culvert site is located within an outwash plain deposit consisting primarily of sand.

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

¹ Ministry of Natural Resources, Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 4ENW

² Ministry of Northern Development of Mines. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey – Map 2542



4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The detailed results of geotechnical laboratory testing are contained in Appendix B. The results of the in situ field tests (i.e., SPT 'N' values) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profile and cross-sections on Drawings 1 and 2 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsoil conditions encountered at the site consist of asphalt and granular fill (for boreholes advanced through the embankment) and peat (for boreholes advanced beyond the embankment toe of slope) underlain by deposits of organic silty sand to organic sand, silty sand to sand, and silt. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is provided below.

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows)	Laboratory Testing
				Relative Density	
Ice	WT-1 & WT-2	0.075 – 0.150	316.0 & 315.6	n/a	n/a
Asphalt	WT-3 & WT-4	0.125	318.3	n/a	n/a
(FILL)¹ Sand to Sand and Gravel, trace to some silt; brown, frozen to moist	WT-3 & WT-4	3.0 & 2.9	318.2	N = 7 & 10	w = 2% & 9% 2 – M (Fig. B1)
				Loose to Compact	
(FILL) Silty Sand, trace organics; brown to grey, wet	WT-3 & WT-4	0.7 & 1.4	315.3 – 315.2	N = 3 - 13	w = 24% & 35%
				Very Loose to Compact	
Peat (Fibrous to Amorphous); black, frozen to wet	WT-1 & WT-2	0.2 & 1.6		N = 2 – 4	w = 136%
				Very Loose	
Organic Silty Sand to Organic Sand; dark brown to brown; frozen to wet	WT-1, WT-3 to WT-6	0.5 – 2.2	316.3 – 313.8	N = 1 – 6 ²	w = 40% - 59% 2 – MH (Fig. B2) OC = 5.4% & 7.6%
				Very Loose to Loose	
Silty Sand to Sand; trace organics; brown to grey; wet	WT-1, WT-2, WT-5 & WT-6	0.8 – 1.5	314.9 – 313.8	N = 1 – 19	w = 30% 1 – MH (Fig. B3)
				Very Loose to Compact	
Silt, trace to some clay, trace to some sand; grey; wet	WT-1 to WT-6	6.6 – 7.9 (boreholes terminated in this deposit)	313.4 – 312.6	N = 7 – 16	w = 20% - 25% 12 – MH (Fig. B4.1 & B4.2) 6 – AL (NP)
				Loose to Compact	



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Where:

N = SPT 'N'-value; number of blows for 0.3 m of penetration
w = Natural moisture content (%)
M = Sieve analysis
MH = Combined sieve and hydrometer analysis
OC = Organic Content (%)
AL = Atterberg limits test
NP = Non-plastic Atterberg limits test result

Notes:

¹ Wood, asphalt and polystyrene fragments were encountered within the sand to gravelly sand fill in Boreholes WT-3 and WT-4.

² An SPT 'N'-value of 38 blows per 0.3 m of penetration was measured in the organic silty sand to organic sand deposit; however this is likely due to the frozen state of the material and is not representative.

Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The creek ice level was surveyed by Golder in February 2016 at Elevation 315.5 m at the inlet end. Groundwater and creek ice/water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole No.	Depth to Groundwater Level (m)	Groundwater Elevation (m)
WT-1	0.5	315.5 ¹
WT-2	1.0	314.6 ¹
WT-3	2.8	315.5
WT-4	2.7	315.6
WT-5	0.7	315.6
WT-6	0.9	314.7

¹ Boreholes WT-1 and WT-2 were advanced using NW casing and wash boring techniques and as such, the measured groundwater levels may not be representative of the in-situ groundwater conditions.

5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Shane Albert and Mr. Mathew Riopelle under the overall direction of Mr. Adam Core, P.Eng. This Foundation Investigation Report was prepared by Mr. Adam Core, P.Eng., and Mr. David Muldowney, P.Eng. provided a technical review of the report. Mr. Jorge M. A. Costa, P.Eng., a Senior Consultant with and Designated MTO Foundations Contact for Golder conducted an independent quality control review of this report.

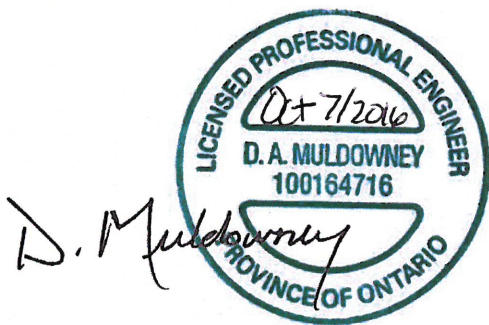


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WATSON CREEK CULVERT - SITE NO. 48E-63/C

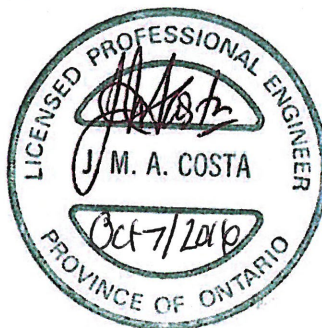
Report Signature Page

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Designated MTO Foundations Contact, Senior Consultant

