FOUNDATION INVESTIGATION AND DESIGN REPORT
UNNAMED CREEK CULVERT REHABILITATION
HIGHWAY 567
NEW LISKEARD DISTRICT, ONTARIO

G.W.P. No. 5201-13-00, W.P. No. 5176-13-01, SITE NO. 47-316/C

GEOCRES Number: 31M-116

Report to

MMM Group Limited

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) at the culvert on Highway 567 over Unnamed Creek, located in the Township of Lorrain, New Liskeard District, Ontario.

The purpose of this investigation was to obtain subsurface information at the culvert location and, based on the data obtained, to provide a borehole location plan, stratigraphic profile, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by MMM Group Limited to carry out this foundation investigation under the MTO Assignment Number 5014-E-0019.

2 SITE DESCRIPTION

The culvert site is located on Highway 567, approximately 8 km south of old Highway 11B (Rorke Avenue) in the Township of Lorrain, New Liskeard District, Ontario. This culvert allows Unnamed Creek to flow, from south to north, under Highway 567 towards Lake Temiskaming. Highway 567 generally runs in a northwest-southeast direction, and locally runs east-west at the culvert site.

An Ontario Structure Inspection Manual (OSIM) report conducted in 2011 reports the existing structure to be a 30 m long composite culvert that consists of a cast-in-place concrete box culvert at the outlet and a corrugated steel pipe (CSP) culvert at the inlet. The CSP culvert is reported as 14.6 m in length with a diameter of 3.3 m in the OSIM report. The OSIM reports the cast-in-place concrete box culvert to be 15.4 m in length, with a height and width of 2.5 and 2.4 m respectively. The OSIM report also indicates that there is approximately 3.7 m of fill above the culvert. A cross-section provided by MMM Group Limited shows the composite culvert to be approximately 45 m long. It is understood that the structure is in good condition with minor deterioration of several elements with more significant deterioration of the structural steel coatings. The culvert is proposed for rehabilitation.

The grade level of Highway 567 at the existing culvert is at approximate Elevation 193 m.

The site is located approximately 8 km east of Cobalt with residential and agricultural properties nearby. Naturally low-lying areas are present near the inlet and outlet of the culvert, with vegetation consisting of tall grass and shrubs with frequent trees. Areas surrounding the properties are heavily forested. The area in the immediate vicinity of the culvert is undulating and generally sloping downwards from the highway grade to the creek.

Based on published geological information, the general area of the project is covered by glaciolacustrine fine-textured deposits of clays and silts deposited during the Pleistocene period. These deposits are often rhythmically laminated or varved and are overlain by thin layer of swamp and alluvium deposits composed of silt, sand, possible gravel and organics. The bedrock in the area consists of Precambrian quartz sandstone, siltstone, and minor conglomerate of the Lorrain Formation (Cobalt Group).

3 SITE INVESTIGATION AND FIELD TESTING

This borehole investigation and field testing program was carried out in two segments. The first on June 11, 2015 and the second on June 26, 2015. The program consisted of drilling and sampling 3 boreholes, numbered UNC-01 to UNC-03, to depths ranging from 2.7 to 4.2 m. Of these boreholes, two were located near the culvert outlet (UNC-01 and UNC-02) and one was located near the culvert inlet (UNC-03). All of the boreholes were drilled through the native ground near the base of the highway embankment.

Prior to the start of drilling, the borehole locations were marked/staked in the field and utility clearances were obtained. The coordinates and ground surface elevations for the boreholes were derived from topographic plans provided to Thurber by MMM Group Limited. The coordinate system MTM NAD 83, Zone 12 was used for the boreholes. The approximate borehole locations are shown on the Borehole Locations and Soil Strata drawing included in Appendix C.

A portable tripod drill rig was used to advance the boreholes to the target depth using NW casing and wash boring techniques. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). Groundwater conditions in the open boreholes were observed throughout the drilling operations. The details regarding borehole completion are summarized in Table 3.1.

Table 3.1 - Borehole Completion and Backfilling Details

Borehole	Borehole Depth/ Elevation (m)	Borehole Backfilling Details
UNC-01	4.2 / 181.1	Bentonite holeplug from 4.2 m to ground surface.
UNC-02	2.7 / 183.6	Bentonite holeplug from 2.7 m to ground surface.
UNC-03	3.5 / 182.7	Bentonite holeplug from 3.5 m to ground surface.

The results of the field drilling and sampling are presented on the Record of Borehole sheets in Appendix A.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, secured the recovered soil samples in labelled containers, and transported the samples to Thurber's laboratory for further examination and testing.

