THURBER ENGINEERING LTD.

DETAILED FOUNDATION INVESTIGATION AND DESIGN REPORT
GORGE CREEK CULVERT REPLACEMENT
HIGHWAY 11, UNSURVEYED TERRITORY
THUNDER BAY DISTRICT, ONTARIO
LATITUDE: 49.301882º, LONGITUDE: -88.098751º

G.W.P. 6802-14-00, W.P. 6803-14-01 SITE No. 48C-182C

GEOCRES No: 52H-48

Report

to

HATCH

Date: November 12, 2018
File: 15595

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the detailed design of the proposed Gorge Creek Culvert replacement. The Gorge Creek culvert is located on Highway 11, north of Nipigon, in Unsurveyed Territory, District of Thunder Bay, Ontario. Thurber previously completed a preliminary foundation investigation at the culvert site in 2018.

The purpose of this investigation was to explore the subsurface conditions 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 Hatch to carry out this detailed foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0008.

The preliminary investigation previously conducted by Thurber is described in the following report:

- Preliminary Foundation Investigation and Design Report, Gorge Creek Culvert Replacement, Highway 11, Unsurveyed Territory, Thunder Bay District, Ontario, GEOCRES Number 52H-43, prepared by Thurber Engineering Ltd.

The borehole logs from the preliminary investigation are included in this report.

2. SITE DESCRIPTION

The site is located along Highway 11, approximately 39 km North of Nipigon. The existing culvert allows Gorge Creek to flow in an east to west direction under Highway 11. Highway 11 generally runs in a north-south direction at the culvert site. A pair of twin CSP culverts are located approximately 27 m north of the Gorge Creek Culvert on Highway 11.

Based on the Ontario Structure Inspection Manual (OSIM) prepared by MTO on November 20, 2014, the existing culvert is a cast in place, open footing, concrete culvert that is 6.1 m wide, 1.8 m high and 21.8 m long. The culvert barrel is in fair condition with some rust staining, delamination, spalling and exposed rebar at the inlet and outlet soffits.

The estimated culvert invert is at approximate Elevation 263.7 m at the inlet (east) and 263.6 m at the outlet (west). The existing road grade at the culvert location is at approximate Elev. 266.8 m, which indicates approximately 1 m of fill above the culvert. The elevation of the water flowing through the culvert on October 20, 2015 was reported to be approximately 264.9 m upstream of the inlet and 263.7 m downstream of the outlet.

The area on either side of the creek near the inlet and outlet of the culvert is vegetated with grass, shrubs and small trees, and the overall surrounding area is densely forested. A natural gas power plant is located approximately 750 m to the south of the culvert and an associated natural gas pipeline is located approximately 300 m the south east of the culvert. Photographs in Appendix D show the culvert and the surrounding area.

Based on published geological information, the site lies within an area of glaciofluvial outwash deposits of sand and gravel and is bounded by bedrock plains and knobs, and talus (rubble) to the east and west of the highway. The bedrock at the site consists of undifferentiated metasedimentary rocks.

3. INVESTIGATION PROCEDURES

The current investigation and field testing program was carried out between June 20 to July 10, 2018, and consisted of drilling and sampling five (5) boreholes, designated as Boreholes 18-10 to 18-14, to depths ranging from 6.7 m to 10.4 m below the existing ground surface. Dynamic Cone Penetration Tests (DCPTs) conducted at the base of Boreholes 18-11, 18-12 and 18-14 extended the boreholes to depths from 10.7 to 18.6 m. Boreholes 18-10 to 18-12 were drilled along the alignment of the existing twin CSP culverts located approximately 27 m north of the Gorge Creek Culvert. Boreholes 18-13 and 18-14 were drilled near the inlet and outlet of the existing Gorge Creek Culvert near the locations of the proposed cofferdams.

The previous preliminary investigation was carried out between August 23 and 25, 2017, during which time six (6) boreholes denoted as Boreholes 17-42 to 17-47 were advanced to depths of between 3.5 m and 14.3 m below existing ground surface.

The Record of Borehole sheets for the boreholes from the current and previous preliminary investigations are included in Appendix A. The approximate locations of the boreholes from both investigations are shown on the Borehole Locations and Soil Strata Drawings included in Appendix D.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from topographic drawings provided to Thurber by Hatch. The boreholes from the current investigation were drilled using a track-mounted drill rig and wash boring techniques for Borehole 18-11 and a portable Hilti drill and tripod equipment using wash boring techniques for the Boreholes 18-10, 18-12, 18-13, and 18-14. Samples of the overburden soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A Dynamic Cone Penetration Test (DCPT) was carried out at Boreholes 18-11, 18-12 and 18-14 to depths of between 10.7 m and 18.6 m.

The field investigation was supervised on a full-time basis by a member of Thurber's technical staff who directed the drilling, sampling and in-situ testing operations, logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Piezometers were installed as part of the current investigation in Boreholes 18-10, 18-12, 18-13, and 18-14, and water level readings were taken throughout the investigation. The piezometers were decommissioned at the completion of the field investigation. The boreholes were backfilled in general accordance with Ontario regulation 903, as amended. A piezometer was also installed in Borehole 17-42 drilled during the preliminary investigation. Caving was noted in a number of boreholes in the sand and gravel soils.

Completion details of the boreholes are summarized in Table 3.1 below.

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Table 3.1 -Borehole Completion Details

Borehole Number	Borehole, DCPT Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
18-10	9.8 / 255.3	9.8 / 255.3	Sand to 7.9 m then bentonite holeplug to surface.
18-11	18.6 / 248.5	None installed	Borehole caved to 3.5 m, then backfilled with bentonite holeplug to 0.3 m, then sand and gravel to 0.2 m, then asphalt cold patch to surface.
18-12	10.7 / 254.3	5.5 / 259.5	Borehole caved to 5.5 m then backfilled with sand to 3.7 m then bentonite holeplug to surface.
18-13	9.8 / 255.0	9.8 / 255.0	Sand to 7.3 m then bentonite holeplug to surface.
18-14	14.3 / 250.9	6.9 / 258.3	Borehole caved to 6.9 m, then backfilled with sand to 5.0 m then bentonite holeplug to surface.
17-42	14.3/251.1	13.7/251.7	Sand to 1.5 m then bentonite holeplug to surface
17-43	14.3/252.5	None Installed	Bentonite holeplug and cuttings to 0.9 m below surface, then dry cement to 0.2 m, then cold patch asphalt to surface
17-44	14.3/252.0	None Installed	Bentonite holeplug and cuttings to surface

Borehole Number	Borehole, DCPT Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
17-45	3.7/263.0	None Installed	Cuttings to 0.9 m below surface then dry cement to 0.2 m, then cold patch asphalt to surface
17-46	3.5/263.1	None Installed	Cuttings to 0.9 m below surface then dry cement to 0.2 m, then cold patch asphalt to surface
17-47	3.7/262.8	None Installed	Cuttings to 0.9 m below surface then dry cement to 0.2 m, then cold patch asphalt to surface

4. LABORATORY TESTING

The 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 (hydrometer and/or sieve) and Atterberg Limits testing, where appropriate. Laboratory testing results are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included 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, during the previous investigation, a sample of the existing native soil, and a sample of the surface water from the creek upstream of the existing culvert were collected. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A. 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 should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the subsurface conditions encountered in these boreholes beneath the asphalt and sand and gravel embankment soil consisted of native sand to sand and gravel deposits. Descriptions of the individual strata are presented below.

5.1 Asphalt

Boreholes 18-11, 17-43, 17-45, 17-46 and 17-47 were drilled through the paved section of Highway 11 and encountered a surface layer of asphalt that ranged in thickness from 150 mm to 200 mm.

5.2 Topsoil

Topsoil was encountered at the surface in Boreholes 18-10, 18-12, 18-13, and 18-14. The topsoil ranged in thickness from approximately 25 mm to 600 mm.

5.3 Fill

Fill was encountered below the asphalt at Boreholes 18-11, 17-43, 17-45, 17-46 and 17-47 and from the surface in for Boreholes 17-42 and 17-44. The fill layer varied from sand with trace silt and trace gravel to sand and gravel with trace to some silt. Occasional cobbles and boulders were noted in the fill. Where fully penetrated, the fill layer varied in thickness between 2.2 and 3.0 m and extended to depths of between 2.2 and 3.0 m (Elev. 263.2 to 264.1 m). Boreholes 17-45 to 17-47 were terminated within the fill at depths of 3.5 to 3.7 m (Elev. 262.8 to 263.1 m).

SPT ‘N’ values within the fill ranged from 11 to over 100 blows per 0.3 m of penetration, indicating a compact to very dense relative density. Moisture contents between 1 percent and 25 percent were measured in the cohesionless fill.

The results of grain size distribution analyses carried out on selected samples of the fill are presented on the Record of Borehole sheets included in Appendix A and on Figures B1 and B2 of Appendix B. The results of the grain size distribution analyses are summarized below:

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Soil Particle	Percentage (%)
Gravel	9 to 43
Sand	51 to 82
Silt and Clay	2 to 12

5.4 Sand and Gravel to Gravelly Sand

Sand and Gravel, containing trace to some silt and occasional cobbles was encountered in Boreholes 18-11 to 18-14, and 17-43 at depths of approximately 0.1 m to 3.0 m (Elevations 264.9 m to 262.8 m). The sand and gravel layer was approximately 3.5 m to 5.7 m thick where fully penetrated and extended to depths of approximately 4.1 m to 8.7 m (Elevation 257.9 m to 263.8 m). Borehole 18-12 was terminated in the sand and gravel layer at a depth of 6.7 m (Elevation 258.3 m)

A lower layer of gravelly sand was encountered in Boreholes 18-13, 17-43, and 17-44 at depths of between approximately 9.1 m to 10.2 m (Elevations 256.6 m to 255.7 m). Where fully penetrated the lower gravelly sand layer was approximately 3.1 m thick and extended to a depth of approximately 13.3 m (Elevations 253.5 m to 253.0 m). Borehole 18-13 was terminated in the lower gravelly sand layer at a depth of 9.8 m (Elevations 255.0 m).

SPT ‘N’ values within the sand and gravel to gravelly sand layers ranged from 4 to over 100 blows per 0.3 m of penetration, indicating a very loose to very dense relative density although the deposits is generally compact. The higher blow counts may representative of the presence of cobbles. Measured moisture contents within this layer varied between 7 percent and 20 percent.

The results of grain size distribution analyses carried out on selected samples of the sand and sand and gravel to gravelly sand are presented on the Record of Borehole sheets included in Appendix A and on Figures B3 in Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	26 to 60
Sand	37 to 71
Silt and Clay	3 to 6

5.5 Sand

Sand layers, containing trace to some gravel, trace to some silt, occasional cobbles, and trace organics near the surface, were encountered in all boreholes, with the exceptions of Boreholes 17-45 to 17-47, at depths ranging between approximately 0.1 m to 8.7 m (Elevations 264.7 m to 258.4 m). Lower layers of sand were encountered in Boreholes 17-43 and 17-44 at depths of approximately 13.3 m (Elevations 253.5 m to 253.0 m). Where fully penetrated the sand layers ranged in thickness from 2.0 m to 7.2 m. Boreholes 18-10, 18-11, 18-14, and 17-42 to 17-44 were terminated in sand layers at depths of between 6.7 m to 14.3 m (Elevations 258.5 m to 251.1 m).

SPT 'N' values within the sand layers ranged from 1 to 70 blows per 0.3 m of penetration, indicating a loose to very dense relative density. The inconsistent and high blow counts may be representative of the presence of cobbles. Measured moisture contents within the sand deposit varied between 10 percent and 40 percent.

The results of grain size distribution analyses carried out on selected samples of the sand are presented on the Record of Borehole sheets included in Appendix A and on Figure B4 and B5 in Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0 to 18
Sand	77 to 96
Silt and Clay	3 to 18

5.6 Groundwater Conditions

Groundwater conditions were observed during drilling operations, and groundwater levels were measured in the open boreholes upon completion of drilling. Standpipe piezometers were installed in Boreholes 18-10, 18-12, 18-13, 18-14 and 17-42 to monitor the groundwater level at the site. The groundwater levels measured in the open boreholes and in the standpipe piezometers are summarized below.