KH/AC/DAM/JMAC/kp

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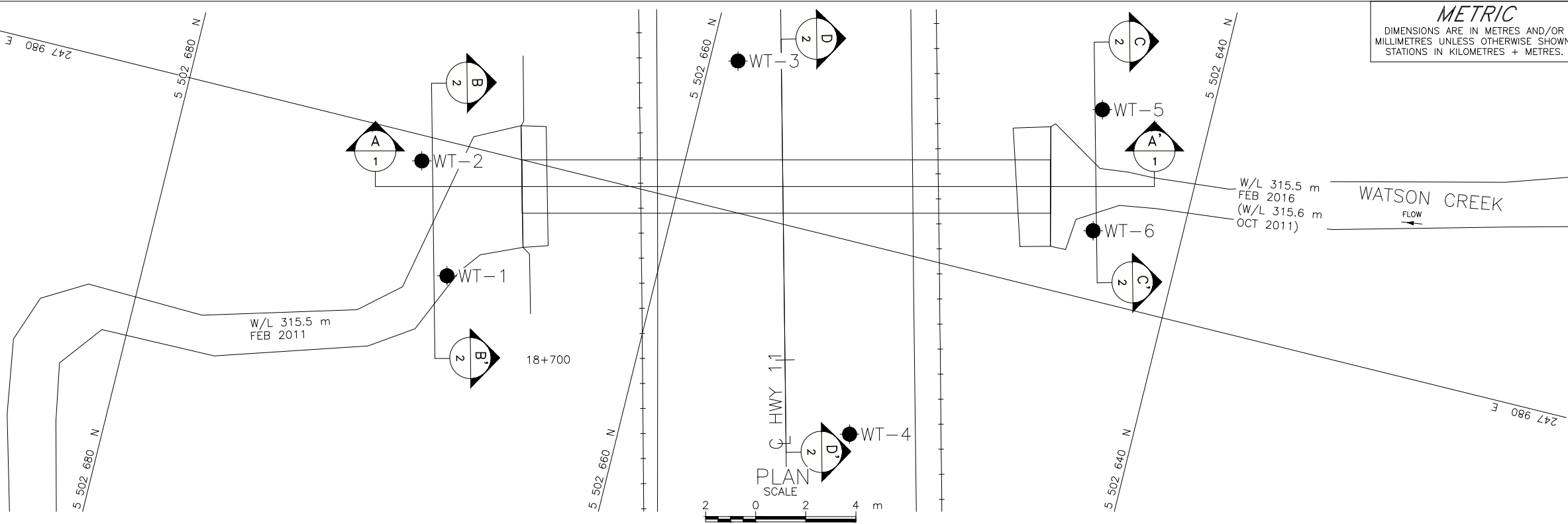
FOUNDATION REPORT WATSON CREEK CULVERT - SITE NO. 48E-63/C

Table 1: Summary Details of Existing Culvert

Culvert Location	Site #	Approximate Height of Embankment ¹ (m)	Existing Culvert			Approximate Invert Elevation ²	
			Type	Approximate Dimension ²	Approximate Length (m)	South End of Culvert (m)	North End of Culvert (m)
Hwy 11 STA 18+707	48E-63/C	3.3	Twin Cell Timber Box	2.1 m wide (total) x 1.6 m high	21	315.0	315.1

- Notes:
1. Embankment height is relative to existing ground surface at the centreline of the roadway and the existing culvert invert.
 2. Culvert dimensions and invert elevations are based on the plan and profile drawings provided by MTO (Drawing bc904113.dwg).

Prepared by: AC
Checked by: DAM
Reviewed by: JMAC

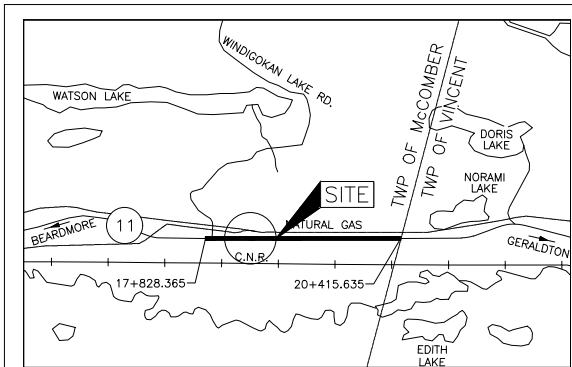


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 6166-04-00

HIGHWAY 11
WATSON CREEK CULVERT STA 18+707
BOREHOLE LOCATIONS AND
SOIL STRATA

SHEET



KEY PLAN
SCALE
1 0 1 2 km

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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
WT-1	316.0	5502668.1	247974.8
WT-2	315.6	5502670.2	247979.0
WT-3	318.3	5502658.9	247985.9
WT-4	318.3	5502651.0	247972.5
WT-5	316.3	5502644.3	247987.5
WT-6	315.6	5502643.5	247982.7

NOTES

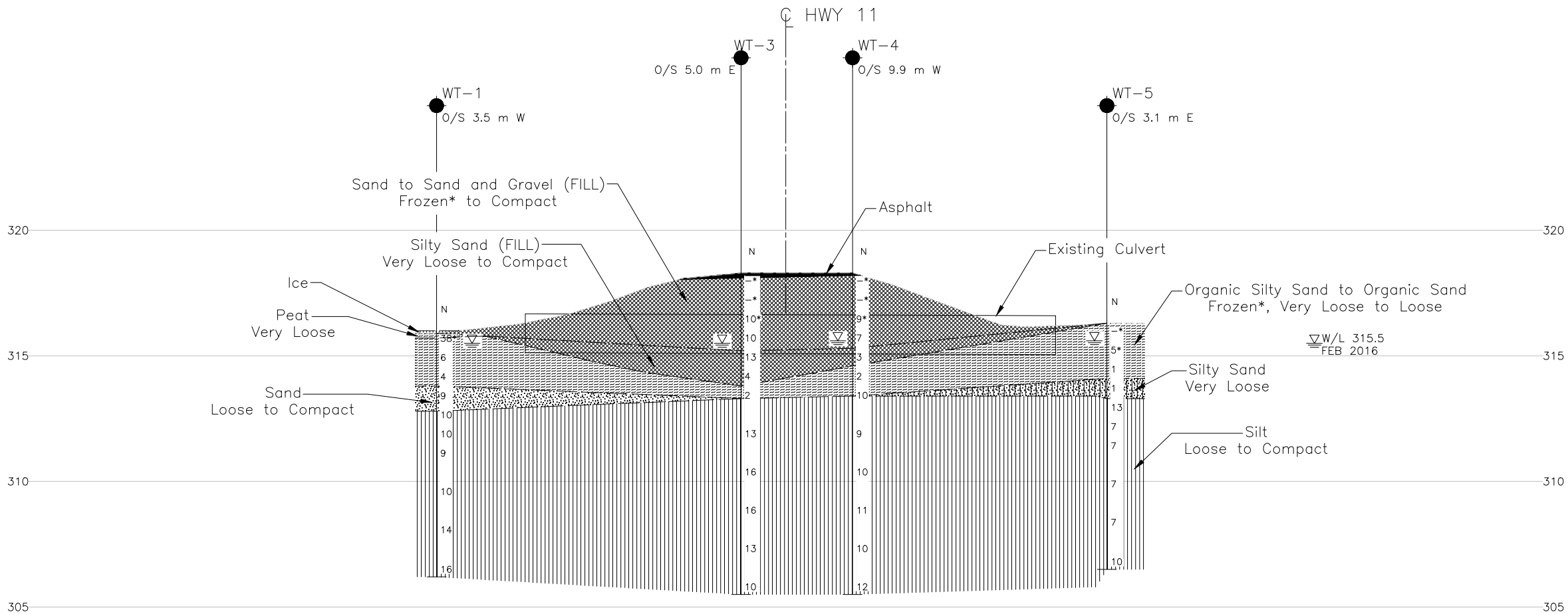
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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 MTO, drawing file nos. BC904113.dwg received Dec. 11, 2015.