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected soil samples were subjected to grain size distribution analyses (sieve and hydrometer). The small amount of soil recovered in the tri-pod sampling process was not sufficient to allow for plasticity testing (Atterberg Limits). The results of this laboratory testing program are shown on the Record of Borehole sheets in Appendix A and on the figures in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the surface water from the creek upstream of the existing culvert was collected. An insufficient quantity of soil was recovered in the sampling process to allow for soil corrosivity testing. The water sample was submitted to AGAT Laboratories in Mississauga, Ontario for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 below and are presented in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix A for details of the soil stratigraphy encountered in the boreholes. A stratigraphic section for this culvert site is presented on the Borehole Locations and Soil Strata Drawing in Appendix C for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs;

however, the factual data presented in the record of boreholes governs any interpretation of the site conditions.

In general, the subsurface conditions encountered in the boreholes located at the culvert inlet and outlet consist of silty clay overlying a deposit of sand and gravel, which is further underlain by sandy silt. All of the boreholes were terminated due to tripod casing refusal in very dense or hard soil. Groundwater levels are generally in the order of 0.8 to 1.0 m below original ground surface. More detailed descriptions of the individual stratum are presented below.

5.2 Silty Clay

Silty clay was encountered at surface in all of the boreholes drilled at the site. This dark brown to grey soil was typically sandy, and contained trace gravel, occasional cobbles, and trace organic inclusions (roots and wood fibres) at shallow depths. The thickness of the silty clay ranged from 1.5 to 4.0 m, with base Elevations from 184.8 to 181.3 m where fully penetrated. Borehole UNC-03 was terminated within the silty clay upon casing refusal at a depth of 3.5 m (Elevation 182.7 m).

SPT N-values measured in the silty clay ranged between 6 blows per 0.3 m penetration and 50 blows per 0.05 m penetration, indicating that the consistency of the silty clay ranges from firm to hard; typically becoming hard below Elevation 184 m.

The measured water contents of samples recovered from the silty clay ranged from 10% to 63%. Grain size analyses conducted on samples of the silty clay are presented in Figure B1 in Appendix B. The results are summarized in the following table.

Soil Particles	%
Gravel	0 to 7
Sand	19 to 57
Silt	14 to 56
Clay	24 to 36

5.3 Sand and Gravel

Underlying the silty clay layer, a sand and gravel deposit containing trace silt was encountered in Boreholes UNC-01 and UNC-02. Borehole UNC-01 was terminated within the sand and gravel layer upon casing refusal at a depth of 4.2 m (Elevation 181.1 m). The sand and gravel layer in Borehole UNC-02 was fully penetrated with a thickness of 1.1 m and a lower base depth of 2.6 m (Elevation 183.7 m).

SPT N-values measured within the sand and gravel varied between 27 blows per 0.3 m penetration and 101 blows per 0.175 m penetration, indicating that the deposit is compact to very dense.

Measured water contents of samples recovered from the sand and gravel deposit ranged from 7% to 13%. A grain size analysis conducted on a sample of the sand and gravel is presented in Figure B2 in Appendix B. The results are summarized in the following table.

Soil Particles	**%**
Gravel	55
Sand	41
Silt and Clay	4

5.4 Sandy Silt

A layer of sandy silt with some clay and trace gravel was encountered beneath the sand and gravel in Borehole UNC-02. The borehole was terminated within the sandy silt layer upon casing refusal at a depth of 2.7 m (Elevation 183.6 m). The measured water content of a sample recovered from the sandy silt was 14%.

5.5 Groundwater Conditions

Free water was observed in Boreholes UNC-01 and UNC-02 upon completion of drilling and the water level measurements are presented in Table 5.1 below. Borehole UNC-03 was dry upon completion of drilling at 3.5 m depth (Elevation 182.7 m). Wash boring methods were used to advance the boreholes and therefore the water level recorded during or upon completion of drilling may not reflect natural groundwater levels.

Table 5.1 – Water Level Measurements in Open Boreholes

Borehole	**Date of Reading**	**Water Level**	
		Depth (m)	**Elevation (m)**
UNC-01	June 11, 2015	0.8	184.5
UNC-02	June 11, 2015	1.0	185.3

A water level was measured in the creek by MMM Group Limited at Elevation 185.1 near the midpoint of the culvert on June 3, 2015. The groundwater level should be assumed to reflect the local creek water level. The groundwater levels are expected to vary seasonally and are subject to severe weather events such as rainstorms.

6 HYDRAULIC CONDUCTIVITY OF SUBSURFACE SOILS

The estimated hydraulic conductivity values for the subsurface soils encountered within the depth of exploration are provided in Table 6.1. The silty clay value is based on the typical range of hydraulic conductivity and the sand and gravel value is estimated from an empirical relationship with grain size distribution.

Table 6.1 – Hydraulic Conductivity Values for Subsurface Soils

Material	Hydraulic Conductivity (m/s)
Silty Clay	1×10^{-10} to 1×10^{-8}
Sand and Gravel	1×10^{-4} to 1×10^{-3}

7 CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the surface water from the creek was submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 7.1. The laboratory certificates of analysis are presented in Appendix B.

