



October 7, 2016

## FOUNDATION INVESTIGATION AND DESIGN REPORT

**SISSON CREEK, ENGLISH RIVER TRIBUTARY AND BAKER CREEK  
CULVERTS**

**SITES 48W-9/C, 48W-188/C AND 48W-12/C**

**HIGHWAY 17, DISTRICT OF THUNDER BAY**

**MINISTRY OF TRANSPORTATION, ONTARIO**

**G.W.P. 6336-14-00 W.P. 6338-14-01, W.P. 6337-14-01 & W.P. 6336-14-01**

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REPORT







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# **PART A**

**DETAIL FOUNDATION INVESTIGATION REPORT  
SISSON CREEK, ENGLISH RIVER TRIBUTARY AND BAKER CREEK CULVERTS  
SITES 48W-9/C, 48W-188/C AND 48W-12/C  
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## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by Hatch Ltd. (Hatch) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the rehabilitation of the Sisson Creek Culvert (Site 48W-9/C), English River Tributary Culvert (Site 48W-188/C) and Baker Creek Culvert (Site 48W-12/C) on Highway 17 in the District of Thunder Bay, Ontario. The general locations of the culverts are shown on the Key Plan on Figure 1.

## **2.0 SITE DESCRIPTION**

The existing Sisson Creek, English River Tributary and Baker Creek culvert details (size, length, type, etc.) are summarized in Table 1, following the text of this report.

It should be noted that the orientation (i.e., north, south, east, west) stated in the text of the report is typically referenced to project north and therefore may differ from magnetic north shown on the drawings.

### **2.1 Sisson Creek Culvert**

The Sisson Creek culvert is located on Highway 17 at approximately Sta. 10+959 in the Township of Pyramid, about 66 km east of Highway 599. For the purpose of this report, Highway 17 runs in a west-east direction at the Sisson Creek location with the culvert perpendicular to the highway in north-south orientation.

In general, the topography in the area is relative flat, with low lying grassy/swampy ground bordering the creek on both sides of the highway. Sisson Creek flows from north to south. At the culvert location, the highway grade is at Elevation 465.1 m with the existing culvert inverts at Elevation 462.1 m and 462.0 m at the inlet (north end) and outlet (south end), respectively. The creek water level, as surveyed by Golder on January 25, 2016, was at Elevation 463.4 m at both the inlet and outlet ends of the culverts. Ground surface conditions at the culvert location are shown on Photographs A1 to A4 in Appendix A.

### **2.2 English River Tributary Culvert**

The English River Tributary culvert is located on Highway 17 at approximately Sta. 11+592 in the Township of Trewartha, about 73 km east of Highway 599. For the purpose of this report, Highway 17 runs in a west-east direction at the English River Tributary location with the culvert perpendicular to the highway in north-south orientation.

In general, the topography in the culvert area is relatively flat, with low-lying grassy/swampy ground bordering the tributary on both sides of the highway. The English River Tributary flows from north to south. The highway grade at the culvert location is at Elevation 469.9 m with the existing culvert invert at Elevation 467.0 m and 467.1 m at the inlet (north end) and outlet (south end), respectively. The Tributary ice level, as surveyed by Golder on January 22, 2016, was at Elevation 467.9 m at both the inlet and outlet ends of the culvert. Ground surface conditions at the culvert location are shown on Photographs B1 to B4 in Appendix B.





## **2.3 Baker Creek Culvert**

The Baker Creek culvert is located on Highway 17 at approximately 14+907 in the Township of Trewartha, about 76 km east of Highway 599. For the purpose of this report, Highway 17 runs in a west-east direction at the Baker Creek location with the culvert perpendicular to the highway in north-south orientation.

In general, the topography in the culvert area is relatively flat, with low lying grassy ground bordering the creek on both sides of the highway. Baker Creek flows north to south. The highway grade at the culvert location is at Elevation 469.7 m with the existing culvert invert at Elevation 466.2 m at both the inlet (north end) and outlet (south end). The creek ice level, as surveyed by Golder on January 20, 2016 was at Elevation 467.8 m at the outlet end of the culvert. Ground surface conditions at the culvert location are shown on Photographs C1 to C4 in Appendix C.

## **3.0 INVESTIGATION PROCEDURES**

The fieldwork for the investigation at the Sisson Creek, English River Tributary and Baker Creek culvert sites was carried out between January 19 and 30, 2016, during which period a total of twelve (12) boreholes were advanced at the three culvert sites (4 boreholes at each site). A summary of the boreholes advanced at each culvert site is presented and the locations of the boreholes and culvert sites are shown on Drawings A1, B1 and C1 in Appendices A to C, respectively.

The field investigation was carried out using a track mounted CME 850 drill rig supplied and operated by Cartwright Drilling Ltd. of Thunder Bay, Ontario and a portable tripod drill supplied and operated by Landcore of Sudbury, Ontario. The boreholes were advanced through the overburden using 108 mm inside diameter hollow stem augers and/or HW/NW casing with wash boring techniques. Where bedrock coring was performed, an HQ size core barrel was utilized. In general, soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm outer diameter split-spoon sampler, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). All open boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The fieldwork was supervised on a full-time basis by a member of Golder's technical staff who: located the boreholes in the field; arranged for the clearance of underground services; observed the drilling, sampling and in situ testing operations; logged the boreholes and examined and cared for the soil samples. The soil and bedrock samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury Geotechnical Laboratory where the samples and core underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO Laboratory Standards and/or ASTM Standards, as appropriate. Classification testing (water content, grain size distribution and Atterberg limits) was carried out on selected soil samples. Unconfined compressive strength tests were carried out on selected specimens of the recovered bedrock cores.

A sample of the creek/tributary water was obtained during the field investigation at each culvert location, using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by members of our technical staff, referenced to the highway centerline and existing culvert and converted into northing/easting coordinates on the plan drawings. The ground surface elevation of the highway centerline at each culvert





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location was obtained from the profile drawings provided by MTO (drawings BC322172.dwg, e745172.dwg and e745171.dwg). The MTM NAD83 (Zone 15) northing and easting coordinates, ground surface elevations referenced to Geodetic datum, and borehole depths at each borehole location are presented on the Record of Borehole sheets in Appendices A, B and C and summarized below.

Culvert	Borehole	MTM NAD 83 Coordinates (m)		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing	Easting		
Sisson Creek Culvert (Site 48W-9/C)	SI-1	5 450 504.7	241 789.6	463.6	9.8
	SI-2	5 450 494.3	241 798.6	463.9	9.8
	SI-3	5 450 487.2	241 770.6	463.7	9.1
	SI-4	5 450 477.2	241 780.6	463.9	9.8
English River Tributary Culvert (Site 48W-188/C)	ER-1	5 445 736.4	246 362.4	468.2	7.0*
	ER-2	5 445 732.5	246 373.7	468.3	5.9
	ER-3	5 445 713.0	246 352.5	468.3	6.8
	ER-4	5 445 708.2	246 363.1	468.4	6.1*
Baker Creek Culvert, (Site 48W-12/C)	BK-1	5 444 570.8	249 466.2	468.3	9.8
	BK-2	5 444 568.1	249 477.6	467.8	9.8
	BK-3	5 444 544.0	249 453.2	468.2	9.8
	BK-4	5 444 538.6	249 467.9	468.3	9.8

\*Includes 3.1 m and 3.2 m bedrock core at the respective boreholes.

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

#### 4.1.1 Sisson Creek

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS)<sup>1</sup> mapping, the subsoils at the Sisson Creek culvert site consists of knobby/hummocky bedrock knobs bordering with organic terrain deposits comprised of peat and outwash plain/valley terrain deposits comprised of sand.

Based on the geological mapping by the Ministry of Northern Development and Mines (MNDM)<sup>2</sup>, the Sisson Creek culvert site is underlain by bedrock of the foliated tonalite suite comprised of foliated to massive tonalite to granodiorite.

<sup>1</sup> Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society. Electronic Mapping, Map 52GSE.

<sup>2</sup> Ministry of Northern Development and Mines. Bedrock Geology – West Central Sheet, Ontario Geological Survey – Map 2542





#### **4.1.2 English River Tributary**

Based on NOEGTS mapping, the subsoils at the English River Tributary culvert site consists knobby/hummocky bedrock knobs bordering with organic terrain deposits comprised of peat.

Based on the geological mapping by the MNDM, the English River Tributary culvert site is underlain by bedrock of the gneissic tonalite suite comprised of foliated to gneissic tonalite to granodiorite with minor supracrustal inclusions.

#### **4.1.3 Baker Creek**

Based on NOEGTS mapping, the subsoils at the Baker Creek culvert site consists of organic terrain comprised of peat, bordering knobby/hummocky bedrock knobs and ground moraine deposit consisting sand till.

Based on the geological mapping by the MNDM, the Baker Creek culvert site is underlain by bedrock of the foliated tonalite suite comprised of foliated to massive tonalite to granodiorite.

### **4.2 General Overview of Local Subsurface Conditions**

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the Record of Borehole sheets and the laboratory test sheets in Appendices A to C for Sisson Creek, English River Tributary and Baker Creek, respectively. The results of in situ field tests (i.e., SPT 'N'-values) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the stratigraphic cross-sections on Drawings A1, B1 and C1 are inferred from non-continuous sampling, observations of drilling progress and in situ testing. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

Detailed descriptions of the subsurface conditions at each investigated culvert crossing are provided in the following sections of this report. Where relatively significant thicknesses of overburden were encountered, the various soil types are described in detail for each main deposit or stratum.

#### **4.3 Sisson Creek Culvert**

A total of four boreholes (Boreholes SI-1 to SI-4) were advanced at the Sisson Creek culvert site. The borehole locations, ground surface elevations and interpreted stratigraphic conditions are shown on Drawing A1.

In summary, the subsoil conditions encountered at the site consist of granular fill and peat underlain by deposits of silty sand to sand, silt to silt and sand, a silty clay pocket at one location, and sand to gravelly sand. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is presented below.





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Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows)	Laboratory Testing
				Relative Density/ Consistency	
<b>Sand (FILL)<sup>1</sup></b> , trace to some gravel, trace organics; brown; frozen to wet	SI-1 - SI-4	0.7	463.9 – 463.6	n/a	n/a
<b>Peat (Amorphous)</b> ; trace to some silt, trace to some sand; black; wet	SI-2 & SI-4	1.1 & 0.7	463.2	N = 6 <sup>2</sup> <b>Loose</b>	w = 54% & 140%
<b>Silty Sand to Sand</b> , trace to some organics; brown to grey; wet	SI-1 - SI-4	0.8 – 1.5	463.0 – 462.1	N = 3 - 12 <b>Very Loose to Compact</b>	w = 22% 1 – MH (Fig. A1)
<b>Silt to Sandy Silt to Silt and Sand <sup>3</sup></b> , trace clay; grey; wet	SI-1 - SI-4	2.2 – 5.0	462.1 – 460.9	N = 6 - 16 <b>Loose to Compact</b>	w = 24% - 28% 6 – MH (Fig. A2) 2 – AL (NP)
<b>Silty Clay</b> , trace to some sand; reddish brown; wet	SI-1	0.8	459.9	N = 4 <b>Soft</b>	w = 39%
<b>Sand to Gravelly Sand</b> , trace to some silt; grey; wet	SI-1 - SI-4	3.5 (fully penetrated in Borehole SI-3 ) >2.6 to >5.3 (Boreholes SI-1, SI-2 and SI-4 terminated in this deposit)	459.1 – 456.7	N = 1 – 63 <sup>4</sup> <b>Very Loose to Very Dense</b>	w = 13% - 23% 3 – M (Fig. A3)

N = SPT 'N'-value; number of blows for 0.3 m of penetration

w = Natural Moisture Content (%)

M = Sieve analysis

MH = Combined Sieve and Hydrometer analysis

AL = Atterberg Limits Test

NP = Non-Plastic Atterberg Limits Test Result

### Notes:

<sup>1</sup> Cobbles inferred from augers grinding in Borehole SI-4.

<sup>2</sup> An SPT 'N'-value of 15 blows per 0.3 m of penetration was measured in the peat deposit in Borehole SI-2 due to the presence of wood.

<sup>3</sup> Reddish brown silty clay seams were noted in the silt deposit in Borehole SI-4, similar in composition to the deposit encountered in Borehole SI-1.

### Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The creek water levels at the inlet and outlet were surveyed by Golder at Elevation 463.4 m in January





2016. Groundwater and creek water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

<b>Borehole No.</b>	<b>Depth to Groundwater Level (m)</b>	<b>Groundwater Elevation (m)</b>
SI-1	0.2	463.4
SI-2	0.5	463.4
SI-3	0.3	463.4
SI-4	0.5	463.4

## 4.4 English River Tributary Culvert

A total of four boreholes (Boreholes ER-1 to ER-4) were advanced at the English River Tributary culvert site. The borehole locations, ground surface elevations and interpreted stratigraphic conditions are shown on Drawing B1.

In summary, the subsoil conditions encountered at the site consist of granular fill and/or peat underlain by deposits of silty sand to sand and gravelly silty sand till, further underlain by granitic gneiss bedrock. A more detailed description of the soil deposits, bedrock and groundwater conditions encountered in the boreholes is presented below.

<b>Deposit/Layer Description</b>	<b>Boreholes</b>	<b>Deposit Thickness (m)</b>	<b>Deposit Surface Elevation (m)</b>	<b>N Values (blows)</b>	<b>Laboratory Testing</b>
				<b>Relative Density</b>	
<b>(FILL) Sand</b> , trace to some silt, trace organics; brown to grey; frozen to wet	ER-4	1.4	468.4	N = 3 <b>Very Loose</b>	w = 25% 1 – M (Fig. B1)
<b>Peat</b> (Fibrous), trace sand; black; frozen to wet	ER-1 to ER-4	0.7 – 2.2	468.3 – 467.0	N = 1 <b>Very Loose</b>	w = 124% & 798%
<b>Silty Sand to Sand</b> , trace clay, trace to some gravel, trace to some organics; brown to grey; wet	ER-1 to ER-4	1.5 – 4.9	467.6 – 466.0	N = 1 – 30 <b>Very Loose to Compact</b>	w = 16% - 29% 6 – M/MH (Fig. B2)
<b>Gravelly Silty Sand (TILL)</b> , trace clay; grey; wet	ER-1 to ER-3	0.2 – 1.4	464.5 – 462.7	N = 36 - 80 <sup>2</sup> <b>Dense to Very Dense</b>	w = 14 1 – MH (Fig. B3)

N = SPT 'N'-value; number of blows for 0.3 m of penetration

w = Natural Moisture Content (%)

M = Sieve analysis

MH = Combined Sieve and Hydrometer analysis





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### Notes:

<sup>1</sup> SPT 'N'-values of 1, 2 and 5 blows per 0.3 m of penetration were noted within the peat deposit; however, these values are indicative of the frozen nature of the material and may not be representative of the relative density of this deposit.