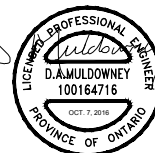


SCALE 1:200
VERT. SCALE 1:200

A-A
1

PROFILE

SCALE
2 0 2 4 m



NO.	DATE	BY	REVISION
Geocres No. 42E-25			
HWY. 11		PROJECT NO. 1533879	DIST. .
SUBM'D. AC	CHKD. .	DATE: 10/7/2016	SITE: 48E-63/C
DRAWN: JJL	CHKD. DAM	APPD. JMAC	DWG. 1

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

CONT No.
GWP No. 6166-04-00

HIGHWAY 11
WATSON CREEK CULVERT STA 18+707

SOIL STRATA

SHEET



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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
WT-1	316.0	5502668.1	247974.8
WT-2	315.6	5502670.2	247979.0
WT-3	318.3	5502658.9	247985.9
WT-4	318.3	5502651.0	247972.5
WT-5	316.3	5502644.3	247987.5
WT-6	315.6	5502643.5	247982.7

NOTES

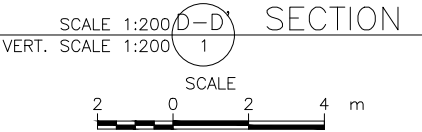
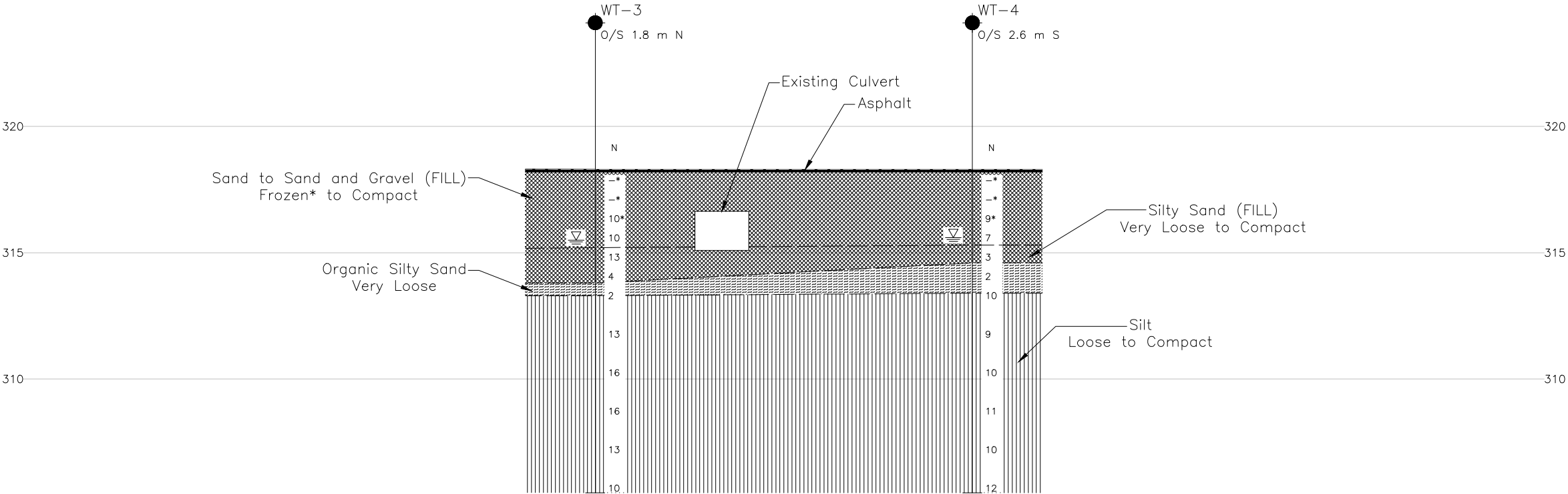
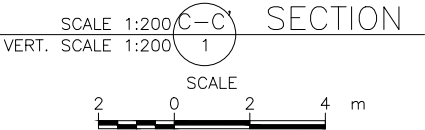
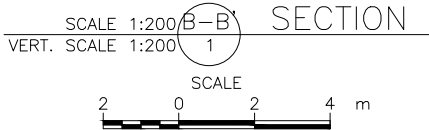
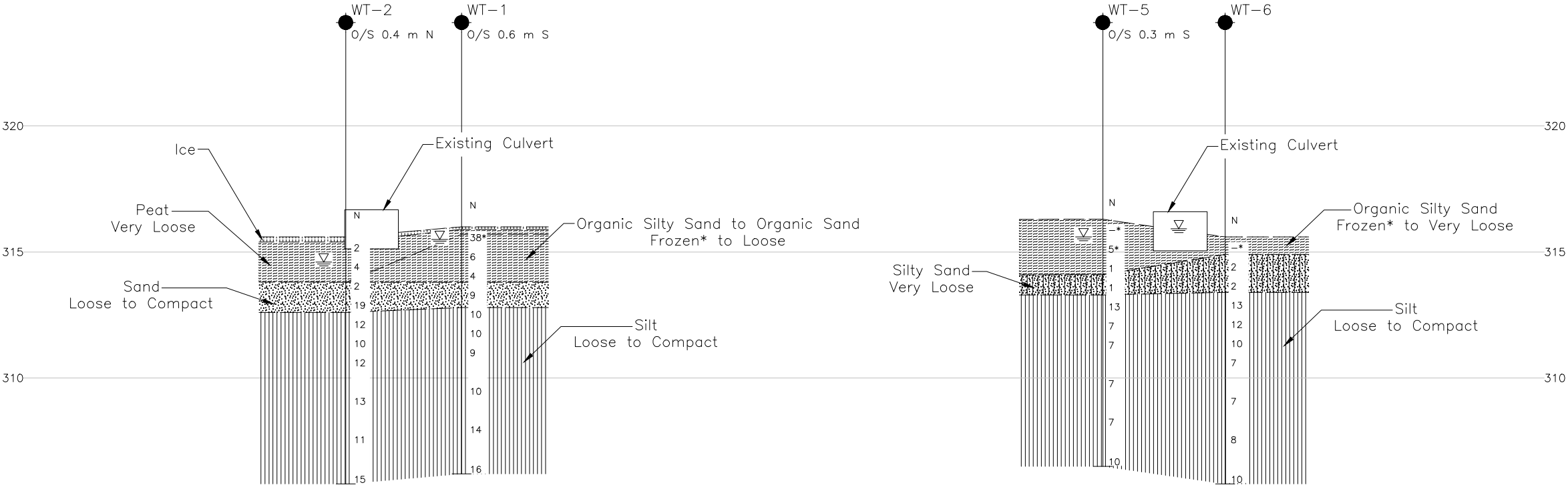
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NO.	DATE	BY	REVISION
Geocres No. 42E-25			
HWY. 11	PROJECT NO. 1533879		DIST. .
SUBM'D. AC	CHKD. .	DATE: 10/7/2016	SITE: 48E-63/C
DRAWN: JJL	CHKD. DAM	APPD. JMAC	DWG. 2