Table 7.1 – Analytical Test Results

Parameter	Units (Water)	Test Results Unnamed Creek Culvert (Creek Water)
Sulphide	mg/L	<0.05
Chloride	mg/L	1.94
Sulphate	mg/L	2.64
pH	pH Units	8.14
Electrical Conductivity	µS/cm	338
Resistivity	ohm.cm	2960
Redox Potential	mV	297
Langlier Index	-	0.82
Total Hardness (as $CaCO_3$)	mg/L	186
Total Dissolved Solids	mg/L	174
Alkalinity (as $CaCO_3$)	mg/L	174

8 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field relative to the topographic plans provided by MMM Group Limited.

Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied and operated a portable tripod drill rig to carry out the drilling, sampling and in-situ testing operations. The drilling and sampling operations in the field were supervised on a full time basis by Ms. Eckie Siu and Mr. Amir Fereidouni of Thurber. Geotechnical laboratory testing was carried out by Thurber in its MTO-approved laboratory.

A sample of creek water was submitted to AGAT Laboratories in Mississauga, Ontario for testing of selected corrosivity parameters.

Overall supervision of the field program, interpretation of the data, and preparation of the report were carried out by Mr. Stephane Loranger, CET, Ms. Deanna Pizycki, EIT, 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.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

9 GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical recommendations for the proposed rehabilitation of the existing Unnamed Creek Culvert on Highway 567, in the Township of Lorrain, New Liskeard District, Ontario.

The existing structure is a composite culvert that consists of a cast-in-place 2.5 m high by 2.4 m wide concrete box culvert at the outlet and a 3.3 m diameter corrugated steel pipe (CSP) culvert at the inlet. Based on the terms of reference, it is understood that the culvert is in good condition, with minor deterioration of several elements, and more significant deterioration of the structural steel coatings. The culvert therefore is proposed for structural rehabilitation, which may include placement of a liner system, shotcrete treatment, or both. The purpose of the foundation investigation is to provide dewatering recommendations to enable rehabilitation of the culvert in the dry.

The discussions and recommendations presented in this report are based on information provided by MMM Group Limited (MMM) and on the factual data obtained during the course of this investigation.

Selected photographs of the culvert area are included in Appendix D for reference.

10 EXCAVATIONS, DEWATERING AND TEMPORARY SUPPORT

10.1 Excavations

Where excavations are required in order to rehabilitate the culvert they must be conducted in accordance with the requirements of the Occupational Health and Safety Act and Regulations (OHSA) for Construction Projects. The soil types at this site should be classified as follows:

• Embankment Fill	Type 3
• Silty Clay (firm to stiff, above 1.5 m depth)	Type 3
• Silty Clay (very stiff to hard, below 1.5 m depth)	Type 2
• Sand and Gravel (compact to very dense)	Type 3

The Contract Documents should alert the Contractor to the risks associated with excavations near the creek and below the groundwater level and specify that an appropriate dewatering system must be provided to maintain a stable and dry work area.

10.2 Dewatering

The Contractor must be prepared to control the groundwater and surface water flow at the site to permit the culvert rehabilitation works to be conducted in a dry and stable excavation. The groundwater level for the site at the time of the proposed works should be taken as the water level in the creek. It is recommended that the rehabilitation works be conducted during a drier season when the creek level is likely to be low.

Temporary water course diversion may be required to rehabilitate the culvert in the dry. Water from either surface flow and/or groundwater must be diverted away from the excavation at all times. Groundwater within the native sand and gravel deposits or perched within the embankment fill, surface water runoff, and/or the water from the creek will tend to seep into and accumulate in proposed excavations.

If excavations below the groundwater level or into the sand and gravel deposits below the silty clay (greater than 1.5 m deep) are anticipated, a cofferdam may be required to control the inflow of water into the excavation.

Dewatering and surface water diversion must remain operational and effective until the culvert is repaired and excavations are backfilled. Decisions regarding dewatering must be taken by the Contractor.

It is recommended that the Contract Documents identify a water level in Unnamed Creek against which the cofferdam must provide protection and prevent flooding of the work area. The appropriate water level must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field. At a minimum the expected spring thaw level or the level reached by a storm of appropriate return period should be used as the design water level.

A permit to take water (PTTW) should be obtained prior to commencement of dewatering operations.

Further discussion with regards to dewatering at this site is provided in the Non-Standard Special Provision (NSSP) in Appendix E.

10.3 Cofferdam

Culvert rehabilitation works should be conducted in a dry and stable excavation.

One option to control groundwater and surface water flow and support temporary excavations is to construct a cofferdam using interlocking, steel sheetpiles, driven into the hard silty clay or underlying sand and gravel. The work area could then be kept dry through the use of sump pits and pumps. The creek flow should be temporarily diverted around the cofferdam and work area using a flume pipe or, if necessary, by pumping.