<sup>2</sup> An SPT 'N'-value of 100 blows for 0.1 m of penetration was measured in Borehole ER-1; however this is due to the proximity of the bedrock surface and not representative of the relative density of this deposit.

### Bedrock/Refusal

Bedrock was cored in Boreholes ER-1 and ER-4 and refusal to auger and split-spoon advancement was encountered in Boreholes ER-2 and ER-3. The depth to the confirmed/inferred bedrock surface and bedrock surface elevations are presented below.

Borehole No.	Depth to Bedrock (below ground surface) (m)	Bedrock Surface Elevation (m)	Core Length (m)
ER-1	3.9	464.3	3.1
ER-2	5.9	462.4	auger and split-spoon refusal
ER-3	6.8	461.5	auger and split-spoon refusal
ER-4	2.9	465.5	3.2

The retrieved bedrock core is described as a medium to coarse grained, weakly foliated, pinkish grey, very strong, granitic gneiss as presented in the Record of Drillhole sheets in Appendix B. Photographs of the retrieved bedrock core samples are shown on Figure B4. A more detailed description of the bedrock properties encountered in the boreholes is provided below.

Borehole No.	Total Core Recovery	Rock Quality Designation	Quality Classification Table 3.10 of CFEM 2006 <sup>3</sup>	Uniaxial Compressive Strength (MPa)	Strength Classification Table 3.5 of CFEM 2006 <sup>3</sup>
ER-1	100%	79% - 100%	Good to Excellent	139	(R5) Very Strong
ER-4	100%	88% - 100%	Good to Excellent	137	(R5) Very Strong

### Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The creek ice levels at the inlet (north end) and outlet (south end) of the culvert were surveyed by Golder

<sup>3</sup> Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4<sup>th</sup> Edition.





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at Elevations 467.9 m in January 2016. The water levels at the inlet and outlet ends of the culvert were surveyed by others at Elevation 468.1 m in October 2014. Groundwater and creek ice/water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole No.	Depth to Groundwater Level (m)	Groundwater Elevation (m)
ER-1	0.4	467.8
ER-2	0.4	467.9
ER-3	0.4	467.9
ER-4*	Ground Surface	468.4

Note: The groundwater elevation in Borehole ER-4 was obtained after completion of HQ coring any may not be representative of the in-situ groundwater conditions.

### 4.5 Baker Creek Culvert

A total of four boreholes (Boreholes BK-1 to BK-4) were advanced at the Baker Creek culvert site. The borehole locations, ground surface elevations and interpreted stratigraphic conditions are shown on Drawing C1.

In summary, the subsoil conditions encountered at the site consist of peat to sandy peat and organic sand underlain by a deposit of silt and sand to sand. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is presented below.

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows)	Laboratory Testing
				Relative Density or Consistency	
<b>Ice/Snow</b>	BK-1 & BK-2	0.5 & 0.2	468.3 & 467.8	n/a	n/a
<b>Peat to Sandy Peat (Amorphous)</b> , some silt; black to brown; frozen to wet	BK-3 & BK-4	1.4 & 0.7	468.2 & 468.3	N = 2 <b>Very Soft</b>	w = 222%
<b>Organic Sand</b> , trace to some silt, trace gravel, trace wood; dark brown to black; wet	BK-3	0.8	466.8	N = 2 <b>Very Loose</b>	w = 57% 1-M (Fig. C1)
<b>Silt and Sand to Sand<sup>1</sup></b> , trace clay, trace gravel; brown to grey; wet	BK-1 – BK-4	>7.6 – >9.6 (boreholes terminated in this deposit)	467.8 – 466.0	N = 1 – 20 <b>Very Loose to Compact</b>	w = 19% - 29% 10 – M/MH (Fig. C2)

N = SPT 'N'-value; number of blows for 0.3 m of penetration

w = Natural Moisture Content (%)

M = Sieve analysis

MH = Combined Sieve and Hydrometer analysis





### **Groundwater Conditions**

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The creek ice level at the outlet (south end) of the culvert was surveyed by Golder in January 2016 at Elevation 467.8 m. The water levels at the inlet and outlet ends of the culvert were surveyed by others at Elevation 468.0 m in October 2014. Groundwater and creek ice/water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

<b>Borehole No.</b>	<b>Depth to Groundwater Level (m)</b>	<b>Groundwater Elevation (m)</b>
BK-1	1.0	467.3
BK-2	0.2	467.6
BK-3	0.6	467.6
BK-4	0.8	467.5

## **4.6 Analytical Testing of Creek/Tributary Water Samples**

The results of an analytical test on a sample of creek/river water taken from the Sisson Creek, English River Tributary and Baker Creek culvert sites are presented in Table 2. The suite of parameters tested include pH, sulphate, chloride, resistivity and conductivity.

## **5.0 CLOSURE**

The drilling program was supervised by Mr. Mathew Riopelle and Mr. Shane Albert under the direction of Mr. Adam Core P.Eng. This report was prepared by Mr. Adam Core, P.Eng. The technical aspects were reviewed by Mr. David Muldowney, P.Eng., and Mr. Jorge M. A. Costa, P.Eng., a Senior Consultant with and Designated MTO Foundations Contact for Golder, carried out a quality control review of the report.





## Report Signature Page

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# PART B

DETAIL FOUNDATION DESIGN REPORT  
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G.W.P. 6336-14-00 W.P. 6338-14-01, W.P. 6337-14-01 & W.P. 6336-14-01





## **6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS**

This section of the report provides foundation engineering recommendations for the design of temporary excavations and cofferdams for the rehabilitation of the Sisson Creek Culvert (Site 48W-9/C), English River Tributary Culvert (Site 48W-188/C) and Baker Creek Culvert (Site 48W-12/C) crossing Highway 17 in the District of Thunder Bay, Ontario. These recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current investigation at this site. This foundation and investigation design report with the interpretation and recommendations are intended for use of the Ministry of Transportation, Ontario and shall not be used or relied upon for any other purpose or by any other parties including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data in Part A of the report. Where comments are made on construction, they are provided to highlight aspects of construction that could affect the design of the project. Contractors must make their own interpretation of the subsurface information provided as it affects their proposed construction methods, costs, equipment selection, scheduling and the like.

### **6.1 General**

The details of the three existing culverts addressed in this report are summarized in Table 1. Based on the information provided in the Request for Proposal (RFP), we understand that the proposed rehabilitation consists of localized concrete patching inside the culvert and at the exposed ends with possible total reconstruction of the culvert ends at Sisson Creek. We further understand that the culverts will be rehabilitated with both lanes maintained open to traffic during the rehabilitation works.

### **6.2 Excavations and Temporary Embankment Cut Slopes**

At this time, a final design has not been established for the three culverts, however, based on the anticipated required rehabilitation works, excavations into the embankment side slopes will likely be required to expose the top and sidewalls of the culvert potentially exposing the entire culvert ends. Based on the groundwater conditions observed during the subsurface investigation, the measured creek/tributary water levels and considering the proposed rehabilitation works, groundwater should be expected to be encountered during excavation of all three sites.

As no boreholes were drilled on the roadway platform at any of the culvert sites, the depth and type of embankment fill is not known, although a layer of granular fill was encountered at the toe of slope at the Sisson Creek and English River Tributary culvert sites. Based on our site reconnaissance and given the relatively limited embankment heights, as well as our experience at other MTO culvert sites associated with this project, it is anticipated that the embankment fill at these sites consists of granular fill material(s).

All excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects (as amended). Above the groundwater level, the fill materials and native soils at these sites can be considered Type 3 soils. The amorphous peat deposit encountered at each of the three sites should be considered Type 4 soil. All soils below the groundwater level should be considered Type 4 soils. Temporary open-cut excavations in Type 3 soils should remain stable if side





slopes are formed no steeper than 1 Horizontal to 1 Vertical (1H:1V). In Type 4 soils, the side slopes should be formed no steeper than 3H:1V.

### 6.3 Temporary Protection Systems

A temporary protection system is likely required to support excavations into the side slopes of the existing embankment and into the original ground adjacent to the culvert. The excavations could potentially extend to the culvert inverts as outlined below.

- **Sisson Creek Culvert:** Excavations will likely be required to extend to the existing culvert invert at approximately Elevation 462 m, if end reconstruction is required, that is, to approximately 1.6 m to 1.9 m below the adjacent ground surface (based on Borehole SI-1 to SI-4).
- **English River Tributary Culvert:** Excavations will likely be required to extend to the existing culvert invert at approximately Elevation 467 m, if end reconstruction is required, that is, to approximately 1.2 m to 1.4 m below the adjacent ground surface (based on Borehole ER-1 to ER-4).
- **Baker Creek Culvert:** Excavations will likely be required to extend to the existing culvert invert at approximately Elevation 466.2 m, if end reconstruction is required, that is, to approximately 1.6 m to 2.2 m below the adjacent ground surface (based on Borehole BK-1 to BK-4).

The temporary support systems for these site could consist of steel sheet piles driven to a suitable depth with horizontal lagging in the form of struts and wales installed as the excavation proceeds. The temporary excavation support system and the cofferdams at all three culvert sites should be designed and constructed in accordance with Ontario Provincial Standard Specification (OPSS). PROV 539 (Temporary Protection Systems). The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS. PROV 539. Design of the temporary excavation support system and cofferdam system should include an evaluation of base stability and hydraulic uplift stability as defined in the Canadian Foundation Engineering Manual (CFEM 2006). The contractor is responsible for the complete detailed design of the temporary protection systems.

The temporary protection systems (or cofferdams) may be designed using the flowing parameters:

Culvert	Soil Type	Unit Weight ( $\gamma$ , kN/m <sup>3</sup> )	Internal Angle of Friction ( $\phi$ , degrees)	Undrained Shear Strength ( $S_u$ , kPa)	Coefficients of Earth Pressure		
					Active, $K_a$	At-Rest, $K_o$	Passive, $K_p$
Sisson Creek Culvert (Site 48W-9/C)	Granular Fill	20	30	-	0.33	0.50	3.00
	Amorphous Peat (Firm to Stiff)	12	27	1	0.38	0.55	2.66
	Silty Sand to Sand (Very Loose to Compact)	19	29	-	0.35	0.52	2.88
	Silt to Silt and Sand (Loose to Compact)	19	28	-	0.36	0.53	2.77
	Silty Clay (Soft)	17	25	25	0.41	0.58	2.46





## FOUNDATION REPORT - SISSON CREEK, ENGLISH RIVER TRIBUTARY AND BAKER CREEK CULVERTS

Culvert	Soil Type	Unit Weight ( $\gamma$ , kN/m <sup>3</sup> )	Internal Angle of Friction ( $\phi$ , degrees)	Undrained Shear Strength ( $S_u$ , kPa)	Coefficients of Earth Pressure		
					Active, $K_a$	At-Rest, $K_o$	Passive, $K_p$
	Sand to Gravelly Sand (Loose to Very Dense)	20	30	-	0.33	0.50	3.00
English River Tributary Culvert (Site 48W-188/C)	Granular Fill (Very Loose)	20	30	-	0.33	0.50	3.00
	Fibrous Peat (Very Loose)	12	27	1	0.38	0.55	2.66
	Silty Sand to Sand (Very Loose to Compact)	19	29	-	0.35	0.52	2.88
	Gravelly Silty Sand Till (Dense to Very Dense)	19	35	-	0.27	0.43	3.69
Baker Creek Culvert (Site 48W-12/C)	Amorphous Peat to Sandy Peat (Very Loose)	12	27	1	0.38	0.55	2.66
	Organic Sand (Very Loose)	18	28	-	0.36	0.53	2.77
	Sand to Silt and Sand (Very Loose to Compact)	19	28	-	0.36	0.53	2.77

The temporary protection system design for the Sisson Creek culvert site should be assessed for both the drained ( $\phi$ ) and undrained cases ( $S_u$ ), based on the more conservative earth pressure conditions. The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficient of earth pressure should be adjusted accordingly.

At the Sisson Creek culvert, the installation of sheet-piles for temporary shoring may be impeded by the presence of inferred cobbles within the granular fill as encountered in Borehole SI-4 and/or wood encountered within the peat deposit as encountered in Borehole SI-2. Further, the native soils (i.e., silty sand, silt to silt and sand) at this site are sensitive to disturbance from vibration and/or driving operations for pile installation, which should be considered in the design and installation of the temporary protection system. It is recommended that an NSSP be included in the contract documents to address obstructions; a sample NSSP is included in Appendix D.

At the English River Tributary culvert, due to the relatively shallow and variable depth to bedrock and the presence of a dense to very dense gravelly silty sand till deposit, a temporary support system comprised of sheet piling may not be feasible depending on the required depth of excavation and required depth of sheet piling installation at this site. Soldier piles and lagging (with the piles socketted into bedrock and supported by tiebacks or rakers) may need to be considered at this site. Further, the native soil (i.e., silty sand) at this site is





sensitive to disturbance from vibration and/or driving operations for pile installation, which should be considered in the design and installation of the temporary protection system.

At the Baker Creek culvert, the installation of sheet-piles for temporary shoring may be impeded by the presence of wood within the organics sand deposit as encountered in Borehole BK-3. Further, the native soils (i.e., silty sand, sand and silt) at this site are sensitive to disturbance from vibration and/or driving operations for pile installation, which should be considered in the design and installation of the temporary protection system. It is recommended that an NSSP be included in the contract documents to address obstructions; a sample NSSP is included in Appendix D.

## **6.4 Control of Groundwater and Surface Water**

Groundwater flow into the excavations can be expected due to the depth of the excavations and the presence of the relatively permeable native soils (i.e., peat, sand, silty sand, etc.) and adjacent inferred granular embankment fill at the three sites. Therefore, control of groundwater will be necessary to allow for construction to be carried out in dry conditions, if required. Surface water should be directed away from the excavation areas to prevent ponding of water that could result in disturbance and weakening of the foundation subgrade.

Temporary shoring and groundwater control could be in the form of a sheet-pile cut off wall or cofferdam advanced to an appropriate depth to control groundwater inflow from the creek and to prevent base heaving of the foundation subgrade. As noted in Section 6.3, obstructions to sheet pile installation may be encountered at the Sisson Creek and Baker Creek Culvert sites.

Depending on the creek flow, surface water flow conditions and groundwater levels at the time of construction, water flow could be diverted and/or pumped from behind a temporary cofferdam; however, if pumping volumes are anticipated to exceed 50 m<sup>3</sup>/day, an Environmental Activity Section Registry (EASR) will be required as per the recently introduced changes to the Environmental Protection Act by the Ontario Ministry of the Environment and Climate Change (MOECC).

## **6.5 Backfill Materials**

It is expected that excavated material will be re-used to backfill the excavations within the cofferdam areas. Backfill behind the culvert walls and on top of the culvert for reconstruction of the embankment side slopes should consist of free draining granular fill meeting the specifications for OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I, II or III. For backfilling below the water level, if required, we recommend that only Granular B Type II be utilized.