PHOTOGRAPHS

**Photograph 1: Watson Creek Culvert
Looking West at North End (Outlet) of Culvert (December 2015)**



**Photograph 2: Watson Creek Culvert
Looking East at South End (Inlet) of Culvert (December 2015)**





PHOTOGRAPHS

**Photograph 3: Watson Creek Culvert
Looking North at Outlet (December 2015)**



**Photograph 4: Watson Creek Culvert
Looking South at Inlet (December 2015)**





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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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

PROJECT 1533879		RECORD OF BOREHOLE No WT-1				1 OF 1 METRIC											
G.W.P. 6166-04-00		LOCATION N 5502668.1; E 247974.8				ORIGINATED BY SA											
DIST _____ HWY 11		BOREHOLE TYPE NW Casing, Wash Boring				COMPILED BY AC											
DATUM GEODETIC		DATE February 9, 2016				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									WATER CONTENT (%)
316.0	GROUND SURFACE																
0.0	ICE (75 mm)		1A	SS	38*	▽											
0.3	PEAT (Amorphous) Black Wet		1B														
	ORGANIC SILTY SAND to ORGANIC SAND, trace to some gravel, trace clay Loose Dark brown to brown Frozen* to wet		2	SS	6												
			3	SS	4												
313.8																	
2.2	SAND, some silt Loose Grey Wet		4	SS	9												
312.8																	
3.2	SILT, trace clay Loose to compact Grey Wet		5	SS	10												
			6	SS	10												
			7	SS	9												
			8	SS	10												
			9	SS	14												
			10	SS	16												
306.2																	
9.8	END OF BOREHOLE																
	Note: 1. Water level at a depth of 0.5 m below ground surface (Elev. 315.5 m) upon completion of drilling.																

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 02/09/16 DATA INPUT:

PROJECT 1533879		RECORD OF BOREHOLE No WT-2				1 OF 1 METRIC											
G.W.P. 6166-04-00		LOCATION N 5502670.2; E 247979.0				ORIGINATED BY SA											
DIST _____ HWY 11		BOREHOLE TYPE NW Casing, Wash Boring				COMPILED BY AC											
DATUM GEODETIC		DATE February 9 and 10, 2016				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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
315.6	GROUND SURFACE							20	40	60	80	100					
0.0	ICE (150 mm)																
0.2	PEAT (Fibrous) Very loose Black Wet		1	SS	2	▽	315										
			2	SS	4		314										
	Amorphous below 1.4 m depth.		3A	SS	2												
313.8	SAND, trace to some silt Compact Grey Wet		3B														
1.8			4	SS	19		313										
312.6	SILT, trace clay, trace sand Compact Grey Wet		5	SS	12		312										
3.0			6	SS	10		311										
			7	SS	12		310										
			8	SS	13		309										
			9	SS	11		308										
			10	SS	15	307											
						306											
305.8	END OF BOREHOLE																
9.8	Note: 1. Water level at a depth of 1.0 m below ground surface (Elev. 314.6 m) upon completion of drilling.																

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 02/08/16 DATA INPUT:

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 02/08/16 DATA INPUT:

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

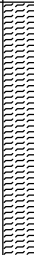

PROJECT <u>1533879</u>		RECORD OF BOREHOLE No WT-3				2 OF 2 METRIC												
G.W.P. <u>6166-04-00</u>		LOCATION <u>N 5502658.9; E 247985.9</u>				ORIGINATED BY <u>MR</u>												
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers</u>				COMPILED BY <u>AC</u>												
DATUM <u>GEODETIC</u>		DATE <u>February 15, 2016</u>				CHECKED BY <u>AB</u>												
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)					
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED </div>					<div style="display: flex; justify-content: space-between;"> W_p W W_L </div>						
305.5	SILT, trace clay, trace sand Compact Grey Wet		12	SS	10		306											
12.8	END OF BOREHOLE Note: 1. Water level at a depth of 2.8 m below ground surface (Elev. 315.5 m) upon completion of drilling.																	

