



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT
NISSIAMKIKAM CREEK CULVERT REPLACEMENT
TEMPORARY MODULAR BRIDGE
HIGHWAY 11, DISTRICT OF THUNDER BAY,
TOWNSHIP OF WALTERS, ONTARIO
LATITUDE: 49.669263°, LONGITUDE: -87.712472°
G.W.P. 6561-16-00, SITE No. 48E-0123/C0**

GEOCRES Number: 42E-34

Report

to

HATCH

Date: February 23, 2021
File: 29478



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1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed Temporary Modular Bridge (TMB) for use during the construction of the Nissiamkikam Creek Culvert replacement. The Nissiamkikam Creek Culvert is located on Highway 11, 18 kilometers northeast of the Town of Beardmore, Ontario

The purpose of this investigation was to explore the subsurface conditions at the proposed TMB abutments, and based on the data obtained, to provide a borehole location plan, stratigraphic profiles, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by Hatch to carry out this foundation investigation under the Ministry of Transportation (MTO) Northwest Region Agreement Number 6019-E-0009, Assignment #17.

2. SITE DESCRIPTION

The site is located on Highway 11, 18 km northeast of the Town of Beardmore, in the Township of Walters, Thunder Bay District, Ontario, at Latitude: 49.669263°, Longitude: -87.712472°. The existing culvert allows Nissiamkikam Creek to flow under the highway from north to south. Highway 11 runs in a general east – west direction at the culvert site. The highway along the site is classified as a two-lane undivided rural arterial highway.

The Ontario Structure Inspection report prepared by MTO on August 25, 2018 indicates that the existing structure is comprised of two closed, elliptical, corrugated steel culverts. The culverts are



approximately 42.7 m in length, 1.93 m wide, and 2.69 m high. Based on existing survey data for the site, the ground surface elevation of Highway 11 at the existing culverts is approximately 321 m. The invert level of the existing culverts is at approximate Elevation 313.5 m. Measurements collected in August 2016 indicate that the surface water level of Nissiamkikam Creek ranged from an approximate elevation of 314.41 to 314.06 m at the north and south ends of the culverts respectively.

The land surrounding the site is gently undulating and predominantly forested, with marshy conditions along the creek floodplain. A TransCanada Pipeline easement lies approximately 50 m to the north of the site. Bedrock is visible in roadcuts along the highway within 200 m west of the site. Possible rockfill is exposed along the Highway 11 embankment slope.

Photographs of the existing culverts and surrounding area are presented in Appendix C.

Based on published geological information, the culverts lie within an area consisting of glaciofluvial outwash deposits of sand and gravel, with recent organic deposits of peat, muck and marl. The bedrock surrounding the site is Pre-Cambrian metasedimentary rock, consisting of wacke, siltstone, arkose, argillite, slate, mudstone, marble, chert, iron formation, conglomerate, arenite, and some minor metavolcanic rocks.

An existing foundation investigation report for the culvert replacement was prepared by EXP in 2019, entitled, "Foundation Investigation and Design Report, Nissiamkikam Creek Culvert Replacement, Site No. 48e-123/C, Hwy 11, Township of Walters, Ontario", Geocres No. 42E-31, dated May 1, 2019. The borehole information from the EXP report is included in Appendix E.

3. INVESTIGATION PROCEDURES

The field investigation for the TMB was carried out on September 19th and 20th, 2020 and consisted of drilling and sampling two (2) foundation boreholes, labeled 20-01 and 20-02 and twelve (12) pavement boreholes, labelled PVT-01 to PVT-12. Further details regarding the pavement boreholes and investigation are discussed in a separate Pavement Design Memorandum by Thurber, entitled, "Pavement Design Memorandum, Highway 11 – Nissiamkikam Creek Culvert Replacement, GWP 6561-16-00, Site No. 48E-123/C Township of Walters, Ontario".

Boreholes 20-01 and 20-02 were drilled on the eastbound lane of Highway 11 and located near the approximate west and east abutment locations for the proposed TMB. The foundation boreholes were drilled to depths of 13.4 m and 16.5 m (Elevation 308.0 m and 304.8 m)



respectively. Full-time traffic protection was utilized in order to carry-out lane closures for the drilling program.

The borehole logs from the foundation investigation are included in Appendix A. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata drawing included in Appendix D.

Utility clearances were obtained prior to the start of drilling. The northing and easting coordinates and the ground surface elevations for the boreholes were estimated based on field measurements from existing site features relative to the topographic drawing (E-903-11-1) provided to Thurber by MTO. The coordinate system MTM NAD 83, Zone 14 was used for the boreholes.

A rubber tracked CME 55 drill rig was used to advance the boreholes, using solid stem augers and NW casing. Soil samples were obtained in the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) (ASTM D1586). NQ coring methods were used to advance Borehole 20-01 through boulders.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Water Levels were measured in the open boreholes immediately after drilling to assess the groundwater conditions. Upon completion of the investigation the boreholes were decommissioned as per O.Reg. 903.

Completion details of the boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
20-01	13.4 / 308.0	Borehole caved to 2.3 m. Backfilled with bentonite from 2.3 to 0.9 m, dry Cement to 0.2 m, then asphalt to surface.
20-02	16.5 / 304.8	Borehole caved to 2.5 m. Backfilled with bentonite from 2.5 m to 0.9 m, dry cement to 0.2 m, then asphalt to surface.



4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and/or hydrometer), where appropriate. The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

The 2019 EXP report included soil testing for corrosivity parameters, and therefore no corrosion testing was completed during this investigation.

5. SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata Drawings included in Appendix D. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered at the TMB foundation boreholes (20-01 and 20-02) consisted of asphalt, granular fill, and rock fill, underlain by native deposits of sand and gravel, silt, silty sand, and boulders. Bedrock was not encountered in the boreholes but is visible at surface near the site and underlies the overburden. Descriptions of the individual strata are presented below.

5.1 Asphalt

An asphalt layer ranging from 120 to 125 mm thick was encountered at the ground surface in both boreholes.

5.2 Granular and Rock Fill

The asphalt was underlain by a 500 to 600 mm thick layer of granular fill in both boreholes. The fill typically consisted of sand and gravel with some silt. The granular fill extended to depths ranging from 0.6 to 0.7 m (Elev. 320.7 m).



The measured moisture content in the granular fill ranged from 1 to 5%.