10.4 Sheetpile Design

Interlocking steel sheetpiles are considered to be suitable for use at this site for construction of cofferdams or to provide temporary support of excavations near the existing highway embankment. It is anticipated that the sheetpiles will need to be driven into the hard native silty clay or underlying sand and gravel to develop the required toe resistance.

Lateral earth pressures acting on the sheetpiles may be assumed to impose a triangular distribution and should be computed in accordance with the Canadian Highway Bridge Design Code (CHBDC) but are generally given by the expression:

$$p_h = K(\gamma h + q)$$

where,

p_h	=	horizontal pressure on the wall at depth h (kPa)
K	=	earth pressure coefficient (see below)
γ	=	bulk unit weight of retained soil (see below)
h	=	depth below top of fill where pressure is computed (m)
q	=	value of any surcharge (kPa)

An interlocking sheetpiled wall, assuming a horizontal back-slope may be designed using the parameters given below:

γ	=	21 kN/m^3 (embankment fill);
	=	17 kN/m^3 (silty clay)
	=	21 kN/m^3 (sand and gravel)
γ_w	=	10 kN/m^3
K_a	=	0.33 (road embankment fill)
	=	0.36 (silty clay)
	=	0.31 (sand and gravel)
K_p	=	2.8 (silty clay)
	=	3.0 (sand and gravel)

Full hydrostatic pressure should be considered assuming a water level at least equal to the design creek water level.

The actual pressure distribution acting on the support system is a function of the construction sequence and the relative flexibility of the wall, and these factors must be considered when designing the shoring system.

The designer of the sheetpiles must check whether the penetration depth is sufficiently deep to provide base fixity.

All support systems must be designed by a Professional Engineer experienced in such designs.

11 CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the creek water indicate the following:

- The potential for corrosion or sulphate attack on concrete treatment systems from the surface water is considered to be negligible due to the low concentration of sulphate in the sample tested.
- The potential for surface water corrosion on metal is considered to be mild to moderate.
- Appropriate protection measures are recommended to address the mild to moderate potential for corrosion on metal structural rehabilitation elements.

12 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to, the following:

- Seasonal fluctuations of the groundwater and creek level are to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall, which may impact the construction.

13 CLOSURE

Preparation of this foundation design report was carried out by Mr. Mark Farrant, P.Eng. The report was reviewed by Mr. Alastair Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng.

THURBER ENGINEERING LTD.

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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.

<u>UNIFIED SOILS CLASSIFICATION</u>

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			

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No UNC-01

METRIC

GWP# 5201-13-00 | LOCATION Unnamed Creek Culvert N 5 249 919.0 E 412 159.4 | ORIGINATED BY ES

HWY 567 | BOREHOLE TYPE Tripod | COMPILED BY MFA

DATUM Geodetic | DATE 2015.06.11 - 2015.06.11 | CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
185.3	GROUND SURFACE										
0.0	Silty **CLAY**, sandy, trace organics (roots and rootlets) Firm to Stiff Dark Brown to Grey Moist	1	SS	6		185	○ (~25)				
					▽ (0.8 m)						
		2	SS	10			○ (~33)	0	34	40	26
						184					
	Occasional cobbles Becoming Hard Wet	3	SS	60			○ (~62)				
	Becoming some sand, trace gravel					183					
		4	SS	63							
		5	SS	75		182	○ (~9)	1	19	56	24
181.3 / 4.0	**SAND** and **GRAVEL**, trace silt Very Dense Grey Wet	6	SS	101/0.175			○ (~12)				
181.1 / 4.2	END OF BOREHOLE AT 4.2m UPON CASING REFUSAL. WATER LEVEL AT 0.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.										

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

20 / 15 ◆ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No UNC-02

METRIC

GWP# 5201-13-00 | LOCATION Unnamed Creek Culvert N 5 249 914.6 E 412 145.8 | ORIGINATED BY ES

HWY 567 | BOREHOLE TYPE Tripod | COMPILED BY MFA

DATUM Geodetic | DATE 2015.06.11 - 2015.06.11 | CHECKED BY MEF

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
186.3	GROUND SURFACE										
0.0	Silty **CLAY**, sandy, trace gravel, trace organics (roots and rootlets) Stiff Dark Brown to Brown Wet; Wood fibres	1	SS	10		186					
		2	SS	15	▽			7	23	34	36
184.8 / 1.5	**SAND** and **GRAVEL**, trace silt Compact to Very Dense Grey Wet	3	SS	27		185					
183.7		4	SS	104/0.250		184		55	41	4 (SI+CL)	
183.6 / 2.6; 2.7	Sandy **SILT**, some clay, trace gravel Very Dense Grey Moist										

END OF BOREHOLE AT 2.7m UPON CASING AND SPOON REFUSAL.
WATER LEVEL AT 1.0m UPON COMPLETION.
BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%).