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

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 02/08/16 DATA INPUT:




PROJECT 1533879		RECORD OF BOREHOLE No WT-4				2 OF 2 METRIC												
G.W.P. 6166-04-00		LOCATION N 5502651.0; E 247972.5				ORIGINATED BY MR												
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY AC												
DATUM GEODETIC		DATE February 15, 2016				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										
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100					WATER CONTENT (%) 20 40 60						
305.5	SILT, trace to some clay, trace sand Loose to compact Grey Wet		12	SS	12		306											
12.8	END OF BOREHOLE Note: 1. Water level at a depth of 2.7 m below ground surface (Elev. 315.6 m) upon completion of drilling.																	

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 02/08/16 DATA INPUT:

PROJECT 1533879		RECORD OF BOREHOLE No WT-5				1 OF 1 METRIC												
G.W.P. 6166-04-00		LOCATION N 5502644.3; E 247987.5				ORIGINATED BY MR												
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY AC												
DATUM GEODETIC		DATE January 26, 2016				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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
316.3	GROUND SURFACE							20	40	60	80	100						
0.0	ORGANIC SILTY SAND Very loose Dark brown Frozen* to wet		1	AS	-*		316											
			2	SS	5*		315											
			3	SS	1		314											
314.1	SILTY SAND, trace organics Very loose Brown to grey Wet	4	SS	1	313													
313.3	SILT, trace to some clay, trace to some sand Loose to compact Grey Wet	5	SS	13	312													
		6	SS	7	311													
		7	SS	7	310													
		8	SS	7	309													
		9	SS	7	308													
		10	SS	10	307													
306.5	END OF BOREHOLE																	
9.8	Note: 1. Water level at a depth of 0.7 m below ground surface (Elev. 315.6 m) upon completion of drilling.																	

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 02/08/16 DATA INPUT:

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

PROJECT 1533879		RECORD OF BOREHOLE No WT-6				1 OF 1 METRIC											
G.W.P. 6166-04-00		LOCATION N 5502643.5; E 247982.7				ORIGINATED BY MR											
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY AC											
DATUM GEODETIC		DATE January 27, 2016				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									
315.6	GROUND SURFACE							20	40	60	80	100					
0.0	ORGANIC SILTY SAND Dark brown Frozen*		1	AS	-*												
314.9							315										
0.7	SILTY SAND, trace organics Very loose Dark brown Wet		2	SS	2												0 72 25 3
							314										
			3	SS	2												
313.4																	
2.2	SILT, trace to some clay, trace to some sand Loose to compact Grey Wet		4	SS	13		313										
			5	SS	12		312										0 16 80 4
			6	SS	10												
							311										
			7	SS	7												
							310										
			8	SS	7		309										
							308										
			9	SS	8												0 1 93 6
							307										
			10	SS	10		306										
305.8																	
9.8	END OF BOREHOLE																
	Note: 1. Water level at a depth of 0.9 m below ground surface (Elev. 314.7 m) upon completion of drilling.																

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 02/08/16 DATA INPUT:



APPENDIX B

Laboratory Test Results



FOUNDATION REPORT WATSON CREEK CULVERT - SITE NO. 48E-63/C

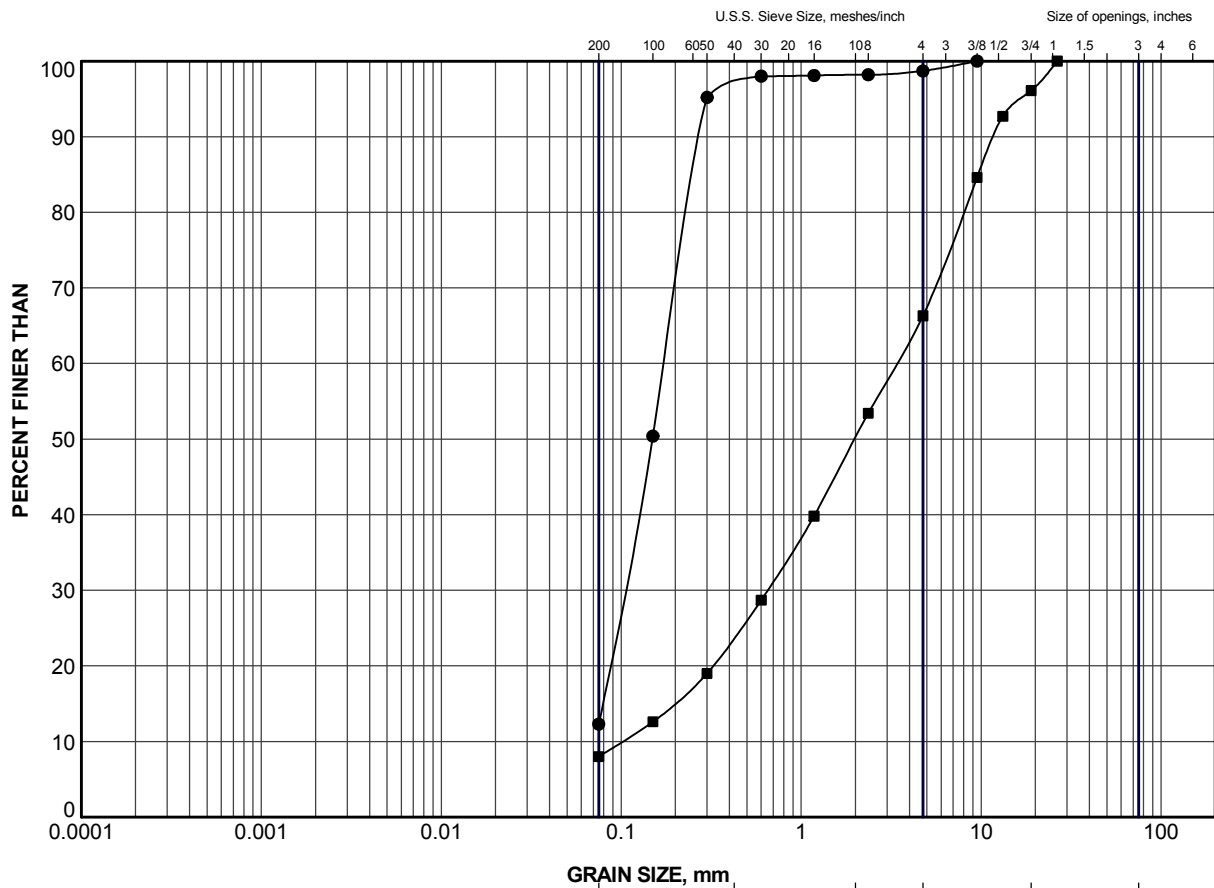
Table B1: Summary of Analytical Testing of Watson Creek Water Sample