The granular fill was underlain by 2.4 to 3.7 m of rock fill / crushed gravel, extending to depths of 3.1 to 4.3 m (Elev. 318.3 to 317.0 m) in Boreholes 20-01 and 20-02 respectively. Wash boring drilling methods were required to penetrate the rock fill / crushed gravel.

5.3 Upper Sand and Gravel

A deposit of native sand and gravel containing trace silt was encountered below the rock fill in Borehole 20-02. The thickness of the deposit was 1.3 m and extended to a depth of 5.6 m (Elev. 315.7 m).

The SPT 'N' value measured in the sand and gravel deposit was 14 blows for 0.3 m of penetration, indicating that the deposit is compact. The measured moisture content of the deposit was 13%.

The results of a grain size analysis conducted on a sample of the sand and gravel are illustrated on Figure B1 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	41
Sand	51
Silt and Clay	8

5.4 Silt

A deposit of silt with trace sand and trace to some clay was encountered below the sand and gravel deposit in Borehole 20-02 and beneath the rock fill at 20-01. The thickness of the silt deposit ranged from 6 m to 8.7 m and extended to depths of 9.1 m to 14.3 m (Elev. 312.3 to 307.0 m)

SPT 'N' values measured in the silt deposit typically ranged from 14 to 35 blows for 0.3 m of penetration, indicating that the deposit is compact to dense. One N value of 52 blows for 0.3 m of penetration (very dense) was recorded in Borehole 20-01 immediately below the rock fill layer, and may therefore be higher due to the presence of rock fill or crushed gravel in the sample. The measured moisture contents in the silt ranged from 15 to 25%.

The results of grain size analyses conducted on samples of the silt are illustrated on Figure B2 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	0 - 6
Silt	89 - 94
Clay	5 - 12

5.5 Lower Sand and Gravel

A deposit of sand and gravel with some silt and trace clay was encountered below the silt deposit in Borehole 20-01. The thickness of this deposit was approximately 1.3 m and extended to a depth of 10.4 m (Elev. 311.0 m).

An SPT 'N' value measured in the lower sand and gravel deposit was 40 blows for 0.3 m of penetration, indicating that the deposit is dense. The measured moisture content in the deposit was approximately 7%.

The result of a grain size analysis conducted on a sample of the sand and gravel are illustrated on Figure B1 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	35
Sand	44
Silt and Clay	21

5.6 Boulders

A layer of boulders with cobbles and occasional sand seams was encountered below the lower sand and gravel deposit in Borehole 20-01. Rock coring was required to advance through cobbles in this deposit. A boulder of approximately 580 mm diameter and cobbles of 30 to 80 mm diameter were observed within this deposit. Borehole 20-01 was terminated within the boulder deposit at a depth of 13.4 m (Elev. 308.0 m).

5.7 Silty Sand

A deposit of grey, silty sand with trace gravel and occasional cobbles was encountered below the silt deposit in Borehole 20-02. Borehole 20-02 was terminated within this deposit at a depth of 16.5 m (Elev. 304.8 m).



SPT 'N' values measured in the silty sand deposit ranged from 22 to 23 blows for 0.3 m of penetration, indicating that the deposit is compact. The measured moisture content in the deposit was approximately 12%.

5.8 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes. A summary of the water level measurements is provided in Table 5.1 below:

Table 5.1 - Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
20-01	September 19, 2020	7.7	313.7	Open borehole
20-02	September 20, 2020	7.8	313.5	Open borehole

The above measurements represent unstabilized, short-term water level readings that were collected upon completion of drilling each borehole.

The groundwater level should be anticipated to reflect the local creek water level. The water level of Nissiamkikam Creek in August 2016 was measured at approximate Elevation 314.4 to 314.1 m at the inlet and outlet of the existing culverts respectively.

Groundwater levels are short-term observations and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.

6. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. The northing and easting coordinates and ground surface elevations were estimated based on field measurements relative to the topographic plans provided by MTO.

RPM Drilling Ltd. of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Mr. Randy Pomerleau of Thurber. The overall supervision of the field program was conducted by Mr. Mark Farrant, P.Eng. of Thurber. Geotechnical laboratory testing was carried out in Thurber's geotechnical laboratory.



Interpretation of the field data and preparation of this report was carried out by Ms. Rachel Bourassa, E.I.T. and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Rachel Bourassa

Rachel Bourassa, E.I.T.
Geotechnical E.I.T.



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Review Principal, Designated MTO Contact



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W _L < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W _L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W _L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W _L > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE No 20-01

1 OF 2

METRIC

GWP# 6561-16-00 LOCATION Nissiamkikam Creek Culvert, N 5 503 754.2 E 253 353.1 ORIGINATED BY RP
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2020.09.19 - 2020.09.19 LATITUDE 49.669264 LONGITUDE -87.712769 CHECKED BY MF

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									WATER CONTENT (%)
321.4	GROUND SURFACE					▽											
0.0	ASPHALT: (120mm)																
0.1	SAND and GRAVEL, some silt Moist/Dry (FILL)		1	GS			321							○			
320.7	ROCKFILL/CRUSHED GRAVEL Wash bored through rockfill		2	GS			320										
0.7							319										
318.3							318							○			0 1 94 5
3.1	SILT, trace sand, trace clay Very Dense Light Brown Moist Becoming compact		1	SS	52		317							○			
			2	SS	14		316										
							315							○			
			3	SS	21		314										
							313										
			4	SS	19		312							○			0 2 89 9
312.3																	
9.1	SAND and GRAVEL, some silt, trace clay Dense Grey Moist		5	SS	40									○			35 44 21 (SI+CL)

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-29478.GPJ 2017TEMPLATE(MTO).GDT 1/14/21

RECORD OF BOREHOLE No 20-01

2 OF 2

METRIC

GWP# 6561-16-00 LOCATION Nissiamkikam Creek Culvert, N 5 503 754.2 E 253 353.1 ORIGINATED BY RP
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2020.09.19 - 2020.09.19 LATITUDE 49.669264 LONGITUDE -87.712769 CHECKED BY MF

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
							20	40	60	80	100	20	40	60			
	Continued From Previous Page																
311.0																	
310.4	BOULDERS occasional sand seams																
10.5	Boulder (580mm diameter) Cored through cobbles ranging from 30 to 80mm diameter		1	RUN													
310.3																	
11.1																	
			2	RUN													
308.0																	
13.4	END OF BOREHOLE AT 13.4m UPON CASING REFUSAL. BOREHOLE CAVED TO 2.3m AND WATER LEVEL AT 7.7m IN OPEN BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.9m, DRY CEMENT TO 0.2m, THEN COLD PATCH TO SURFACE.																