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UNC-03

METRIC

GWP# 5201-13-00
LOCATION Unnamed Creek Culvert N 5 249 868.4 E 412 171.8
ORIGINATED BY AHF

HWY 567
BOREHOLE TYPE Tripod
COMPILED BY MFA

DATUM Geodetic
DATE 2015.06.26 - 2015.06.26
CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) (approx.)	GR	SA	SI	CL
186.2	GROUND SURFACE									
0.0	Silty **CLAY**, sandy, trace gravel, trace organics (roots and rootlets) Firm Brown Moist	1	SS	6	186	~21	0	40	27	33
	Grey Wet	2	SS	8	185	~35	0	57	14	29
	Becoming Very Stiff to Hard	3	SS	19	184	~24				
		4	SS	50/ 0.050		~17	2	26	47	25
182.7 / 3.5		5	SS	90/ 0.125	183	~16				
	END OF BOREHOLE AT 3.5m UPON CASING REFUSAL. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.									

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Appendix B

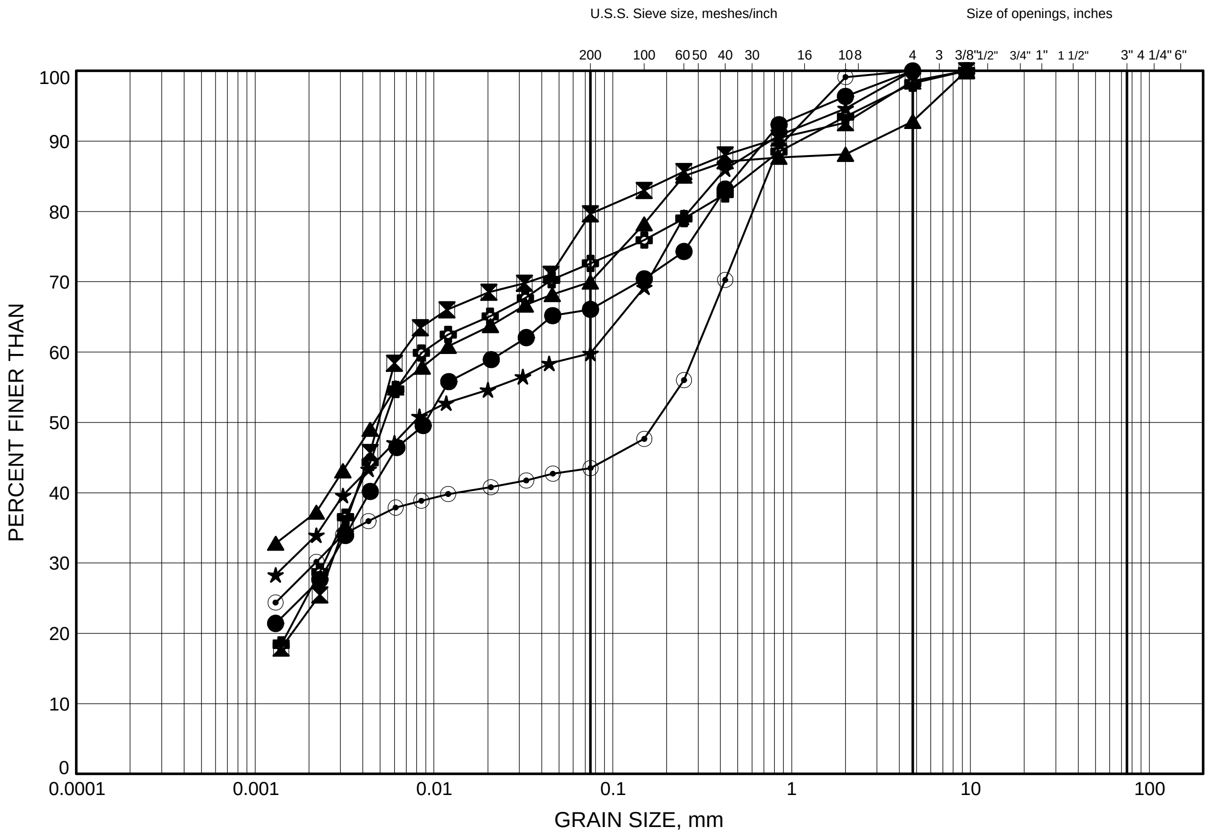
Laboratory Test Results

Unnamed Creek Culvert

GRAIN SIZE DISTRIBUTION

FIGURE B1

Silty CLAY, Sandy



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	UNC-01	1.07	184.23
⧗	UNC-01	3.34	181.96
▲	UNC-02	1.07	185.23
★	UNC-03	0.30	185.90
⊙	UNC-03	1.07	185.13
✿	UNC-03	2.59	183.61