Parameter	Units	Result
Chloride (CL)	mg/L	2.30
Sulphate (SO4)	mg/L	1.08
Conductivity (EC)	µS/cm	136
Resistivity	ohm-cm	7340
pH	n/a	7.59

Notes:

1. Sample obtained on January 27, 2016.
2. Analytical testing carried out by ALS Canada Ltd.

Prepared by: TB
Checked by: DAM
Reviewed by: JMAC



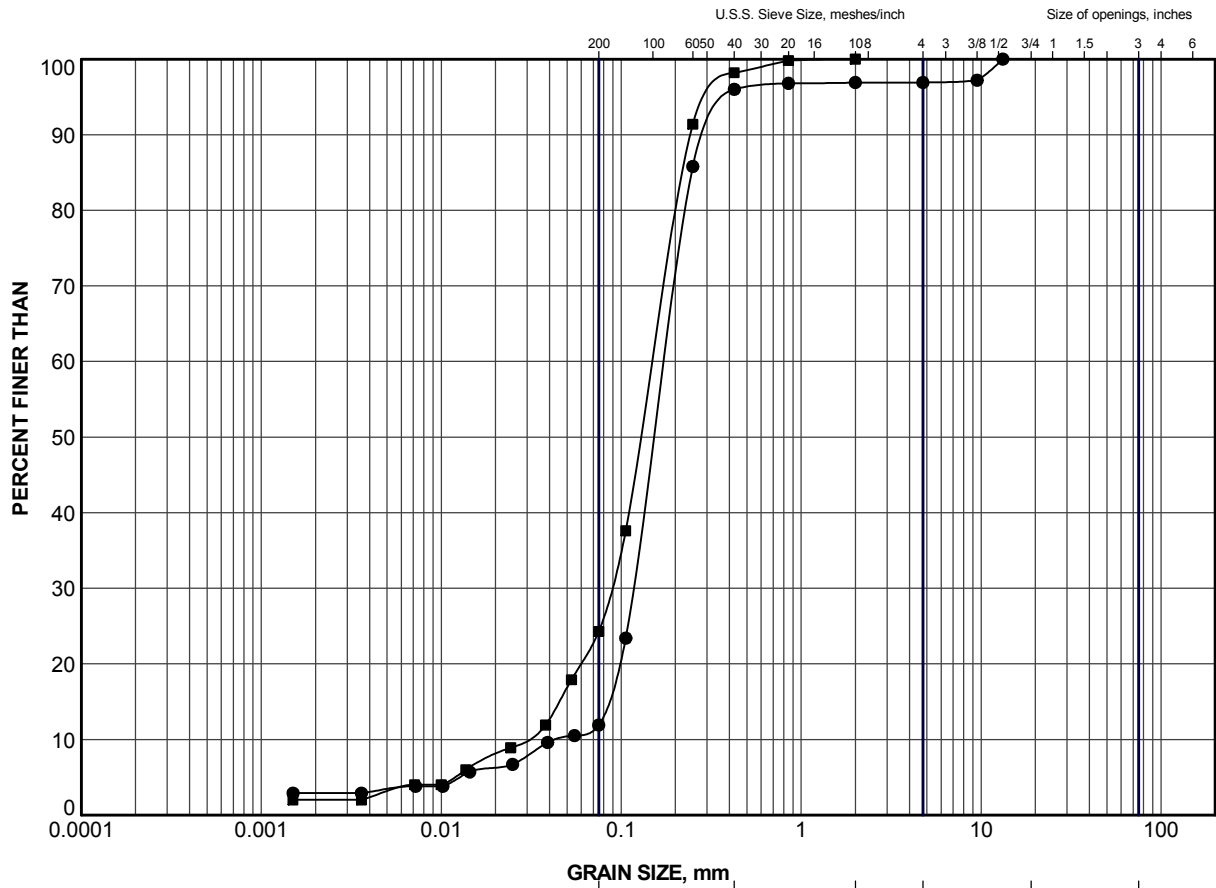
CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WT-3	4	315.7
■	WT-4	2	317.2

PROJECT					
HIGHWAY 11 WATSON CREEK CULVERT STA 18+707					
TITLE					
GRAIN SIZE DISTRIBUTION SAND to SAND and GRAVEL (FILL)					
PROJECT No.		1533879		FILE No. 1533879.GPJ	
DRAWN	JJL	Jul 2016	SCALE	N/A	REV.
CHECK	AB	Jul 2016	FIGURE B1		
APPR	JMAC	Jul 2016			