+³, ×³: Numbers refer to
Sensitivity

20
15 10 5 0
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-02

1 OF 2

METRIC

GWP# 6561-16-00 LOCATION Nissiamkikam Creek Culvert, N 5 503 753.7 E 253 396.1 ORIGINATED BY RP
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY AN
DATUM Geodetic DATE 2020.09.20 - 2020.09.20 LATITUDE 49.669263 LONGITUDE -87.712174 CHECKED BY MF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
321.3	GROUND SURFACE											
0.0	ASPHALT: (125mm)											
0.1	SAND and GRAVEL, some silt Brown Dry		1	GS			321					
320.7	(FILL)											
0.6	ROCKFILL/CRUSHED GRAVEL Wash bored through rockfill		2	GS			320					
							319					
							318					
							317					
317.0							316					
4.3	SAND and GRAVEL, trace silt Compact Brown Wet		1	SS	14							41 51 8 (SI+CL)
							315					
315.7			2	SS	13							
5.6	SILT, trace sand, trace to some clay Compact to Dense Brown Moist/Wet		3	SS	31							
			4	SS	35							0 6 89 5
							314					
			5	SS	20							
							313					
							312					0 0 88 12
			6	SS	28							

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S2 MTO-29478.GPJ 2017TEMPLATE(MTO).GDT 1/14/21

RECORD OF BOREHOLE No 20-02

2 OF 2

METRIC

GWP# 6561-16-00 LOCATION Nissiamkikam Creek Culvert, N 5 503 753.7 E 253 396.1 ORIGINATED BY RP
DIST Thunder Bay HWY 11 BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY AN
DATUM Geodetic DATE 2020.09.20 - 2020.09.20 LATITUDE 49.669263 LONGITUDE -87.712174 CHECKED BY MF

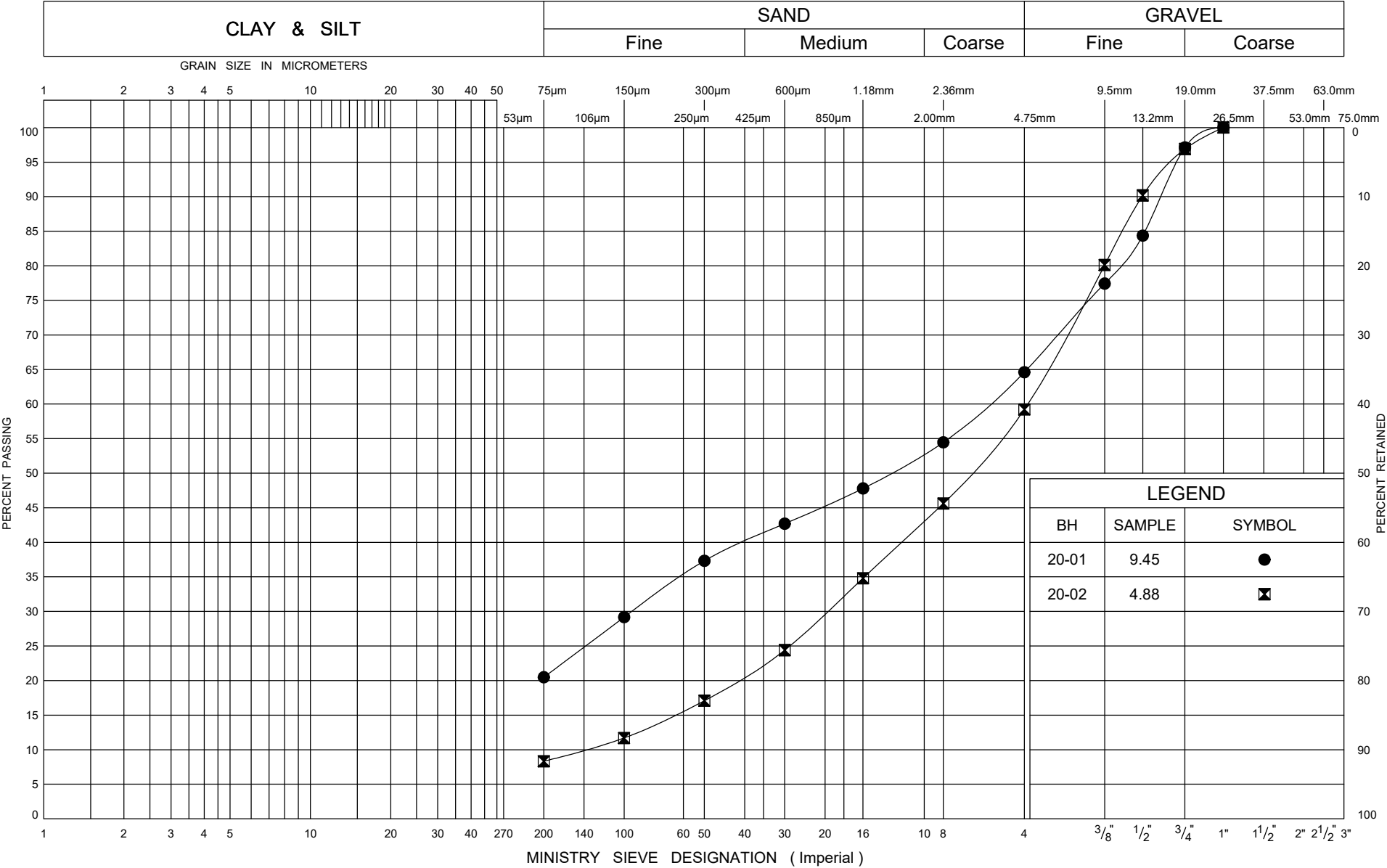
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
	Continued From Previous Page						20	40	60	80	100	20	40	60					
307.0							311												
			7	SS	14														
			8	SS	17														
			9	SS	16														
14.3	Silty SAND , trace gravel, occasional cobbles Compact Grey Wet						307									0	1	90	9
							306												
304.8			10	SS	22														
			11	SS	23														
16.5	END OF BOREHOLE AT 16.5m. BOREHOLE CAVED TO 2.5m AND WATER LEVEL AT 7.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.9m, DRY CEMENT TO 0.2m, THEN COLD PATCH TO SURFACE.						305												