Table 5.1 – Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
18-10	July 6, 2018	0.7	264.4	Standpipe piezometer
	July 7, 2018	0.6	264.5	
	July 8, 2018	0.7	264.4	
	July 9, 2018	0.7	264.4	
18-11	June 20, 2018	2.4	264.7	Open borehole
18-12	July 8, 2018	1.3	263.7	Standpipe piezometer
	July 9, 2018	1.3	263.7	
	July 10, 2018	1.3	263.7	
18-13	July 5, 2018	1.0	263.8	Standpipe piezometer
	July 6, 2018	1.0	263.8	
	July 7, 2018	0.9	263.9	
18-14	July 10, 2018	1.3	263.9	Standpipe piezometer
	July 11, 2018	1.3	263.9	
17-42	August 27, 2017	1.0	264.4	Standpipe piezometer
17-43	August 25, 2017	3.0	263.8	Open borehole
17-44	August 24, 2017	1.8	264.5	Open borehole
17-45	August 23, 2017	2.4	264.3	Open borehole
17-46	August 23, 2017	Dry	Dry	Open borehole
17-47	August 23, 2017	2.1	264.4	Open borehole

The creek water level on October 20, 2015 was reported to be Elevation 264.9 m upstream of the inlet and 263.7 m downstream of the outlet.

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

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the fill layer from Borehole 17-43 and a sample of the creek water were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results	
			17-43, SS#3, 1.5 m – 2.1 m	Gorge Creek
			(Silty Sand)	(Creek Water)
Sulphide	%	mg/L	<0.02	<0.006
Chloride	mg/L	mg/L	1100	0.57
Sulphate	mg/L	mg/L	21	1.5
pH	No unit	No unit	9.6	7.89
Electrical Conductivity	µS/cm	µS/cm	1150	107
Resistivity	Ohms.cm	Ohms.cm	867	9350
Redox Potential	mV	mV	230	261

7. MISCELLANEOUS

Thurber marked the borehole locations in the field and obtained subsurface utility clearances prior to drilling. Thurber estimated the northing and easting coordinates and ground surface elevations from measurements taken in the field relative to the topographic plans provided by Hatch.

OGS Inc. of Almonte, Ontario, and Downing Drilling of Hawkesbury, Ontario, supplied and operated the drilling, sampling and in-situ testing equipment for the current field investigation. The field investigation was supervised on a full-time basis by Mr. Ryan McCourt and Ms. Judy Mei of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. of Thurber.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by SGS Canada Inc. Interpretation of the field data and preparation of this report was carried out by Mr. Cory Zanatta, P.Eng. 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

8. GENERAL

This report provides an interpretation of the geotechnical data in the factual report and presents detailed foundation design recommendations for the proposed Gorge Creek Culvert replacement on Highway 11, located in the Unsurveyed District of Thunder Bay, Ontario. This detailed foundation report should be read in conjunction with the Preliminary Foundation Report dated March 28, 2018.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

Information on the existing culvert site was obtained from the MTO Terms of Reference, the Ontario Structure Inspection Manual (Inspection Form) prepared by MTO on November 20, 2014. The existing structure is a cast in place, open footing concrete culvert. The culvert measures 6.1 m wide, 1.8 m high and is 21.8 m long. The estimated culvert invert is at approximate Elevation 263.7 m at the inlet (east) and 263.6 m at the outlet (west). The existing road grade at the culvert location is at approximate Elev. 266.8 m, which indicates approximately 1.3 m of fill above the culvert.

The preliminary foundation report provided recommendations for both pipe culverts and box culverts. General Arrangement Drawings and discussions with Hatch, indicate that twin precast concrete box culverts are the preferred replacement option. The twin box culverts are to have an interior width of 5 m and an interior height of 2.5 m each. The invert level of the new box culverts (underside of box) are approximately at Elevation 263.18 m and 263.11 m at the inlet and outlet, respectively.

The new twin box culvert replacements will be constructed generally along the same alignment as the existing box culvert. No grade raise is proposed for the culvert replacement. No headwalls or wingwalls are proposed.

The twin pipe culverts located approximately 27 m north of the existing Gorge Creek culvert will be replaced with a single CSP pipe with a proposed invert level at approximately 263.73 m upstream and 263.71 m downstream. The new CSP pipe will then be used as a diversion pipe for Gorge Creek during the construction of the twin box culverts.

9. CULVERT FOUNDATION DESIGN

In general, the subsurface conditions encountered in the boreholes consists of sand to sand and gravel embankment fill overlying native layers of sand and gravel and sand. The groundwater levels, as measured in the piezometers, ranged from 263.7 m to 264.5 m.

The founding soils encountered at the proposed invert level (underside of box, Elevations 263.18 m to 263.11 m) generally consist of native loose to compact sand and gravel with occasional cobbles. There is approximately 0.5 m to 1.0 m of fill above the proposed culvert replacement.

Foundation design aspects for the replacement culvert include subgrade conditions and preparation, settlement of founding soils, lateral earth pressures, roadway protection system design, groundwater control, cofferdams, stage construction, and restoration of the roadway embankment.

The preliminary investigation report provided foundation recommendations for different types of culverts and these recommendations are not repeated here but may be used for detailed design where applicable.

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9.1 Foundations

Replacement of the culvert with twin concrete box culverts on the same alignment is being considered for this site. It is anticipated that the subgrade soils within the culvert footprint will not be subjected to any significant additional loading due to the culvert replacement.

In order to provide a uniform foundation subgrade, a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements should be provided under the base of the box culverts, similar to as shown on OPSD 803.010, and compacted as per OPSS.PROV 501. The bedding material should be placed on the prepared subgrade as soon as practicable following its inspection and approval. The subgrade preparation and placement and compaction of the bedding material should be carried out in the dry. A separation layer consisting of a non-woven geotextile should be placed between the subgrade soils and the bedding material. The geotextile should meet the specifications for the OPSS Class II, and have a fabric opening size (FOS) not greater than 212 µm. The subgrade surface prepared to support the box units should have a minimum 75 mm thick top levelling course consisting of uncompacted Granular A as per OPSS 422. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction.

The underside of the bedding layer should be placed at or below Elevation 262.5 m, which corresponds to loose to compact sand and gravel subgrade. Any excessively loose soil, large cobbles and boulders, and any soft, very loose organic or other deleterious material encountered during subgrade preparation should be sub-excavated and replaced with compacted granular material to provide a uniformly competent subgrade condition.

The following geotechnical resistances are recommended for the preliminary design of an 11 m to 12 m wide twin box culvert founded at or below Elevation 262.5 m on the loose to compact sand and gravel:

Geotechnical Resistance	11 to 12 m wide Twin Culvert
Factored Geotechnical Resistance at ULS	225 kPa
Geotechnical Resistance at SLS (for up to 25 mm settlement)	100 kPa

A consequence factor of 1.0 was utilized in this design adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing and 0.8 for settlement, both adopted for typical degree of understanding, were used to obtain the above values, as per the Canadian Highway Bridge Design Code (CHBDC) 2014, Section 6.9.

The factored ultimate resistance and settlement are dependent on the footing/culvert size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the culvert width or founding/invert elevation differs significantly from that given above.

The above geotechnical resistances are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with the CHBDC 2014, Clause 6.10.3 and Clause 6.10.4.

Resistance to sliding between the concrete and the underlying Granular A or B Type II bedding material should be calculated assuming an ultimate coefficient of friction of 0.45.

The culvert should be designed to resist external loadings including frost forces, lateral earth pressures, hydrostatic pressure, weight of embankment fill, traffic loadings and surcharge due to construction equipment.

9.2 Frost Cover

The depth of frost penetration at this site is approximately 2.4 m based on OPSD 3090.100. The frost cover requirement does not apply to the twin box culverts.

The proposed culvert replacement will occur within the same area as the existing culvert, and at a similar elevation. As the existing embankment and underlying subgrade soil within this area predominantly comprise sand and gravel to sand fill material, construction of a frost taper does not appear warranted as part of the culvert replacement.

9.3 Subgrade Preparation

Performance of the replacement culvert will depend on the preparation of the subgrade. After the excavation reaches the design subgrade elevation, the exposed surface should be inspected to confirm that the subgrade is suitable and uniformly competent. Any remaining fill, topsoil, organic, loose, creek bed deposits, disturbed soils and any deleterious materials within the replacement culvert footprint must be removed and replaced with granular material compacted as per OPSS.PROV 501.

In the event that sub-excavation is required, the width of the sub-excavation should be defined by a line extending from 0.3 m beyond the outside edge of the proposed culvert, outward and downward at 1H:1V. The sub-excavated area should then be backfilled with granular material meeting OPSS.PROV 1010 Granular A or Granular B Type II requirements and compacted as per OPSS.PROV 501.

The work should be carried out in accordance with OPSS 902 and culvert construction, and subgrade preparation must be carried out in the dry.

9.4 Settlement

The replacement culvert will be constructed approximately on the same alignment and with a larger opening size than the existing culvert with no grade raise on the overlying embankment or embankment widening. Therefore, changes in the loading conditions on the foundation soils consisting of loose to compact sand and gravel are not expected to be significant. The post-construction settlements after culvert construction and embankment reconstruction at this site are estimated to be less than 25 mm. The post-construction settlements will essentially be complete at the end of construction.

If the final design involves embankment widening or grade raise, foundation soil settlement due to this addition of fill must be assessed to determine the impact of such settlement on the performance of the replacement culvert.

10. EXCAVATION AND GROUNDWATER CONTROL

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the embankment fill, native sand and gravel and sand at this site are classified as Type 3 soils above the water level and Type 4 soils below the water level.

Excavation and backfilling for culvert construction should be carried out in accordance with OPSS 902.

Excavations for culvert replacement will be carried out through the existing embankment fill and extended into the native sand and gravel and native sandy soils.

Installation of the culvert must be carried out in the dry. Excavation for culvert replacement will be carried out below the creek water level, and diversion of the creek flow will be required. Given the relatively high permeability of the embankment fill materials and native sand and gravel soils, water inflow/seepage into the excavation should be anticipated. A combination of creek diversion and sheet pile cofferdam enclosures along with the use of sumps/pumps within a sheet pile enclosure will be required to maintain a relatively dry excavation and culvert subgrade during the course of staged construction. Recommendations for cofferdam design are provided in Sections 14 and 15 below. The dewatering scheme must be effective to lower the groundwater level at least 0.5 m below the final subgrade level to avoid base boiling in the native soils.

The invert level of the proposed CSP to be used as a diversion pipe for the twin box culvert replacement will also be below the groundwater table. Dewatering will also be required for the construction and installation of the diversion pipe.

The design of dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP FOUN0003 which amends OPSS 902.

In accordance with SP FOUN0003, the dewatering system is to be designed in accordance with OPSS.PROV 517 and SP517F01. Based on the potential of a natural gas pipeline within the dewatering zone of influence, a preconstruction survey is required, thus Designer Fill-In ****** in SP FOUN0003 should be “Yes”. A 400 m radius for the dewatering zone of influence can be used in the NSSP FOUN0003. Considering the conditions on site, a design Engineer and design-checking Engineer with a minimum of 5 years of experience in designing dewatering systems of similar nature and scope to the required work is required, and thus Designer Fill-In ***** in SP517F01 should be “Yes”.

Dewatering must remain operational and effective until the culvert is installed and backfilled. Suggesting wording for an NSSP in this regard is included in Appendix E.

11. STREAM DIVERSION PIPE

A CSP stream diversion pipe is proposed to replace the twin CSP located to the north of Gorge Creek culvert and will accommodate creek water flow during the twin box culvert replacement. Based on the preliminary general arrangement drawing, the invert of the diversion pipe is at approximately Elevation 263.73 m upstream and 263.71 m downstream, which corresponds to loose to compact sand to sand and gravel fill and compact native sand and gravel.

The CSP should be placed on a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements as per OPSD 802.010. The bedding material should be placed on the prepared subgrade as soon as practical, following its inspection and approval. The subgrade preparation should be carried out in the dry. The prepared subgrade should be protected from disturbance during construction.

The stream diversion pipe could be installed within the temporary open cut excavations, or within a shored excavation using a trench box.

12. CULVERT BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the culvert should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 802.010 or 803.010, as appropriate. Backfilling for the culvert should be in accordance with OPSS 422 and 902. All fills should be placed in regular lifts and be compacted in accordance with OPSS.PROV 501. The backfill should be placed and compacted in simultaneous lifts on both sides of the culvert, and the top of backfill elevation should not differ more than 400 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used adjacent to the walls and on the roof of the culvert. Compaction equipment to be used adjacent to the culvert should be restricted in accordance with OPSS PROV 501.

Lateral earth pressures acting on the culvert walls may be assumed to be a triangular distribution. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC 2014, 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 table below)
γ = bulk unit weight of retained soil (see table below)
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the culvert walls are dependent on the material used as backfill. Recommended unfactored values are shown in Table 12.1 below.

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Table 12.1 – Lateral Earth Pressure Coefficients (K)

Loading Condition	OPSS Granular A or Granular B Type II ϕ = 35°; γ = 22.8 kN/m^3		OPSS Granular B Type I (modified) or Type III ϕ = 32°; γ = 21.2 kN/m^3	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48
At-rest (Restrained Wall)	0.43	0.62	0.47	0.70
Passive	3.7	-	3.3	-

Note: Submerged unit weight should be used below the groundwater level/high creek level.

For rigid structures such as concrete box culverts, at-rest horizontal earth pressures should be used for design. Active pressures should be used for any unrestrained wall.

The use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the culvert.

In accordance with Clause 6.12.3 of the CHBDC 2014, a compaction surcharge should be added. The magnitude of the surcharge should be 12 kPa at the top of fill and decrease to 0 kPa at a depth of 1.7 m for Granular B Type I, or at a depth of 2.0 m for Granular A or B Type II.

13. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2014, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy. The stratigraphy of the site includes a loose to very dense sand and sand and gravel soils. This would correspond to a Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2% in 50-year probability of exceedance at this site is 0.034 g as per the National Building Code of Canada (NBCC).

In accordance with Clause 4.6.5 of the CHBDC 2014, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 13.1 may be used:

Table 13.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3	OPSS Granular B Type I (modified) or Type III $\phi = 32°, \gamma = 21.2$ kN/m^3
Active (K_{AE})*	0.29	0.32
Passive (K_{PE})	3.6	3.2
At Rest (K_{OE})**	0.49	0.53

Note 1: Mononobe and Okabe, 1929, World Engineering Congress 9: 179-187

Note 2: Passive case assumes a horizontal surface in front of the wall.

Note 3: Wood, J. H. 1973, earthquake induced soil pressures on structures, PhD Thesis, California Institute of Technology, Pasadena, CA.

The site is underlain by loose to dense sand to sand and gravel. In view of the low potential for seismic activity in the area, liquefaction is not considered to be a concern at this site.

14. COFFERDAMS

Construction of cofferdams will be required to construct the culvert replacement in the dry. It is recommended that excavations be enclosed within a water tight enclosure. Due to the presence of highly permeable granular foundation soils and the high water table, a sand bag cofferdam system may not be as effective where work is required below the creek level. Interlocking sheet piles are however considered to be feasible for cofferdam construction in this situation. The recommendations provided in Section 15 below for Temporary Protection Systems are also applicable to sheet piled cofferdams. The cofferdams should extend deep enough to penetrate a sufficient distance in the native sand and sand and gravel layers to reduce the upward seepage flow into the culvert excavation.

Further assessment of dewatering requirements and the need for a PTTW should be carried out by specialists experienced in this field. Design of a suitable and effective dewatering system is the responsibility of the Contractor as indicated in Section 10. The dewatering system must be effective to lower the water table a minimum of 0.5 m below the final culvert subgrade.

15. TEMPORARY PROTECTION SYSTEM

The temporary roadway protection system should be implemented in accordance with OPSS PROV 539 and designed for Performance Level 2.

Options for roadway protection are a soldier pile-lagging system or interlocking sheet piles. The presence of occasional cobbles may however impede driving of sheet piles.

The soil parameters in Table 14.1 may apply for the design of the temporary roadway protection system with horizontal backfill.

Table 15.1 – Soil Parameters for Temporary Protection System Design

Soil Parameter	Sand to Sand and Gravel Fill	Native Sand to Sand and Gravel
ϕ (angle of internal friction)	32˚	32˚
γ (total unit weight)	20 kN/m^3	20 kN/m^3
γ_{sub} (submerged unit weight)	10 kN/m^3	10 kN/m^3
K_a	0.31	0.31
K_p	3.3	3.3

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

The temporary protection system may be removed or partially removed upon completion of the work. Care must be taken when removing the sheet piles or soldier piles as to not incur damage to the subgrade of the newly installed culvert.

The design of temporary protection system is the responsibility of the Contractor. The actual pressure distribution acting on the protection/shoring system is a function of the construction sequence and the relative flexibility of the wall, and these factors have to be considered when designing the shoring system. All protection systems should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system.

In light of the loose granular foundation soil, which will be prone to settlement, vibratory methods should not be permitted at the site for installation or extraction of sheet piles.

16. EMBANKMENT RESTORATION

Provided that the embankment is reconstructed with side slopes inclined not steeper than 2H:1V, the restored embankment slope should remain stable. As discussed in Section 9.4, and if there is no grade raise or embankment widening, settlement of the embankment under the existing culvert footprint should be less than 25 mm.

Embankment restoration after completion of the culvert replacement should be carried out in accordance with OPSS PROV 206 and OPSS PROV 209. The embankment reconstruction material may consist of imported Granular A, Granular B Type II, or Granular B Type III material.

In general, surface vegetation, peat, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from the areas around the culvert inlets and outlets, and within the embankment footprints. Inspection and approval of the foundation surfaces by qualified geotechnical personnel should be conducted.

17. SCOUR AND EROSION PROTECTION

Erosion protection should be provided at the culvert inlet and outlet. Design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field in accordance with OPSD 810.010, OPSS 511 and OPSS PROV 1004.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS PROV 804.

A concrete cut-off wall and a clay seal (only at the inlet) should be used to minimize the potential for erosion or piping around the culvert. The clay seal should extend to approximately 0.3 m above the high-water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS PROV 1205. A geosynthetic clay liner may be used in place of a compacted clay seal.

18. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the fill and creek water indicate the following conditions at the locations tested:

- The potential for corrosion or sulphate attack on concrete foundations from the surface water is considered to be negligible due to the low concentration of sulphate and chloride in the sample tested. However, the fill sample had a high chloride content, indicating that the surrounding soil may be corrosive to steel reinforcement in concrete structures. The effect of road deicing salt should also be considering while selecting the class of concrete.

- The potential for surface water corrosion on metal is considered to be mild. However, the corrosion potential from the fill on steel, cast iron, and other metals is very severe based on the low resistivity value and high pH of the soil sample tested.
- Appropriate protection measures are recommended for concrete and metal structural elements. The effect of road deicing salt should be considered while selecting the corrosion protection measures.

19. CONSTRUCTION CONCERNS

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

- A suitable dewatering / unwatering system must be employed to enable culvert construction in the dry and prevent base boiling, sloughing and instability of the excavation walls.
- The water level in the creek may fluctuate and be at a higher elevation at the time of construction than indicated in the report.
- Cobbles or other buried obstructions may be encountered during excavation in the existing embankment fill and native soils and may interfere with the installation of the temporary roadway protection system. Suggested wording for an NSSP on obstructions is included in Appendix E.
- The Contractor's selection of construction equipment and methodology should include assessment of the capability of the existing embankment to support the proposed construction equipment and any temporary structures or fill (i.e., as a pad for crane support). Site conditions may limit the type of equipment suitable for use during construction. The design and safety of any temporary works is the responsibility of the Contractor.

20. CLOSURE

Engineering analysis and preparation of this report was carried out by Dr. Nancy Berg, 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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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			

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.

SYMBOLS

CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

Bedding	**Bedding Plane Spacing**
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

STRENGTH CLASSIFICATION

Rock Strength	**Approximate Uniaxial Compressive Strength (MPa)**	**(psi)**	**Field Estimation of Hardness***
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

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RECORD OF BOREHOLE No 18-10

METRIC

W.P. 6330-14-01 | LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 259.4 E 224 860.6 | ORIGINATED BY JM

DIST TB HWY 11 | BOREHOLE TYPE Portable B Casing | COMPILED BY AN

DATUM Geodetic | DATE 2018.07.06 - 2018.07.06 | LATITUDE 49.302100° | LONGITUDE -88.099288° | CHECKED BY CZ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
265.1	GROUND SURFACE					
0.0	**TOPSOIL**: (200mm) Stiff Moist				265	
0.2	**SAND**, trace to some gravel, trace silt, some organice, trace rootlets, occasional cobbles Very Loose to Dense Brown Moist to Wet	1	SS	15		
		2	SS	9	264	
	No organics below 1.7m	3	SS	3	263	
		4	SS	44		18 77 5 (SI+CL)
	Very Loose Grey Wet	5	SS	2	262	
					261	
		6	SS	3	260	
		7	SS	4	259	
257.9 / 7.2	**SAND**, some silt Compact Grey Moist to Wet				258	
		8	SS	13	257	
					256	
255.3 / 9.8	END OF BOREHOLE AT 9.8m.	9	SS	23		0 82 18 (SI+CL)

Continued Next Page

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

GROUND WATER CONDITIONS

+ 3, × 3: Numbers refer to Sensitivity

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

ONTMT4S2 MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 7/27/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18-10

METRIC

W.P. 6330-14-01 LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 259.4 E 224 860.6 ORIGINATED BY JM

DIST TB HWY 11 BOREHOLE TYPE Portable B Casing COMPILED BY AN

DATUM Geodetic DATE 2018.07.06 - 2018.07.06 LATITUDE 49.302100° LONGITUDE -88.099288° CHECKED BY CZ

SOIL PROFILE			SAMPLES			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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.07.06	0.7	264.4
2018.07.07	0.6	264.5
2018.07.08	0.7	264.4
2018.07.09	0.7	264.4

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

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

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RECORD OF BOREHOLE No 18-11

METRIC

W.P. 6330-14-01 LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 267.5 E 224 872.6 ORIGINATED BY BRM

DIST TB HWY 11 BOREHOLE TYPE Wash Boring/Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2018.06.20 - 2018.06.20 LATITUDE 49.302174° LONGITUDE -88.099126° CHECKED BY CZ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	GR	SA	SI	CL
267.1	GROUND SURFACE									
0.0	**ASPHALT:** (150mm)									
0.2	**SAND** and **GRAVEL**, trace silt, occasional cobbles and boulders, Very Dense to Compact, Brown, Moist to Wet (FILL)	1	SS	99						
		2	SS	36						
		3	SS	21			43	55	2 (SI+CL)	
		4	SS	28	∇					
264.1 / 3.0	**SAND** and **GRAVEL**, trace silt, Compact to Dense, Grey, Wet	5	SS	22			44	51	5 (SI+CL)	
		6	SS	34						
	Loose	7	SS	5						
		8	SS	5						
258.4 / 8.7	**SAND**, trace to some silt, Very Loose, Grey, Wet	9	SS	4						

Continued Next Page

Plot headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 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 (%). ELEVATION SCALE 267–258.

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

ONTMT4S2 MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 7/27/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18-11

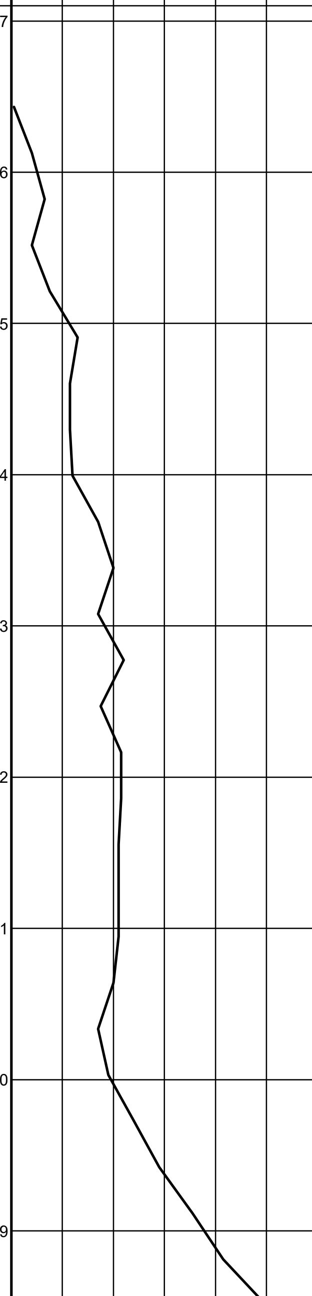
METRIC

W.P. 6330-14-01 LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 267.5 E 224 872.6 ORIGINATED BY BRM

DIST TB HWY 11 BOREHOLE TYPE Wash Boring/Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2018.06.20 - 2018.06.20 LATITUDE 49.302174° LONGITUDE -88.099126° CHECKED BY CZ

ELEV / DEPTH	SOIL PROFILE – 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
	Continued From Previous Page										
256.7 / 10.4	End of sampling and start DCPT						257, 256, 255, 254, 253, 252, 251, 250, 249				
248.5 / 18.6	END OF BOREHOLE AT 18.6m UPON DCPT REFUSAL. WATER LEVEL AT 2.4m. BOREHOLE CAVED TO 3.5m, THEN BACKFILLED WITH BENTONITE HOLEPLUG TO 0.3m, SAND AND GRAVEL TO 0.2m, THEN ASPHALT TO SURFACE.										



+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

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RECORD OF BOREHOLE No 18-12

METRIC

W.P. 6330-14-01
LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 274.0 E 224 883.4
ORIGINATED BY JM

DIST TB HWY 11
BOREHOLE TYPE Portable B Casing/Dynamic Cone Penetration Test
COMPILED BY AN

DATUM Geodetic
DATE 2018.07.07 - 2018.07.08
LATITUDE 49.302234°
LONGITUDE -88.098978°
CHECKED BY CZ

SOIL PROFILE | SAMPLES | 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

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS (GR SA SI CL)
265.0	GROUND SURFACE				
265.0 / 0.0	**TOPSOIL**: (100mm)				
0.1	Firm, Brown, Moist	1	SS	5	
	SAND and **GRAVEL** to Gravelly **SAND**, trace to some silt, some organics, occasional cobbles, Compact to Very Dense, Brown, Moist to Wet	2	SS	25	
		3	SS	23	
	No organics below 2.1m	4	SS	100/ 0.125	
	Becoming grey	5	SS	15	
	Becoming loose	6	SS	7	26 71 3 (SI+CL)
		7	SS	6	
258.3 / 6.7	End of sampling and start DCPT				

Elevation scale: 264, 263, 262, 261, 260, 259, 258, 257, 256

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18-12

METRIC

W.P. 6330-14-01 | LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 274.0 E 224 883.4 | ORIGINATED BY JM

DIST TB HWY 11 | BOREHOLE TYPE Portable B Casing/Dynamic Cone Penetration Test | COMPILED BY AN

DATUM Geodetic | DATE 2018.07.07 - 2018.07.08 | LATITUDE 49.302234° | LONGITUDE -88.098978° | CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O 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
ELEV / DEPTH	DESCRIPTION (Continued From Previous Page)	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
254.3											
10.7	END OF BOREHOLE AT 10.7m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.07.08	1.3	263.7
2018.07.09	1.3	263.7
2018.07.10	1.3	263.7

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 18-13

METRIC

W.P. 6330-14-01 LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 240.2 E 224 850.3 ORIGINATED BY JM

DIST TB HWY 11 BOREHOLE TYPE Portable B Casing COMPILED BY AN

DATUM Geodetic DATE 2018.07.05 - 2018.07.05 LATITUDE 49.301945° LONGITUDE -88.099420° CHECKED BY CZ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
264.8	GROUND SURFACE					
0.0	**TOPSOIL:** (25mm)					
	SAND, trace to some silt, trace gravel, trace organics, occasional cobbles Very Loose to Compact Black-Brown Moist	1	SS	1		
		2	SS	8	264	
		3	SS	14	263	
262.8 2.0	**SAND** and **GRAVEL**, trace silt, trace organics, occasional cobbles Very Dense to Loose Grey-Brown Wet	4	SS	50/ 0.125	262	60 37 3 (SI+CL)
		5	SS	8	261	
	no organics below 4.0m					
		6	SS	8	260	
259.2 5.6	**SAND**, some silt, occasional cobbles Loose Grey Wet				259	
		7	SS	8	258	
		8	SS	4	257	
					256	
255.7 9.1	Gravelly **SAND**, occasional cobbles Compact Grey Wet	9	SS	25		
255.0 9.8	END OF BOREHOLE AT 9.8m.					

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; 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

Continued Next Page

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

ONTMT4S2 MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 7/27/18

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 18-13

METRIC

W.P. 6330-14-01 | LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 240.2 E 224 850.3 | ORIGINATED BY JM

DIST TB HWY 11 | BOREHOLE TYPE Portable B Casing | COMPILED BY AN

DATUM Geodetic | DATE 2018.07.05 - 2018.07.05 | LATITUDE 49.301945° | LONGITUDE -88.099420° | CHECKED BY CZ

SOIL PROFILE			SAMPLES					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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
	Continued From Previous Page										
	Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.07.05	1.0	263.8
2018.07.06	1.0	263.8
2018.07.07	0.9	263.9

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

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18-14

METRIC

W.P.	6330-14-01	LOCATION	Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 238.7 E 224 905.3	ORIGINATED BY	JM
DIST	TB HWY 11	BOREHOLE TYPE	Portable B Casing/Dynamic Cone Penetration Test	COMPILED BY	AN
DATUM	Geodetic	DATE	2018.07.09 - 2018.07.10 LATITUDE 49.301919° LONGITUDE -88.098670°	CHECKED BY	CZ

SOIL PROFILE | SAMPLES | 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

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
265.2	GROUND SURFACE							
0.0	**TOPSOIL**: (600mm) Very Stiff Brown Moist	1	SS	19				
264.6 / 0.6	**SAND** and **GRAVEL**, trace silt, trace organics, occasional cobbles Very Dense to Loose Brown Moist to Wet	2	SS	37	51	44	5 (SI+CL)	
		3	SS	50/ 0.150				
		4	SS	28	40	55	5 (SI+CL)	
		5	SS	4				
261.1 / 4.1	**SAND**, trace to some silt, some gravel, occasional cobbles Compact Grey Wet	6	SS	16				
		7	SS	15				
258.5 / 6.7	End of sampling and start DCPT							

Elevation scale: 265, 264, 263, 262, 261, 260, 259, 258, 257, 256

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

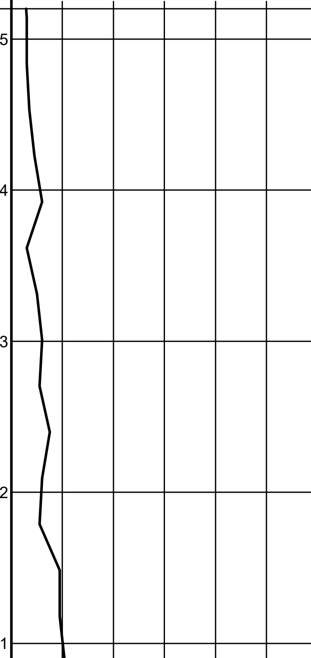
RECORD OF BOREHOLE No 18-14

METRIC

W.P. 6330-14-01 LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 238.7 E 224 905.3 ORIGINATED BY JM

DIST TB HWY 11 BOREHOLE TYPE Portable B Casing/Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2018.07.09 - 2018.07.10 LATITUDE 49.301919° LONGITUDE -88.098670° CHECKED BY CZ

SOIL PROFILE			SAMPLES			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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page						255 254 253 252 251				
250.9 14.3	END OF DCPT AT 14.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.07.10 1.3 263.9 2018.07.11 1.3 263.9										

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-43

METRIC

W.P. 6803-14-01 LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 244.2 E 224 873.4 ORIGINATED BY TTB

DIST HWY 11 BOREHOLE TYPE Solid Stem Augers/Hollow Stem Augers/ Wash Boring COMPILED BY AN

DATUM Geodetic DATE 2017.08.25 - 2017.08.25 LATITUDE 49.301965° LONGITUDE -88.099109° CHECKED BY NLB

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
266.8	GROUND SURFACE						
0.0	**ASPHALT:** (150mm)						
0.2	**SAND**, trace silt, trace gravel Compact Brown Dry (FILL)	1	GS				
						266	
		1	SS	15			9 82 9 (SI+CL)
		2	SS	27		265	
	No recovery	3	SS	11		264	
263.8 3.0	**SAND** and **GRAVEL**, some to trace silt, with cobbles Compact to Very Dense Brown Wet				▽		
		4	SS	24			57 37 6 (SI+CL)
						263	
	No recovery	5	SS	163/ 0.250		262	
						261	
		6	SS	13			
						260	
259.6 7.2	**SAND**, some to trace silt, trace gravel Loose to Very Loose Brown Wet						
		7	SS	8		259	
						258	
		8	SS	2		257	0 94 6 (SI+CL)

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.

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity   (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-43

METRIC

W.P. 6803-14-01 | LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 244.2 E 224 873.4 | ORIGINATED BY TTB

DIST ____ HWY 11 | BOREHOLE TYPE Solid Stem Augers/Hollow Stem Augers/ Wash Boring | COMPILED BY AN

DATUM Geodetic | DATE 2017.08.25 - 2017.08.25 | LATITUDE 49.301965° | LONGITUDE -88.099109° | CHECKED BY NLB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page									
256.6 / 10.2	Gravelly **SAND**, trace silt Loose Brown Wet						256			
			9	SS	4			~19		
							255			
	No recovery		10	SS	5		254	~20		
253.5 / 13.3	**SAND**, some silt, trace gravel Loose Grey Wet						253			
			11	SS	5			~22		
252.5 / 14.3	END OF BOREHOLE AT 14.3m. BOREHOLE OPEN TO 3.7m AND WATER LEVEL AT 3.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.9m, DRY CEMENT TO 0.2m, THEN ASPHALT TO THE SURFACE.									

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-44

METRIC

W.P. 6803-14-01 | LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 249.7 E 224 887.9 | ORIGINATED BY TTB

DIST ____ HWY 11 | BOREHOLE TYPE Washboring | COMPILED BY AN

DATUM Geodetic | DATE 2017.08.24 - 2017.08.24 | LATITUDE 49.302016° | LONGITUDE -88.098911° | CHECKED BY NLB

ELEV / DEPTH (m)	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
266.3	GROUND SURFACE							
0.0	**SAND** and **GRAVEL**, some silt Very Dense Grey/Brown Wet (FILL)	Fill	1	SS	50/ 0.075			
			2	SS	100/ 0.075			
			3	SS	54	∇	o (~18)	33 56 11 (SI+CL)
	Occasional cobbles Becoming Dense		4	SS	34		o (~26)	
263.3 3.0	**SAND**, trace gravel, trace silt, occasional cobbles, occasional wood fragments Dense to Loose Brown Wet	Sand	5	SS	38			
	No recovery		6	SS	8			
	No recovery		7	SS	5			
259.3 7.0	**SAND**, some silt, trace gravel Loose Brown Wet	Sand	8	SS	4		o (~20)	
			9	SS	7		o (~34)	

Elevation scale: 266, 265, 264, 263, 262, 261, 260, 259, 258, 257

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

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity; 20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-44

METRIC

W.P. 6803-14-01 LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 249.7 E 224 887.9 ORIGINATED BY TTB

DIST HWY 11 BOREHOLE TYPE Washboring COMPILED BY AN

DATUM Geodetic DATE 2017.08.24 - 2017.08.24 LATITUDE 49.302016° LONGITUDE -88.098911° CHECKED BY NLB

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Continued From Previous Page									
256.1 / 10.2	Gravelly **SAND**, trace silt Loose Brown Wet				256					
		10	SS	6	255	o				
		11	SS	9	254	o				
253.0 / 13.3	**SAND**, some gravel, trace silt Very Loose Brown Wet				253					
		12	SS	3		o	12	84	4 (SI+CL)	
252.0 / 14.3	END OF BOREHOLE AT 14.3m. BOREHOLE OPEN TO 2.4n AND WATER LEVEL AT 1.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG SURFACE.				252					

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; 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   15-◆-5 (20/10) (%) STRAIN AT FAILURE

ONTMT4S2 MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 7/27/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-44A

METRIC

W.P. 6803-14-01 | LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 249.7 E 224 887.9 | ORIGINATED BY TTB

DIST ___ HWY 11 | BOREHOLE TYPE Dynamic Cone Penetration Test | COMPILED BY AN

DATUM Geodetic | DATE 2017.08.24 - 2017.08.24 | LATITUDE 49.302016° | LONGITUDE -88.098911° | CHECKED BY NLB

SOIL PROFILE			SAMPLES								
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	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
266.3	GROUND SURFACE										
0.0	Auger to 1.5m and start DCPT						266				
							265				
264.8 / 1.5	Start of DCPT						264				
							263				
							262				
							261				
							260				
							259				
							258				
							257				

Continued Next Page

+ ³, × ³ : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-44A

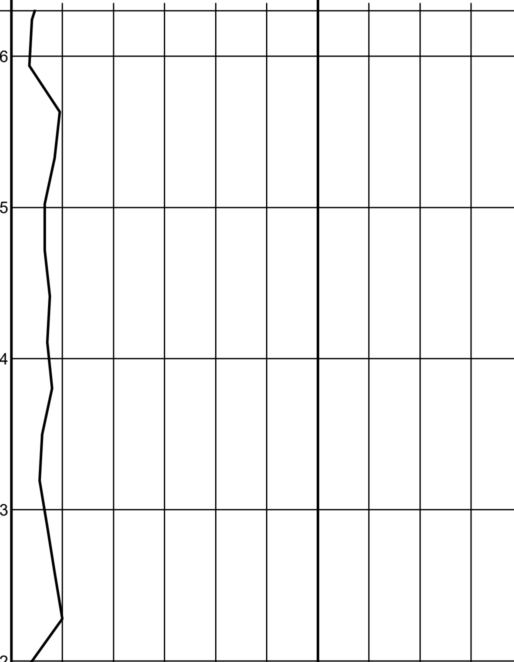
METRIC

W.P. 6803-14-01 | LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 249.7 E 224 887.9 | ORIGINATED BY TTB

DIST ____ HWY 11 | BOREHOLE TYPE Dynamic Cone Penetration Test | COMPILED BY AN

DATUM Geodetic | DATE 2017.08.24 - 2017.08.24 | LATITUDE 49.302016° | LONGITUDE -88.098911° | CHECKED BY NLB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O 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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page						256				
							255				
							254				
							253				
252.0 / 14.3	END OF DCPT AT 14.3m.						252				



+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 17-45

METRIC

W.P. 6803-14-01 | LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 223.5 E 224 877.0 | ORIGINATED BY TTB

DIST ____ HWY 11 | BOREHOLE TYPE Solid Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2017.08.23 - 2017.08.23 | LATITUDE 49.301779° | LONGITUDE -88.099056° | CHECKED BY NLB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
266.7	GROUND SURFACE													
0.0	**ASPHALT:** (150mm)													
0.2	**SAND** and **GRAVEL**, trace to some silt Brown Dry to Wet (FILL)		1	GS					o					
							266							
			2	GS					o					
							265							
						∇								
							264							
	Dense		1	SS	39				o		37	53	10 (SI+CL)	
263.0 3.7	END OF BOREHOLE AT 3.7m. BOREHOLE OPEN TO 2.4m AND WATER LEVEL AT 2.4m UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.9m, DRY CEMENT TO 0.2m, THEN ASPHALT TO THE SURFACE.													

Legend: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE. Plastic limit w_P, natural moisture content w, liquid limit w_L.

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-46

METRIC

W.P. 6803-14-01 LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 213.6 E 224 878.8 ORIGINATED BY TTB

DIST ______ HWY 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.08.23 - 2017.08.23 LATITUDE 49.301690° LONGITUDE -88.099029° CHECKED BY NLB

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
266.6	GROUND SURFACE					
0.0	**ASPHALT:** (150mm)					
0.2	**SAND** and **GRAVEL**, trace to some silt, Brown, Dry (FILL)	1	GS		~3	31 57 12 (SI+CL)
		2	GS		~0	
263.1 / 3.5	Very Dense, Wet	1	SS	148/0.225	~4	
3.5	END OF BOREHOLE AT 3.5m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.9m, DRY CEMENT TO 0.2m, THEN ASPHALT TO THE SURFACE.					

Elevation scale: 266, 265, 264

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

+³, ×³: Numbers refer to Sensitivity; (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-47

METRIC

W.P. 6803-14-01 LOCATION Gorge Creek Culvert, MTM NAD 83 CSRS Zone 14 N 5 463 203.7 E 224 880.4 ORIGINATED BY TTB

DIST HWY 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.08.23 - 2017.08.23 LATITUDE 49.301602° LONGITUDE -88.099005° CHECKED BY NLB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
266.5	GROUND SURFACE												
0.0	**ASPHALT:** (200mm)												
0.2	**SAND** and **GRAVEL**, trace to some silt Compact Brown Dry (FILL)		1	SS	25		266						
							265						
			1	GS		∇	264						
262.8	Very Dense		2	SS	55		263			38	55	7 (SI+CL)	
3.7	END OF BOREHOLE AT 3.7m. BOREHOLE OPEN AND WATER LEVEL AT 2.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.9m, DRY CEMENT TO 0.2m, THEN ASPHALT TO THE SURFACE.												

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

REMARKS & GRAIN SIZE DISTRIBUTION (%)

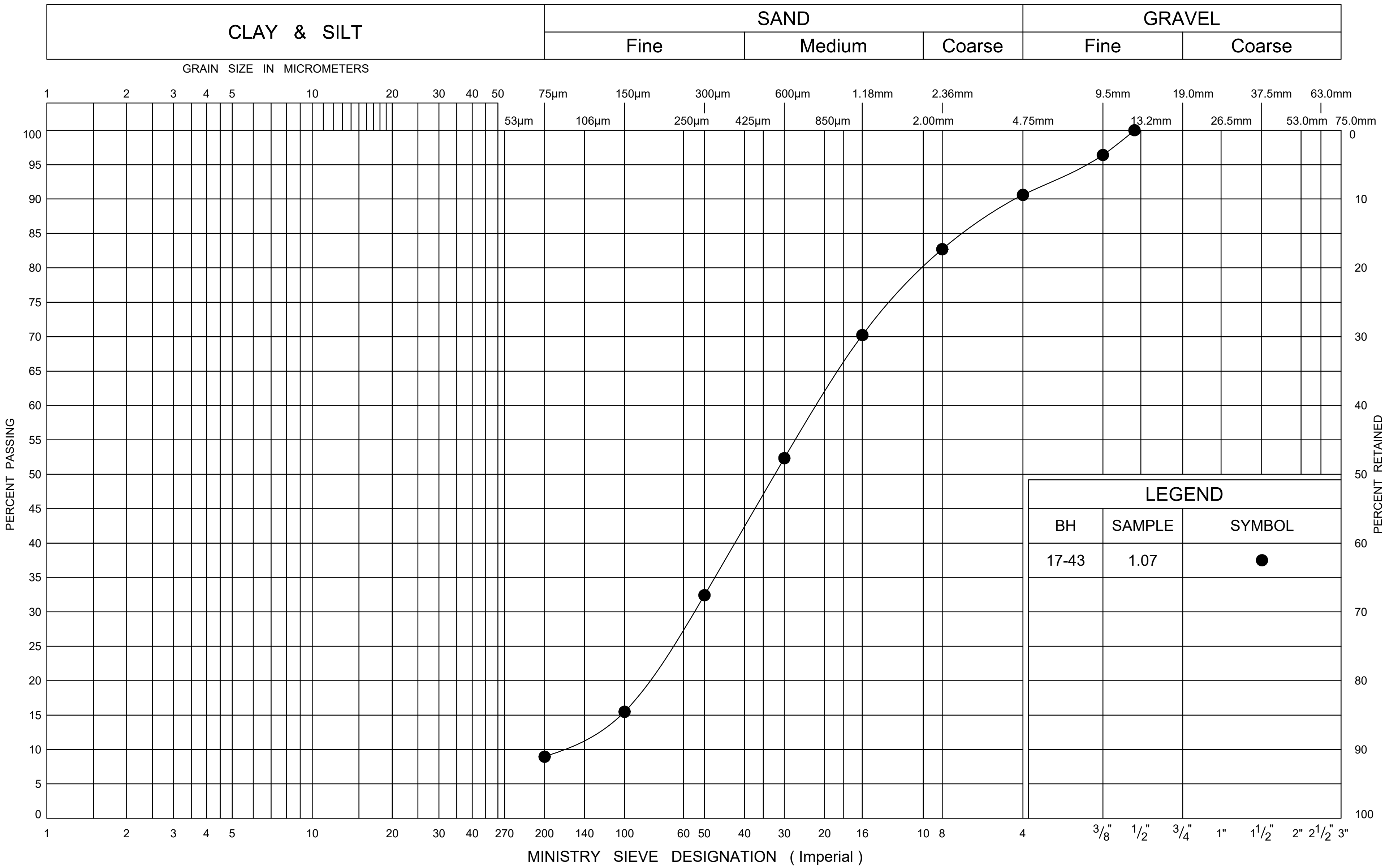
$+^3, \times^3$: Numbers refer to Sensitivity

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

THURBER

Appendix B

Laboratory Test Results



LEGEND		
BH	SAMPLE	SYMBOL
17-43	1.07	●

ONTARIO MOT GRAIN SIZE MTO-15595.GPJ ONTARIO MOT.GDT 7/26/18

Ministry of Transportation
Ontario

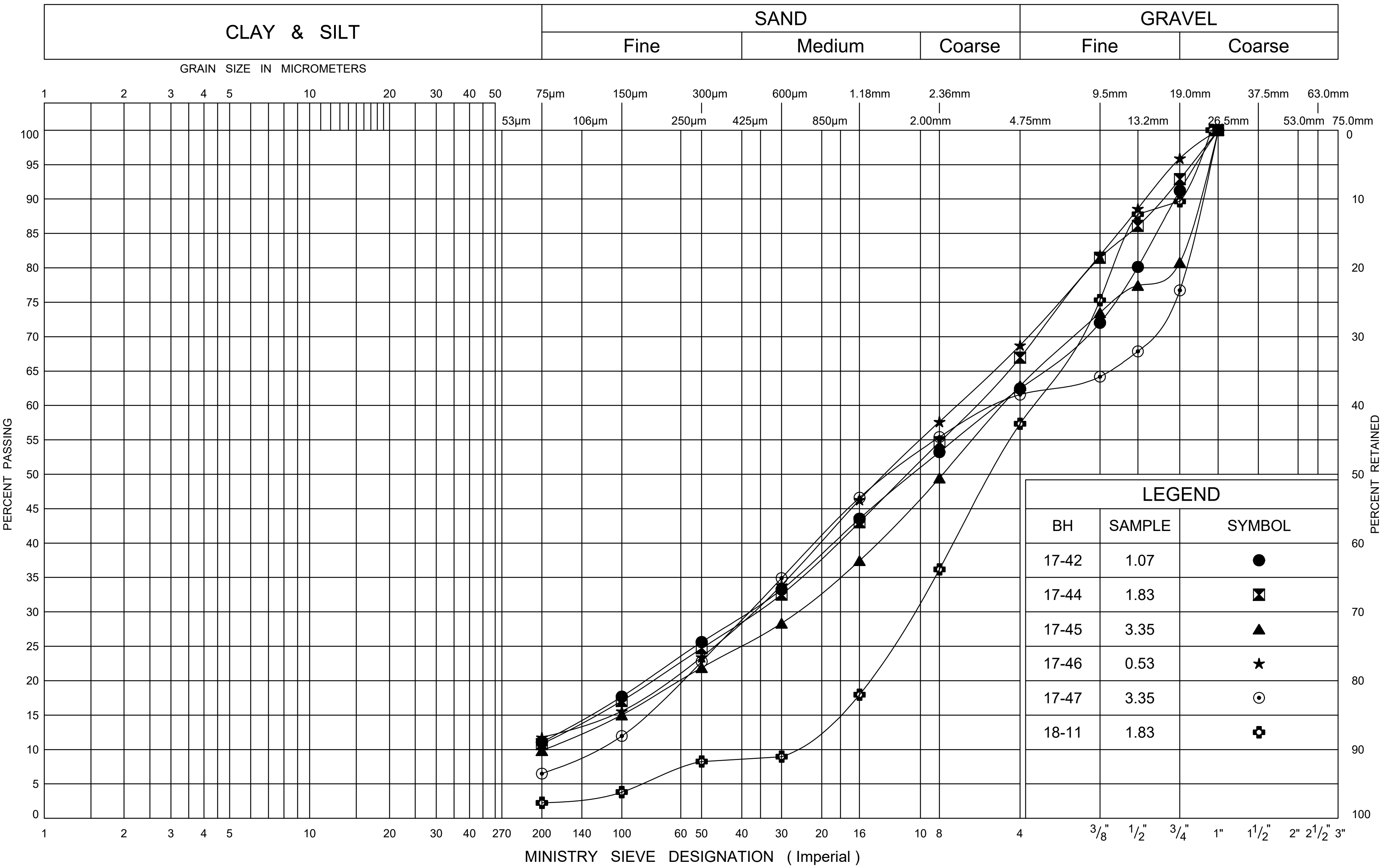
GRAIN SIZE DISTRIBUTION

SAND FILL

FIG No B1

W P 6803-14-01

Gorge Creek Culvert



LEGEND

BH	SAMPLE	SYMBOL
17-42	1.07	●
17-44	1.83	⧗
17-45	3.35	▲
17-46	0.53	★
17-47	3.35	⊙
18-11	1.83	✤

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

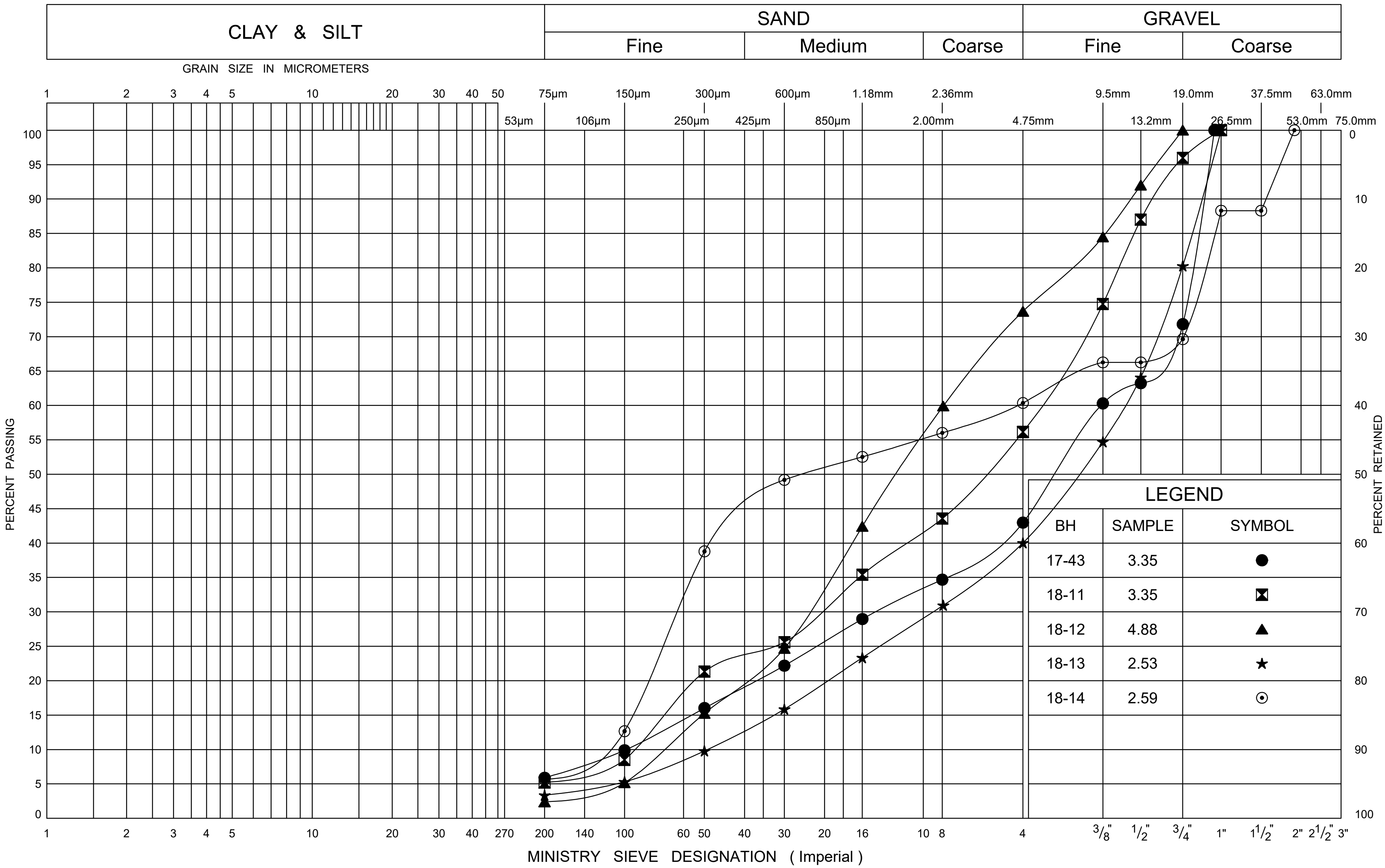
SAND and GRAVEL FILL

FIG No B2

W P 6330-14-01

Gorge Creek Culvert

78 12 M



BH	SAMPLE	SYMBOL
17-43	3.35	●
18-11	3.35	⊠
18-12	4.88	▲
18-13	2.53	★
18-14	2.59	⊙

Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

SAND and GRAVEL to Gravelly SAND

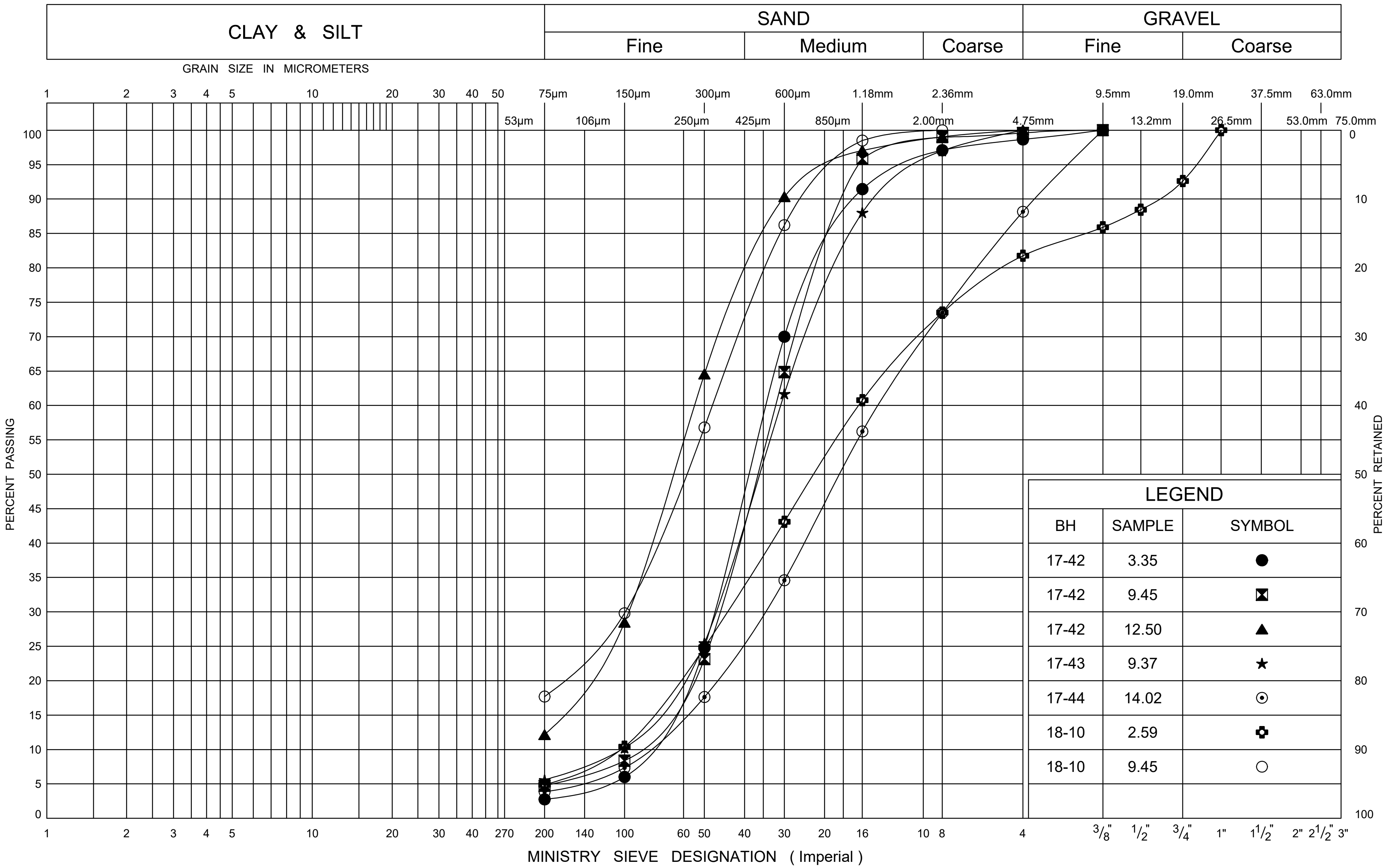
FIG No B3

W P 6330-14-01

Gorge Creek Culvert

ONTARIO MOT GRAIN SIZE MTO-15595.GPJ ONTARIO MOT.GDT 7/26/18

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
17-42	3.35	●
17-42	9.45	⊠
17-42	12.50	▲
17-43	9.37	★
17-44	14.02	⊙
18-10	2.59	✤
18-10	9.45	○

ONTARIO MOT GRAIN SIZE MTO-15595.GPJ ONTARIO MOT.GDT 7/26/18

Ministry of Transportation

Ontario

GRAIN SIZE DISTRIBUTION

SAND

FIG No B4

W P 6330-14-01

Gorge Creek Culvert

Certificate of Analysis

SGS Canada Inc.
185 Concession St. Box 4300
Lakefield, Ont.,Canada,K0L 2H0

Attention: Mark Farrant
Project#: 15595

Client Thurber Engineering Ltd.
SGS LIMS Number CA14253-SEP17
Analysis Package: **Corrosivity (Soil)**

Sample ID	Unit	BH-43, SS#3, 5'-7'
Sample Date/Time		25-Aug-17
Moisture	%	4.7
pH	no unit	9.60
Corrosivity Index	none	13.0
Soil Redox Potential	mV	230
Sulphide	mg/L	<0.02
Chloride	mg/L	1100.0
Sulphate	mg/L	21
Conductivity	uS/cm	1150
Resistivity (calculated)	ohms.cm	867

Corrosivity Scale according to AWWA C-105.
An index greater than 10 indicates the
soil matrix may be corrosive to cast iron alloys.

Deanna Edwards

Deanna Edwards B.Sc., C.Chem
Project Specialist
Environment, Health and Safety

SGS Canada Inc.
185 Concession St.
Box 4300
Lakefield,Ont.
Canada,K0L 2H0

Attention: **Cory Zanatta**
Project#: **15595, North Superior Lake Region**

Client **Thurber Engineering Ltd.**
SGS LIMS Number **CA15829-AUG17**
Analysis Package: **Corrosivity (Solution)**

Sample ID	Unit	Gorge Creek
Sample Date/Time		23-Aug-17
Moisture	%	NA
pH	no unit	7.89
Corrosivity Index	none	NA
Redox Potential	mV	261
Sulphide	mg/L	<0.006
Chloride	mg/L	0.57
Sulphate	mg/L	1.5
Conductivity	uS/cm	107
Resistivity (calculated)	ohms.cm	9350

Corrosivity Scale according to AWWA C-105.
An index greater than 10 indicates the
soil matrix may be corrosive to cast iron alloys.

Deanna Edwards

Deanna Edwards B.Sc., C.Chem
Project Specialist
Environment, Health and Safety

Appendix C

Borehole Locations and Soil Strata Drawing

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

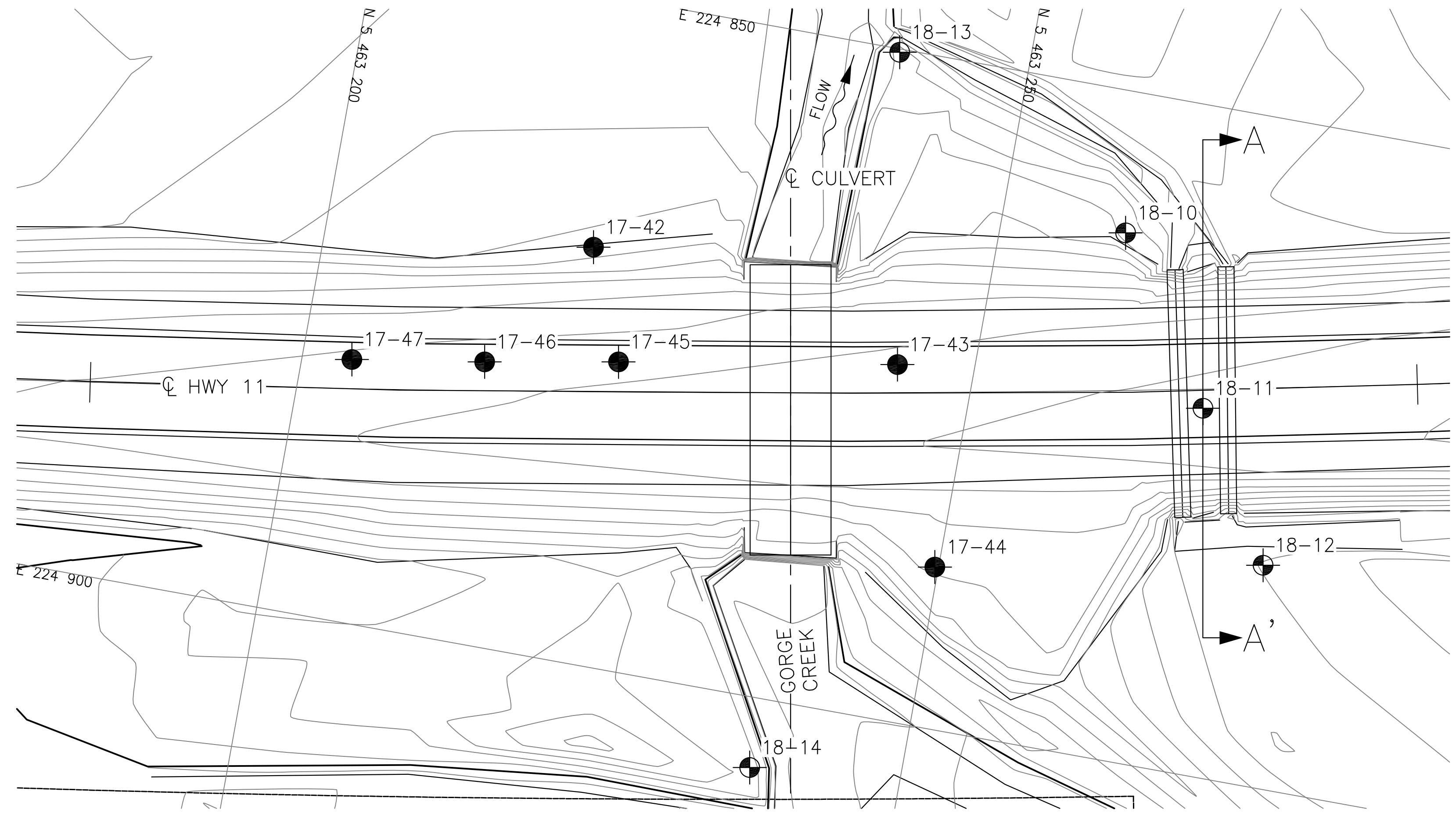
CONT No 2018–6015
WP No 6803–14–01

HIGHWAY 11
GORGE CREEK
CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA I

SHEET 26

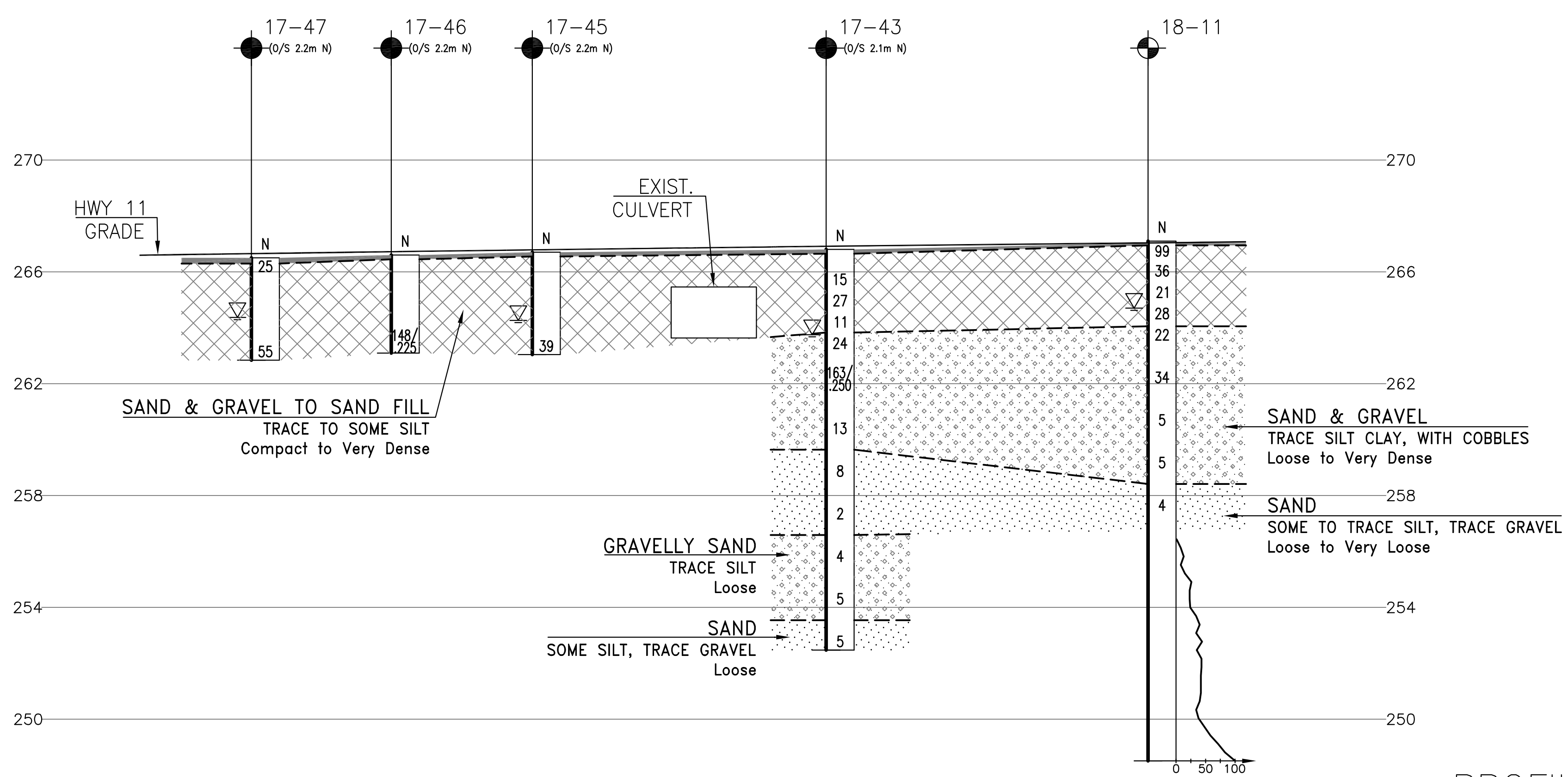
HATCH

THURBER ENGINEERING LTD.



PLAN

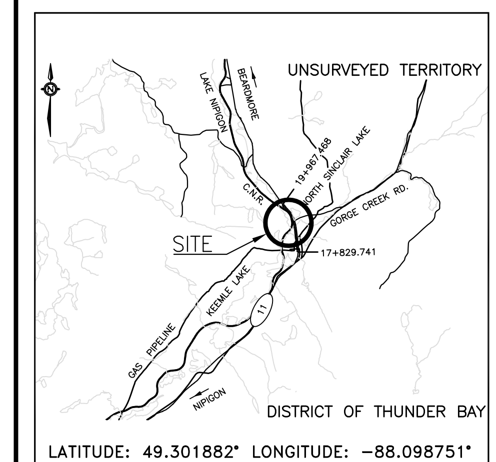
SCALE 1:500



PROFILE ALONG ℄ HWY 11

H 1:500

V 1:250



KEYPLAN

LEGEND

●	Borehole (Previous Investigation)
⊕	Borehole (Current Investigation)
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
17–42	265.4	5 463 220.1	224 868.8
17–43	266.8	5 463 244.2	224 873.4
17–44	266.3	5 463 249.7	224 887.9
17–45	266.7	5 463 223.5	224 877.0
17–46	266.6	5 463 213.6	224 878.8
17–47	266.5	5 463 203.7	224 880.4
18–10	265.1	5 463 259.4	224 860.6
18–11	267.1	5 463 267.5	224 872.6
18–12	265.0	5 463 274.0	224 883.4
18–13	264.8	5 463 240.2	224 850.3
18–14	265.2	5 463 238.7	224 905.3

-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.
3) Coordinate system is MTM NAD 83 CSRS Zone 14.

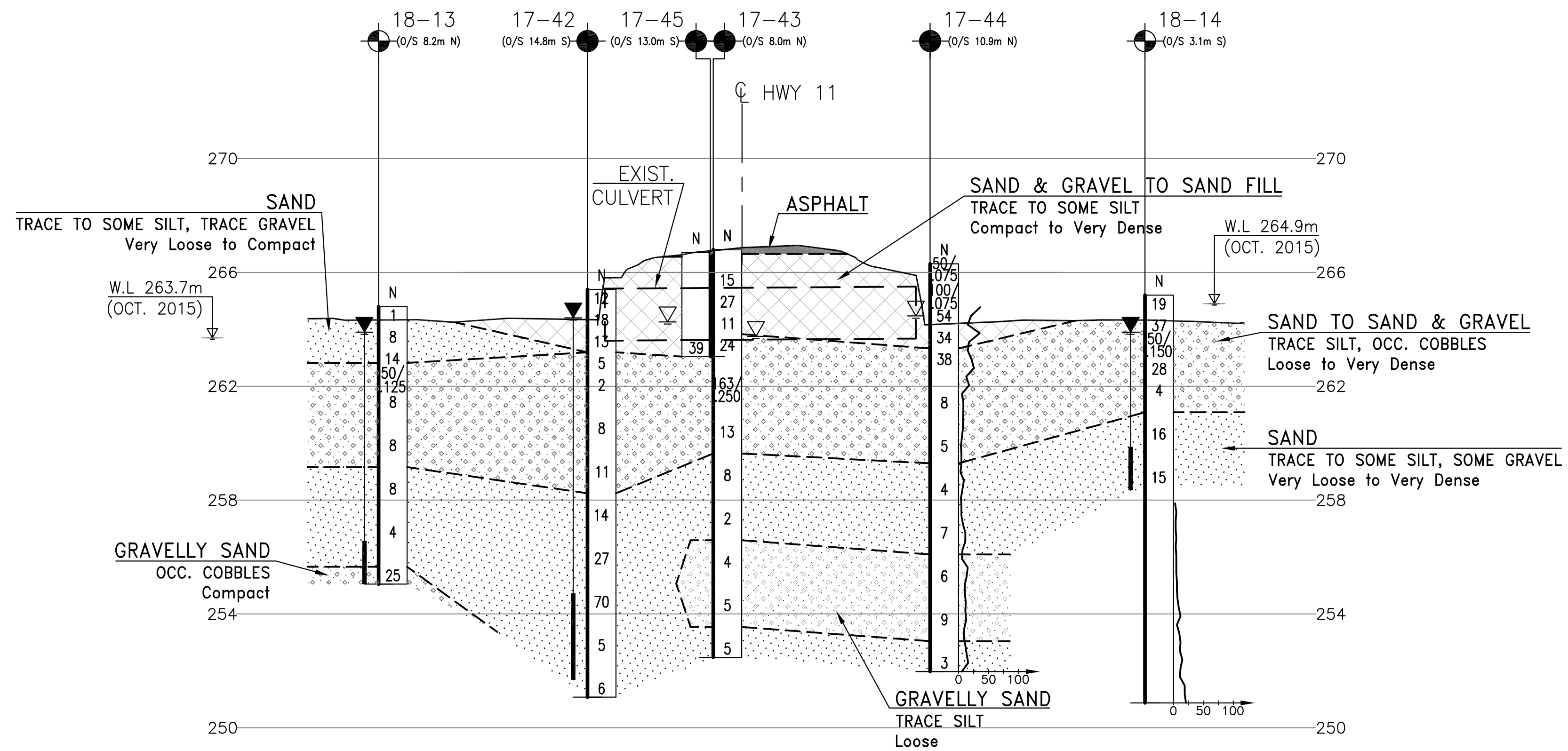
GEOCRES No. 52H-48

REVISIONS	DATE	BY	DESCRIPTION

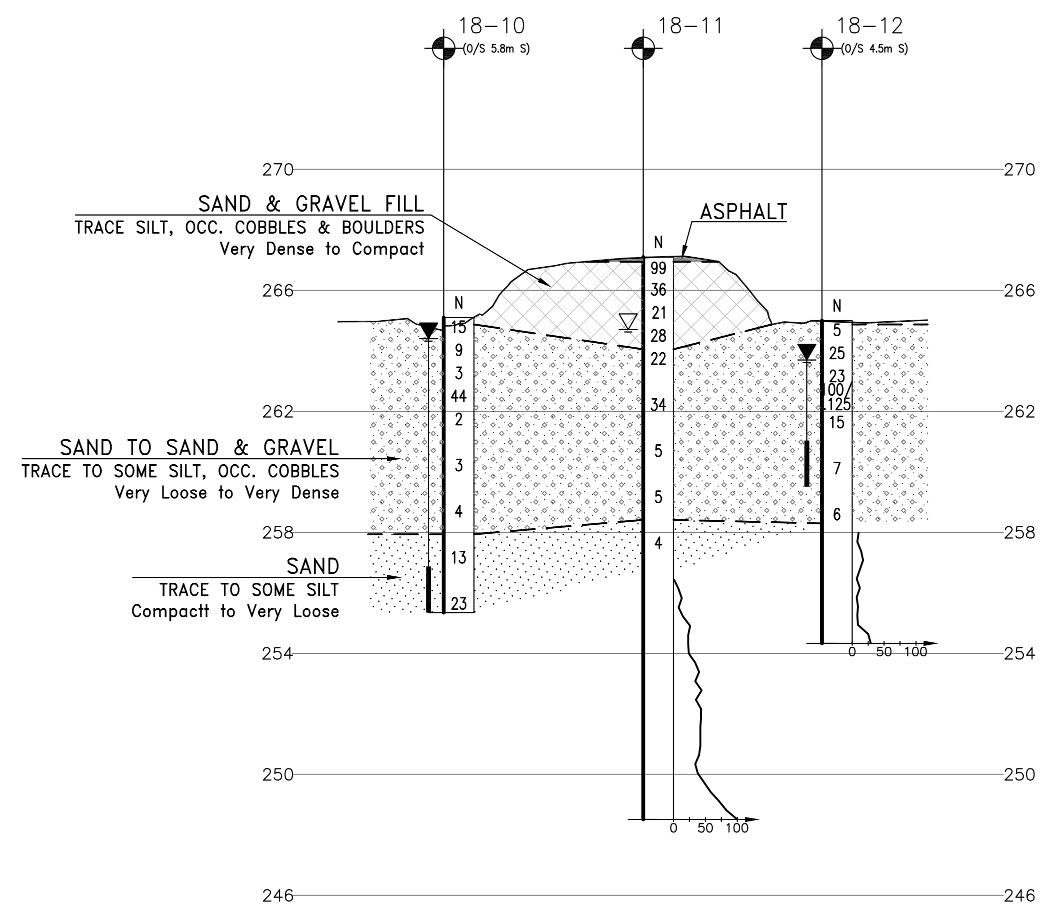
DESIGN CZ	CHK MEF	CODE	LOAD	DATE NOV 2018	
DRAWN AN	CHK CZ	SITE 48C–182/C	STRUCT	DWG 2	

FILENAME: H:\Drafting\15000\15595\TED-15595-GC-Jul2018.dwg
PLOTDATE: 11/12/2018 2:53 PM

MINISTRY OF TRANSPORTATION, ONTARIO



PROFILE ALONG ℄ CULVERT



PROFILE ALONG A–A'

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

H 1:500 (10 0 10 20m)
V 1:250 (5 0 5 10m)

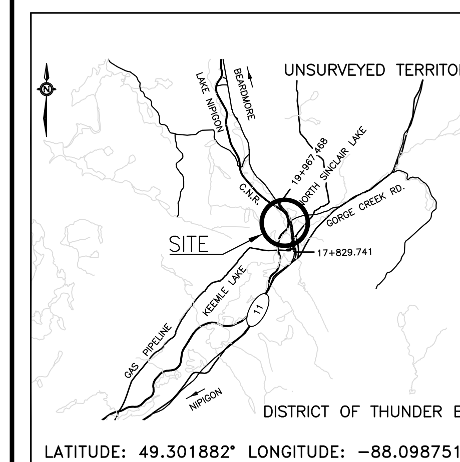
CONT No 2018–6015
WP No 6803–14–01

HIGHWAY 11
GORGE CREEK
CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA II

SHEET 27

HATCH

THURBER ENGINEERING LTD.



LATITUDE: 49.301882° LONGITUDE: –88.098751°

KEYPLAN

LEGEND

⊕	Borehole (Previous Investigation)
⊕	Borehole (Current Investigation)
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
17–42	265.4	5 463 220.1	224 868.8
17–43	266.8	5 463 244.2	224 873.4
17–44	266.3	5 463 249.7	224 887.9
17–45	266.7	5 463 223.5	224 877.0
17–46	266.6	5 463 213.6	224 878.8
17–47	266.5	5 463 203.7	224 880.4
18–10	265.1	5 463 259.4	224 860.6
18–11	267.1	5 463 267.5	224 872.6
18–12	265.0	5 463 274.0	224 883.4
18–13	264.8	5 463 240.2	224 850.3
18–14	265.2	5 463 238.7	224 905.3

-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.
3) Coordinate system is MTM NAD 83 CSRS Zone 14.

GEOCRES No. 52H-48

REVISIONS	DATE	BY	DESCRIPTION			
DESIGN CZ	CHK MEF	CODE	LOAD	DATE NOV 2018		
DRAWN AN	CHK CZ	SITE 48C–182/C	STRUCT	DWG 3		

FILENAME: H:\Drafting\15000\15595\TED–15595–GC–Jul2018.dwg
PLOTDATE: 11/12/2018 2:54 PM

Appendix D

Site Photographs

THURBER

Photo 1: Road approach looking north. Taken May 15, 2017.

THURBER

Photo 2: Road approach looking south. Taken May 15, 2017.

THURBER

Photo 3: East embankment looking north (inlet). Taken June 27, 2017.

Photo 4: East embankment looking south (inlet). Taken June 27, 2017.

THURBER

Photo 5: West embankment looking north (outlet). Taken June 27, 2017.

THURBER

Photo 6: West embankment looking south (outlet). Taken June 27, 2017.

THURBER

Photo 7: Culvert outlet looking southeast. Taken May 15, 2017.

Photo 8: Culvert inlet looking northwest. Taken May 15, 2017.

Appendix E

List of Specifications and Suggested Wording for NSSP

THURBER

1. List of OPSS and OPSD Documents Relevant to this Project

- OPSS PROV 206 (Construction Specification for Grading)
- OPSS PROV 209 (Construction Specification for Embankments over Swamps and Compressible Soils)
- OPSS PROV 401 (Construction Specification for Trenching, Backfilling and Compacting)
- OPSS 422 (Construction Specification for Precast Reinforced Concrete Box Culverts in Open Cut)
- OPSS PROV 501 (Construction Specification for Compacting)
- OPSS 511 (Construction Specification for Rip-Rap, Rock Protection, And Granular Sheeting)
- OPSS PROV 539 (Construction Specification for Temporary Protection Systems)
- OPSS PROV 804 (Construction Specification for Seed and Cover)
- OPSS 902 (Construction Specification for Excavating and Backfilling – Structures)
- SP 109S12 Amendment to OPSS 902 (QVE, Backfilling Compaction, and Certification of Conformance)
- OPSS PROV 1004 (Material Specification for Aggregates – Miscellaneous)
- OPSS PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material)
- OPSS PROV 1101 (Material Specification for Performance Graded Asphalt Cement)
- Special Provision No. 110S13 (Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material)
- OPSS PROV 1205 (Material Specification for Clay Seal)
- OPSS 1860 (Material Specification for Geotextiles)
- OPSD 208.010 (Benching of Earth Slopes)
- OPSD 802.010 (Flexible Pipe Embedment and Backfill, Earth Excavation)
- OPSD 802.014 (Flexible Pipe Embedment in Embankment)
- OPSD 802.034 (Rigid Pipe Bedding and Cover in Embankment, Original Ground: Earth or Rock)

- OPSD 803.010 (Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m)
- OPSD 803.031 (Frost Treatment – Pipe Culverts, Frost Penetration Line Between Top of Pipe and Bedding Grade)
- OPSD 810.010 (General Rip-Rap Layout for Sewer and Culvert Outlets)
- OPSD 3090.100 (Foundation Frost Depths for Northern Ontario)
- Special Provision No. FOUN0003 to OPSS 902 (Dewatering Structure Excavations)

2. Suggested Wording for NSSP

- **Suggested Text for NSSP on "Obstructions"**

"Excavations and installation of a replacement culvert could encounter obstructions such as cobbles and boulders embedded in the fill and native soils. Such obstructions may impede excavation progress and/or sheet pile installation. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths. Vibrating equipment is not permitted for installation and removal of sheet piles."

- **Suggested Text for NSSP on "Groundwater and Dewatering**"

"The Contractor is alerted that water levels may be higher than the water levels shown in the Foundation Investigation Report prepared for this site. While reference should be made to that report for a description of the encountered conditions, the Contractor must satisfy themselves regarding the groundwater levels likely to prevail at the time of construction and be prepared to implement dewatering procedures.

The Contractor is further notified that failure to implement dewatering in advance of excavating below the groundwater table may result in sloughing and boiling of the soil in the excavation and a loss in stability and bearing resistance.

Design and provision of an effective dewatering system is the responsibility of the Contractor. The dewatering system must be effective to lower the groundwater table at a minimum of 0.5 m below the final subgrade level to avoid basal heave and base boiling. The dewatering system is to be designed in accordance with SP FOUN0003, OPSS.PROV. 517 and SP517F01. A preconstruction survey is required and can utilize a 400 m radius for the zone of dewatering influence. A dewatering engineer with a minimum of 5 years of experience in designing dewatering systems shall be retained by the contractor for design of an effective dewatering system. "