Date February 2016

GWP# 5201-13-00

THURBER

Prep'd AN

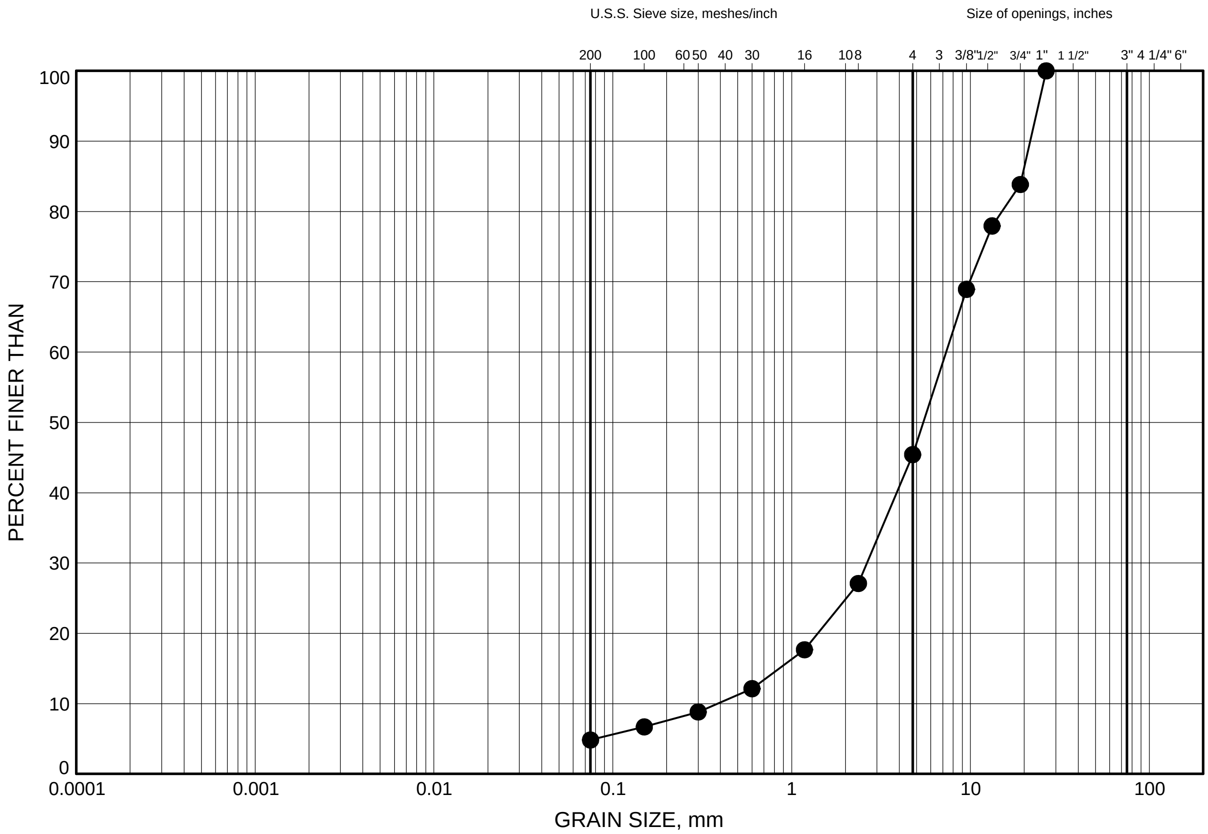
Chkd. MEF

Unnamed Creek Culvert

GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND & GRAVEL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	UNC-02	2.44	183.86

Date February 2016

GWP# 5201-13-00

THURBER

Prep'd AN

Chkd. MEF

GRAIN SIZE DISTRIBUTION - THURBER 19-5161-251.GPJ 2/4/16

AGAT Laboratories
5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

CLIENT NAME: THURBER ENGINEERING LTD
AGAT WORK ORDER: 15T990315
PROJECT: 19-5161-251
ATTENTION TO: MARK FARRANT
SAMPLING SITE:
SAMPLED BY:

Inorganic Chemistry (Water)

SAMPLE TYPE: Water
SAMPLE ID: 6699748
DATE RECEIVED: Jun 29, 2015
DATE SAMPLED: Jun 26, 2015
DATE REPORTED: Jul 07, 2015
SAMPLE DESCRIPTION: Unnamed Creek Culvert

PARAMETER	UNIT	RESULT	G / S	RDL	DATE ANALYZED	INITIAL	DATE PREPARED
Electrical Conductivity	uS/cm	338		2	Jul 03, 2015	JC	Jul 03, 2015
pH	pH Units	8.14		NA	Jul 03, 2015	JC	Jul 03, 2015
Langelier Index		0.82			Jul 06, 2015	SYS	Jul 06, 2015
Total Hardness (as CaCO3)	mg/L	186		0.5	Jul 03, 2015	SYS	Jul 03, 2015
Total Dissolved Solids	mg/L	174		20	Jul 06, 2015	AP	Jul 03, 2015
Alkalinity (as CaCO3)	mg/L	174		5	Jul 03, 2015	JC	Jul 03, 2015
Chloride	mg/L	1.94		0.10	Jul 03, 2015	WZ	Jul 03, 2015
Sulphate	mg/L	2.64		0.10	Jul 03, 2015	WZ	Jul 03, 2015
Calcium	mg/L	52.3		0.05	Jul 03, 2015	PB	Jul 03, 2015
Magnesium	mg/L	13.4		0.05	Jul 03, 2015	PB	Jul 03, 2015
Resistivity	ohms.cm	2960			Jul 03, 2015	SYS	Jul 03, 2015
Sulphide	mg/L	<0.05		0.05	Jul 02, 2015	SN	Jul 02, 2015
Redox Potential	mV	297		5	Jul 06, 2015	BG	Jul 06, 2015