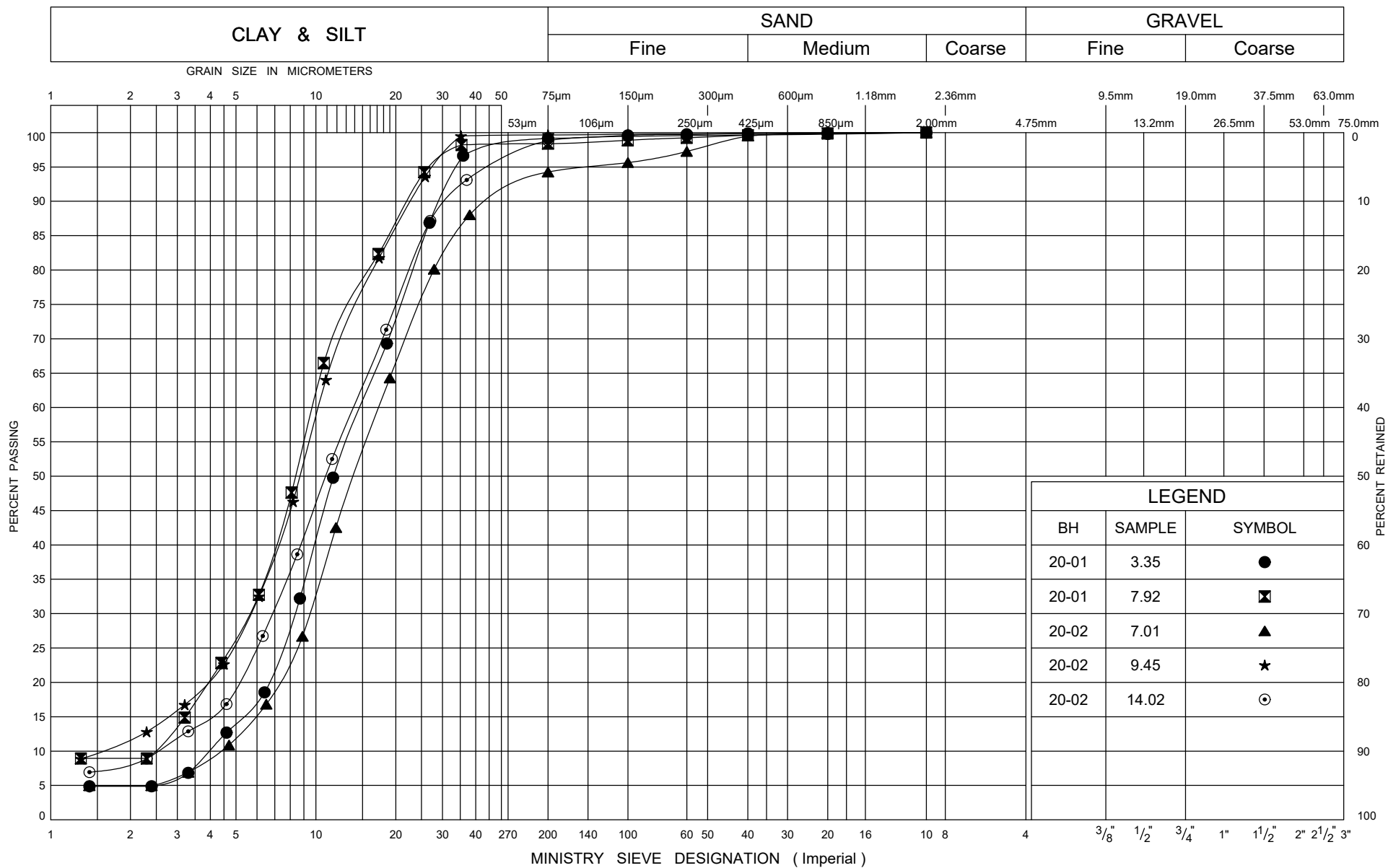
ONTMT4S2 MTO-29478.GPJ 2017TEMPLATE(MTO).GDT 1/14/21



Appendix B

Geotechnical Laboratory Test Results







Appendix C

Site Photographs



**Photo C1: East approach to existing culvert looking west along Highway 11.
(Date taken: September 20, 2020)**



**Photo C2: West approach to existing culverts, looking east along Highway 11.
(Date taken: September 20, 2020)**



**Photo C3: South side of Highway 11, south end of culverts looking north.
(Date taken: September 20, 2020)**



**Photo C4: North side of Highway 11, above culverts looking north along Nissiamkikam Creek.
(Date taken: September 20, 2020)**