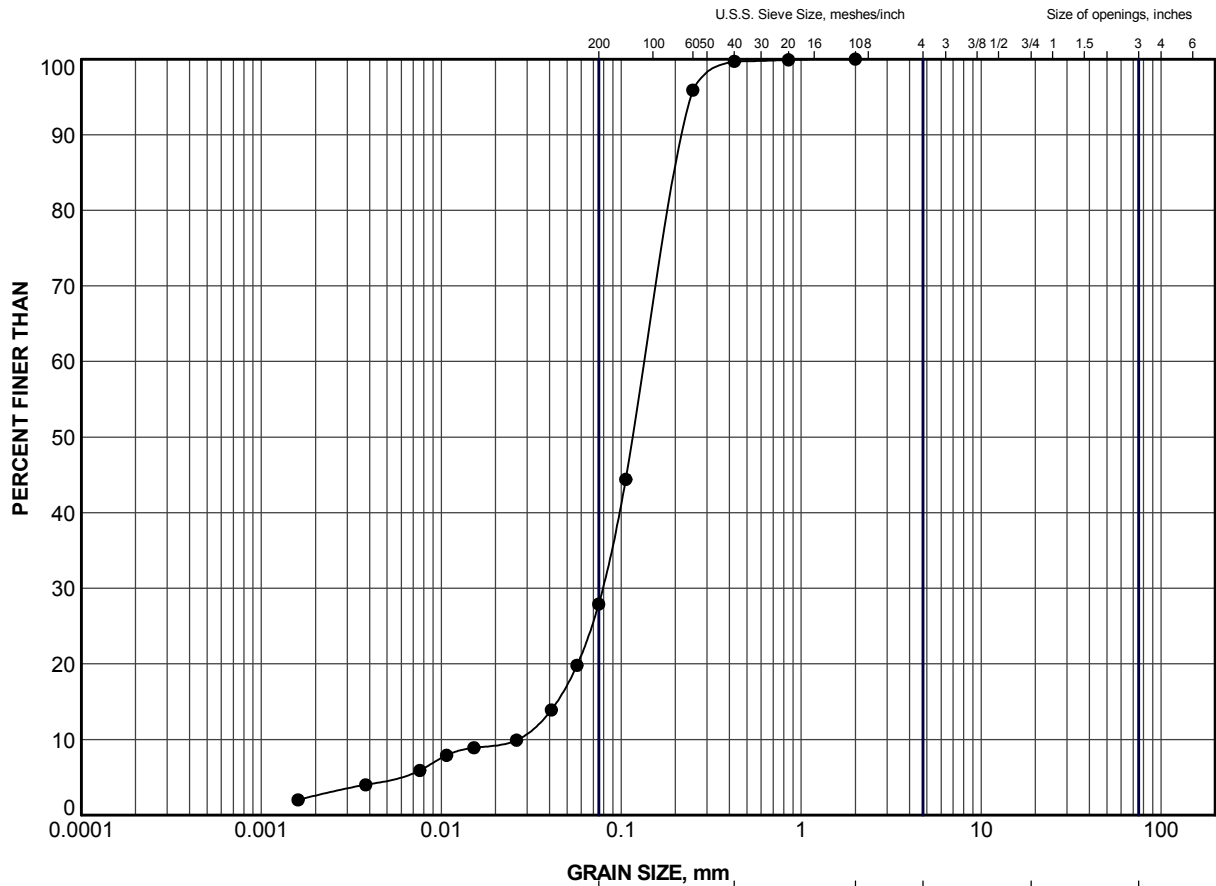


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WT-1	3	314.2
■	WT-4	6	314.2

PROJECT						HIGHWAY 11 WATSON CREEK CULVERT STA 18+707					
TITLE						GRAIN SIZE DISTRIBUTION ORGANIC SILTY SAND to ORGANIC SAND					
PROJECT No.			1533879			FILE No.			1533879.GPJ		
DRAWN	JJL	Jul 2016	SCALE	N/A	REV.	FIGURE B2					
CHECK	AB	Jul 2016									
APPR	JMAC	Jul 2016									
 Golder Associates SUDBURY, ONTARIO											



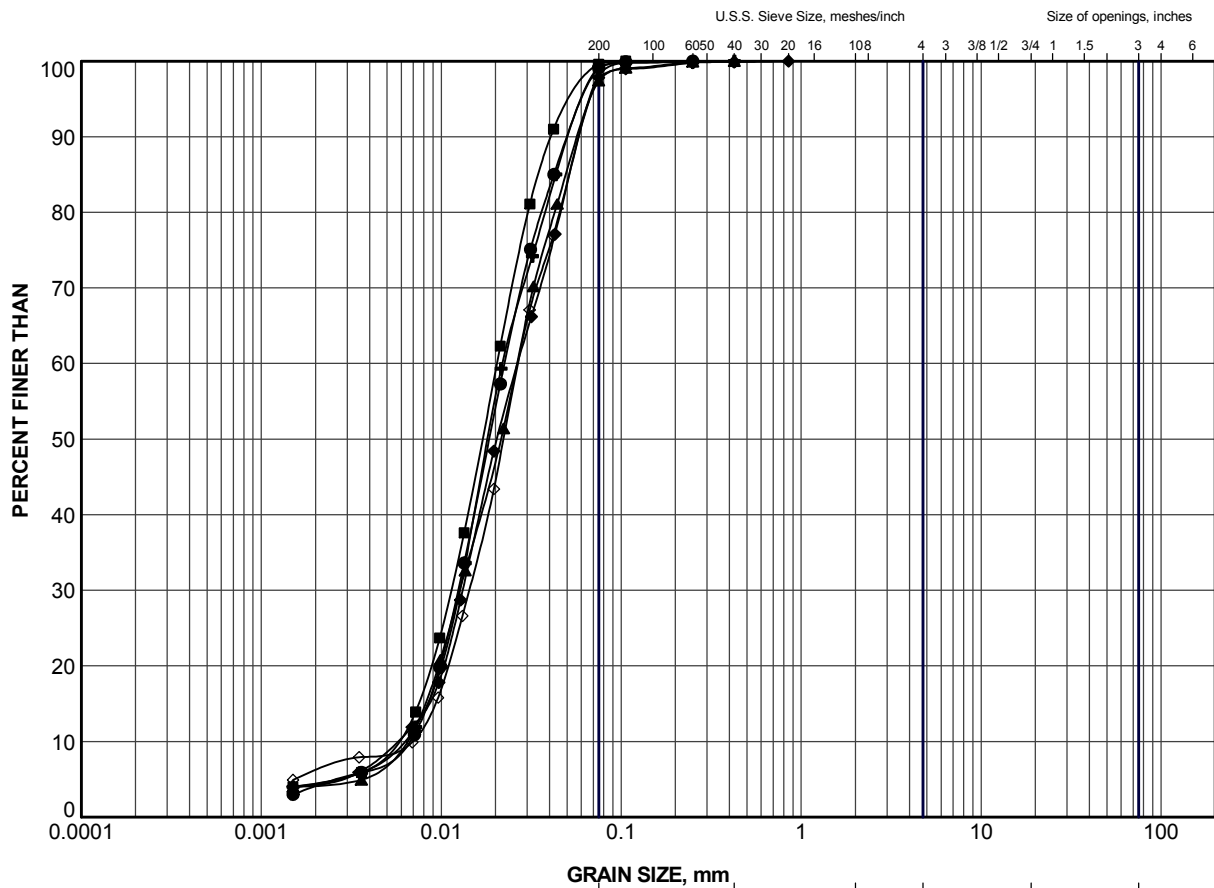
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WT-6	2	314.5