COMMENTS:

RDL - Reported Detection Limit; G / S - Guideline / Standard

CHARTERED CHEMIST

Certified By:

Appendix C

Borehole Locations and Soil Strata Drawings

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

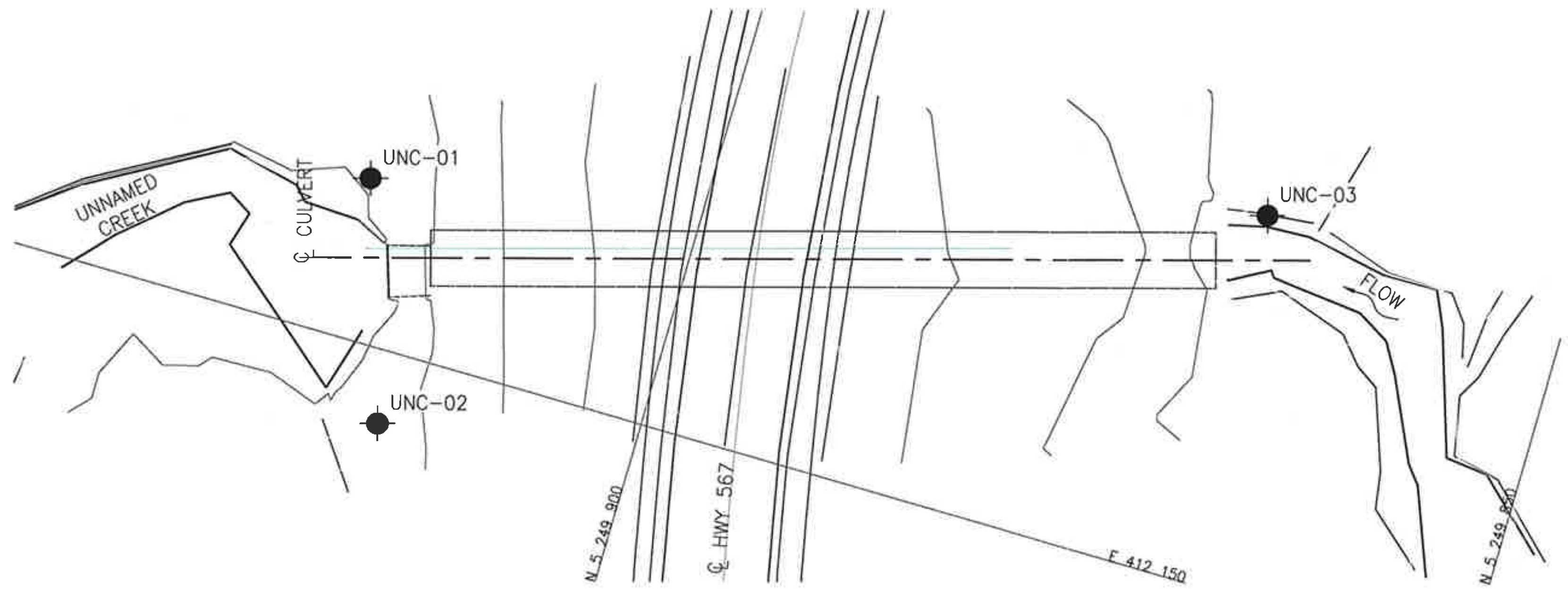
CONT No
GWP No 5201-13-00

SHEET

HIGHWAY 567
UNNAMED CREEK CULVERT REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