The granular backfill should be placed in maximum 200 mm thick loose lifts and compacted to a minimum 95 per cent of the material's standard Proctor maximum dry density (SPMDD) in accordance with OPSS.PROV 501 (Compacting). The fill should also be placed concurrently on both sides of the culvert, ensuring that the backfill depth on one side does not exceed the other side by more than 400 mm similar to OPSS 422 (Precast Reinforced Concrete Box Culverts). Backfill placement for reconstruction of the roadway embankments along and over the culvert should be carried out as per OPSD 208.010 (Benching of Earth Slopes) to integrate the existing embankment fill and new fill along the cut faces.





Inspection and field density testing should be carried out by qualified geotechnical personnel during all engineered fill placement operations to ensure that appropriate materials are used, and that adequate levels of compaction have been achieved.

## **6.6 Analytical Testing for Construction Materials**

The results of analytical tests on samples of the creek/tributary water taken at all three culvert sites are presented in Table 2 following the text of this report. The suite of parameters tested is intended to allow the design engineer to assess the requirements for the appropriate type of cement to be used in construction and the need for corrosion protection of steel reinforcing elements.

For potential sulphate attack on concrete, the results of the creek/tributary water analyses were compared to Table 3 in CSA A23-1-09, and indicate that the relative degree of sulphate attack is low (less than the moderate range) at the three sites. However, given that the culverts are located on Highway 17 and will be exposed to de-icing salts it is recommended that C-1 class exposure concrete be considered for the repairs. Further, the resistivity results indicate that the creek/tributary water at the three sites has a very low degree of corrosiveness based on the "Service Life of Drainage Pipe" (Transportation Research Board, National Research Council, 1998 as referenced in the MTO Gravity Pipe Guidelines, 2014).

It should be noted that the creek/tributary water levels in the area are subject to seasonal fluctuations and variations due to precipitation events and the water chemistry could also be variable. These recommendations are provided as guidance only; the structural designer should take the results of the laboratory testing, the potential for corrosion and the ultimate selection of materials into consideration.

## **7.0 CLOSURE**

This Detail Foundation Design Report was prepared by Mr. Adam Core, P.Eng. and the technical aspects were reviewed by Mr. David Muldowney, P.Eng. Mr. Jorge M. A. Costa, P.Eng., Designated MTO Foundations Contact and Principal of Golder, conducted an independent quality control review of this report.





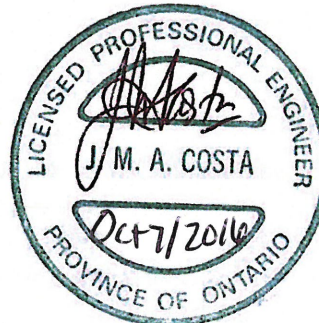
## Report Signature Page

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Transportation Research Board, National Research Council, 1998. Service Life of Drainage Pipe, National Cooperative Highway Research Program (NCHRP) Synthesis 254.

ASTM International:

ASTM D1586 Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

Ontario Provincial Standard Drawings (OPSD)

OPSD 208.010 Benching of Earth Slopes

Ontario Provincial Standard Specifications (OPSS)

OPSS 422 Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut

Ontario Provincial Standard Specifications (OPSS) – Provincial Oriented

OPSS.PROV 501 Construction Specification for Compacting

OPSS.PROV 539 Construction Specification for Temporary Protection Systems

OPSS.PROV 1010 Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario Water Resource Act:

Regulation 903 Wells (as amended)





## FOUNDATION REPORT - SISSON CREEK, ENGLISH RIVER TRIBUTARY AND BAKER CREEK CULVERTS

**Table 1: Summary Details of Existing Culverts**

Culvert	Approximate Existing Embankment Height <sup>1</sup> (m)	Existing Culvert			Approximate Inlet/Outlet Invert Elevation (m)	Boreholes	Reference Appendix
		Type	Height x Span (m)	Length (m)			
Sisson Creek Culvert (Site 48W-9/C)	3.1 (~1 m soil cover)	Cast-in-place Reinforced Concrete Box	3.7 x 1.7	24	462.1 / 462.0	4 Boreholes SI-1 to SI-4	A
English River Tributary Culvert (Site 48W-188/C)	2.9 (~ 0.5 m soil cover)	Cast-in-place Reinforced Concrete Box	3.7 x 1.9	22	467.0 / 467.1	4 Boreholes ER-1 to ER-4	B
Baker Creek Culvert (Site 48W-12/C)	3.5 (~0.6 m soil cover)	Cast-in-place Reinforced Concrete Box	6.1 x 2.5	25	466.2 / 466.2	4 Boreholes BK-1 to BK-4	C

Note: 1. Embankment height is relative to the existing ground surface at the centerline of the roadway and the existing culvert invert.  
2. Culvert dimensions and invert elevations are based on the plan and profile drawings provide by MTO (bc322172, e745172 and e755171, respectively).

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





## FOUNDATION REPORT - SISSON CREEK, ENGLISH RIVER TRIBUTARY AND BAKER CREEK CULVERTS

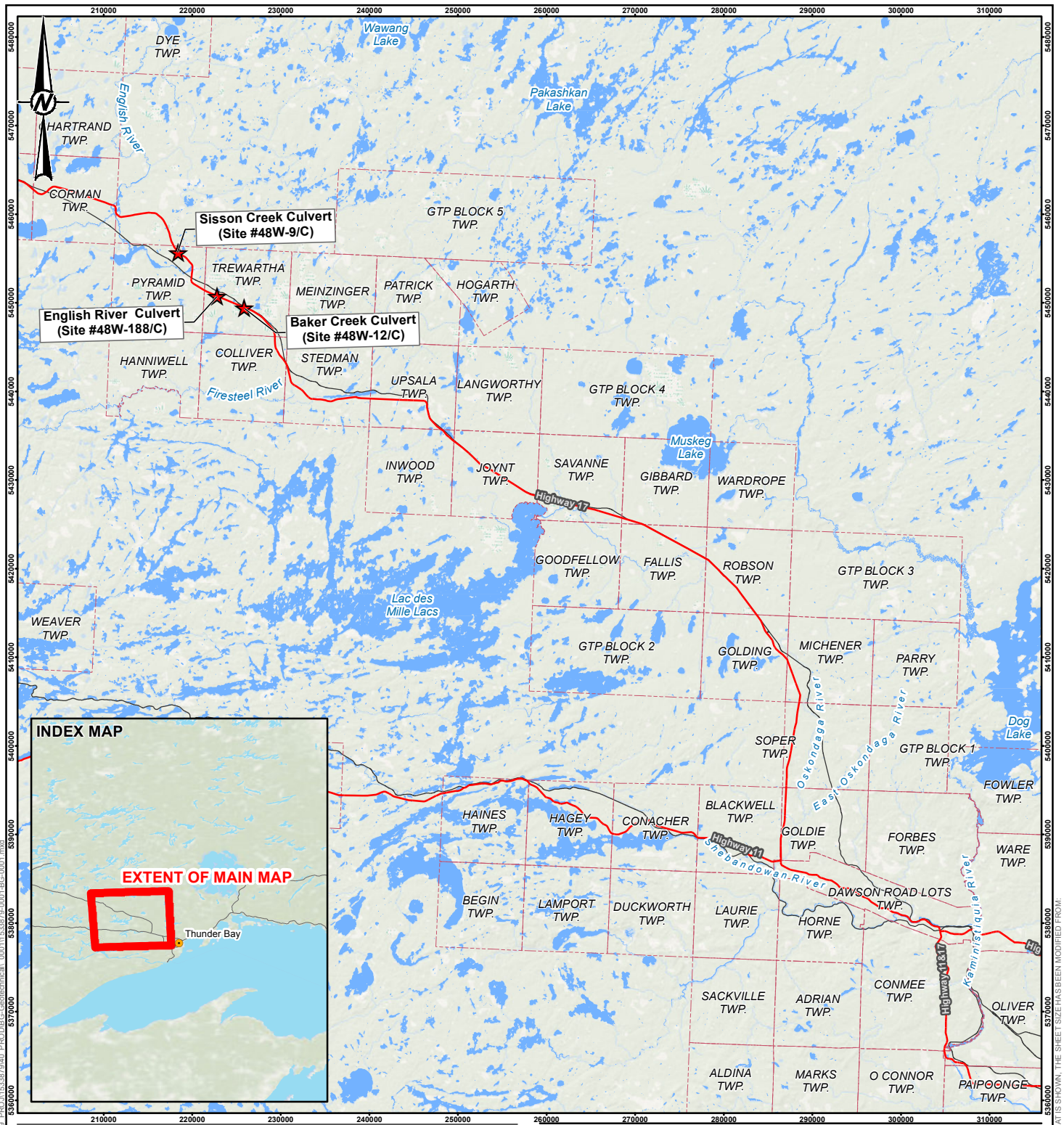
**Table 2: Summary of Analytical Testing of Sisson Creek, English River Tributary and Baker Creek Water Samples**

Culvert	Parameter (Units)				
	Chloride (mg/L)	Sulphate (mg/L)	Conductivity (µS/cm)	Resistivity (ohm-cm)	pH
Sisson Creek Culvert (Site 48W-9/C)	8.43	1.63	68.7	14600	6.51
English River Tributary Culvert (Site 48W-188/C)	3.20	<0.3	63.8	15700	6.04
Baker Creek Culvert (Site 48W-12/C)	3.45	0.86	68.1	14700	6.54

Note: 1. Samples obtained January 25, 2016.  
2. Analytical testing carried out by ALS Environmental

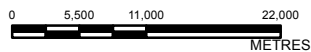
Prepared by: AC  
Checked by: DAM  
Reviewed by: JMAC





#### Legend

- ★ Site Location
- Highway
- Townships
- Railways
- Waterbodies



#### NOTE(S)

THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1533879-R01

#### REFERENCE(S)

SERVICE LAYER CREDITS: ESRI, DELORME, GEBCO, NOAA NGDC, AND OTHER CONTRIBUTORS CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO.  
[HTTPS://WWW.ONTARIO.CA/GOVERNMENT/OPEN-GOVERNMENT-LICENCE-ONTARIO](https://www.ontario.ca/government/open-government-licence-ontario)  
 PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83  
 COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

CLIENT

ONTARIO MINISTRY OF TRANSPORTATION

PROJECT

SISSON CREEK, ENGLISH RIVER TRIBUTARY AND BAKER CREEK CULVERT, REHABILITATIONS

TITLE

LOCATION PLAN

CONSULTANT



YYYY-MM-DD 2016-08-09

DESIGNED ---

PREPARED RRD

REVIEWED AC

APPROVED JMAC

PROJECT NO.  
1533879

CONTROL  
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1





## LIST OF SYMBOLS

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

### I. GENERAL

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

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

### III. SOIL PROPERTIES

#### (a) Index Properties

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

#### (a) Index Properties (continued)

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

#### (b) Hydraulic Properties

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

#### (c) Consolidation (one-dimensional)

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

#### (d) Shear Strength

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

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

Notes: 1  
2

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

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





## LIST OF ABBREVIATIONS

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

### I. SAMPLE TYPE

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

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

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

#### Dynamic Cone Penetration Resistance; $N_d$ :

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

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

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

### III. SOIL DESCRIPTION

#### (a) Non-Cohesive (Cohesionless) Soils

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

#### (b) Cohesive Soils Consistency

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

### IV. SOIL TESTS

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

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

### V. MINOR SOIL CONSTITUENTS

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





## LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

### WEATHERINGS STATE

**Fresh:** no visible sign of weathering

**Faintly weathered:** weathering limited to the surface of major discontinuities.

**Slightly weathered:** penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

**Moderately weathered:** weathering extends throughout the rock mass but the rock material is not friable.

**Highly weathered:** weathering extends throughout rock mass and the rock material is partly friable.

**Completely weathered:** rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

### BEDDING THICKNESS

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

### JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

### GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: \* Grains greater than 60 microns diameter are visible to the naked eye.