**Photo C5: South side of Highway 11, above south end of culverts looking west.
(Date taken: September 20, 2020)**



**Photo C6: South side of Highway 11, above south end of culverts looking east.
(Date taken: September 20, 2020)**



**Photo C7: North side of Highway 11, above north end of culverts looking west.
(Date taken: September 20, 2020)**

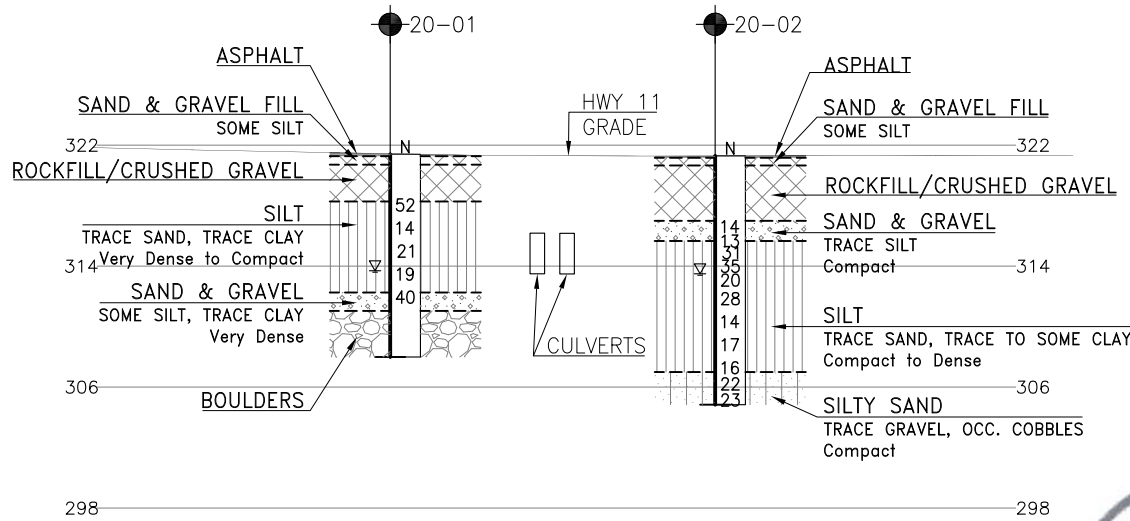
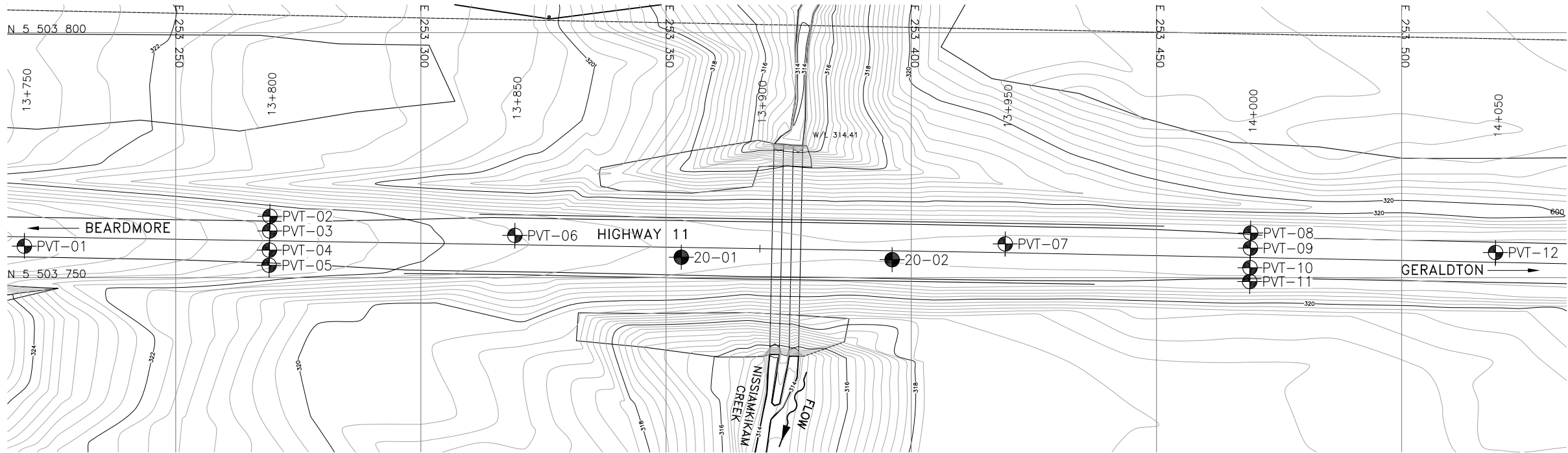


**Photo C8: South side of Highway 11, West edge of site looking north west toward bedrock
outcrops. (Date taken: September 20, 2020)**

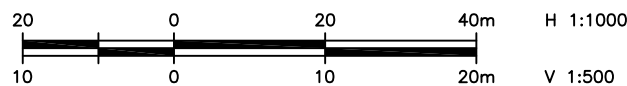


Appendix D

Borehole Locations and Soil Strata Drawings



PROFILE ALONG CL HWY 11



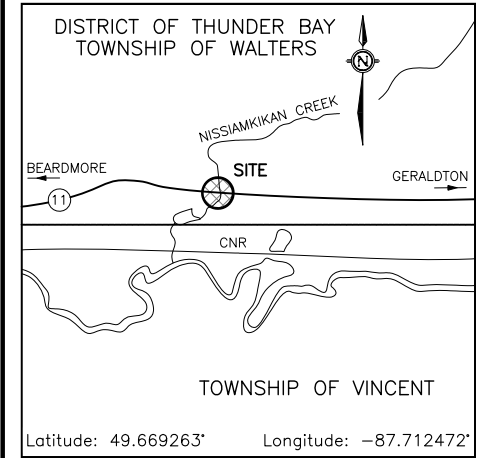
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 6561-16-00

HIGHWAY 11
NISSIAMKIKAM CREEK
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET
13



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

PVT-11	321.2	5 503 749.2	253 469.0
PVT-12	321.4	5 503 755.1	253 519.1

- NOTES-**
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
 - This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
 - Coordinate system is MTM NAD 83 Zone 14.

GEOCRES No. 42E-34



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RB	CHK MEF	CODE
DRAWN	AN	CHK RB	SITE 48E-0123/CO
			STRUCT
			DWG 1
			DATE FEB 2021



Appendix E

Borehole Data from Geocres Report 42E-31

METRIC

DIMENSIONS ARE IN METERS AND/OR
MILLIMETERS UNLESS OTHERWISE SHOWN.
STATIONS ARE IN KILOMETERS +METERS

Agreement No.: 6017-E-0066
Assignment No. 2
GWP 6561-00

NISSIAMKIKAN CREEK CULVERTS REPLACEMENT
Hwy 11, ONTARIO, CANADA
BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET

exp Services Inc.

KEY PLAN



LEGEND

- Location of Drilled Boreholes
- N Standard Penetration Test (Blows/0.3 m)
- Water Level Upon Completion of Drilling
- Temporary Bench Mark (EL. 321.31m)

SOIL STRATA SYMBOLS

- TOPSOIL
- SANDY ROOT MAT
- ASPHALT
- FILL/ROCK FILL
- SILTY SAND/ SAND AND SILT
- SILT
- SILTY SAND AND GRAVEL

BH No.	APPROX. ELEV.	MTM CO-ORDINATES (ZONE ON-14)	
		NORTH	EAST
BH-1	316.3	5503777.6	253365.8
BH-2	321.3	5503759.5	253381.5
BH-3	316.1	5503716.3	253385.1
BH-4	320.9	5503769.4	253264.3
BH-5	319.2	5503771.2	253333.1
BH-6	319.9	5503764.4	253488.1