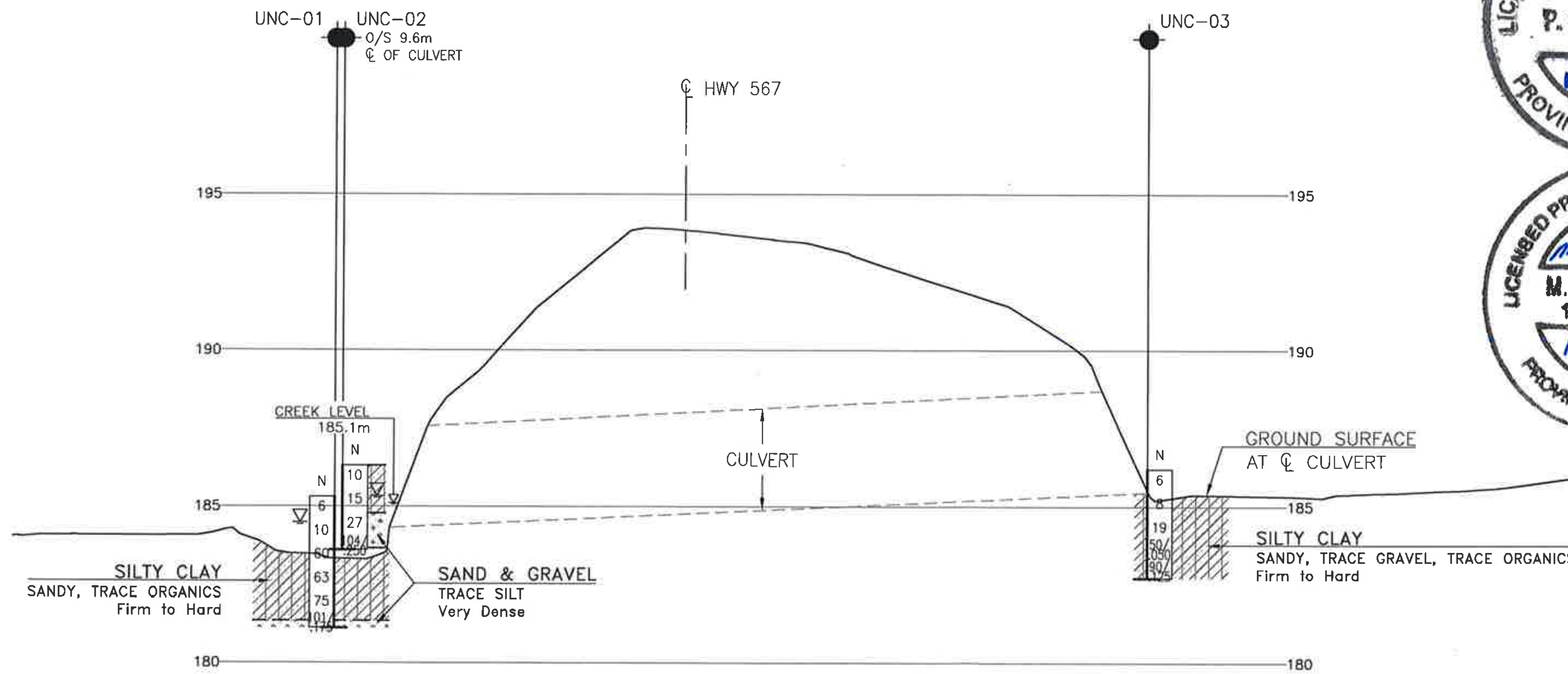
MMM GROUP

THURBER ENGINEERING LTD.



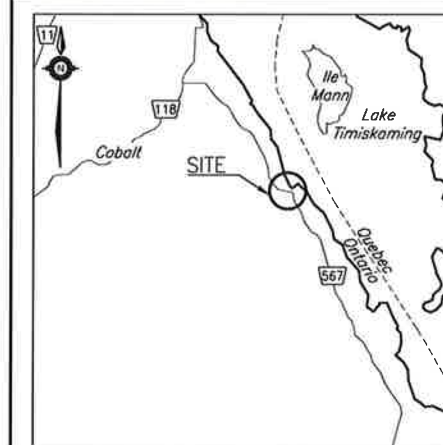
PLAN

SCALE 1:400



SECTION ALONG ℄ CULVERT

H 1:400
V 1:200



KEYPLAN

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 19/16
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
M.E. FARRANT
100053767
May 19/16
PROVINCE OF ONTARIO

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

NO	ELEVATION	NORTHING	EASTING
UNC-01	185.3	5 249 919.0	412 159.4
UNC-02	186.3	5 249 914.6	412 145.8
UNC-03	186.2	5 249 868.4	412 171.8

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31M-116

REVISIONS | DATE | BY | DESCRIPTION

DESIGN MEF | CHK MEF | CODE | LOAD | DATE MAY 2016
DRAWN AN | CHK | SITE 47-316/C | STRUCT | DWG 1

FILENAME: H:\Drafting\19\5161\251\ted1251-Plan&Profile(UnnamedCreekBridge).dwg
PLOTDATE: 5/19/2016 9:57 AM

Appendix D

Selected Photographs of Culvert Location

Photo 1: Unnamed Culvert Inlet Looking North

Photo 2: Unnamed Culvert Outlet Looking South

Photo 3: Composite Culvert Looking North

Photo 4: Composite Culvert Looking South

Photo 5: Road Surface Looking West

Photo 6: Road Surface Looking East

Appendix E

Non-Standard Special Provision

DEWATERING NSSP

The contractor shall implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and dry excavation.

The dewatering system shall be designed by a dewatering specialist engaged by the Contractor.

Where a cofferdam is required, the Contractor shall engage an experienced geotechnical engineer licensed to practice in Ontario to carry out the cofferdam design.