### CORE CONDITION

#### Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

#### Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

#### Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

### DISCONTINUITY DATA

#### Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

#### Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

#### Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

#### Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

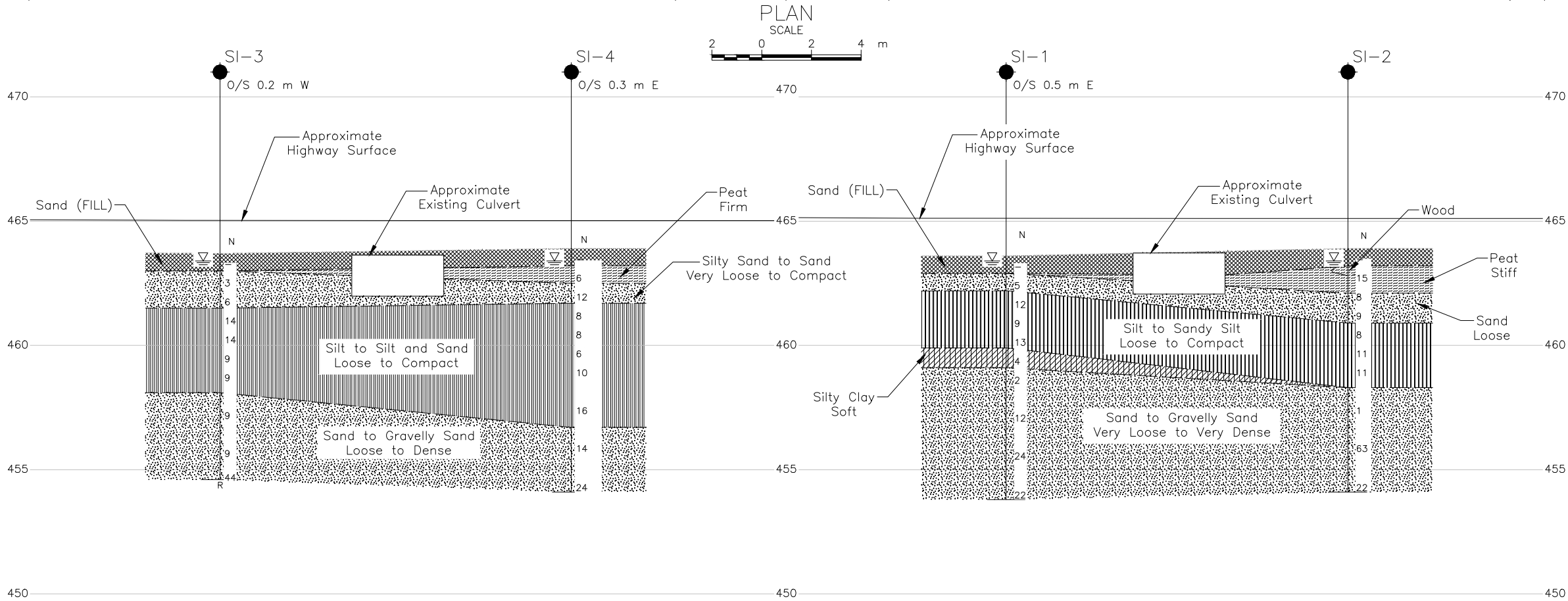
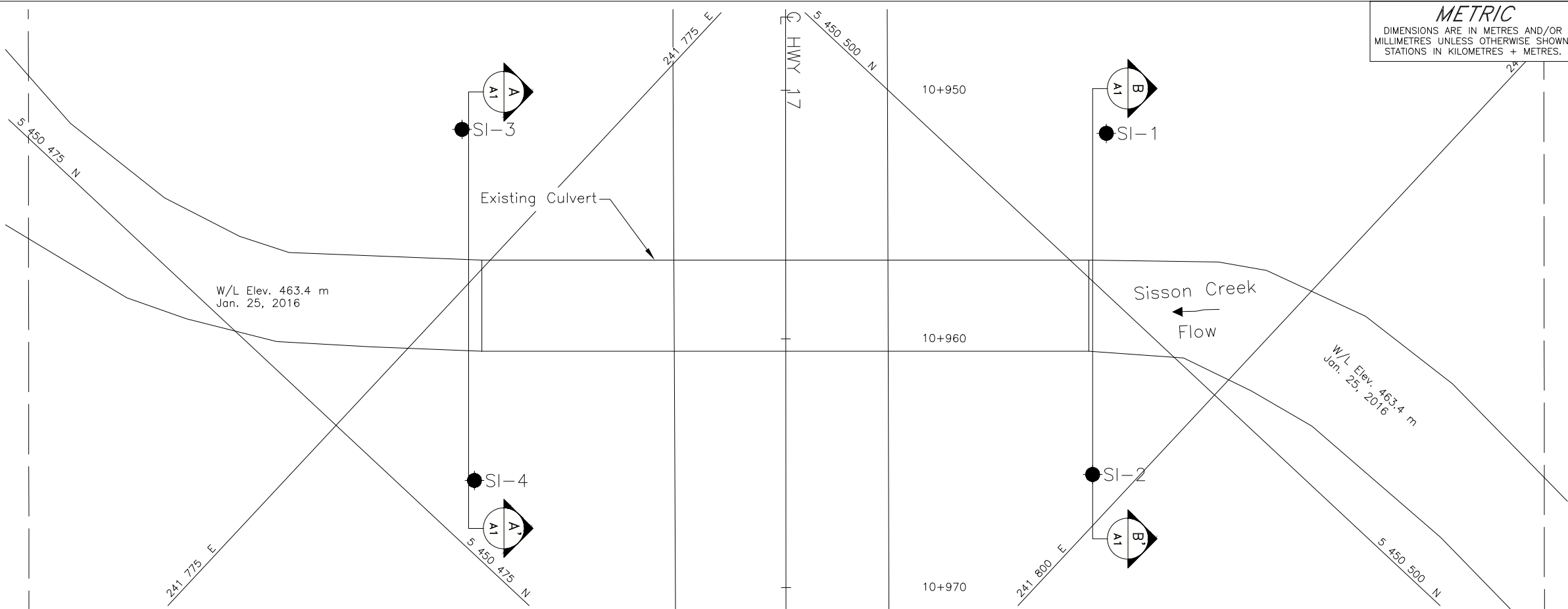




# **APPENDIX A**

## **Sisson Creek Culvert (Site 48W-9/C)**





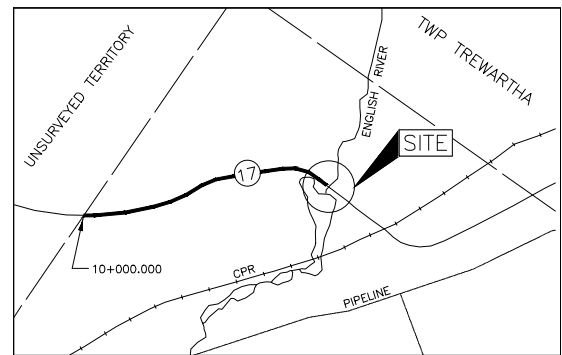
SCALE 1:200  
VERT. SCALE 1:200  
CROSS-SECTION AT OUTLET  
SCALE 2 0 2 4 m

SCALE 1:200  
VERT. SCALE 1:200  
CROSS-SECTION AT INLET  
SCALE 2 0 2 4 m

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

CONT No. .  
GWP No. 6336-14-00

HIGHWAY 17  
SISSON CREEK CULVERT STA 10+959  
BOREHOLE LOCATIONS AND  
SOIL STRATA



KEY PLAN  
SCALE 1 0 1 2 km

LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- R Refusal
- ▽ WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
SI-1	463.6	5450504.7	241789.6
SI-2	463.9	5450494.3	241798.6
SI-3	463.7	5450487.2	241770.6
SI-4	463.9	5450477.2	241780.6

NOTES

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

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by MTO, drawing file nos. BC322172 received Dec. 11, 2015.



NO.	DATE	BY	REVISION
Geocres No. 52G-15			
HWY. 17		PROJECT NO. 1533879	
SUBM'D. AC	CHKD.	DATE: 10/7/2016	SITE: 48W-9/C
DRAWN: JJL	CHKD. DAM	APPD. JMAC	DWG. A1





## PHOTOGRAPHS

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**Photograph A1: Sisson Creek Culvert  
Looking West at the Culvert Inlet (North End) (December 2015)**



**Photograph A2: Sisson Creek Culvert  
Looking West at the Culvert Outlet (South End) (December 2015)**







## PHOTOGRAPHS

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



**Photograph A3: Sisson Creek Culvert  
Looking North at the Culvert Inlet (North End) (December 2015)**



**Photograph A4: Sisson Creek Culvert  
Looking South at the Culvert Outlet (South End) (December 2015)**










PROJECT 1533879		RECORD OF BOREHOLE No SI-1				1 OF 1 METRIC												
G.W.P. 6336-14-00		LOCATION N 5450504.7; E 241789.6				ORIGINATED BY MR												
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY AC												
DATUM GEODETIC		DATE January 24, 2016				CHECKED BY DAM												
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
463.6	GROUND SURFACE							20	40	60	80	100						
0.0	Sand, trace to some gravel, trace organics (FILL) Brown Wet		1	AS	-		463											
462.9																		
0.7	SAND, trace to some organics Loose Brown to grey Wet		2	SS	5		462											
462.1																		
1.5	Sandy SILT Loose to compact Grey Wet		3	SS	12		461											0 29 69 2
			4	SS	9													
			5	SS	13		460											
459.9																		
3.7	SILTY CLAY, trace to some sand Soft Reddish brown Wet		6	SS	4		459											
459.1																		
4.5	SAND to Gravelly SAND, trace silt Very loose to compact Grey Wet Approximately 0.8 to 0.9 m of heave encountered in augers below 4.6 m depth.		7	SS	2	458												
			8	SS	12	457												
			9	SS	24	456											22 77 (1)	
			10	SS	22	455												
453.8	END OF BOREHOLE						454											
9.8	Note:  1. Water level at a depth of 0.2 m below ground surface (Elev. 463.4 m) upon completion of drilling.																	

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











PROJECT 1533879		RECORD OF BOREHOLE No SI-2				1 OF 1 METRIC											
G.W.P. 6336-14-00		LOCATION N 5450494.3; E 241798.6				ORIGINATED BY MR											
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY AC											
DATUM GEODETIC		DATE January 23 and 24, 2016				CHECKED BY DAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
463.9	GROUND SURFACE							20	40	60	80	100					
0.0	Sand, some gravel, trace organics (FILL) Brown Frozen*		1	AS	-												
463.2																	
0.7	PEAT (Amorphous) Stiff Black Wet		2	SS	15												
	Wood encountered in upper 0.3 m of Sample 2.																
462.1			3A	SS	8												
1.8	SAND, some silt, trace organics Loose Grey Wet		3B														
			4	SS	9												
460.9																	
3.0	SILT, trace clay Loose to compact Grey Wet		5	SS	8												
			6	SS	11												
	Reddish brown silty clay seams below 4.6 m depth.		7	SS	11												
458.3																	
5.6	SAND to Gravelly SAND, trace silt Very loose to very dense Brown to grey Wet		8	SS	1												
	Approximately 0.1 to 0.6 m of heave encountered in augers below 7.6 m depth.		9	SS	63												
454.1																	
9.8	END OF BOREHOLE		10	SS	22												
	Note: 1. Water level at a depth of 0.5 m below ground surface (Elev. 463.4 m) upon completion of drilling.																



PROJECT 1533879		RECORD OF BOREHOLE No SI-3				1 OF 1 METRIC											
G.W.P. 6336-14-00		LOCATION N 5450487.2; E 241770.6				ORIGINATED BY MR											
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY AC											
DATUM GEODETIC		DATE January 24 and 25, 2016				CHECKED BY DAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
463.7	GROUND SURFACE							20	40	60	80	100					
0.0	Sand, trace gravel, trace organics (FILL) Brown Wet		1	AS	-	▽											
463.0							463										
0.7	SILTY SAND to SAND, trace organics Very loose to loose Grey Wet		2	SS	3												
			3	SS	6		462										
461.5																	
2.2	SILT to SILT and SAND, trace clay Loose to compact Grey Wet		4	SS	14		461										0 42 55 3
			5	SS	14		460										
			6	SS	9		459										0 1 95 4
			7	SS	9		458										
458.1																	
5.6	SAND, trace to some gravel Loose to dense Brown to grey Wet						458										
	Approximately 0.8 m to 0.9 m of heave encountered in augers between 6.1 m and 7.6 m depth.		8	SS	9		457										0 98 (2)
	Augers grinding below 7.6 m depth.																
			9	SS	9		456										
							455										
454.6	Spoon bouncing at 9.1 m depth.		10	SS	44												
9.1	END OF BOREHOLE SPLIT-SPOON AND AUGER REFUSAL																
	Note:  1. Water level at a depth of 0.3 m below ground surface (Elev. 463.4 m) upon completion of drilling.																

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

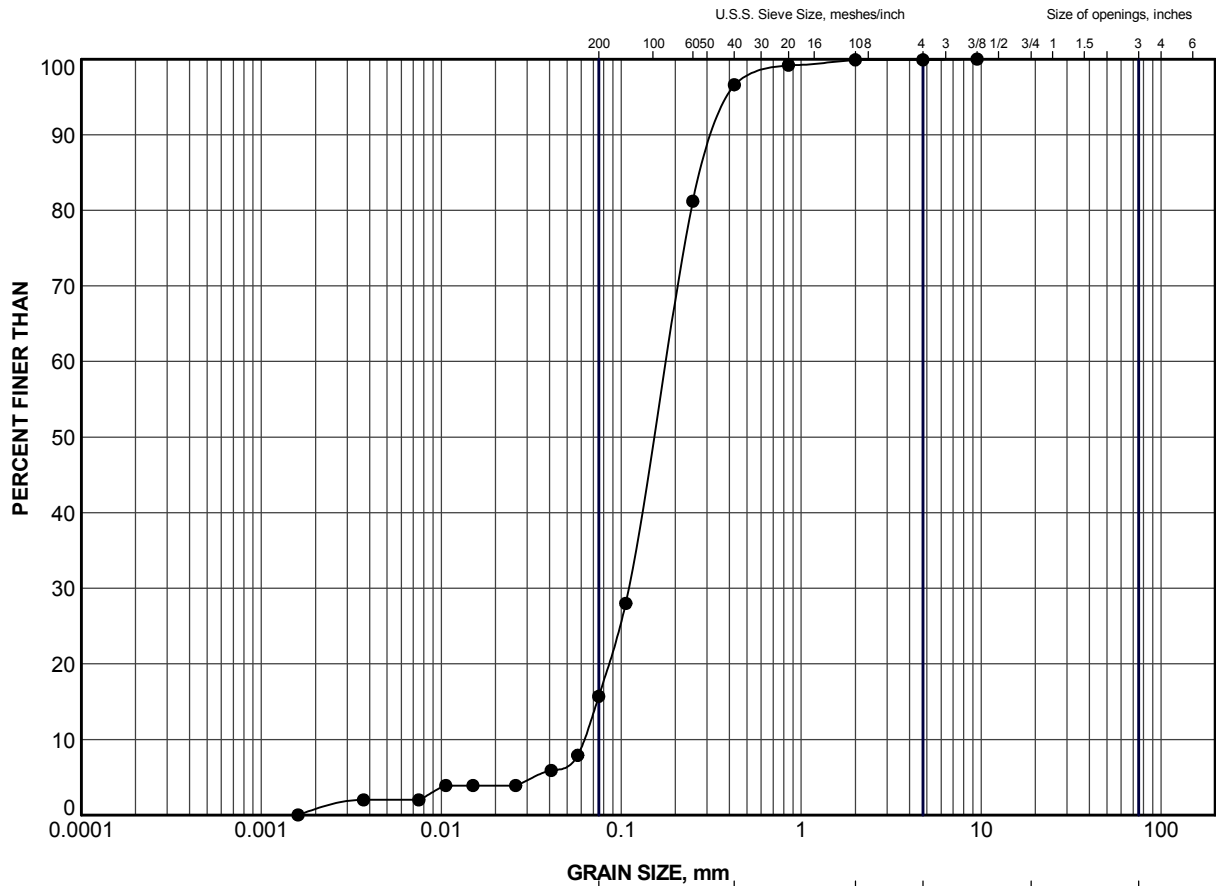


PROJECT 1533879			RECORD OF BOREHOLE No SI-4				1 OF 1 METRIC									
G.W.P. 6336-14-00			LOCATION N 5450477.2; E 241780.6				ORIGINATED BY MR									
DIST _____ HWY 17			BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY AC									
DATUM GEODETIC			DATE January 25, 2016				CHECKED BY DAM									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
463.9	GROUND SURFACE						20	40	60	80	100	20	40	60		
0.0	Sand, trace to some gravel, trace organics (FILL) Brown Frozen		1	AS	-											
463.2	Augers grinding throughout on inferred cobbles.		2	SS	6											
462.5	PEAT (Amorphous), trace to some silt, trace to some sand Firm Black Wet		3	SS	12											
461.7	SILTY SAND Compact Grey Wet		4	SS	8											
2.2	SILT, trace to some sand Loose to compact Grey Wet		5	SS	8											
			6	SS	6											
			7	SS	10											
			8	SS	16											
	Reddish brown silty clay seams below 6.1 m depth.															
456.7	SAND to Gravelly SAND Compact Grey Wet		9	SS	14											
7.2			10	SS	24											
454.1	END OF BOREHOLE															
9.8	Note:  1. Water level at a depth of 0.5 m below ground surface (Elev. 463.4 m) upon completion of drilling.															

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

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE





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

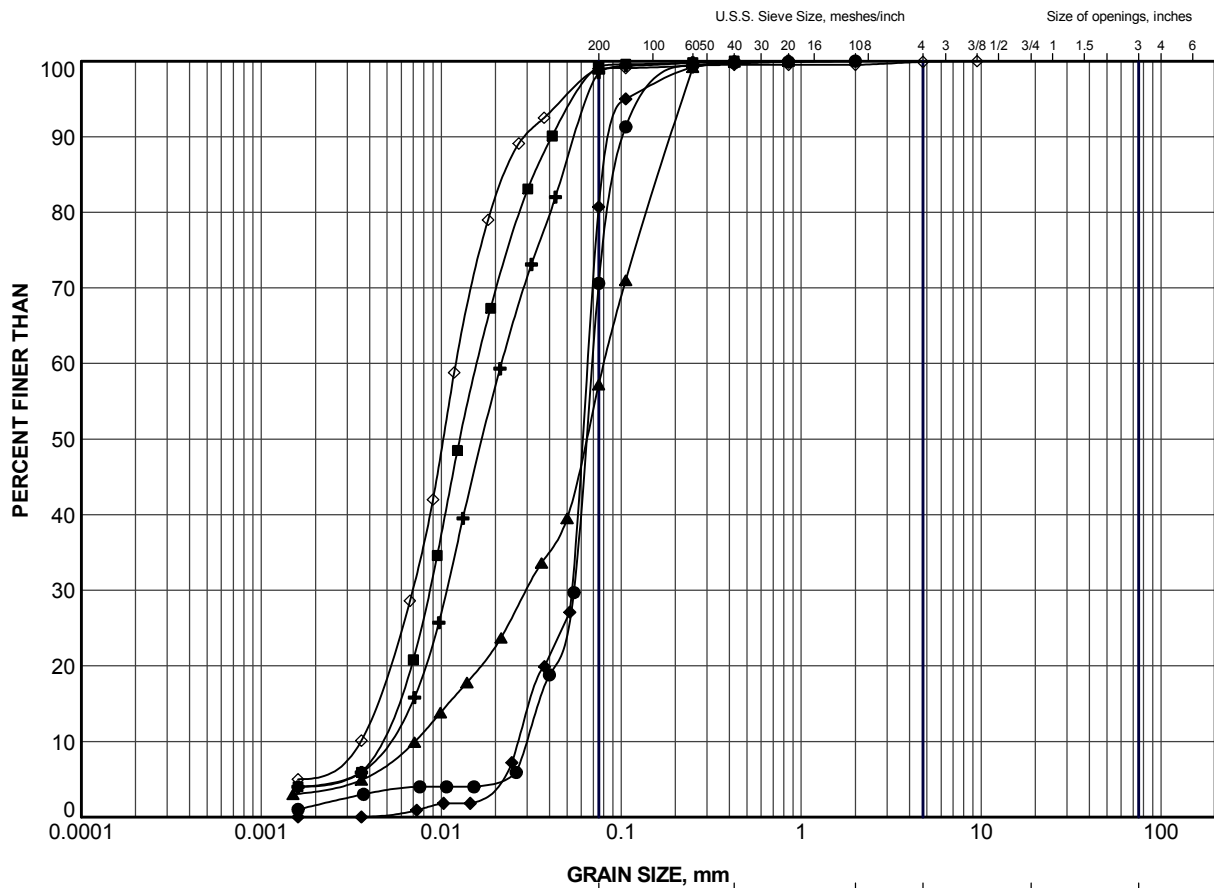
### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	SI-2	4	461.3

PROJECT						HIGHWAY 17 SISSON CREEK CULVERT STA 10+959					
TITLE						GRAIN SIZE DISTRIBUTION SAND					
PROJECT No.			1533879			FILE No.			1533879.GPJ		
DRAWN	JJL	Jul 2016	SCALE	N/A	REV.						
CHECK	DAM	Jul 2016									
APPR	JMAC	Jul 2016									
						FIGURE A1					








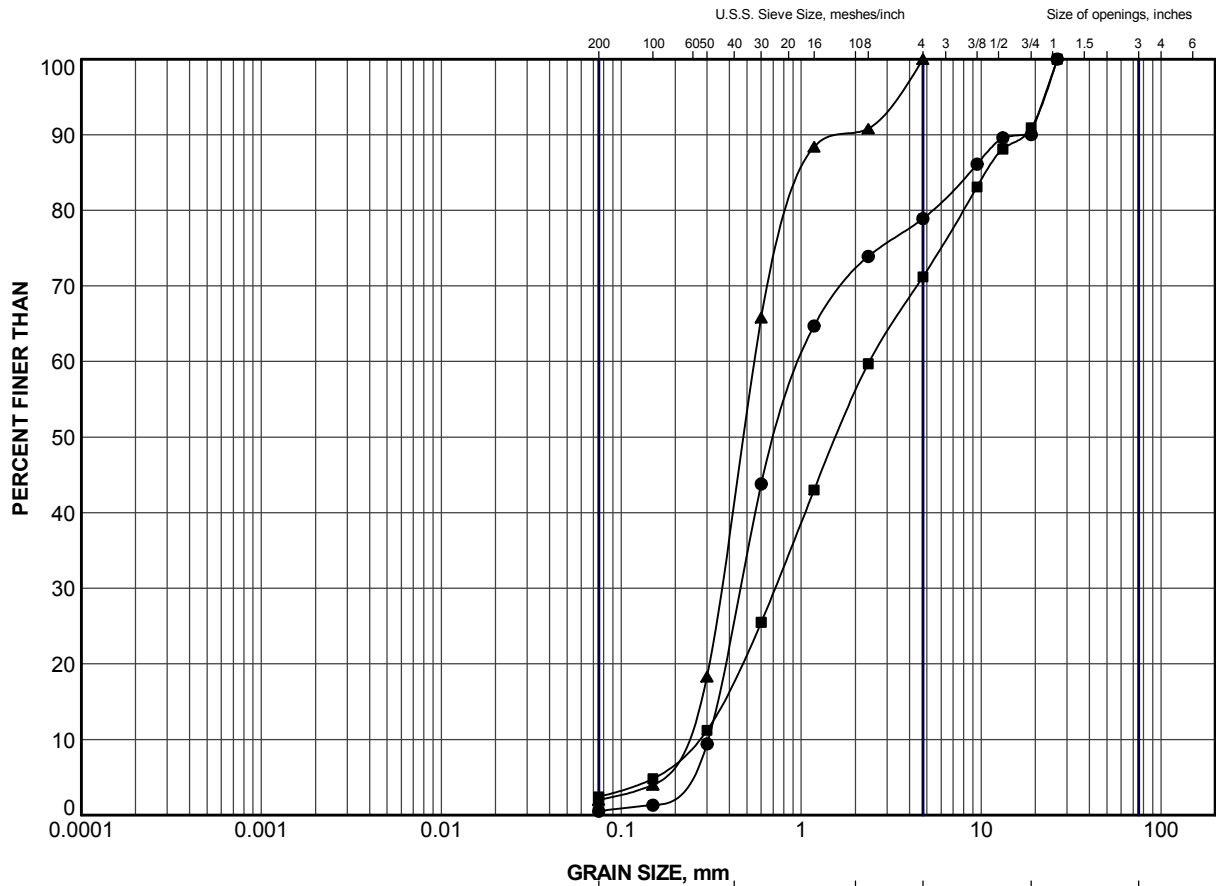
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	SI-1	4	461.0
■	SI-2	6	459.8
▲	SI-3	4	461.1
+	SI-3	6	459.6
◆	SI-4	4	461.3
◇	SI-4	8	457.5

PROJECT						HIGHWAY 17 SISSON CREEK CULVERT STA 10+959					
TITLE						GRAIN SIZE DISTRIBUTION SILT to SILT and SAND					
PROJECT No.			1533879			FILE No.			1533879.GPJ		
DRAWN	JJL	Jul 2016	SCALE	N/A	REV.						
CHECK	DAM	Jul 2016									
APPR	JMAC	Jul 2016									
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE A2</b>								





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

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	SI-1	9	455.7
■	SI-2	10	454.4
▲	SI-3	8	457.3

PROJECT					
HIGHWAY 17 SISSON CREEK CULVERT STA 10+959					
TITLE					
GRAIN SIZE DISTRIBUTION SAND to GRAVELLY SAND					
PROJECT No.		1533879		FILE No. 1533879.GPJ	
DRAWN	JJL	Jul 2016	SCALE	N/A	REV.
CHECK	DAM	Jul 2016	FIGURE A3		
APPR	JMAC	Jul 2016			



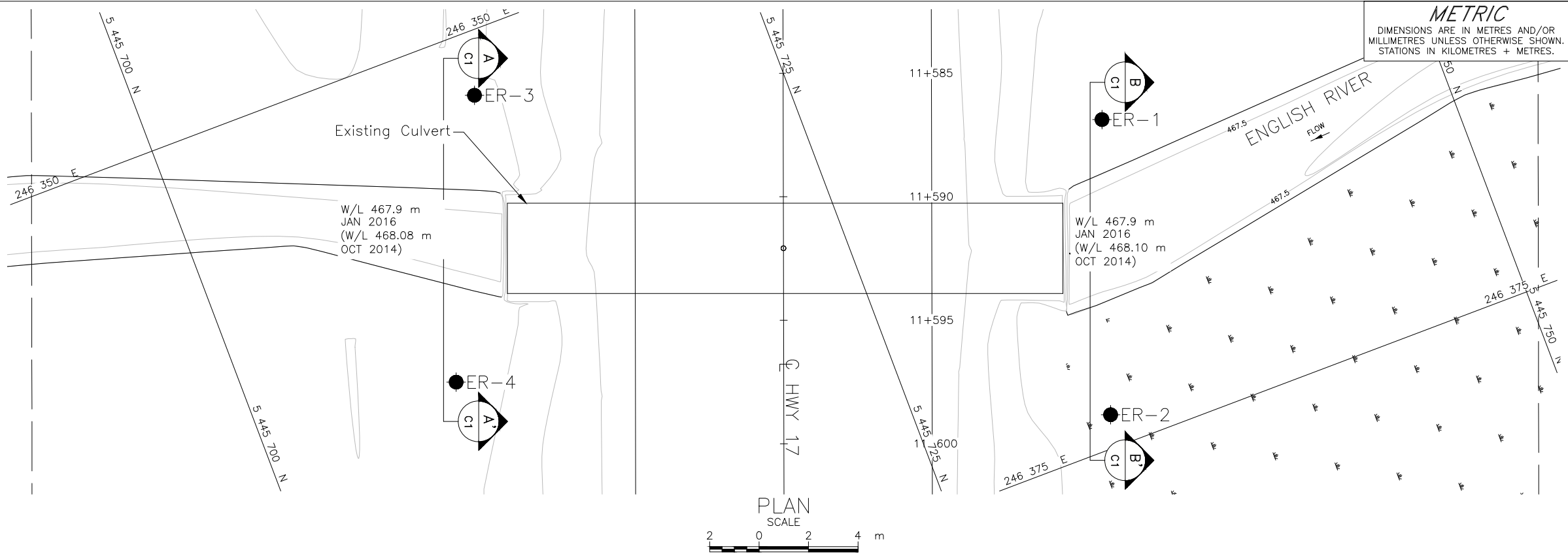




# APPENDIX B

## English River Tributary Culvert (Site 48W-188/C)

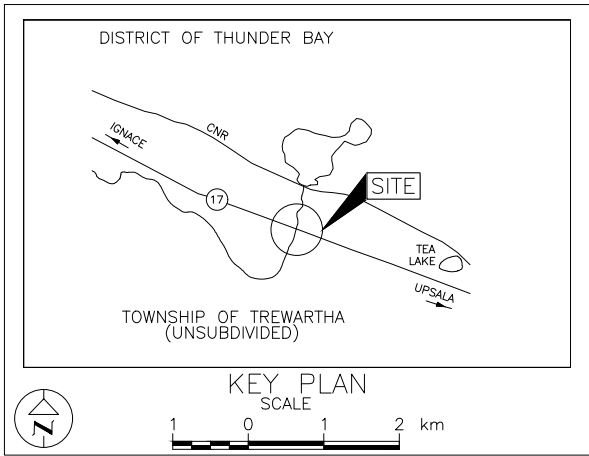




**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 6336-14-00

HIGHWAY 17  
ENGLISH RIVER TRIBUTARY CULVERT STA 11+592  
BOREHOLE LOCATIONS AND  
SOIL STRATA



LEGEND

●

Borehole - Current Investigation

N

Standard Penetration Test Value

16

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

100%

Rock Quality Designation (RQD)

R

Refusal

▽

WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
ER-1	468.2	5445736.4	246362.4
ER-2	468.3	5445732.5	246373.7
ER-3	468.3	5445713.0	246352.5
ER-4	468.4	5445708.2	246363.1

**NOTES**

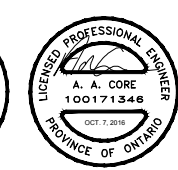
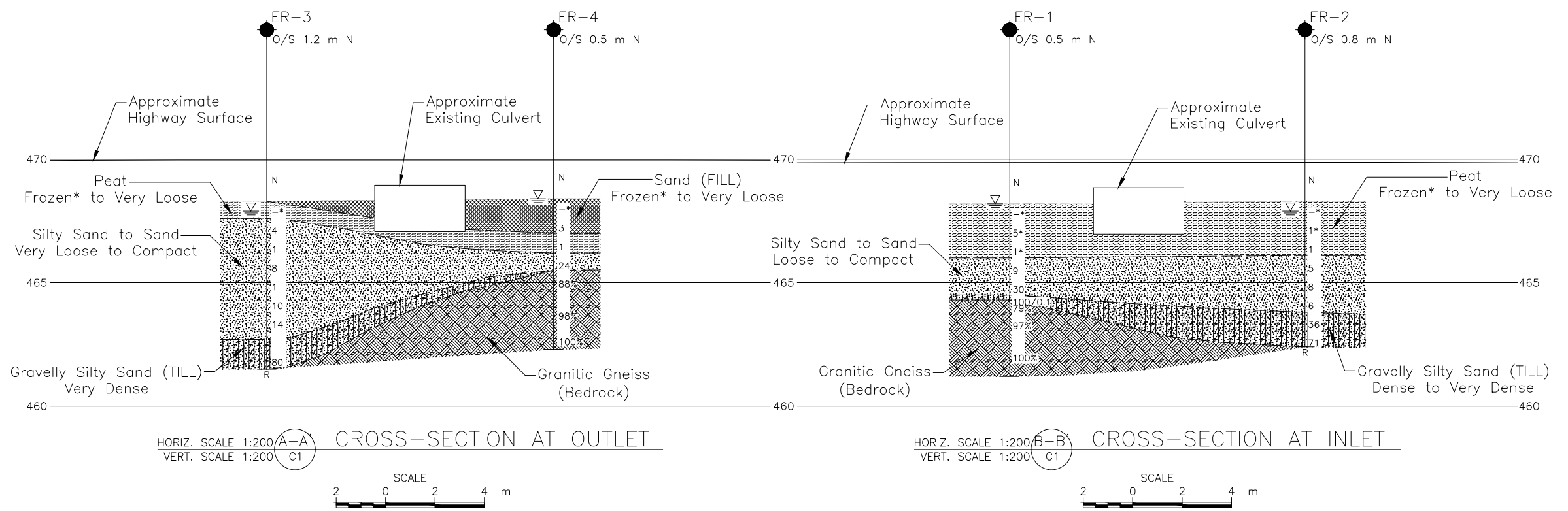
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

**REFERENCE**

Base plans provided in digital format by MTO, drawing file nos. E745172.dwg received Dec. 11, 2015.



NO.	DATE	BY	REVISION
Geocres No. 52G-15			
HWY. 17		PROJECT NO. 1533879	
SUBM'D. AC	CHKD.	DATE: 10/7/2016	SITE: 48W-188/C
DRAWN: JJL	CHKD. DAM	APPD. JMAC	DWG. B1





## PHOTOGRAPHS

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**Photograph B1: English River Culvert  
Looking West at the Culvert Inlet (North End) (December 2015)**



**Photograph B2: English River Culvert  
Looking East at the Culvert Inlet (North End) (December 2015)**







## PHOTOGRAPHS

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**Photograph B3: English River Culvert  
Looking North at the Culvert Inlet (North End) (December 2015)**



**Photograph B4: English River Culvert  
Looking South at the Culvert Outlet (South End) (December 2015)**





PROJECT 1533879		RECORD OF BOREHOLE No ER-1				1 OF 2 METRIC											
G.W.P. 6336-14-00		LOCATION N 5445736.4; E 246362.4				ORIGINATED BY MR											
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, HW Casing, HQ Coring				COMPILED BY AC											
DATUM GEODETIC		DATE January 21, 2016				CHECKED BY DAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
468.2	GROUND SURFACE							20	40	60	80	100					
0.0	PEAT (Fibrous), trace sand Black Frozen*		1	AS	-*	▽	468										124.2
			2	SS	5*		467										
			3	SS	1*		466										
466.0	SILTY SAND, trace to some gravel Loose to compact Grey Wet		4	SS	9		465										0 71 (29)
			5	SS	30		464										12 65 (23)
464.5	Gravelly SILTY SAND (TILL) Grey Wet		6	SS	100/0.1		463										
3.9	GRANITIC GNEISS (BEDROCK)  Bedrock cored from 3.9 m depth to 7.0 m depth.  For coring details see Record of Drillhole ER-1.		1	RC	REC 100%		462										RQD = 79%
			2	RC	REC 100%		461										RQD = 97%
			3	RC	REC 100%		460										RQD = 100%
461.2	END OF BOREHOLE																
7.0	Note:  1. Water level at a depth of 0.4 m below ground surface (Elev. 467.8 m) prior to coring.																

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 08/09/16 DATA INPUT:



PROJECT: 1533879

**RECORD OF DRILLHOLE: ER-1**

SHEET 2 OF 2

LOCATION: N 5445736.4 ; E 246362.4

DRILLING DATE: January 21, 2016

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850 Trackmount

DRILLING CONTRACTOR: Cartwright Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SHR- Shear VN - Vein CJ - Conjugate										BD- Bedding FO- Foliation CO- Contact OR- Orthogonal CL - Cleavage										PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular										PO- Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break										BR - Broken Rock	NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY		Diametral Point Load Index (MPa)	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k, cm/s	10 <sup>0</sup>	10 <sup>-1</sup>	10 <sup>-2</sup>	10 <sup>-3</sup>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
4	HW	TOP OF BEDROCK  GRANITIC GNEISS Medium to coarse grained Weakly foliated Pinkish grey Very strong		464.3	3.9	1	GREY 100%																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														

DEPTH SCALE

1 : 60



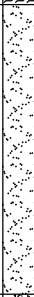
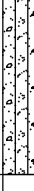


LOGGED: MR

CHECKED: DAM






SUD-RCK 1533879 GPJ GAL-MISS GDT 08/08/16 DATA INPUT:



PROJECT 1533879		RECORD OF BOREHOLE No ER-2				1 OF 1 METRIC												
G.W.P. 6336-14-00		LOCATION N 5445732.5; E 246373.7				ORIGINATED BY MR												
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY AC												
DATUM GEODETIC		DATE January 22, 2016				CHECKED BY DAM												
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
468.3	GROUND SURFACE							20	40	60	80	100						
0.0	PEAT (Fibrous) Very loose Black Frozen* to wet		1	AS	-*		468											
			2	SS	2*		467											
			3	SS	1		466											
466.1	SAND, trace clay, trace to some silt Loose Grey Wet  Approximately 0.3 m to 0.8 m of heave encountered below 3.1 m depth.		4	SS	5		466										0 81 18 1	
			5	SS	8	465												
			6	SS	6	464											0 98 (2)	
463.8	Gravelly SILTY SAND, trace clay (TILL) Dense to very dense Grey Wet		7	SS	36		463										21 50 27 2	
			8	SS	71													
462.4	Spoon bouncing at 5.9 m depth. END OF BOREHOLE AUGER AND SPLIT-SPOON REFUSAL  Note:  1. Water level at a depth of 0.4 m below ground surface (Elev. 467.9 m) upon completion of drilling.																	
5.9																		

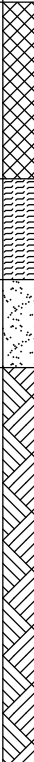

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 08/08/16 DATA INPUT:



PROJECT 1533879		RECORD OF BOREHOLE No ER-3				1 OF 1 METRIC											
G.W.P. 6336-14-00		LOCATION N 5445713.0; E 246352.5				ORIGINATED BY MR											
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY AC											
DATUM GEODETIC		DATE January 20 and 21, 2016				CHECKED BY DAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
468.3	GROUND SURFACE							20	40	60	80	100					
0.0	PEAT (Fibrous) Black Frozen*		1	AS	-*		468										
467.6																	
0.7	SAND, trace some silt, trace gravel Very loose to compact Grey Wet		2	SS	4			467									
			3	SS	2												
			4	SS	8												
	Approximately 0.5 m to 1.0 m of heave encountered in augers below 3.1 m depth.		5	SS	1												
			6	SS	10												
			7	SS	14												
462.7	Gravelly SILTY SAND (TILL) Very dense Grey Wet		8	SS	80		462										
461.5	Split-spoon attempted at 6.8 m depth. Spoon bouncing.																
6.8	END OF BOREHOLE AUGER AND SPLIT-SPOON REFUSAL  Note:  1. Water level at a depth of 0.4 m below ground surface (Elev. 467.9 m) upon completion of drilling.																

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 08/09/16 DATA INPUT:



PROJECT 1533879		<b>RECORD OF BOREHOLE No ER-4</b>				1 OF 2 <b>METRIC</b>											
G.W.P. 6336-14-00		LOCATION N 5445708.2; E 246363.1				ORIGINATED BY MR											
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, HW Casing, HQ Coring				COMPILED BY AC											
DATUM GEODETIC		DATE January 23, 2016				CHECKED BY DAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
468.4 0.0	GROUND SURFACE Sand, trace to some silt, trace organics (FILL) Very loose Brown to grey Frozen* to wet		1	AS	-*		468										0 91 (9)
			2	SS	3		467										
467.0 1.4	PEAT (Fibrous) Very loose Black Wet		3	SS	1		466										
466.2 2.2	SILTY SAND, trace organics Compact Brown Wet		4	SS	24		465										
465.5 2.9	GRANITIC GNEISS (BEDROCK)  Bedrock cored from 2.9 m depth to 6.1 m depth.  For coring details see Record of Drillhole ER-4.		1	RC	REC 100%		465									RQD = 88%	
			2	RC	REC 100%		464									RQD = 98%	
			3	RC	REC 100%		463									RQD = 100%	
462.3 6.1	END OF BOREHOLE  Note:  1. Water level at ground surface (Elev. 468.4 m) upon completion of coring.																

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



PROJECT: 1533879

**RECORD OF DRILLHOLE: ER-4**

SHEET 2 OF 2

LOCATION: N 5445708.2 ; E 246363.1

DRILLING DATE: January 23, 2016

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850 Trackmount

DRILLING CONTRACTOR: Cartwright Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SHR- Shear VN - Vein CJ - Conjugate										BD- Bedding FO- Foliation CO- Contact OR- Orthogonal CL - Cleavage										PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular										PO- Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break										BR - Broken Rock	NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
							RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY		Diametral Point Load Index (MPa)	RMC -Q' AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k, cm/s	10 <sup>0</sup>	10 <sup>1</sup>	10 <sup>2</sup>	10 <sup>3</sup>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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DEPTH SCALE

1 : 60

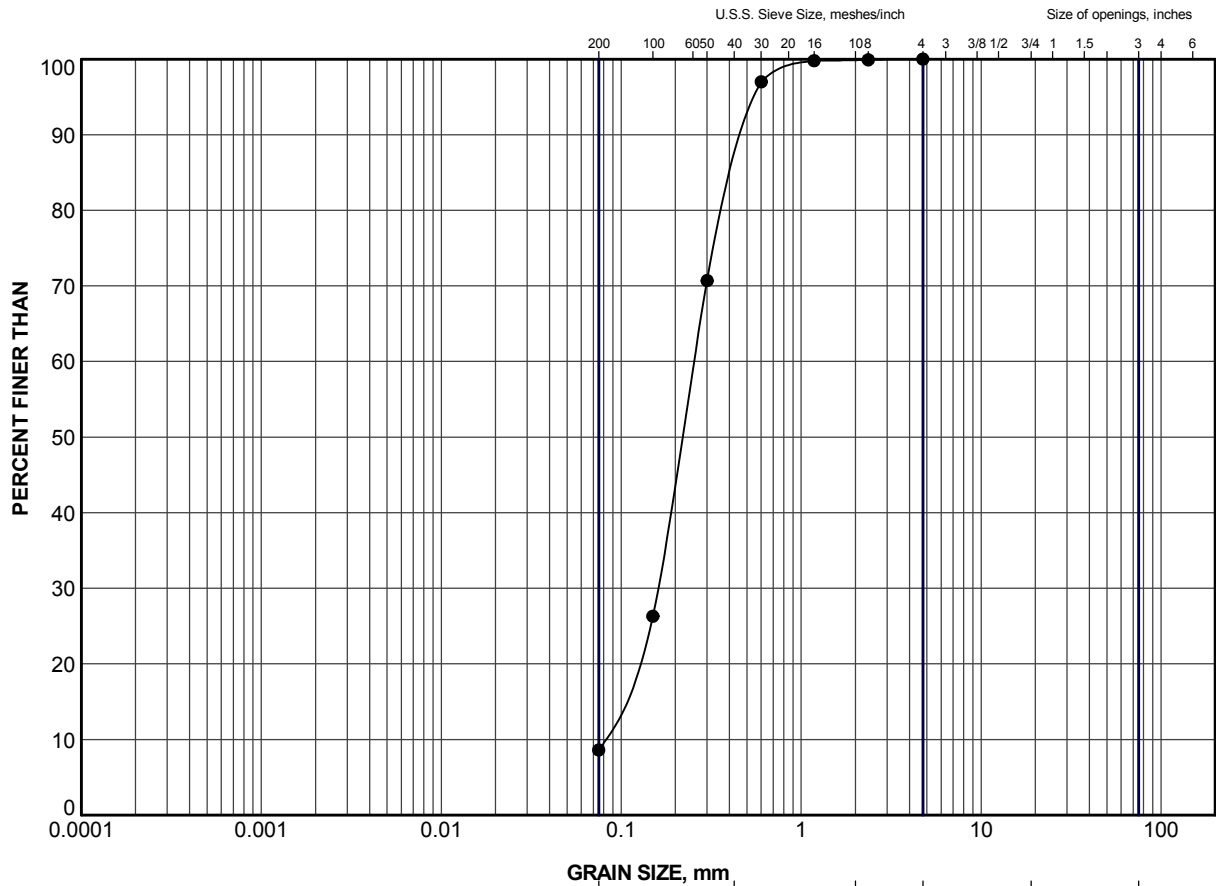


LOGGED: MR

CHECKED: DAM

SUD-RCK 1533879 GPJ GAL-MISS GDT 08/08/16 DATA INPUT:





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

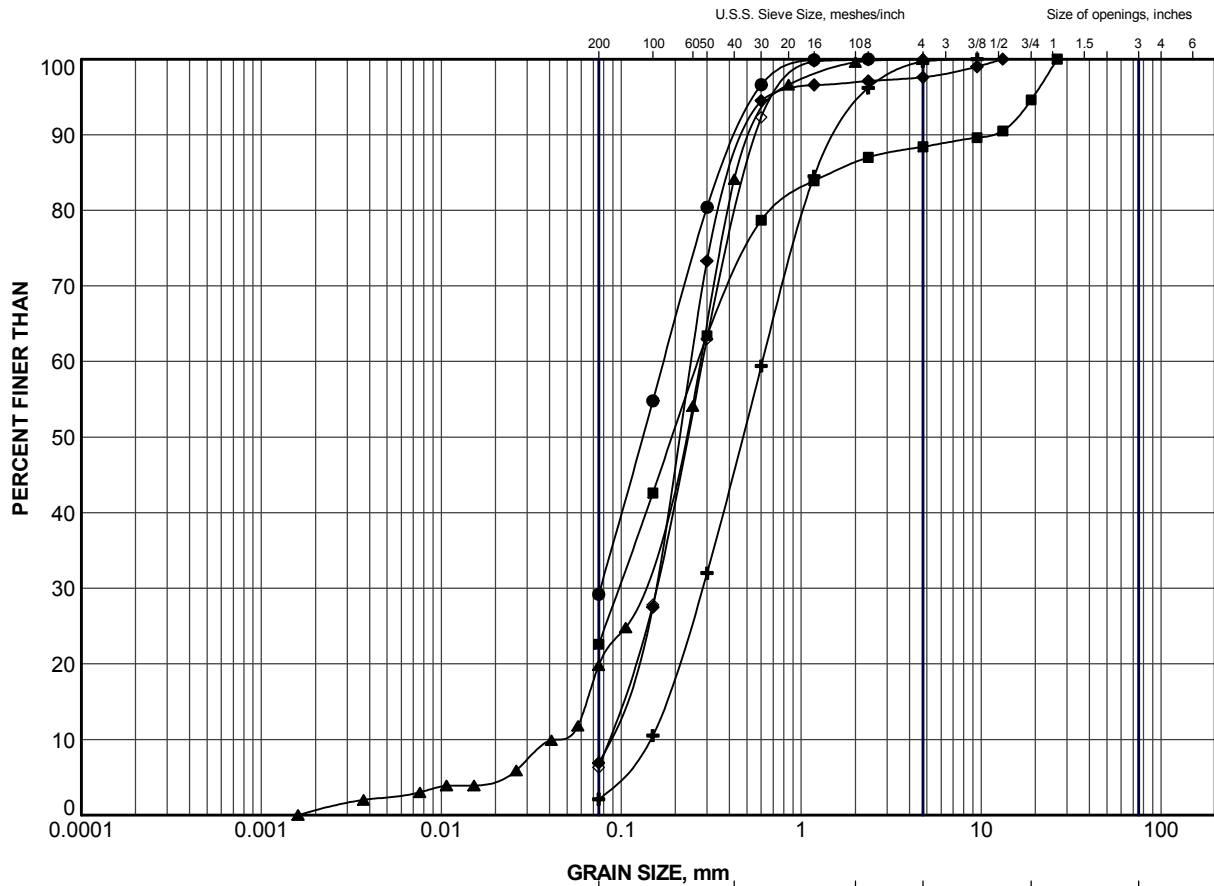
### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	ER-4	2	467.3

PROJECT					
HIGHWAY 17 ENGLISH RIVER TRIBUTARY CULVERT STA 11+592					
TITLE					
GRAIN SIZE DISTRIBUTION SAND (FILL)					
PROJECT No.		1533879		FILE No. 1533879.GPJ	
DRAWN	JJL	Jul 2016	SCALE	N/A	REV.
CHECK	DAM	Jul 2016	FIGURE B1		
APPR	JMAC	Jul 2016			







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

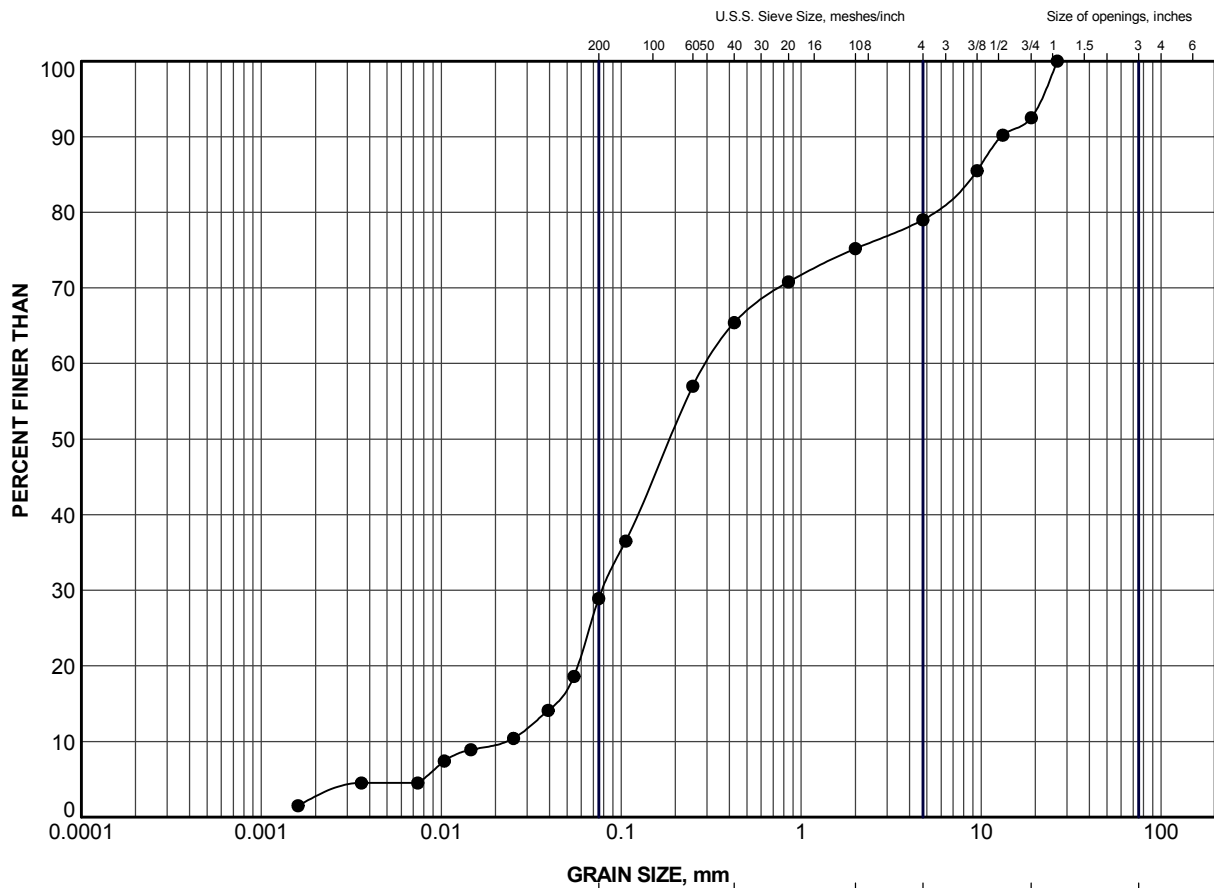
### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	ER-1	4	465.6
■	ER-1	5	464.8
▲	ER-2	4	465.7
+	ER-2	6	464.2
◆	ER-3	3	466.5
◇	ER-3	7	463.4

PROJECT					
HIGHWAY 17 ENGLISH RIVER TRIBUTARY CULVERT STA 11+592					
TITLE					
GRAIN SIZE DISTRIBUTION SILTY SAND to SAND					
PROJECT No.		1533879		FILE No. 1533879.GPJ	
DRAWN	JJL	Jul 2016	SCALE	N/A	REV.
CHECK	DAM	Jul 2016	FIGURE B2		
APPR	JMAC	Jul 2016			








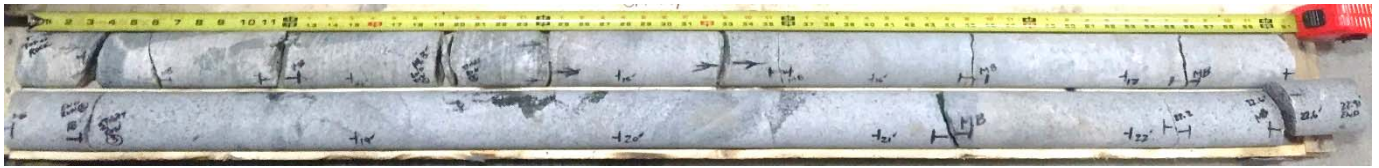
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	ER-2	7	463.4

PROJECT						HIGHWAY 17 ENGLISH RIVER TRIBUTARY CULVERT STA 11+592									
TITLE															
<b>GRAIN SIZE DISTRIBUTION</b> GRAVELLY SILTY SAND (TILL)															
PROJECT No.				1533879				FILE No.				1533879.GPJ			
DRAWN		JJL		Jul 2016		SCALE		N/A		REV.					
CHECK		DAM		Jul 2016											
APPR		JMAC		Jul 2016											
 <b>Golder Associates</b> SUDBURY, ONTARIO						<b>FIGURE B3</b>									

SUD-MTO GSD (2016) GLDR\_LDN.GDT

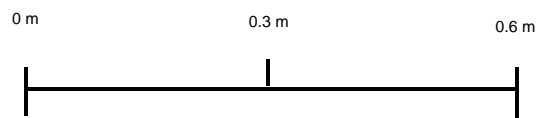





Borehole ER-1  
Elevation 464.3 m to 461.2 m



Borehole ER-4  
Elevation 465.5 m to 462.3 m



PROJECT		HIGHWAY 17	
		ENGLISH RIVER TRIBUTARY CULVERT STA 11+592	
TITLE			
BEDROCK CORE PHOTOGRAPHS			
	PROJECT No. 1411523		FILE No. ----
	DESIGN		SCALE AS SHOWN REV.
	CADD	AC July 2016	FIGURE B4
	CHECK	DAM July 2016	
	REVIEW	JMAC July, 2016	

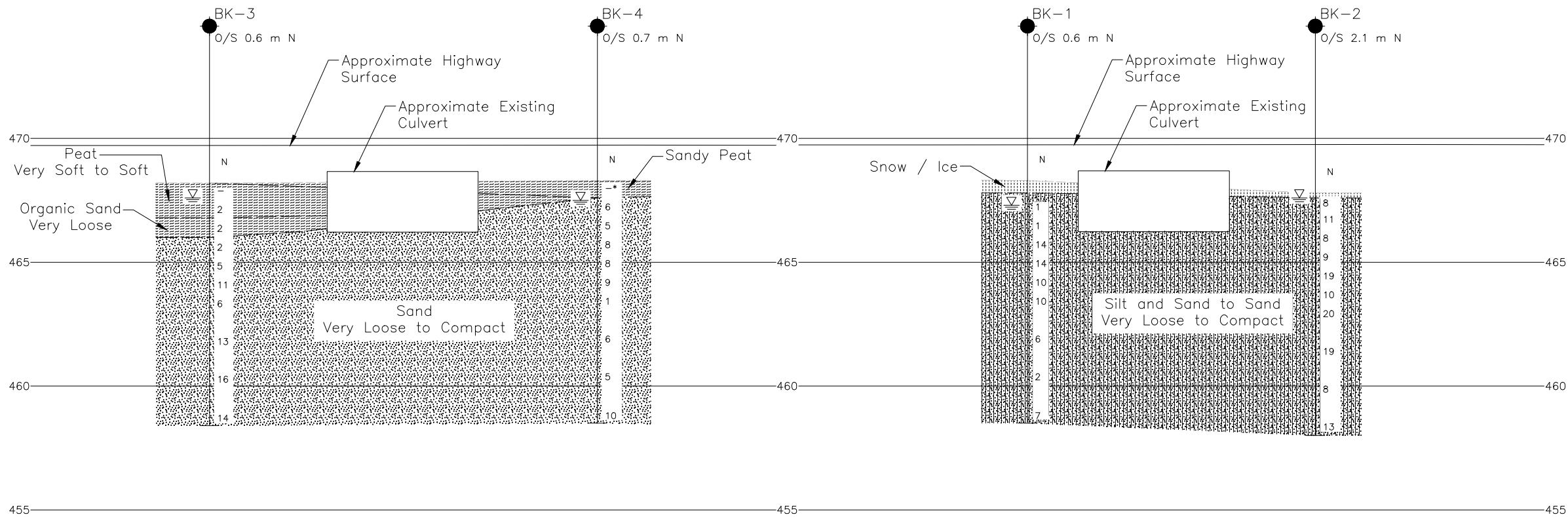
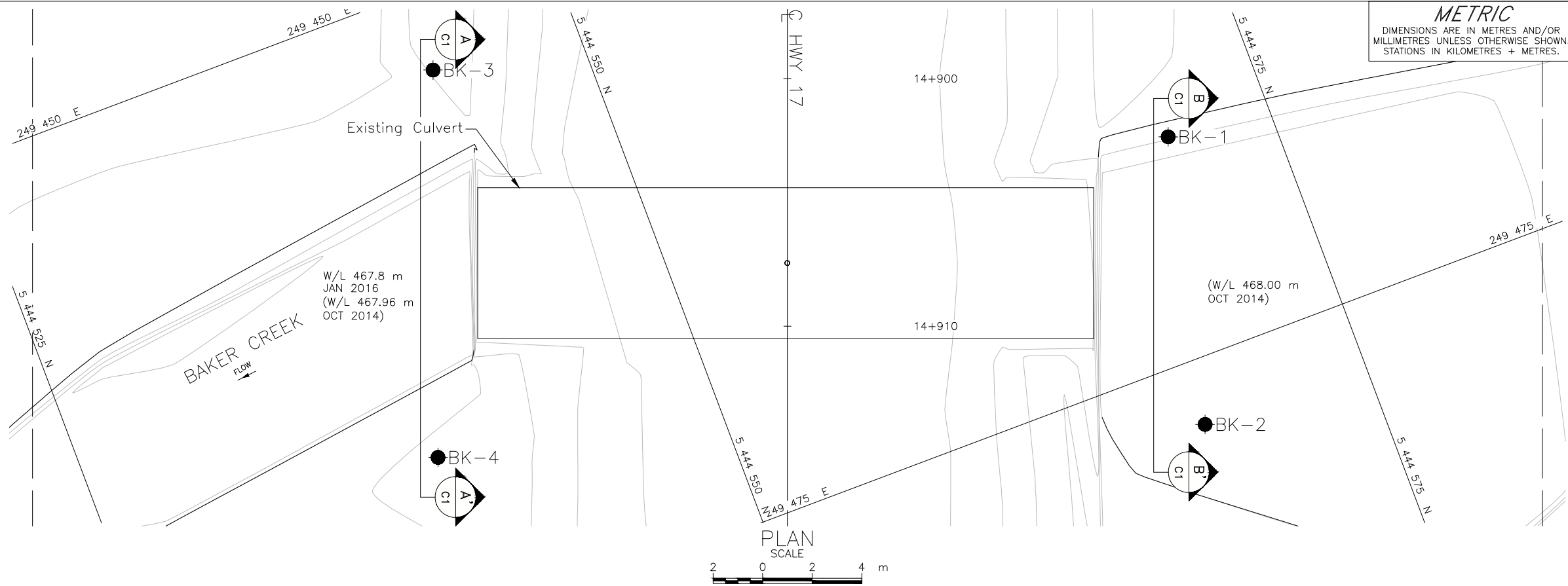




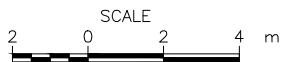
# **APPENDIX C**

## **Baker Creek Culvert (Site 48W-12/C)**





HORIZ. SCALE 1:200  
VERT. SCALE 1:200

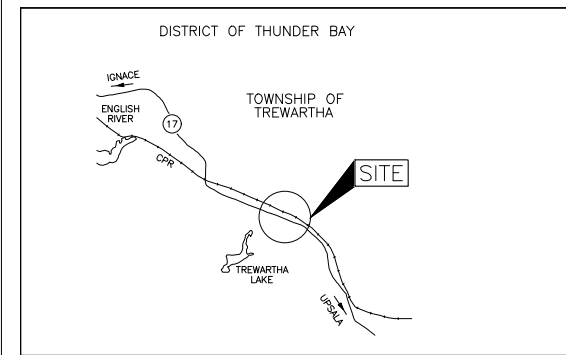


HORIZ. SCALE 1:200  
VERT. SCALE 1:200



CONT No.  
GWP No. 6336-14-00

HIGHWAY 17  
BAKER CREEK CULVERT STA 14+907  
BOREHOLE LOCATIONS AND  
SOIL STRATA



LEGEND			
	Borehole - Current Investigation		
N	Standard Penetration Test Value		
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)		
	WL upon completion of drilling		

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
BK-1	468.3	5444570.8	249466.2
BK-2	467.8	5444568.1	249477.6
BK-3	468.2	5444544.0	249453.2
BK-4	468.3	5444538.6	249467.9

**NOTES**

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

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

**REFERENCE**

Base plans provided in digital format by MTO, drawing file nos. E745171.dwg received Dec. 11, 2015.

NO.	DATE	BY	REVISION
Geocres No. 52G-15			
HWY. 17	PROJECT NO. 1533879		DIST. .
SUBM'D. AC	CHKD. .	DATE: 10/7/2016	SITE: 48W-12/C
DRAWN: JJL	CHKD. DAM	APPD. JMAC	DWG. C1





## PHOTOGRAPHS

**Photograph C1: Baker Creek Culvert  
Looking West at the Culvert Inlet (North End) (December 2015)**



**Photograph C2: Baker Creek Culvert  
Looking East at the Culvert Outlet (South End) (December 2015)**







## PHOTOGRAPHS

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**Photograph C3: Baker Creek Culvert  
Looking North at Culvert Inlet (North End) (December 2015)**



**Photograph C4: Baker Creek Culvert  
Looking South at Culvert Outlet (South End) (December 2015)**





PROJECT 1533879		RECORD OF BOREHOLE No BK-1				1 OF 1 METRIC						
G.W.P. 6336-14-00		LOCATION N 5444570.8; E 249466.2				ORIGINATED BY SA						
DIST _____ HWY 17		BOREHOLE TYPE NW Casing and Wash Boring				COMPILED BY AC						
DATUM GEODETIC		DATE January 29 and 30, 2016				CHECKED BY DAM						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>			WATER CONTENT (%)
468.3 0.0	GROUND SURFACE SNOW / ICE (500 mm)						468					
467.8 0.5	SILT and SAND to SAND, some silt, trace clay Very loose to compact Brown to grey Wet  Trace organics encountered in Sample 1.          Approximately 0.1 m of heave below 4.6 m depth.		1	SS	1	▽	467					
			2	SS	1		466					
			3	SS	14		465					
			4	SS	14		464					
			5	SS	10		463					
			6	SS	10		462					
			7	SS	6		461					
			8	SS	2		460					
			9	SS	7		459					
458.5 9.8	END OF BOREHOLE  Note:  1. Water level at a depth of 1.0 m below ground surface (Elev. 467.3 m) upon completion of drilling.											

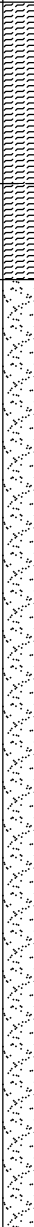

SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 08/08/16 DATA INPUT:



PROJECT 1533879		RECORD OF BOREHOLE No BK-2				1 OF 1 METRIC											
G.W.P. 6336-14-00		LOCATION N 5444568.1; E 249477.6				ORIGINATED BY SA											
DIST _____ HWY 17		BOREHOLE TYPE HW and NW Casing and Wash Boring				COMPILED BY AC											
DATUM GEODETIC		DATE January 28, 2016				CHECKED BY DAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
467.8	GROUND SURFACE							20	40	60	80	100					
0.0	ICE (200 mm)																
0.2	SILTY SAND to SAND, trace gravel Loose to compact Brown to grey Wet  Trace organics in Sample 1.		1	SS	8		467										
			2	SS	11												
			3	SS	8		466										0 99 (1)
			4	SS	9		465										
			5	SS	19		464										
			6	SS	10		463										1 86 (13)
			7	SS	20		462										
							461										
			8	SS	19		460										
							459										
			9	SS	8		458										0 77 (23)
			10	SS	13												
458.0	END OF BOREHOLE																
9.8	Note:  1. Water level at a depth of 0.2 m below ground surface (Elev. 467.6 m) upon completion of drilling.																











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



PROJECT 1533879		RECORD OF BOREHOLE No BK-3				1 OF 1 METRIC											
G.W.P. 6336-14-00		LOCATION N 5444544.0; E 249453.2				ORIGINATED BY MR											
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY AC											
DATUM GEODETIC		DATE January 20, 2016				CHECKED BY DAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
468.2 0.0	GROUND SURFACE PEAT (Amorphous) Very soft Black Wet		1	AS	-		468									222.9	1 90 (9)
			2	SS	2		467										
466.8 1.4	ORGANIC SAND, trace to some silt, trace gravel, trace wood Very loose Dark brown to black Wet		3	SS	2		466									o	
466.0 2.2	SAND, trace to some silt Very loose to compact Grey Wet  Approximately 0.6 m to 0.8 m of heave below 3.0 m depth.		4	SS	2		465										
			5	SS	5		464										
			6	SS	11		463										
			7	SS	6		462									o	
			8	SS	13		461										
			9	SS	16		460									o	
			10	SS	14		459										
458.4 9.8	END OF BOREHOLE  Note: 1. Water level at a depth of 0.6 m below ground surface (Elev. 467.6 m) upon completion of drilling.															0 97 (3)	

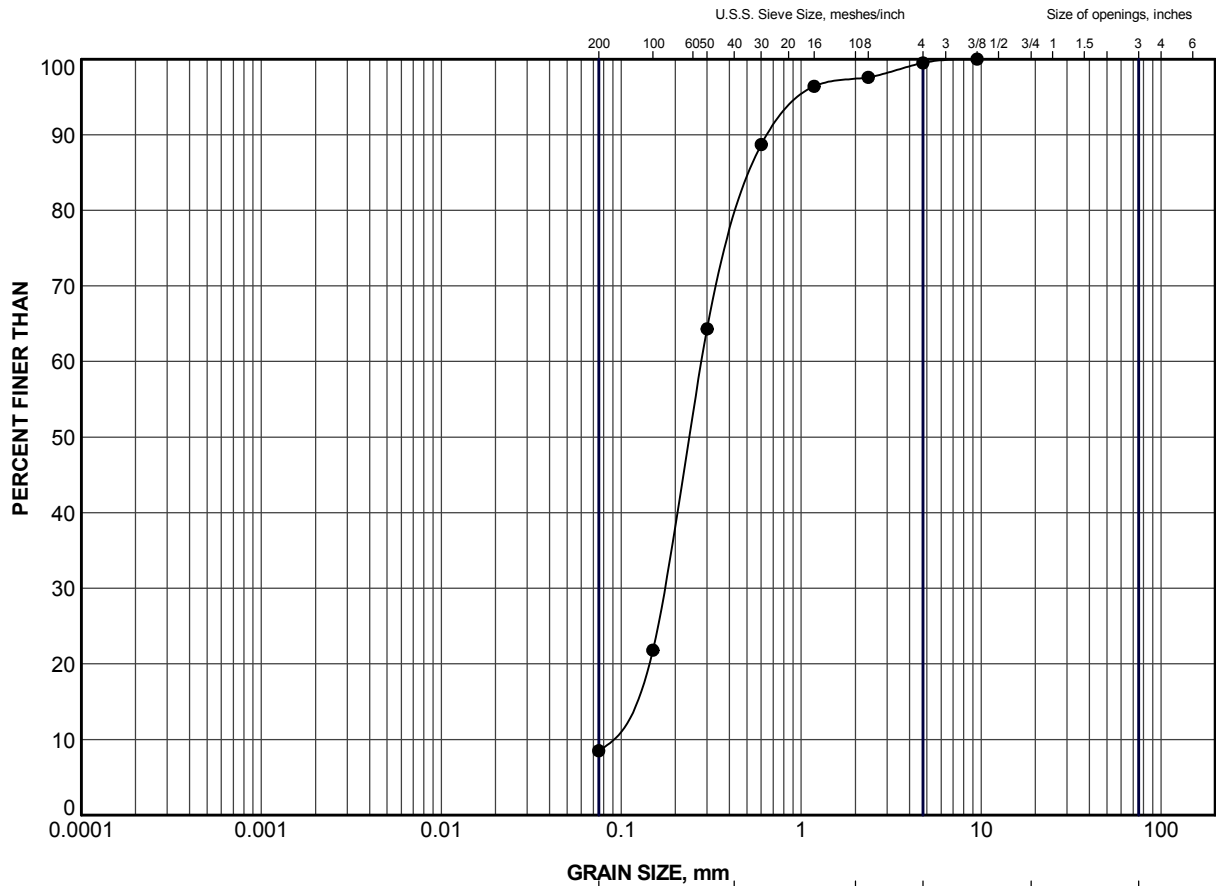
SUD-MTO 001 1533879.GPJ GAL-MISS.GDT 08/08/16 DATA INPUT:



PROJECT 1533879		<b>RECORD OF BOREHOLE No BK-4</b>				1 OF 1 <b>METRIC</b>												
G.W.P. 6336-14-00		LOCATION N 5444538.6; E 249467.9				ORIGINATED BY MR												
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY AC												
DATUM GEODETIC		DATE January 19, 2016				CHECKED BY DAM												
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
468.3	GROUND SURFACE							20	40	60	80	100						
0.0	Sandy PEAT (Amorphous), some silt Brown Frozen*		1	AS	-*	▽	468											
467.6	SAND, trace to some silt, trace gravel Very loose to compact Brown to grey Wet		2	SS	6		467											1 92 (7)
0.7	Trace organics encountered in Sample 2.		3	SS	5		466											
	Approximately 0.2 m to 1.4 m of heave below 2.3 m depth.		4	SS	8		465											0 98 (2)
			5	SS	8		464											
			6	SS	9		463											
			7	SS	1		462											
			8	SS	6		461											
			9	SS	5		460											0 94 (6)
			10	SS	10		459											
458.5	END OF BOREHOLE																	
9.8	Note:  1. Water level at a depth of 0.8 m below ground surface (Elev. 467.5 m) upon completion of drilling.																	


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





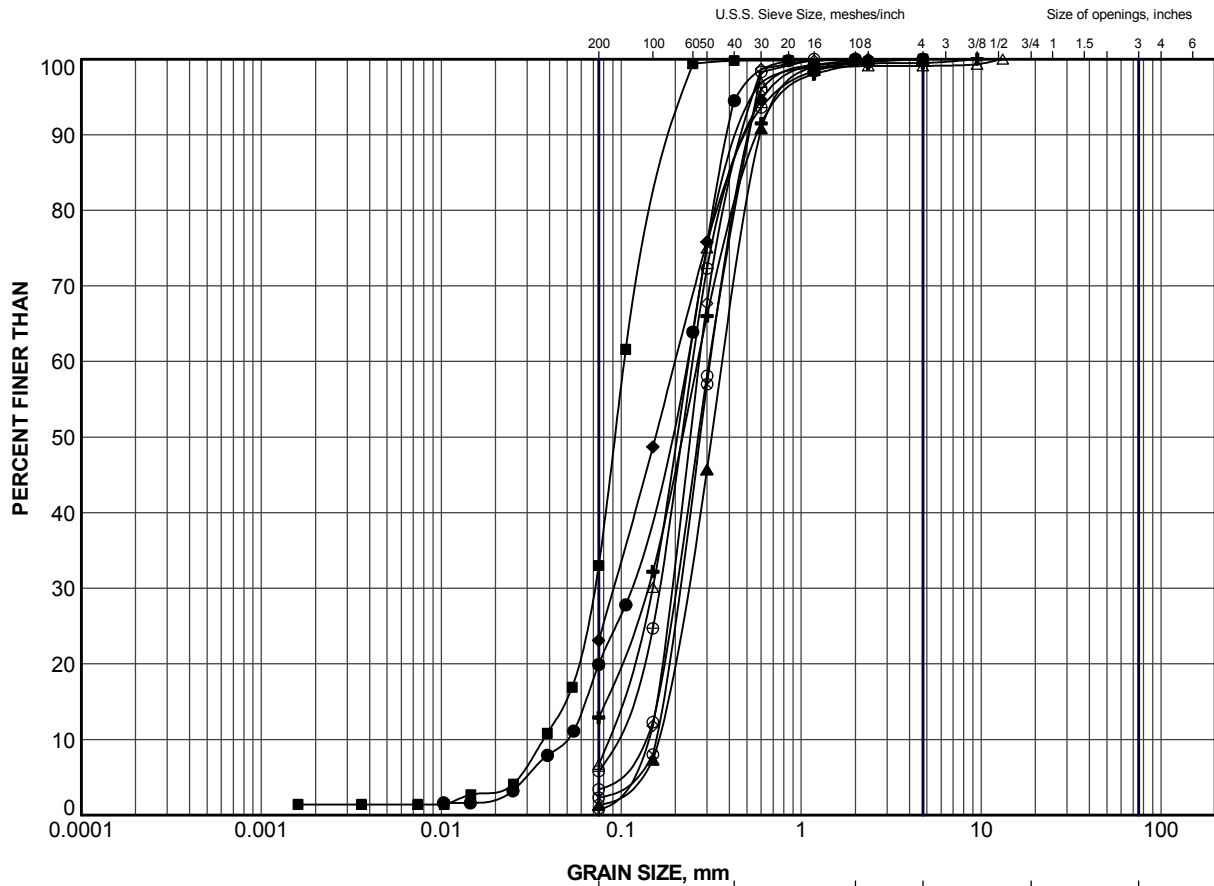
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BK-3	3	466.4

PROJECT					HIGHWAY 17 BAKER CREEK CULVERT STA 14+907				
TITLE					GRAIN SIZE DISTRIBUTION SAND				
PROJECT No.			1533879		FILE No.			1533879.GPJ	
DRAWN	JJL	Aug 2016	SCALE	N/A	REV.				
CHECK	DAM	Aug 2016							
APPR	JMAC	Aug 2016							
			<b>FIGURE C1</b>						

SUD-MTO GSD (2016) GLDR\_LDN.GDT





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

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BK-1	5	464.2
■	BK-1	9	458.8
▲	BK-2	3	466.0
+	BK-2	6	463.7
◆	BK-2	9	459.9
◇	BK-3	7	463.3
○	BK-3	9	460.3
△	BK-4	2	467.2
⊗	BK-4	5	464.9
⊕	BK-4	9	460.4

PROJECT

HIGHWAY 17  
BAKER CREEK CULVERT STA 14+907

TITLE

**GRAIN SIZE DISTRIBUTION**  
SILT and SAND to SAND



**Golder Associates**  
SUDBURY, ONTARIO

PROJECT No.		1533879	FILE No.		1533879.GPJ
DRAWN	JJL	Aug 2016	SCALE	N/A	REV.
CHECK	DAM	Aug 2016	<b>FIGURE C2</b>		
APPR	JMAC	Aug 2016			





# **APPENDIX D**

## **Non-Standard Special Provisions**



## **OBSTRUCTIONS – Sisson Creek Culvert**

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### Non-Standard Special Provision

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As part of the work for the culvert rehabilitation work at the Sisson Creek culvert, the Contactor shall be alerted to the presence of inferred cobble size material within the granular fill as encountered in Borehole SI-4 and the presence of wood within the peat deposit as encountered in Borehole SI-2.



**OBSTRUCTIONS – Baker Creek Culvert**

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Non-Standard Special Provision

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As part of the work for the culvert rehabilitation work at the Baker Creek culvert, the Contactor shall be alerted to the presence wood within the organic sand deposit as encountered in Borehole BK-3.



At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

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