NOTE

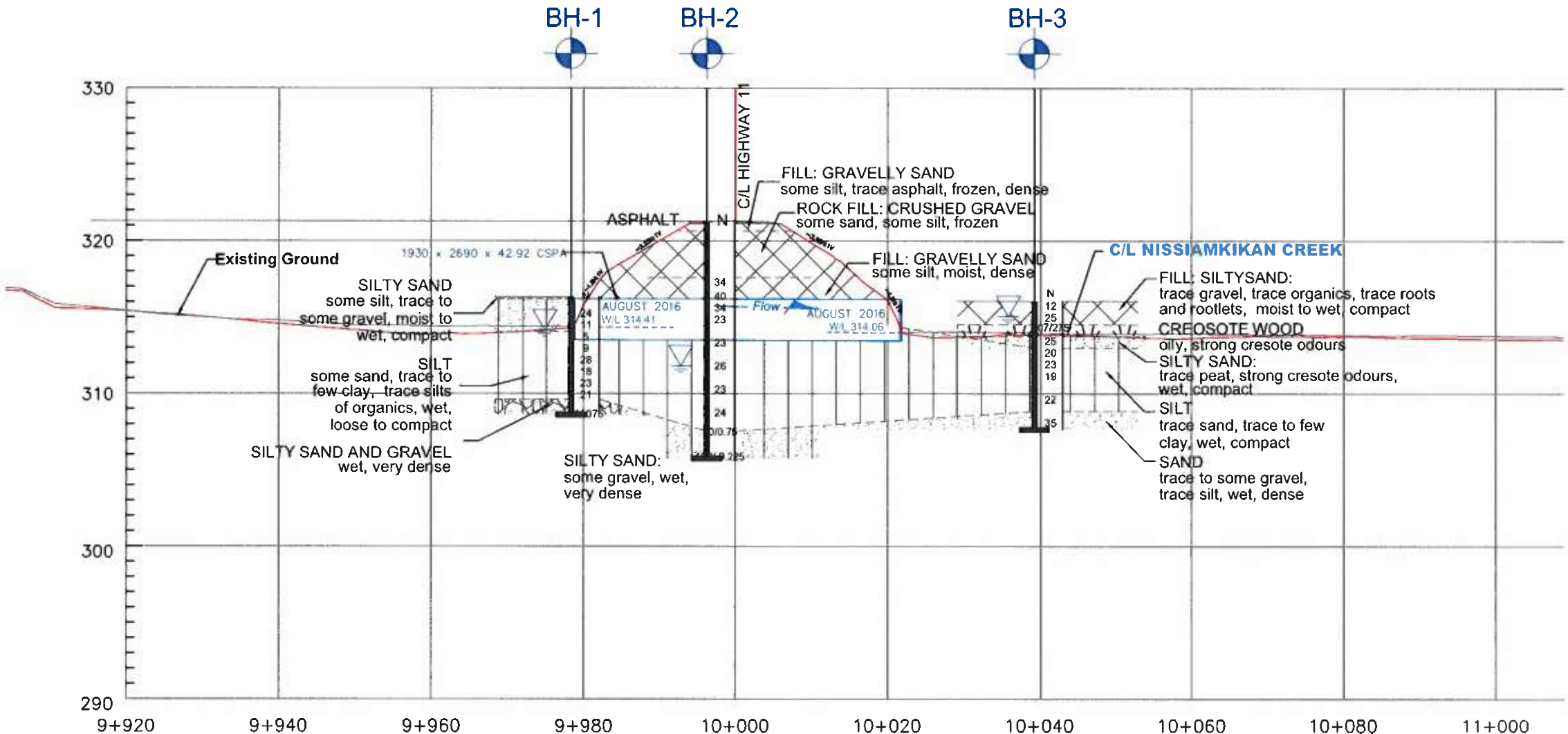
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The 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 the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

SCALE:
HOR 0 10 20 m
VERT 0 5 10 m

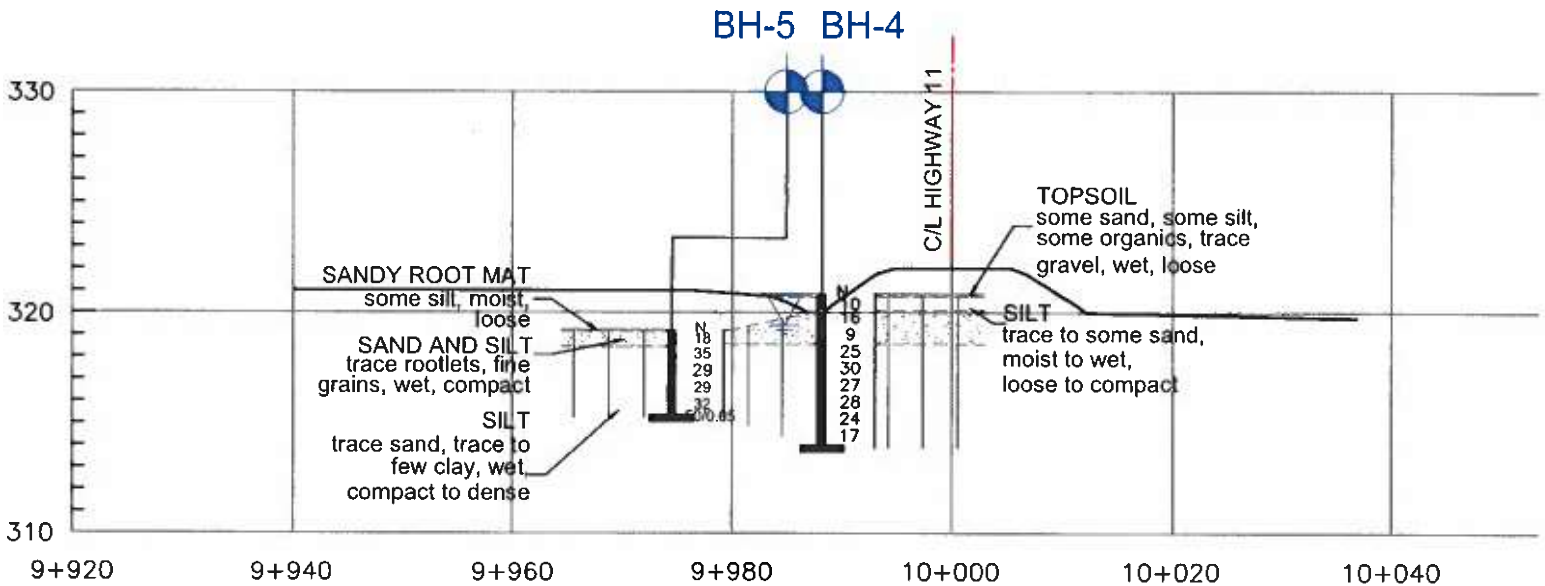
29/04/2019	SM	SUBMISSION FOR MTO REVIEW	
DATE	BY	DESCRIPTION	
		GEOCRE NO. 42E-31	
		PROJECT NO. ADM-00248798-B0	
SUBMD	SM	CHECKED	SM
DRAWN	SH	CHECKED	SG
DATE	29/04/2019	APPROVED	SG
DWG.	2		