PROJECT					
HIGHWAY 11 WATSON CREEK CULVERT STA 18+707					
TITLE					
GRAIN SIZE DISTRIBUTION SILTY SAND					
PROJECT No.		1533879		FILE No. 1533879.GPJ	
DRAWN	JJL	Jul 2016	SCALE	N/A	REV.
CHECK	AB	Jul 2016	FIGURE B3		
APPR	JMAC	Jul 2016			




SUD-MTO GSD (2016) GLDR_LDN.GDT

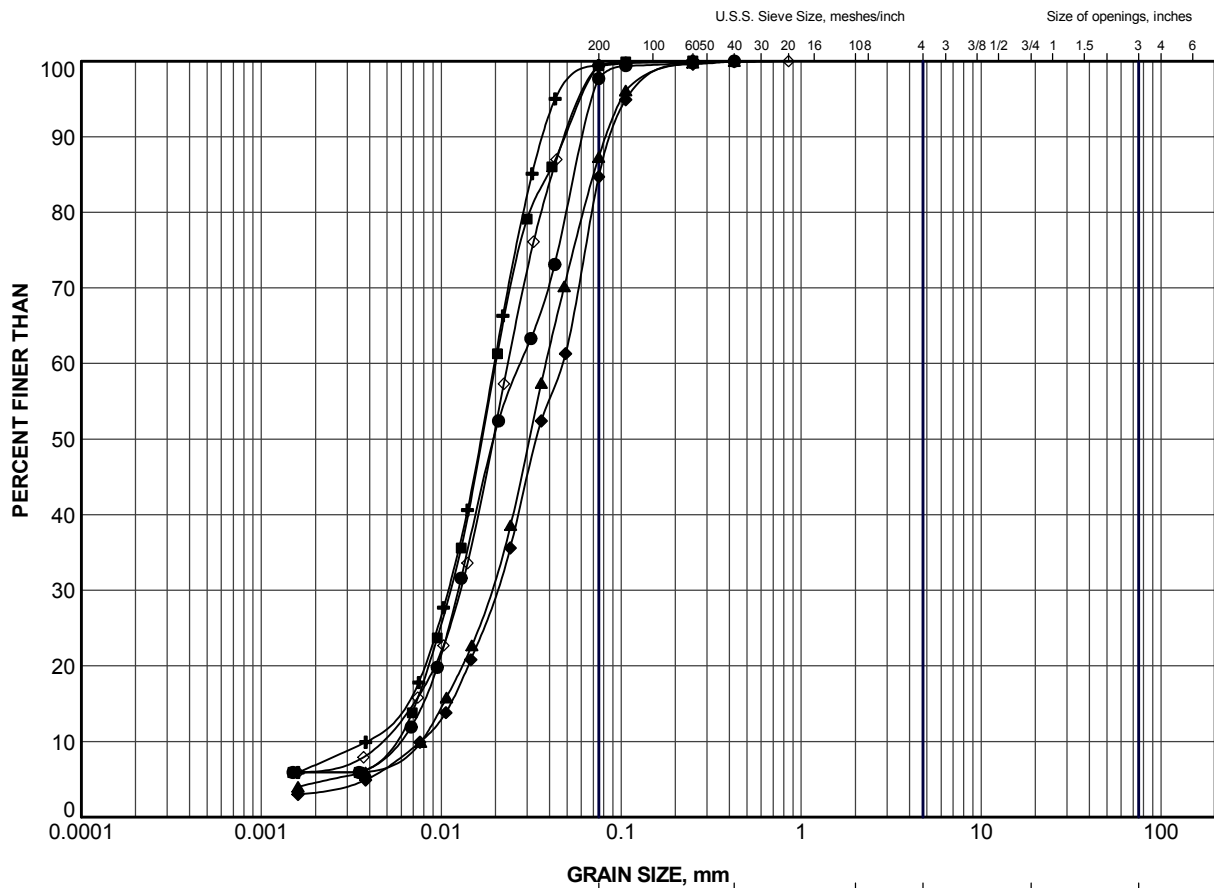


CLAY AND SILT	SAND SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WT-1	6	311.9
■	WT-1	9	308.1
▲	WT-2	5	312.3
+	WT-2	8	309.2
◆	WT-3	9	310.4
◇	WT-3	11	307.3

PROJECT						HIGHWAY 11 WATSON CREEK CULVERT STA 18+707					
TITLE						GRAIN SIZE DISTRIBUTION SILT					
PROJECT No.			1533879			FILE No.			1533879.GPJ		
DRAWN	JJL	Jul 2016	SCALE	N/A	REV.						
CHECK	AB	Jul 2016									
APPR	JMAC	Jul 2016									
 Golder Associates SUDBURY, ONTARIO			FIGURE B4.1								



As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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