SECTION A-A' ALONG
C/L CULVERT

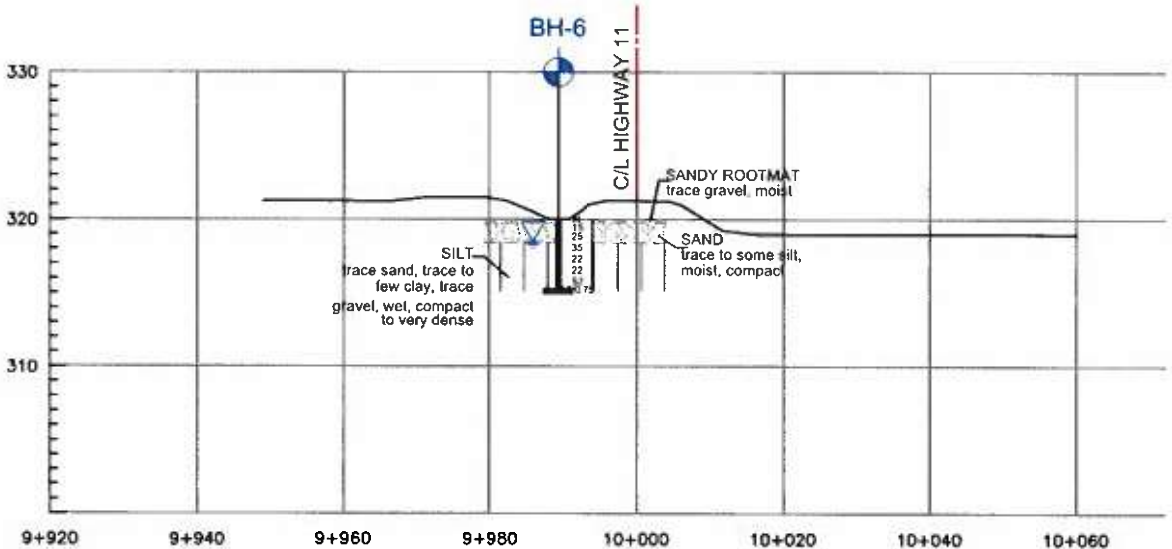


METRIC

DIMENSIONS ARE IN METERS AND/OR
MILLIMETERS UNLESS OTHERWISE SHOWN.
STATIONS ARE IN KILOMETERS +METERS



SECTION B-B'



SECTION C-C'

Agreement No. 6017-E-0066
Assignment No. 2
GWP 6561-00

NISSIAMKIKAN CREEK CULVERTS REPLACEMENT
Hwy 11, ONTARIO, CANADA
BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET

exp. exp Services Inc.

KEY PLAN



LEGEND

- Location of Drilled Boreholes
- N Standard Penetration Test (Blows/0.3 m)
- Water Level Upon Completion of Drilling
- Temporary Bench Mark (EL. 321.31m)

SOIL STRATA SYMBOLS

- TOPSOIL/ SANDY ROOT MAT
- ASPHALT
- FILL/ ROCK FILL
- SILT
- SILTY SAND AND GRAVEL
- SILTY SAND/ SAND AND SILT

BH No.	APPROX. ELEV.	MTM CO-ORDINATES (ZONE ON-14)	
		NORTH	EAST
BH-1	316.3	5503777.6	253365.8
BH-2	321.3	5503759.5	253381.5
BH-3	316.1	5503716.3	253385.1
BH-4	320.9	5503769.4	253264.3
BH-5	319.2	5503771.2	253333.1
BH-6	319.9	5503764.4	253488.1

NOTE

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 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 the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

SCALE:



29/04/2019	SM	SUBMISSION FOR MTO REVIEW	
DATE	BY	DESCRIPTION	
		GEOCRE NO. 42E-31	
		PROJECT NO. ADM-00248798-B0	
SUBMD	SM	CHECKED	SG
DATE	29/04/2019	APPROVED	SG
DRAWN	SH	CHECKED	SG
DWG	3		

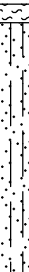



Brampton, Ontario

RECORD OF BOREHOLE No BH-1

1 OF 1

METRIC

W.P. 6561-00 LOCATION Hwy 11, Thunder Bay, 253365.784E, 5503777.576N ORIGINATED BY EF
 DIST Thunder Bay HWY 11 BOREHOLE TYPE 108 mm I.D HSA, Acker MP5 COMPILED BY SH
 DATUM Geodetic DATE 2018.12.12 - 2018.12.13 LATITUDE 49.6694753 LONGITUDE -87.7125968 CHECKED BY SM

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 (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL P. PENETROMETER											
316.3	Ground Surface							20	40	60	80	100							
316.0	SANDY ROOTMAT: trace gravel, dark brown, moist, loose SILTY SAND: trace to some gravel, brown to greyish brown, moist to wet, compact		1	AS		▽	316												
0.2			2	SS															
			3	SS	24														14 57 (29)
			4	SS	11														
314.0	SILT: some sand, trace to few clay, trace organics, light brown to light grey, wet, loose to compact -becoming sandy silt		5	SS	5		314												
2.3			6	SS	9		313												0 38 55 7
			7	SS	28		312												
			8	SS	18		311												
			9	SS	23		310												0 0 94 6
			10	SS	21		309												
309.6			SILTY SAND AND GRAVEL: grey, wet, very dense					309											
6.7																			
308.6	End of Borehole: auger/ split-spoon refusal @ 7.7 m. Notes: 1. Upon completion of borehole, groundwater level was measured at 2.2 m.		11	SS	50/ .075														
7.7																			

ONTARIO MTO ASSIGNMENT #2.GPJ ONTARIO MTO.GDT 2/7/19

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

Brampton, Ontario

RECORD OF BOREHOLE No BH-2

1 OF 2

METRIC

W.P. 6561-00 LOCATION Hwy 11, Thunder Bay, 253381.543E, 5503759.512N ORIGINATED BY EF
 DIST Thunder Bay HWY 11 BOREHOLE TYPE 112 mm SSA, 108 mm ID HSA, Acker MP5 COMPILED BY SH
 DATUM Geodetic DATE 2018.12.14 - 2018.12.14 LATITUDE 49.6693143 LONGITUDE -87.7123761 CHECKED BY SM

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 (%)			
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		
321.3	Road Surface																	
320.0	ASPHALT 125 mm thick asphalt		1	AS							○						12	61 (27)
0.1	FILL: GRAVELLY SAND some silt, trace asphalt, frozen, brown, dense		2	AS							○							
320.7			3	AS							○							
0.6	ROCK FILL: CRUSHED GRAVEL some sand, some silt, brown, frozen		4	AS							○							
			5	AS							○							
			6	AS							○							
			7	AS							○							
			8	SS	2													no recovery
317.6	FILL: GRAVELLY SAND some silt, brown, moist, dense		9	SS	34						○						27	59 (14)
3.7			10	SS	40						○							
315.9	SILT: trace sand, trace to few clay, light brown to light grey, wet, dense to compact		11	SS	34						○						0	4 90 6
5.3			12	SS	23						○							
			13	SS	23						○							
			14	SS	26						○						0	1 (99)
			15	SS	23						○							

Continued Next Page

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

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

Brampton, Ontario

RECORD OF BOREHOLE No BH-3

1 OF 1

METRIC

W.P. 6561-00 LOCATION Hwy 11, Thunder Bay, 253385.115E, 5503716.303N ORIGINATED BY EF
 DIST Thunder Bay HWY 11 BOREHOLE TYPE 108 mm I.D HSA, Acker MP5 COMPILED BY SH
 DATUM Geodetic DATE 2018.12.11 - 2018.12.12 LATITUDE 49.6689261 LONGITUDE -87.7123209 CHECKED BY SM

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE									
								● QUICK TRIAXIAL P. PENETROMETER									
316.0	Ground Surface					20	40	60	80	100	20	40	60		GR SA SI CL		
0.0	FILL: SILTYSAND: trace gravel, trace organics, trace roots and rootlets, brown, moist to wet, compact		1	SS	12	▽										4 70 (26)	
			2	SS	25												
314.5																	
1.5	CREOSOTE WOOD oily, strong creosote odours refusal to SPT @ 1.9 m auger through wood		3	SS	107/0.225												
313.8																	
2.3	SILTY SAND: trace peat, strong creosote odours, dark brown, wet, compact		4	SS	25												
313.0																	
3.1	SILT: trace sand, trace to few clay, grey, wet, compact		5	SS	20												
			6	SS	23												
			7	SS	19												
			8	SS	22												
308.8	noted harder strata or change in layer @ approximate 7.2 m.																
7.2	SAND: trace to some gravel, trace silt, grey, wet, dense		9	SS	35												
307.6																	
8.4	End of Borehole: auger/ split-spoon refusal @ 8.4 m Notes: 1. Upon completion of borehole, groundwater level measured at 1.0 m.																

ONTARIO MTO ASSIGNMENT #2.GPJ ONTARIO MTO.GDT 2/7/19

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

Brampton, Ontario

RECORD OF BOREHOLE No BH-4

1 OF 1

METRIC

W.P. 6561-00 LOCATION Hwy 11, Thunder Bay, 253264.348E, 5503769.383N ORIGINATED BY EF
 DIST Thunder Bay HWY 11 BOREHOLE TYPE 108 mm I.D HSA, Acker MP5 COMPILED BY SH
 DATUM Geodetic DATE 2018.12.13 - 2018.12.13 LATITUDE 49.669393 LONGITUDE -87.7140016 CHECKED BY SM

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 (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL P. PENETROMETER			WATER CONTENT (%) w _p w w _L						
320.9	Ground Surface		1	AS		▽	320								0 16 (84)		
320.0	TOPSOIL: some sand, some silt, some organics, trace gravel, dark brown to black, wet, loose SILT trace to some sand, light brown with oxidation, moist to wet, loose to compact SAND AND SILT brown, wet, loose to compact		2	SS	10												
0.2																	
320.1																	
0.8			3	SS	16												
			4	SS	9												
			5	SS	25												
318.6	SILT trace sand, trace to few clay, light brown to grey, wet, compact to dense		6	SS	30												
2.3			7	SS	27												
			8	SS	28												
			9	SS	24												
			10	SS	17												
313.9	End of Borehole: auger/ split-spoon refusal @ 7.0 m Notes: 1. Upon completion of borehole, groundwater level measured at 1.4 m.																
7.0																	

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

Brampton, Ontario

RECORD OF BOREHOLE No BH-5

1 OF 1

METRIC

W.P. 6561-00 LOCATION Hwy 11, Thunder Bay, 253333.101E, 5503771.195N ORIGINATED BY EF
 DIST Thunder Bay HWY 11 BOREHOLE TYPE 108 mm I.D HSA, Acker MP5 COMPILED BY SH
 DATUM Geodetic DATE 2018.12.13 - 2018.12.13 LATITUDE 49.6694152 LONGITUDE -87.7130487 CHECKED BY SM

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 (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL P. PENETROMETER								WATER CONTENT (%)	
319.2	Ground Surface		1	AS			319								1 78 (21)		
319.0	SANDY ROOT MAT some silt, dark brown, moist, loose		2	SS	18												
318.5	SILTY SAND trace rootlets, fine grains, brown to light brown, wet, compact																
0.8	SILT trace sand, trace to few clay, light brown, wet, compact to dense		3	SS	35				318								
			4	SS	29												
		5	SS	29		317							0 1 90 9				
		6	SS	32		316											
315.2			7	SS	50/ 0.05												
4.0	End of Borehole: auger/ split-spoon refusal @ 4.0 m. Notes: 1. No measurable groundwater level in open hole.																

+³, X³: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

Brampton, Ontario

RECORD OF BOREHOLE No BH-6

1 OF 1

METRIC

W.P. 6561-00 LOCATION Hwy 11, Thunder Bay, 253488.055E, 5503764.451N ORIGINATED BY EF
 DIST Thunder Bay HWY 11 BOREHOLE TYPE 108 mm I.D HSA, Acker MP5 COMPILED BY SH
 DATUM Geodetic DATE 2018.12.12 - 2018.12.12 LATITUDE 49.6693677 LONGITUDE -87.7109012 CHECKED BY SM

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 (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL P. PENETROMETER					W _P W W _L WATER CONTENT (%)				GR	SA	SI	CL		
319.9	Ground Surface		1	AS			319															
319.8	SANDY ROOTMAT trace gravel, brown, moist		2	SS	15																	
0.2	SAND trace to some silt, light brown, moist, compact		3	SS	25																	
318.4	SILT trace sand, trace to few clay, trace gravel, light brown to grey, wet, compact to very dense	4	SS	35				318														
1.5		5	SS	22																		
		6	SS	22					317													
		7	SS	52																		
		8	SS	50/ 0.075					316													
315.1	End of Borehole: auger/ split-spoon refusal @ 4.8m Notes: 1. Upon completion of borehole, groundwater level measured at 1.4 m.																					
4.8																						

+³, X³: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE