THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT
BAKER CREEK CULVERT REHABILITATION OR REPLACEMENT
HIGHWAY 17, DISTRICT OF THUNDER BAY, ONTARIO
AGREEMENT 6019-E-0009, WORK ORDER 10
G.W.P. 6336-14-00, SITE NO. 48W-012/C

LATITUDE: 49.1366°, LONGITUDE: -90.7581°

GEOCRES No.: 40P8-274

Report

to

HATCH

Date: February 24, 2021
File: 29181

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for design of the proposed Baker Creek culvert rehabilitation or replacement. The Baker Creek culvert is located on Highway 17, west of Upsala, in the Trewartha Township, District of Thunder Bay, Ontario.

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

Thurber carried out the investigation as a sub-consultant to Hatch Corporation (Hatch), under the Ministry of Transportation Ontario (MTO) Retainer Agreement Number 6019-E-0009, Work Order 10.

Reference has been made to information on subsurface conditions contained in a previous foundation report prepared for this site. The title of the report is:

- Foundation Investigation and Design Report, Sisson Creek, English River Tributary and Baker Creek Culverts, Highway 17, G.W.P. 6336-14-00, W.P. 6338-14-01, W.P. 6337-14-01 & W.P. 6336-14-01, Geocres No. 52G-15, prepared by Golder, dated October 7, 2016. (Reference 1).

The records of borehole sheets and laboratory test results from the previous investigation are included in Appendix E for reference.

2. SITE DESCRIPTION

The site is located on Highway 17, approximately 76 km east of Highway 599, in the Township of Trewartha, District of Thunder Bay, Ontario. The existing culvert allows Baker Creek to flow in a

north to south direction under Highway 17. Highway 17 generally runs in an east-west direction at the culvert site.

The available base plan drawing provided by Hatch indicates that the existing structure is a closed box concrete culvert. The base plan indicates that the span of the structure is 6.0 m, the height is 2.5 m and the length of is 24.9 m. The estimated culvert invert is at approximate Elevation 466.1 m at both the inlet (north) and the outlet (south). The existing road grade at the culvert location is at approximate Elev. 469.7 m, which indicates approximately 1.1 m of fill above the culvert. The local creek water level was reportedly measured at Elev. 468.0 m in October 2014 and Elev. 467.7 m in April 2015. The site topography within the culvert area is generally flat, with low lying grassy land surrounding Baker Creek on both sides of Highway 17.

Photographs in Appendix C show the general nature of the site and the existing culvert.

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS) mapping, the subsoils in the area of the Baker Creek culvert site consists of organic terrain and ground moraine deposits consisting of sand till. Based on the OGS Map MRD126 titled “Bedrock Geology of Ontario”, dated 2011, the bedrock at site is identified as tonalite rock.

3. INVESTIGATION PROCEDURES

The current site investigation and field testing program for this project was carried out between August 10 and August 12, 2020, and consisted of drilling and sampling four (4) boreholes (20-01 to 20-04) to depths of 15.8 m below ground surface (Elevation 453.9 m to 453.5 m). Boreholes 20-01 and 20-04 were drilled through the paved portion of Highway 17 for possible roadway protection systems and stream diversion pipes. Boreholes 20-02 and 20-03 were drilled through the Highway 17 shoulders next to the existing culvert for the culvert replacement design. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

The previous site investigation, as drilled by Golder, consisted of drilling and sampling four (4) boreholes (BK-1 to BK-4) to depths of 9.8 m below the existing ground surface (Elevation 458.5 m to 458.0 m). Two of the boreholes were advanced near the inlet (north end) and two of the boreholes were advanced near the outlet (south end) of the culvert; near the locations of possible cofferdams.

The Record of Borehole sheets for the boreholes from the current investigation are included in Appendix A. The Record of Borehole sheets for the boreholes from the previous investigation by Golder are included in Appendix E. The approximate locations of the boreholes from both

investigations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D.

Utility clearances were obtained prior to the start of drilling. The northing, easting and ground surface elevations at the borehole locations were provided to Thurber by Hatch. The coordinate system MTM NAD 83, Zone 15 was used for the boreholes.

All boreholes were advanced using a truck-mounted CME 75 drill rig, using solid stem augers and NW casing with wash boring techniques. Soil samples were obtained in all boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

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

Monitoring wells were installed in Boreholes 20-02 and 20-03. Both wells consisted of 50 mm Schedule 40 PVC pipe with a 1.5 m long slotted screen, enclosed in a column of filter sand to permit groundwater level monitoring. Piezometer installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets. A sample of the surface water and groundwater was obtained during the field investigation and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters. Single well response tests ("slug") tests were carried out in the 50 mm diameter wells installed in both Boreholes 20-02 and 20-03. Upon collection of the final water level readings on August 21, 2020, the wells were decommissioned in accordance with MOE O.Reg. 903.

Details of the drilling program, including drilling depths, piezometer installation and completion details are summarized in Table 3.1 below.

Table 3.1: Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
20-01	15.8 / 453.9	None installed	Borehole backfilled with bentonite holeplug from 15.8 m to 0.3 m, sand from 0.3 m to 0.1 m and cold patch asphalt from 0.1 m to surface.

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
20-02	15.8 / 453.5	6.2 / 463.1	Borehole caved in from 15.8 m to 6.4 m and was backfilled with filter sand from 6.4 m to 4.1 m, bentonite holeplug from 4.1 m to 0.6 m, sand from 0.6 m to 0.3 m and concrete with a flush mount cover from 0.3 m to ground surface.
20-03	15.8 / 453.8	6.2 / 463.4	Borehole caved in from 15.8 m to 6.4 m and was backfilled with filter sand from 6.4 m to 3.9 m, bentonite holeplug from 3.9 m to 0.6 m, sand from 0.6 m to 0.3 m and concrete with a flush mount cover from 0.3 m to ground surface.
20-04	15.8 / 453.8	None installed	Borehole backfilled with bentonite holeplug from 15.8 m to 0.3 m, sand from 0.3 m to 0.1 m and cold patch asphalt from 0.1 m to surface.

4. LABORATORY TESTING

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

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the fill and a sample of the native soil were collected during the investigation and submitted to Bureau Veritas Canada (2019) Inc., a CALA accredited analytical laboratory in Mississauga, Ontario, for analytical testing of soil corrosivity parameters. In order to assess the quality of the groundwater for disposal purposes, a water sample was collected from the creek and the well installed in Borehole 20-02. The results of the analytical testing are summarized in this report and presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets for the current and previous investigations included in Appendix A and Appendix E, respectively. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata

drawings in Appendix D. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface stratigraphy below the asphalt typically consists of sand to silty sand fill underlain by sand to silty sand, with lower deposits of sandy silt to sand and silt. Layers of organics and peat were encountered below the fill. More detailed descriptions of individual strata are presented below.

5.1 Asphalt

Boreholes 20-01 and 20-04 were drilled through the paved portion of Highway 17. The asphalt ranged in thickness from 125 to 150 mm at these locations.

5.2 Embankment Fill

Embankment fill ranging in composition from sand to gravelly sand to silty sand was encountered below the asphalt in Boreholes 20-01 and 20-04 and from ground surface in Borehole 20-02 and 20-03. The sand fill was brown in colour, and contained trace to some gravel, trace to some silt, trace clay and occasional cobbles. The gravelly sand fill contained trace silt and occasional cobbles. Hydrocarbon odour was observed in the sand fill in Borehole 20-02.

The embankment fill ranged in thickness from 1.7 m to 3.2 m, with an underside depth ranging from 1.9 m to 3.2 m below ground surface (Elevation 467.8 m to 466.1 m).

SPT ‘N’ values in the fill generally ranged from 5 blows to 24 blows, indicating a loose to compact relative density. A SPT ‘N’ Value of zero blows was encountered in the sand fill in Borehole 20-02, at an approximate depth of 2.6 m (Elevation 466.7 m), indicating a very loose relative density.

The measured moisture contents generally ranged from 2 to 20%. A moisture content of 41% was recorded in Borehole 20-02 at an approximate depth of 3.1 m (Elevation 466.2 m), possibly indicating the presence of organics.

The results of grain size analyses conducted on selected samples of sand and gravelly sand fill are provided on the Record of Borehole sheets in Appendix A and plotted in Figures B1 and B2 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)	
	Sand Fill	Gravelly Sand Fill
Gravel	5 to 17	30
Sand	64 to 88	64
Silt & Clay	6 to 11	6

5.3 Peat and Organics

A black amorphous peat layer was encountered at ground surface in Boreholes BK-3 and BK-4, with an underside depth of 1.4 m and 0.7 m (Elevation 466.8 m and 467.6 m), respectively. Black peat mixed with sand was also encountered below the fill in Borehole 20-04 with a thickness of 0.2 m and an underside depth of 2.6 m (Elevation 467.0 m).

A 0.2 m thick organic layer was encountered below the fill in Borehole 20-01, with an underside depth of 2.1 m (Elevation 467.6 m).

An SPT 'N' Value of 2 blows was recorded in the amorphous peat deposit, indicating a very soft consistency.

Recorded moisture contents of the peat and organics ranged from 150 percent to 222 percent.

5.4 Sand to Silty Sand

A deposit ranging in composition from sand to silty sand was encountered below the peat and organics in Boreholes 20-01, 20-04, BK-3 and BK-4, from ground surface in Boreholes BK-1 and BK-2, and below the embankment fill in Boreholes 20-02 and 20-03. The top 0.8 m of the sand to silty sand layer in Borehole BK-3 was noted to contain organics. The sand to silty sand was brown to grey in colour and was noted to contain trace gravel and trace clay in some locations.

Trace organics were observed in the silty sand in Borehole 20-01 and 20-04 at approximate depths of 2.1 m and 2.6 m (Elevation 467.6 m and 467.0 m), respectively. Trace organics were also observed in the sand to silty sand in Boreholes BK-1, BK-2 and BK-4.

Boreholes BK-1 to BK-4 were terminated in the sand to silty sand layer at a depth of 9.8 m (Elevation 458.5 m to 458.0 m). The thickness of the sand to silty sand layer where fully penetrated in Boreholes 20-01 to 20-04 ranged from 5.7 m to 9.1 m, with an underside depth ranging from 8.7 m to 11.7 m (Elevation 461.0 m to 457.9 m).

SPT ‘N’ Values in the sand to silty sand ranged from 1 blow to 20 blows, indicating a very loose to compact relative density; but typically loose.

Measured moisture contents generally ranged from 19 percent and 32 percent. A moisture content of 57 percent was recorded in the organic sand in Borehole BK-3. The results of grain size analyses conducted on samples of sand to silty sand deposit are provided on the Record of Borehole sheets in Appendix A and Appendix E, and plotted on Figures B3 and B4 of Appendix B and Figures C1 and C2 of Appendix E. The results are summarized as follows:

Soil Particle	Percentage (%)	
	Silty Sand	Sand
Gravel	0	0 to 1
Sand	64 to 77	77 to 99
Silt	22 to 35	1 to 23
Clay	1	

5.5 Sandy Silt to Sand and Silt

A sandy silt to sand and silt deposit was encountered below the sand to silty sand layer in Borehole 20-01, 20-02, 20-03 and 20-04. The sandy silt to sand and silt was grey in colour and contained trace clay.

Boreholes 20-01 to 20-04 were all terminated in the sandy silt to sand and silt deposit at a depth of 15.8 m below ground surface (Elevation 453.9 m to 453.5 m).

SPT ‘N’ Values in sandy silt to sand and silt ranged from 1 blow to 10 blows, indicating very loose to loose relative density.

Recorded moisture contents ranged from 19 percent and 28 percent. The results of grain size analyses conducted on samples of the sandy silt to sand and silt deposit are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B5 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	31 to 65
Silt	34 to 67
Clay	1 to 2

5.6 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling, and in the monitoring wells installed in Boreholes 20-02 and 20-03. The measured groundwater levels are summarized in Table 5.1 below. The monitoring wells were decommissioned on August 21, 2020 following final water level readings and slug testing.

Table 5.1: Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
20-01	August 11, 2020	1.4	468.3	Open borehole
20-02	August 14, 2020 August 21, 2020	1.7 1.4	467.6 467.9	In monitoring well
20-03	August 12, 2020 August 21, 2020	2.0 1.7	467.6 467.9	In monitoring well
20-04	August 10, 2020	1.9	467.7	Open Borehole
BK-1	January 30, 2016	1.0	467.3	Open Borehole
BK-2	January 28, 2016	0.2	467.6	Open Borehole
BK-3	January 20, 2016	0.6	467.6	Open Borehole
BK-4	January 19, 2016	0.8	467.5	Open Borehole

The groundwater level is likely to reflect the local creek water level. The surface water level of Baker Creek upstream and downstream of the bridge was measured at Elevation 468.0 m upstream to 467.96 m downstream of the culvert in October 2014, as shown on the site plan in Appendix E. The creek level, at the time of base plan mapping in April 2015 was surveyed to be at Elevation 467.7 m.

It should also be noted that groundwater levels are short term observations and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation and spring snow melts.

6. CORROSIVITY AND SULPHATE TEST RESULTS

Samples of the gravelly sand fill and native sand from Boreholes 20-03 and 20-02, respectively, were submitted for analytical testing of corrosivity parameters and sulphate. A sample of creek water taken from Baker Creek during the previous investigation was tested for pH, sulphate, chloride, resistivity and conductivity. The laboratory certificates of analysis for the current investigation are presented in Appendix B and the analysis results from the previous investigation (creek water sample) are included in Reference 1. The results of the analytical tests are summarized below in Table 6.1.

Table 6.1: Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results		
			20-03, SS3 (5'-7') (1.5 – 2.1 m)	20-02, SS5B (10'6" – 12') (3.2 – 3.7 m)	Baker Creek
			(Gravelly Sand Fill)	(Native Sand)	(Creek Water)
Redox Potential	mV	N/A	210	317	N/A
Sulphide	mg/kg	N/A	<0.5	<0.5	N/A
pH	-	-	6.88	5.29	6.54
Chloride	µg/g	mg/L	280	190	3.45
Sulphate	µg/g	mg/L	<20	<20	0.86
Conductivity	uS/cm	µS/cm	448	269	68.1
Resistivity	ohm-cm	ohm-cm	2200	3700	14 700

7. WATER QUALITY

For assessment of the general groundwater quality in the project area, samples of the surface water from the creek and the groundwater from the monitoring well at Borehole 20-02 were collected on August 21, 2020. Due to a documentation error during transfer of the samples to the analytical laboratory, the water samples were combined prior to analysis. The combined water sample was analyzed for selected inorganic parameters included in the Ontario Provincial Water Quality Objectives (PWQO). The analytical test results are presented in Appendix B.

The analytical results of the water testing were compared to limits for the PWQO for surface water discharge. The concentrations of all parameters tested that did not meet the criteria established in the PWQO are listed below in Table 7.1.

Table 7.1 – Water Parameters Exceeding PWQO Criteria

Sample ID	Parameter	Criteria	Parameter Limit (mg/L)	Result (mg/L)
Baker Creek, 20-02	Sulphide	PWQO	0.02	0.0053
	Total Phosphorus	PWQO	0.01	0.18
	Total Sulphide	PWQO	0.002	0.005
	Dissolved Aluminum	PWQO	15	59
	Total Iron	PWQO	0.3	6.1

It should be noted that an oily sheen was observed in the creek water while obtaining water samples during the field investigation.

8. SINGLE WELL RESPONSE TEST RESULTS

8.1 Test Procedure

Single well response tests (SWRT) (“slug” tests) were carried out on the 50-mm diameter wells installed in Boreholes 20-02 and 20-03. The wells were screened in loose to compact sand to silty sand. The tests were completed using the following method:

- The static water level was measured and recorded, and a datalogger was inserted into the well below the water level. The datalogger was set to record water levels every 5 seconds, based on the anticipated rate of recovery of each well.
- A slug of groundwater was removed from the well with a dedicated bailer for each well to induce a change in hydraulic head (rising head test).
- Manual and electronic measurements were recorded until the water level in the well recovered sufficiently.
- Manual measurements were compared to electronic measurements for quality control of the data.

8.2 Hydraulic Conductivity

The two slug tests were completed and analyzed using the Hvorslev method. Plots of the slug test results are included in Appendix B. The hydraulic conductivity values calculated from the in-

situ slug tests are summarized in Table 8.1 below. The results from the two wells were very similar, ranging from 9.3 x 10^{-5} m/s to 1.0 x 10^{-4} m/s.

Table 8.1: Single Well Response Test Results

Monitoring Well	Hydraulic Conductivity (m/s)	Screened Formation
20-02	1.0 x 10^{-4}	Sand, some silt
20-03	9.3 x 10^{-5}	Silty sand to sand

From the grain size distribution curve of the sand at BH 20-03, the D_{10} value was approximately 0.106 mm. Using the Kozeny-Carman and Hazen correlations of grain size to hydraulic conductivity, the estimated hydraulic conductivity values are 3.4 x 10^{-5} m/s and 1.1 x 10^{-4} m/s, which are generally consistent with the SWRT results.

9. MISCELLANEOUS

Thurber obtained utility clearances for the borehole locations prior to drilling. Borehole locations were selected and established in the field by Thurber Engineering Ltd.

RPM Drilling of Thunder Bay, Ontario supplied a truck-mounted CME 75 drill rig and conducted the drilling, sampling and in-situ testing operations for the boreholes. Traffic control services conforming to Ontario Book 7 TL-20A lane closures and TL-6 shoulder closures were provided by Men at Worx Ltd. of Thunder Bay, Ontario.

Geotechnical laboratory testing was carried out in Thurber's geotechnical laboratory. Analytical testing was carried out by Bureau Veritas Canada (2019) Inc.

The field investigation was supervised on a full-time basis by Mr. Greg Stanhope of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng of Thurber and interpretation of the data was carried out by Ms. Judy Mei, E.I.T.

The report was prepared by Ms. Judy Mei, E.I.T. and Mr. Christopher Murray, P.Eng, and reviewed by Dr. P.K. Chatterji , P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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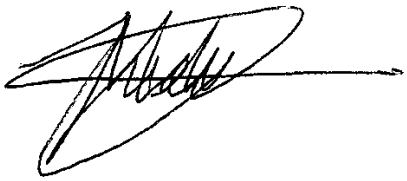

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

10. GENERAL

This section of the report provides an interpretation of the factual data from Part 1 of this report and presents geotechnical recommendations to assist the project team in designing a suitable rehabilitation or replacement of the existing Baker Creek culvert crossing Highway 17. The discussion and recommendations presented in this report are based on the information provided by Hatch and on the factual data obtained during the course of the investigation.

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

The available base plan drawing provided by Hatch indicates that the existing culvert is a closed box concrete culvert. The base plan indicates that the span of the structure is 6.0 m, the height is 2.5 m and the length of is 24.9 m. The existing culvert allows Baker Creek to flow in a north to south direction under Highway 17. Highway 17 generally runs in an east-west direction at the culvert site.

The estimated culvert invert is at approximate Elevation 466.1 m at both the inlet (north) and the outlet (south). The existing road grade centreline at the culvert location is at approximate Elev. 469.7 m, which indicates approximately 0.7 m of fill above the culvert. The existing embankment slopes are inclined between approximately 1.7H:1V to 2H:1V.

Reference has been made to information on subsurface conditions contained in a previous foundation report prepared for this site. The title of the report is:

- Foundation Investigation and Design Report, Sisson Creek, English River Tributary and Baker Creek Culverts, Highway 17, G.W.P. 6336-14-00, W.P. 6338-14-01, W.P. 6337-14-01 & W.P. 6336-14-01, Geocres No. 52G-15, prepared by Golder, dated October 7, 2016. (Reference 1).

The records of borehole sheets and laboratory test results from the previous investigation are included in Appendix E for reference. The terrain around the culvert is swampy and up to 1.4 m of peat was encountered in the off-road boreholes.

10.1 Proposed Structure

Based on discussions with Hatch, the proposed culvert replacement options include twin 3.67 m diameter structural plate corrugated steel pipe (SPCSP) circular pipe culverts, or a twin cell 4.0 m span by 2.4 m rise pre-cast concrete box culvert on the same alignment as the existing culvert. For the purposes of this report it is assumed that no grade raise of Highway 17 will be required and that the streambed elevations will be similar to the existing culvert. If the rehabilitation option is selected, it is anticipated that the rehabilitation will include concrete repair.

10.2 Applicable Codes and Design Considerations

The geotechnical assessment presented below has been prepared based on the available data regarding the proposed foundations and existing ground conditions and in accordance with the Canadian Highway Bridge Design Code (CHBDC), version CSA S6-19.

It is assumed that the proposed culvert structure has a consequence classification of *Typical Consequence*, in accordance with Section 6.5.1 of the CHBDC. Accordingly, a consequence factor (Ψ) of 1.0, as per Table 6.1 of the CHBDC, has been used in assessing factored geotechnical resistances for this structural culvert.

11. SEISMIC CONSIDERATIONS

11.1 Spectral and Peak Acceleration Hazard Values

The seismic hazard data for the CHBDC is based on the fifth generation seismic model developed by the Geological Survey of Canada (GSC). The seismic hazard for this site has been obtained from the GSC calculator. The data includes a peak ground acceleration (PGA), peak ground velocity (PGV) and the 5% spectral response acceleration values (Sa(T)) for the reference ground

condition (Site Class C) for a range of periods (T) and for a range of return periods including 475-year, 975-year and 2475-year events. The GSC seismic hazard calculated data sheet for this site is included in Appendix G.

The site coefficients used to determine the design spectral acceleration and displacement values are a function of the Site Class and the peak ground acceleration (PGA). At this site, the PGA for a reference Site Class C with a 2% probability of exceedance in 50 years (2475-year event) is 0.043g. This value is to be scaled by the F(PGA) based on the site specific Site Class.

11.2 CHBDC Seismic Site Classification

In accordance with the CHBDC, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy below the founding level. The Site Class was assessed based on the harmonic mean of the SPT 'N_{60}' values within the upper 30 m measured during the drilling investigation. Based on the drilling investigation, for design, this site can be classified as Site Class E (N_{60} < 15) in accordance with Section 4.4.3.2 of the CHBDC (S6-19).

11.3 Seismic Liquefaction

The soils beneath the anticipated founding elevation and water table include generally loose sand to silty sand to sandy silt deposits. Based on the PGA value of 0.043g and a de-aggregated earthquake magnitude of 5.87, the subsurface conditions encountered at the drilled locations at this site and using the Simplified Boulanger and Idriss (2014) Method for liquefaction assessment, the foundation soils are considered to be not susceptible to liquefaction during a seismic event.

12. DESIGN OPTIONS

12.1 Culvert Type and Foundation Alternatives

Selection of the culvert type must consider the proposed construction procedures, staging requirements, geotechnical resistance available in the foundation soils, the depth to suitable bearing stratum and post-construction settlement criteria. From a geotechnical perspective, the following culvert types were considered:

- Circular Pipes (Concrete, HDPE, Steel)
  From a foundation engineering perspective, pipe culverts are a feasible culvert option. It is anticipated that a pipe with an internal diameter of 4.5 m or greater will be required to match the existing opening size. Since there is insufficient cover for such a large pipe with

a similar invert elevation, multiple smaller diameter circular pipe culverts would likely be required.

- Closed Bottom Culvert (Box)
  Either a single or a twin precast segmental box culvert is considered a feasible option from a foundation engineering perspective. Precast sections, rather than cast-in-place construction, can be installed expediently with less potential for disturbance of the founding soils during installation.

- Open Bottom Culvert (Box, Arch)
  Open bottom culverts must be founded below frost depth and would require greater excavation and dewatering efforts. Given the highly permeable layer of sand, it may not be possible to maintain a dry excavation with conventional pumps due to excessive groundwater inflow.

A comparison of these alternatives, based on their respective advantages and disadvantages, is included in Appendix F. It is not considered economical or practical to support a culvert on deep foundations at this site and therefore this option is not presented in this report.

12.2 Recommended Approach for the Culvert Replacement

From a foundation engineering perspective, both a set of circular pipes and a single or twin pre-cast segmental box culvert are considered feasible culvert replacement options. A temporary protection system (TPS), or a temporary widening would be required to facilitate construction.

13. FOUNDATION DESIGN RECOMMENDATIONS

Foundation design aspects for the replacement culvert include subgrade conditions, geotechnical resistances, settlement of the founding soils, imposed loading pressures, erosion control, temporary protection system design, groundwater control and stability of stage construction. The culvert must be designed to resist loading including lateral earth pressures, hydrostatic pressure, weight of embankment fill, traffic loading and any surcharge due to construction equipment and activities under static and seismic conditions.

13.1 Culvert Foundation Bearing Resistances

13.1.1 Box Culvert

A single or twin closed pre-cast box culvert may be founded on a bedding layer (see Section 13.2) in a dewatered temporary excavation overlying the existing loose to compact native, undisturbed

layers (e.g. sand to silty sand) at or below the elevation of the existing culvert (invert at approximately 466.1 m). Assuming a base slab thickness of 0.3 m, the existing stratigraphy at the anticipated founding elevation of 465.8 m consists of loose to compact sand to silty sand. For a box culvert the design can be based on the factored geotechnical resistance values presented in Table 13.1.

Table 13.1: Box Culvert Factored Geotechnical Resistances

Culvert Width	6 to 9 m
Factored ULS	240 kPa
Factored SLS (25 mm settlement)	90 kPa
Factored SLS (35 mm settlement)	105 kPa

The factored geotechnical resistances include the following factors:

- Consequence factor (Ψ) of 1.0 (as per CHBDC Table 6.1)
- Geotechnical resistance factors (as per CHBDC Table 6.2):
  - ϕ_{gu} = 0.5 (for bearing, static analysis; typical degree of understanding)
  - ϕ_{gs} = 0.8 (for settlement, static analysis; typical degree of understanding)

The bearing resistance values are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be reduced in accordance with Section 6.10 of the CHBDC. Foundation settlement, based on the supplied SLS resistance values, is expected to be up to 25 mm for a 90 kPa load and up to 35 mm for a 105 kPa load. Most of the settlement will be completed by the end of construction and the remaining will occur when the culvert is subjected to repeated live loads when the road is reopened.

Resistance to lateral forces/sliding resistance between concrete and native granular soil or the underlying Granular 'A' bedding (Section 13.2) should be evaluated in accordance with the CHBDC assuming an unfactored coefficient of 0.45 for precast concrete. A geotechnical resistance factor against sliding (Φ_{gu}) of 0.80 as per Table 6.2 of the CHBDC (analysis – typical understanding) for frictional sliding of shallow foundations is to be applied to the calculated value.

It is noted that construction will extend below the observed creek water level. Water diversion and dewatering (Sections 14.5 to 14.7) will be required to place the bedding material and install the culvert in the dry.

13.1.2 Pipe Culvert

Geotechnical resistance values are not required for pipe culverts.

13.2 Subgrade Preparation, Bedding and Backfilling

Subgrade preparation for the culvert replacement should include excavation and removal of the existing culvert and backfill materials. All organics, soft deposits, disturbed soils, and deleterious materials must be removed from the footprint of the foundation to expose competent subgrade at or below the desired founding elevations. It should be noted that unsuitable organic material was observed in Boreholes 20-01, 20-04 and BK-1 through BK-4 to as deep as elevation 467.0 m.

The exposed final subgrade must be inspected to confirm that the subgrade is suitable and uniformly competent. Any soft or organic materials at the subgrade level should be sub-excavated and backfilled with granular fill consisting of OPSS.PROV 1010 Granular A or Granular B Type II material as soon as practical to protect the subgrade from disturbance during construction. The granular fill should be compacted as per OPSS.PROV 501.

The bedding and backfill requirements should be consistent with Section 7 of the CHBDC, OPSS.PROV 401, OPSS 422, OPSS.PROV 501 and OPSS 902. In order to provide a more uniform foundation subgrade condition for a circular pipe or closed box culvert, a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A, or Granular B Type II with a maximum particle size of 26.5 mm, requirements should be placed on the undisturbed subgrade and compacted to 98% of Standard Proctor Maximum Dry Density (SPMDD) to +/- 2% of Optimum Moisture Content (OMC) as per OPSS.PROV 501. A separation layer consisting of a non-woven geotextile should be placed between the subgrade soils and the bedding material. The geotextile should meet the specifications for OPSS Class II, and have a fabric opening size (FOS) not greater than 212 µm. 75 mm thick layer of uncompacted Granular A should be placed above the bedding layer as a levelling course to receive the placement of the box culvert sections.

For the circular pipe and closed box culvert options, the sand to silty sand subgrade may be disturbed when saturated and should be protected from disturbance from both construction traffic and weather. Construction equipment should not be permitted to travel on the exposed subgrade. The bedding should be placed as soon as possible after reaching the final subgrade level and receipt of written notice to proceed.

It is noted that construction will extend below the creek elevation. Water diversion and dewatering will be required and the bedding must be placed and compacted in the dry. Refer to Sections 14.5

to 14.7 for additional comments on groundwater and surface water control. Due to the large anticipated dewatering discharge volumes, and if it not possible to fully dewater the excavation, consideration may be given to backfilling any sub-excavated areas below the culvert bedding in the wet (if soft or organic materials at the subgrade level require sub-excavation and replacement). Further discussion of construction in the wet is provided in Section 13.3 below.

It is recommended that culvert cover and backfill be placed in accordance with OPSS 902 and consist of free-draining, non-frost susceptible granular materials such as Granular A, or Granular B Type II with a maximum particle size of 26.5 mm, material meeting the requirements of OPSS.PROV 1010.

Culvert backfill above the granular cover should be in accordance with OPSS 902 and consist of material meeting the requirements of OPSS Granular B Type I or III and should be compacted in regular lifts as per OPSS.PROV 501 and the CHBDC. The backfill should be placed and compacted in simultaneous lifts on both sides of the culvert, and the top of backfill elevation should not differ more than 500 mm on both sides of the culvert at all times. Care must be exercised when compacting the fill adjacent to and above the culvert in order not to damage the culvert. Heavy compaction equipment used adjacent to the culvert must be restricted in accordance with OPSS.PROV 501.

13.3 Construction in Wet Conditions

As dewatering of the excavations will result in large dewatering volume and it may be difficult to fully dewater the site in the foundation sands, placement of any backfill below the culvert bedding may have to be done in the wet. When backfilling is conducted in the wet, select rock fill should be used. The recommended gradation of the rock fill is as follows:

Sieve Size	Percent Passing (%)
150 mm	100
106 mm	50 – 100
75 mm	15 – 80
26.5 mm	0 – 15
0.075 mm	0 - 2

A separation layer consisting of a non-woven geotextile should be placed between the native soils and rock fill. The geotextile should meet the specifications for the OPSS.PROV 1860 Class II, and

have a fabric opening size (FOS) not greater than 212 micro millimetres. The rock fill should be completely wrapped with the geotextile to minimize migration of the fines into the rock fill.

Rock fill used to backfill sub-excavated areas below the water table may be placed by end dumping. Granular fill must not be used to backfill excavations below the water table. The rock fill placement below the water level should follow OPSS.PROV 209 (Embankments over Swamps and Compressible Soils). The water level should be maintained at a minimum elevation below the base of the culvert bedding to allow for placement and compaction of the bedding to take place in the dry.

Another option would be to use a coarse 53 mm clear stone wrapped in geotextile for backfilling in the wet below the culvert bedding. Once the clear stone backfill is above the water level, granular bedding for the culvert may be placed in the dry.

Please note that these options will still require dewatering in order to lower the groundwater level to a sufficient depth to allow for placement of the culvert bedding in the dry.

13.4 Frost Depth

The depth of frost penetration at this site is estimated to be 2.5 m (OPSD 3090.100). It is not necessary to found a closed box or pipe culvert at a depth below frost penetration. Frost taper treatment should be provided at this site as per OPSD 803.010 (box culvert) or OPSD 803.031 (pipe culvert).

13.5 Lateral Earth Pressures

Lateral earth pressures parameters provided in Table 13.2 and Table 13.3 in the sections below are based on the assumptions that the wall is vertical and the backfill is fully drained so that there are no unbalanced hydrostatic pressures above the permanent groundwater level. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in design. Where ground surfaces are horizontal or sloped at 2H:1V (for head walls or wing walls) behind vertical walls, the corresponding coefficients provided in Tables 13.2 and 13.3 should be used. For other backfill and wall geometries, Thurber will need to calculate the appropriate earth pressure coefficients.

13.5.1 Static Lateral Earth Pressure

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC. but generally are given by the following expression:

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

where:

p_h = horizontal pressure on the wall at depth h (kPa)
K = earth pressure coefficient (see table below)
(K_a for yielding walls, K_o for non-yielding walls)
γ = unit weight of retained soil (see table below), use submerged unit weight below groundwater level
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

A lateral earth pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with Clause 6.12.3 of the CHBDC S6-2019. Typical earth pressure coefficients for backfill are shown in Table 13.2.

Table 13.2: Static Earth Pressure Coefficients

Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^o, \gamma = 22.8$ kN/m^3		OPSS Granular B Type I or III $\phi = 32^o, \gamma = 21.2$ kN/m^3		Sand Fill and Sand to Silty Sand $\phi = 29^o, \gamma = 20.0$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active, K_A (Yielding Wall)	0.27	0.39	0.31	0.47	0.35	0.58
At Rest, K_O (Non-Yielding Wall)	0.43	-	0.47	-	0.52	-
Passive, K_P (Movement towards Soil Mass)	3.7	-	3.3	-	2.9	-
Soil Group(*)	"medium dense sand"		"loose to medium dense sand"		"loose sand"	

Note: (*) for use with Figure C6.27 of the Commentary to the CHBDC.

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

The parameters in the table correspond to full mobilization of active and passive earth pressures and require certain relative movements between the wall and adjacent soil to produce these conditions. The values to be used in design can be assessed from Figure C6.27 of the Commentary to the CHBDC using the soil group designation as outlined in Table 13.2. Active earth pressures should be used for any head/wing walls or unrestrained walls. For rigid structures such as a concrete box culvert, at-rest horizontal earth pressures would apply for design.

13.5.2 Combined Static and Seismic Lateral Earth Pressure

In accordance with Clause 6.14.7 of the CHBDC (S6-19), retaining structures should be designed using dynamic earth pressure coefficients that incorporate the effects of earthquake loading. The following recommendations are per Section C6.14.7.2 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using the Mononobe-Okabe Method with:

- k_h = ½ * F(PGA) * PGA, for structures that allow 25 to 50 mm of movement, and
- k_h = F(PGA) * PGA, for non-yielding walls

The ratio of wall movement to wall height required to mobilize the active conditions would be approximately 0.002 for a yielding structure with respect to the assessment of seismically induced lateral earth pressures.

The coefficients of horizontal earth pressure for seismic loading presented in Table 13.3 may be used. The provided earth pressure coefficients are based on a Seismic Site Class E and a PGA with a 2% probability of exceedance in 50 years of 0.043g (Geological Survey of Canada – Fifth Generation) and a F(PGA) of 1.81 as per Table 4.8 of the CHBDC (S6-19).

Table 13.3: Dynamic Earth Pressure Coefficients

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^o$, $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I or III $\phi = 32^o$, $\gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Slope Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Slope Surface Behind Wall (2H:1V)
Active, K_{AE} Yielding Wall	0.29	0.44	0.33	0.54
Active, K_{AE} Non-Yielding Wall	0.31	0.51	0.35	0.65

The total pressure due to combined static and seismic loads acting at a specific depth below the top of the wall may be determined using the following equation that includes consideration of material properties and the soils profile.

$$\sigma_h = K * \gamma * d + (K_{AE} - K_A) * \gamma * (H - d)$$

where:

σ_h	=	lateral earth pressure at depth d (kPa)
d	=	depth below the top of the wall (m)
K	=	static earth pressure coefficient (K_A for yielding walls, K_o for non-yielding walls)
γ	=	unit weight of retained soil, use submerged unit weight below groundwater level
K_{AE}	=	combined static and seismic earth pressure coefficient
H	=	total height of the wall (m)

13.6 Embankment Design and Reinstatement

13.6.1 Embankment Reconstruction

Embankment reconstruction after culvert replacement should be carried out in accordance with OPSS.PROV 206. The embankment should be reinstated with side slopes of 2H:1V (or flatter) if constructed using Granular B Type I or III (OPSS.PROV 1010). The fill should be placed and compacted in accordance with OPSS.PROV 501.

Where newly placed embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, benching of the existing slope should be carried out in accordance with OPSD 208.010.

13.6.2 Embankment Settlement and Stability

Provided the subgrade is prepared as outlined above and construction of the embankment is carried out in accordance with recommendations provided within this report, the embankment side slopes should remain stable.

It is understood that no permanent grade raise or widening is anticipated along the alignment of Highway 17 and therefore negligible settlement of the underlying soils is expected to occur.

The magnitude of the embankment compression constructed with granular materials is in the order of 0.5% of the embankment height and is expected to occur following fill placement.

13.7 Cement Type and Corrosion Potential

Analytical tests were completed to determine the potential for degradation of the concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel. The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. Soluble sulphate concentrations less than 1000 μg/g in soil generally indicate a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. The class of concrete selected should consider the effects of road de-icing salts.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The test results provided in Section 6 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. The corrosion effects of road de-icing salts should also be considered.

Based on the test results summarized in Section 6:

- The potential for corrosion or sulphate attack on concrete foundations from the surrounding soil or creek water is considered to be negligible due to the low concentration of sulphate and chloride in the samples tested. However one native sand sample had a low pH of 5.29, which may indicate some potential for corrosion.

- The potential for corrosion on metal is considered to be moderate to mild.

- Appropriate corrosion protection measures are recommended for metal or concrete structural elements.

14. CONSTRUCTION CONSIDERATIONS

14.1 Excavation

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of OHSA, the fill and native soils above the groundwater table may be classified as Type 3 soil. Below the water table (i.e., if the groundwater flow is not controlled), the soils would be classified as Type 4 soils.

Excavations for the culvert replacement must be carried out in accordance with OPSS 902 and will be carried out through the existing embankment fill and extend into the underlying native deposits (silty sand to silty gravel). Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor. Stockpiling or surface surcharge should not be allowed on the embankment or side slopes.

At locations where there are space restrictions or where a slope has to be retained, the excavations will need to be carried out within a protection system. Further discussion on temporary protection systems (TPS) is presented in Section 14.4.

14.2 Stream Diversion Pipe

A stream diversion pipe is assumed to be required to facilitate either the rehabilitation of the existing culvert or the construction of a permanent replacement culvert. Design of the diversion pipe is the responsibility of the contractor and the invert level will depend on the water level in the creek at the time of construction. Based on Boreholes 20-01 and 20-04, located on the highway at possible diversion pipe locations, the pipe invert is expected to lie within embankment fill materials consisting of compact sand or in the underlying loose native sand to silty sand. Thin laminations of organic materials were noted within the native sand to silty sand.

The water level was measured at an Elevation of 467.9 m in the monitoring wells at the site. Hence, dewatering will be required for installation of the diversion pipe.

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

The stream diversion pipe could be installed within a temporary open cut excavation, or alternately within a shored trench. The installation of the diversion pipe in open cut should follow OPSD 802.014 and OPSS.PROV 421.

14.3 Cofferdams

Construction of cofferdams will be required to construct the culvert replacement or facilitate rehabilitation of the culvert in the dry. Since the subsurface soil conditions consist of highly permeable granular soils, it is anticipated that pumping from within an interlocking sheet pile

cofferdam system advanced to an appropriate depth to cut-off groundwater flow into the culvert excavation at this site will be required to prevent basal heaving in the foundation soil. Design of a suitable and effective dewatering system including cofferdams in the responsibility of the Contractor. The recommendations in Section 14.4 below for Temporary Protection Systems are also applicable to sheet piled cofferdams.

14.4 Temporary Protection Systems

Temporary Protection Systems (TPS) may be required during various stages of construction for the culvert replacement or rehabilitation and must be implemented in accordance with OPSS.PROV 539. Since the TPS will be supporting live lanes on Highway 17, it is recommended that the TPS be designed to Performance Level 2 (maximum 25 mm horizontal deflection). The Contractor should select the wall type and design taking into account the soil conditions encountered in the boreholes. The use of sheetpiles or soldier pile and lagging are likely feasible options for temporary roadway protection at this site. However, sheetpiles may potentially encounter obstructions such as cobbles in the embankment fill. In light of the presence of loose to compact native sand to silty sand foundation soils, vibratory equipment should not be used for the installation of sheetpiles. Suggested text for an NSSP on obstructions is included in Appendix H.

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

Lateral earth pressure coefficients, under fully mobilized conditions, that can be used in design of the protection system installed through the embankment fill, culvert backfill and native sand to silty sand are provided in Table 14.1 below. Submerged unit weight should be used below the groundwater level.

Table 14.1: Soil Parameters for Temporary Protection System/Cofferdam Design

Soil Parameter	Existing Sand Fill	Native Sand to Silty Sand
Angle of Internal Friction (ϕ)	29º	29º
Bulk Unit Weight (γ)	20 kN/m^3	19 kN/m^3
Submerged Unit Weight (γ_w)	10 kN/m^3	9 kN/m^3
Coefficient of Active Earth Pressure (K_a)	0.35	0.35
Coefficient of Passive Earth Pressure (K_p)	2.9	2.9

The design of roadway protection is the responsibility of the Contractor. All protection systems should be designed by a licensed Professional Engineer experienced in such designs and retained by the Contractor. The design of the roadway protection system must incorporate traffic loading and surcharge loading due to construction equipment and operations. The roadway protection system or cofferdams should be removed following construction by pulling with static force, rather that vibratory equipment due to the presence of loose to very loose foundation soils.

14.5 Surface and Groundwater Control

Culvert construction, subgrade preparation and placement and compaction of granular bedding should be carried out in the dry. The depth of excavations required to construct the culvert will extend below the creek level observed at the time of the investigation. Furthermore, groundwater and surface runoff will tend to seep into and accumulate into the excavations. The Contractor must make all reasonable efforts to control groundwater and creek/surface water flow at the site to permit the replacement of the culvert in a dry and stable excavation.

Subgrade preparation, placement and compaction of granular bedding, and culvert construction must be carried out with a properly designed dewatering system to control groundwater and creek/surface water and may include cofferdams, creek diversion, pumping etc. The dewatering system will be required to remain operational and effective until the temporary excavations are backfilled and then should be decommissioned and removed. Suggesting wording for an NSSP in this regard is included in Appendix H.

The design of suitable and effective dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system

in accordance with SP FOUN0003 which amends OPSS 902. FOUN0003 has been included in Appendix H.

In accordance with SP FOUN0003, the dewatering system is to be designed in accordance with OPSS.PROV 517. A preconstruction survey is not required, thus Designer Fill-In ** in SP FOUN0003 should be “N/A”.

The groundwater level will fluctuate and the minimum groundwater elevation at the time of the proposed work should be taken as the creek water level of the design storm return period defined by the contract documents for the temporary dewatering system.

Excavation below the creek level without prior dewatering is not recommended since the inflow of water will cause base heave/boiling and sloughing of the soil below the water level, making it difficult to maintain a dry, sound base on which to work. The groundwater level within the work zone should be lowered to a minimum of 500 mm below the underside of the planned excavation base prior to each stage of excavation. The use of wellpoints will likely be required at this site, rather than traditional sumps.

If it is difficult to fully dewater the site for the purposing of sub-excavation and backfilling of unsuitable subgrade soils below the culvert bedding, consideration may be given to carrying out these works in the wet, as described in Section 13.3.

14.6 Dewatering Assessment

Groundwater taking for construction dewatering is governed by the Ontario Water Resources Act (OWRA), Environmental Protection Act (EPA) and the Water Taking and Transfer Regulation 387/04, a regulation under the OWRA.

If the water taking rate will be greater than 50,000 L/day and less than 400,000 L/day then registration on the Environmental Activity and Sector Registry (EASR) will be required. If the water taking rate will be greater than 400,000 L/day, then a Category 3 Permit To Take Water (PTTW) will be required. A preliminary assessment of the need for water taking permitting is provided herein; however, additional analysis will be required to confirm this.

As the proposed replacement structure has not been selected at the time of writing this foundation investigation and design report, a general arrangement drawing was not available for review. The dimensions and conditions that were assumed for the preliminary dewatering assessment are therefore provided in Table 14.2 below. The geologic units that will need to be dewatered include the gravelly sand fill and the native silty sand to sand foundation soils. It is assumed that the predominant unit controlling flow to the excavation will be the sand, and the permeability of the

sand is assumed to be represented by the SWRTs conducted within that layer. Thus, a hydraulic conductivity of 1.0 x 10^{-4} m/s was used in the estimate (as described in Section 8). The bottom elevation of the sand layer was assumed to be approximately 460 m.

Table 14.2: Assumed Excavation Dimensions and Ground Conditions

Structure	Assumed Excavation Footprint (m)	Lowest Assumed Elevation of Excavation (m)	Assumed Groundwater Elevation (m)	Geologic Units to Dewater
Baker Creek Culvert Excavation	30 x 15	465	467.9	Gravelly Sand Fill Silty Sand to Sand

For the purpose of estimating water taking flow rates it was assumed that surface water flow would be directed around the excavation such that surface water will not enter the excavation at a significant rate.

The following approach was used to estimate the budgeted peak water taking rate:

- A base groundwater extraction flow rate was estimated, and a factor of safety of three was applied to this flow rate to provide an allowance for removal of water from soil storage, variation in hydraulic conductivity, actual excavation dimensions and geometry, and ground water levels due to seasonality or other factors;
- An allowance for removal of rainfall directly into the excavation was included, assuming 24 hours are used to remove 50 mm of rainfall; and
- Lowering of groundwater to 1 m below the base of the excavation to facilitate a dry, stable work area was assumed.

The water taking will be temporary in nature for the purpose of construction dewatering for installation of the infrastructure. Dewatering rates were estimated using the Dupuit analytical solution. The radius of influence was calculated using the Sichardt equation.

The preliminary peak water taking rate was estimated to be greater than 1,500,000 litres per day including the safety factor and rainfall allowance. The flow rate is significant because of the permeable nature of the foundation sand and the high groundwater level. The preliminary radius of influence was estimated to be approximately 120 m.

A Category 3 PTTW is anticipated to be required for construction of the culvert under the assumed conditions. A Hydrogeological Study would be required to provide the necessary data and analysis for application to the Ministry of the Environment, Conservation and Parks (MECP). The Hydrogeological Study will need to include an impact assessment as well as mitigation measures, a monitoring plan, and a contingency plan. An assessment of the potential need for additional

field work will need to be assessed. The duration required to receive the permit from MECP once it has been received in good order is typically 3 to 5 months, assuming no further field work or significant revisions are required.

It should be noted that in the event that the rehabilitation option is selected, then a peak water taking rate of greater than 1,000,000 L per day is anticipated, which will also require a PTTW if constructed in the dry.

14.7 Water Quality

For assessment of the general groundwater quality in the project area for potential discharge purposes, surface and groundwater samples were collected from the creek and well at Borehole 20-02. As noted in Section 7, a combined water sample was tested and compared to the Provincial Water Quality Objectives (PWQO) criteria. The water sample test results are summarized in Table 7.1.

The test results indicate that five of the inorganic parameters tested exceeded the PWQO criteria for dissolved or total concentrations. Therefore, if dewatering is used at this site, it is likely that treatment of the discharge water through the use of filtering, settling tanks or other methods may be required prior to discharge into local surface water bodies such as creeks. However as the combined water sample tested is not directly representative of the groundwater, it is recommended that additional water samples be collected and tested prior to and/or during construction to confirm the groundwater quality and monitor the quality of discharge water, if necessary to meet PTTW requirements.

14.8 Scour Protection and Erosion Control

The Contractor should provide silt fences and erosion control blankets as per OPSS 805 throughout the duration of construction to prevent transport of silt/sediment. Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. Slope vegetation should be established as soon as possible after completion of the embankment fills in order to limit surficial erosion.

Particle size analyses in conjunction with the Wischmeier Nomograph indicate that the granular fill and native soils encountered on site have a low erosion potential.

Scour and erosion protection should be provided for the permanent culvert inlet and outlet areas. Design of the scour and erosion protection measures must consider hydrologic and hydraulic concerns and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all earth surfaces subjected to flowing water in accordance with OPSS 511. Treatment at the inlet and outlet should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

It is recommended that a clay seal and/or a concrete cut-off wall be used to minimize the potential for piping and erosion around the inlet of the culvert. The clay seal must extend to approximately 300 mm above the high water level and laterally for the width of the granular material, and have a minimum thickness of 500 mm. The clay seal should also extend below the bedding and scour level if a concrete cut-off wall is not also used. The material requirements for a clay seal should be in accordance with OPSS.PROV 1205. A geosynthetic clay liner may be used as a clay seal. The concrete cut-off wall should be constructed per OPSD 812.010 for CSP culverts.

15. CONSTRUCTION CONCERNS

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

- The terrain around this culvert is swampy with up to 1.4 m of peat encountered in the off-road boreholes.
- A suitable dewatering / unwatering system must be employed to enable culvert construction in the dry and prevent sloughing and instability of the excavation walls. It should be noted that a Category 3 PTTW will likely be required for dewatering at this site.
- Disturbance of the soil subgrade. The native loose to compact sand to silty sand may be easily disturbed. Construction traffic must not be allowed on the final subgrade.
- Creek water levels will fluctuate. Excavation will involve lowering the water level below the excavation base to maintain a reasonably dry excavation and stable side slopes. The dewatering scheme will be critical for culvert construction at this site.
- Cobbles, boulders or other buried obstructions may be encountered during excavation in the existing embankment fill and may interfere with installation of the temporary roadway protection system, if required. Suggested wording for an NSSP on obstructions is included in Appendix H.

The successful performance of the culvert installation will depend largely upon good workmanship and quality control during construction. Subgrade examination should be carried out by qualified geotechnical personal during construction to confirm that foundation recommendations are correctly implemented and material specifications are met.

16. CLOSURE

Engineering analysis and preparation of the design report was carried out by Mr. Christopher Murray, P.Eng. and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Designated MTO Principal Contact

THURBER

Appendix A

Record of Borehole Sheets (Current Investigation)

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 20-01 1 OF 2 METRIC

W.P. 6336-14-00 LOCATION Baker Creek, MTM Zone 15, NAD 83: N 5 444 560.7 E 249 456.0 ORIGINATED BY GS

DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing with Wash Boring COMPILED BY AN

DATUM Geodetic DATE 2020.08.11 - 2020.08.11 LATITUDE 49.136681 LONGITUDE -90.758514 CHECKED BY JM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
469.7	GROUND SURFACE										
0.0	**ASPHALT:** (150mm)										
0.2	**SAND**, some gravel, some silt and clay, occasional cobbles Compact Brown Moist (FILL)		1	GS							12 77 11 (SI+CL)
468.3			2	SS	24	▽	469				
1.4	**SAND**, trace silt, trace gravel Loose Brown		3	SS	7		468				
467.8 1.9 467.6	Moist (FILL)									150	
2.1	Organics layer from 1.9m to 2.1m Black		4	SS	7		467				
	Silty **SAND**, trace clay, trace gravel Very Loose to Compact Brown Wet Trace organics and bark from 2.1m to 3.0m		5	SS	4		466				
			6	SS	17		465				0 77 22 1
			7	SS	3		464				
	Becoming grey		8	SS	13		463				
461.0							462				
8.7	Sandy **SILT** to **SAND** and **SILT**, trace clay Very Loose to Loose Grey Wet		9	SS	5		461				
							460				

Continued Next Page

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

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

ONTMT4S2 MTO-29181.GPJ 2017TEMPLATE(MTO).GDT 11/18/20

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RECORD OF BOREHOLE No 20-01 2 OF 2 METRIC

W.P. 6336-14-00 LOCATION Baker Creek, MTM Zone 15, NAD 83: N 5 444 560.7 E 249 456.0 ORIGINATED BY GS

DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing with Wash Boring COMPILED BY AN

DATUM Geodetic DATE 2020.08.11 - 2020.08.11 LATITUDE 49.136681 LONGITUDE -90.758514 CHECKED BY JM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Sandy **SILT** to **SAND** and **SILT**, trace clay Very Loose to Loose Grey Wet										
			10	SS	4		459		○		0 65 34 1
							458				
			11	SS	2				○		
							457				
			12	SS	5		456		○		
							455				
453.9			13	SS	6		454				
15.8	END OF BOREHOLE AT 15.8m. BOREHOLE OPEN TO 3.5m AND WATER LEVEL AT 1.4m. BOREHOLE BACKFILLED WITH BENTONITE TO 0.3m, SAND TO 0.1m, THEN ASPHALT PATCH TO SURFACE.										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

ONTMT4S2 MTO-29181.GPJ 2017TEMPLATE(MTO).GDT 11/18/20

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THURBER

RECORD OF BOREHOLE No 20-02 1 OF 2 METRIC

W.P. 6336-14-00 LOCATION Baker Creek, MTM Zone 15, NAD 83: N 5 444 548.7 E 249 458.2 ORIGINATED BY GS

DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing with Wash Boring COMPILED BY AN

DATUM Geodetic DATE 2020.08.10 - 2020.08.12 LATITUDE 49.136574 LONGITUDE -90.758482 CHECKED BY JM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
469.3	GROUND SURFACE										
0.0	**SAND**, some gravel, trace silt Loose Brown Moist (FILL)		1	GS			469				
467.9			2	SS	6						17 77 6 (SI+CL)
1.4	**SAND**, trace gravel, trace silt, trace clay, with hydrocarbon odour Very Loose to Loose Brown Wet (FILL)		3	SS	5		468				
			4	SS	0		467				
466.1			5	SS	7						5 88 6 1
3.2	**SAND**, some silt, trace gravel Loose to Compact Brown Wet						466				
			6	SS	17		465				
							464				
	Becoming grey		7	SS	6		463				
							462				
			8	SS	9		461				
460.3											
9.0	Sandy **SILT**, trace clay Very Loose Grey Wet		9	SS	1		460				

Continued Next Page

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

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

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RECORD OF BOREHOLE No 20-02 2 OF 2 METRIC

W.P. 6336-14-00 LOCATION Baker Creek, MTM Zone 15, NAD 83: N 5 444 548.7 E 249 458.2 ORIGINATED BY GS

DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing with Wash Boring COMPILED BY AN

DATUM Geodetic DATE 2020.08.10 - 2020.08.12 LATITUDE 49.136574 LONGITUDE -90.758482 CHECKED BY JM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Sandy **SILT**, trace clay Very Loose to Loose Grey Wet						459				
			10	SS	3		458		○		
			11	SS	1		457		○		0 31 67 2
			12	SS	2		456		○		
							455				
453.5			13	SS	5		454		○		
15.8	END OF BOREHOLE AT 15.8m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2020.08.12	1.7	467.6
2020.08.21	1.4	467.9

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No 20-03 1 OF 2 METRIC

W.P. 6336-14-00 LOCATION Baker Creek, MTM Zone 15, NAD 83: N 5 444 556.9 E 249 472.1 ORIGINATED BY GS

DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing with Wash Boring COMPILED BY AN

DATUM Geodetic DATE 2020.08.11 - 2020.08.11 LATITUDE 49.136649 LONGITUDE -90.758292 CHECKED BY JM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
469.6	GROUND SURFACE										
0.0	Gravelly **SAND**, trace silt, occasional cobbles Loose to Compact Brown Moist (FILL)		1	GS			469	○	○		30 64 6 (SI+CL)
			2	SS	10				○		
			3	SS	13		468		○		
			4	SS	8		467		○		
466.6											
3.0	Silty **SAND**, trace gravel, trace clay Loose to Compact Brown Wet		5	SS	4		466		○		
			6	SS	20		465		○		
464.0							464				
5.6	**SAND**, trace silt, trace clay Loose Grey Wet		7	SS	5		463		○		0 94 5 1
			8	SS	4		462		○		
460.9							461				
8.7	Sandy **SILT**, trace clay Very Loose to Loose Grey Wet		9	SS	4		460		○		

Continued Next Page

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

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

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THURBER

RECORD OF BOREHOLE No 20-03 2 OF 2 METRIC

W.P. 6336-14-00 LOCATION Baker Creek, MTM Zone 15, NAD 83: N 5 444 556.9 E 249 472.1 ORIGINATED BY GS

DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing with Wash Boring COMPILED BY AN

DATUM Geodetic DATE 2020.08.11 - 2020.08.11 LATITUDE 49.136649 LONGITUDE -90.758292 CHECKED BY JM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Sandy **SILT**, trace clay Very Loose to Loose Grey Wet										
			10	SS	3		459				
							458				
			11	SS	3		457				
							456				
			12	SS	10						0 31 67 2
							455				
453.8			13	SS	7		454				
15.8	END OF BOREHOLE AT 15.8m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2020.08.12 2.0 467.6 2020.08.21 1.7 467.9										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 20-04 1 OF 2 METRIC

W.P. 6336-14-00 LOCATION Baker Creek, MTM Zone 15, NAD 83: N 5 444 548.1 E 249 475.3 ORIGINATED BY GS

DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing with Wash Boring COMPILED BY AN

DATUM Geodetic DATE 2020.08.10 - 2020.08.10 LATITUDE 49.136570 LONGITUDE -90.758247 CHECKED BY JM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
469.6	GROUND SURFACE										
0.0	**ASPHALT:** (125mm)										
0.1	**SAND**, trace gravel, trace silt Compact Brown Moist (FILL)		1	GS			469		○		
468.2			2	SS	19				○		8 84 8 (SI+CL)
1.4	Silty **SAND** Loose Brown with Grey pockets Wet (FILL)		3	SS	7	▽	468		○		
467.2											
2.4	**PEAT**, mixed with sand		4	SS	8		467		○	167	0 74 25 1
467.0	Loose Black Wet										
2.6	Silty **SAND**, trace clay Very Loose to Loose Grey to Dark Grey Wet Trace organics from 2.6m to 2.9		5	SS	2		466		○		
			6	SS	8		465		○		
			7	SS	7		464		○		
			8	SS	7		463		○		
			9	SS	3		462		○		0 64 35 1
							461				
							460				

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No 20-04 2 OF 2 METRIC

W.P. 6336-14-00 LOCATION Baker Creek, MTM Zone 15, NAD 83: N 5 444 548.1 E 249 475.3 ORIGINATED BY GS

DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing with Wash Boring COMPILED BY AN

DATUM Geodetic DATE 2020.08.10 - 2020.08.10 LATITUDE 49.136570 LONGITUDE -90.758247 CHECKED BY JM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							20 40 60 80 100	20 40 60		
	Silty **SAND**, trace clay Very Loose Grey Wet										
			10	SS	2		459		○		
457.9							458				
11.7	Sandy **SILT** to **SAND** and **SILT**, trace clay Very Loose to Loose Grey Wet		11	SS	2		457		○		0 43 55 2
			12	SS	9		456		○		
			13	SS	8		455				
453.8							454				
15.8	END OF BOREHOLE AT 15.8m. BOREHOLE OPEN TO 3.0m AND WATER LEVEL AT 1.9m. BOREHOLE BACKFILLED WITH BENTONITE TO 0.3m, SAND TO 0.1m, THEN ASPHALT PATCH TO SURFACE.										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
$\frac{}{10}$

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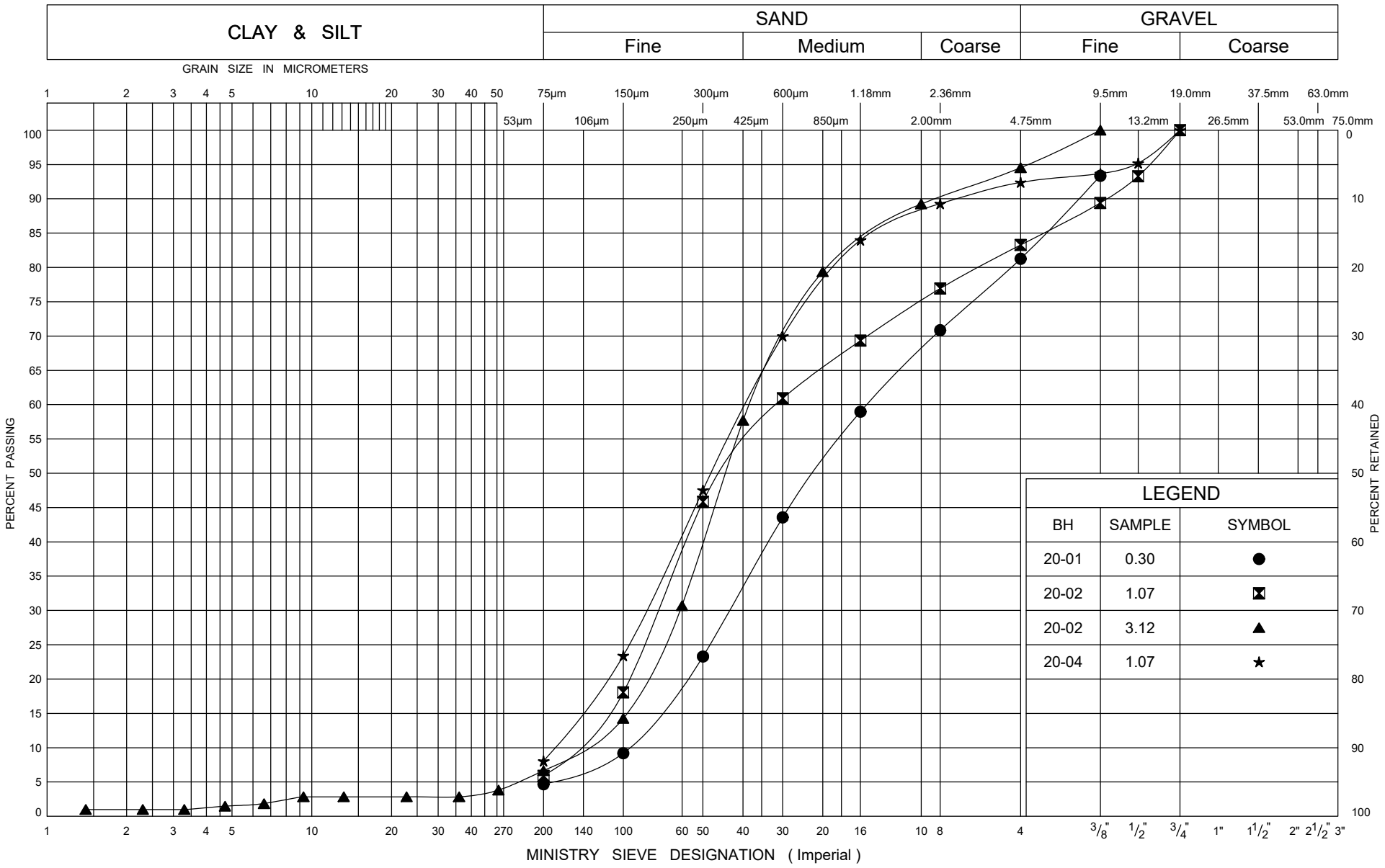
Appendix B

Laboratory Test Results (Current Investigation)



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GRAIN SIZE DISTRIBUTION

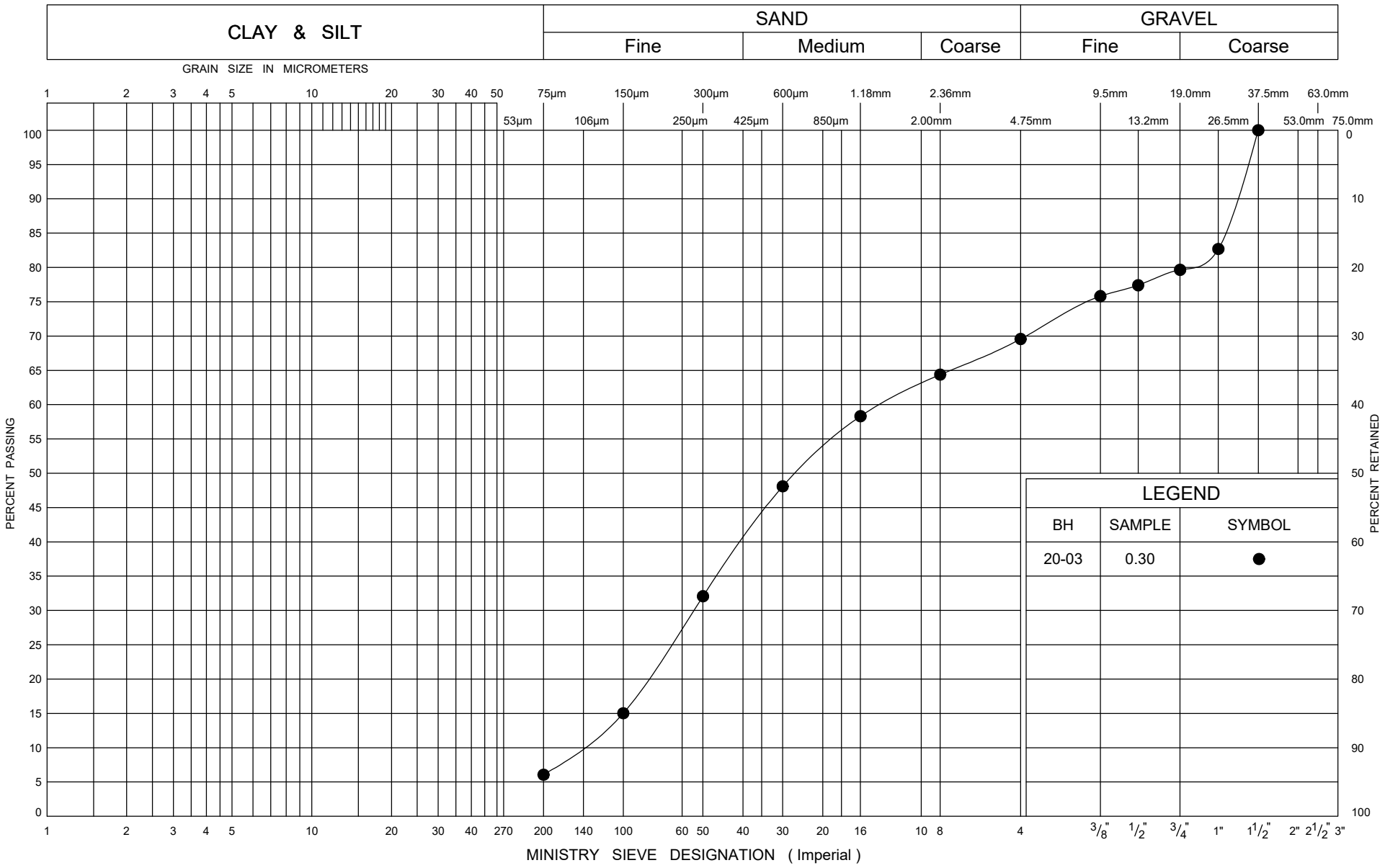
SAND FILL

FIG No B1

W P 6336-14-00

Baker Creek

ONTARIO MOT GRAIN SIZE 2 MTO-29181.GPJ ONTARIO MOT.GDT 9/18/20



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GRAIN SIZE DISTRIBUTION

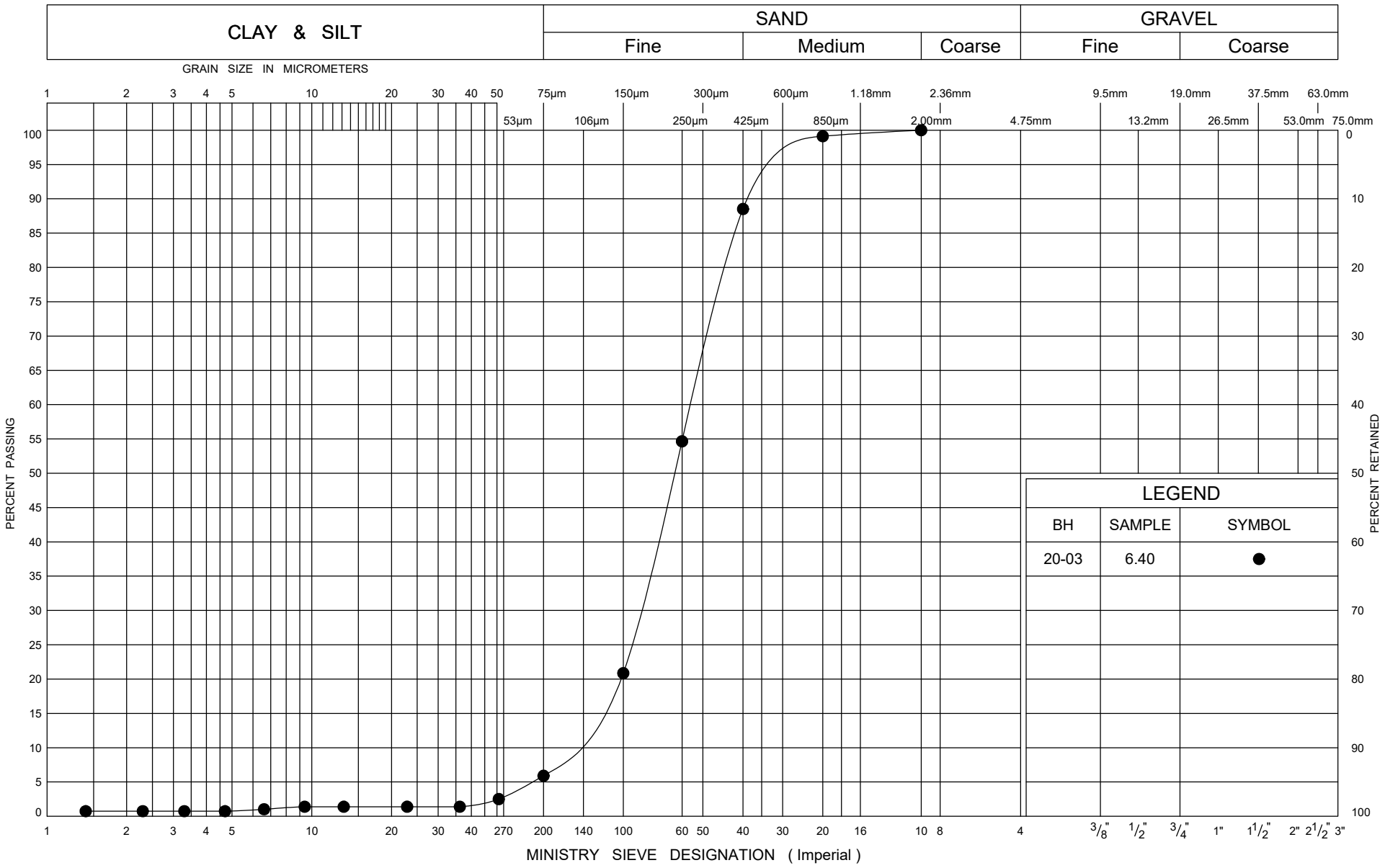
Gravelly SAND FILL

FIG No B2

W P 6336-14-00

Baker Creek

ONTARIO MOT GRAIN SIZE 2 MTO-29181.GPJ ONTARIO MOT.GDT 9/18/20



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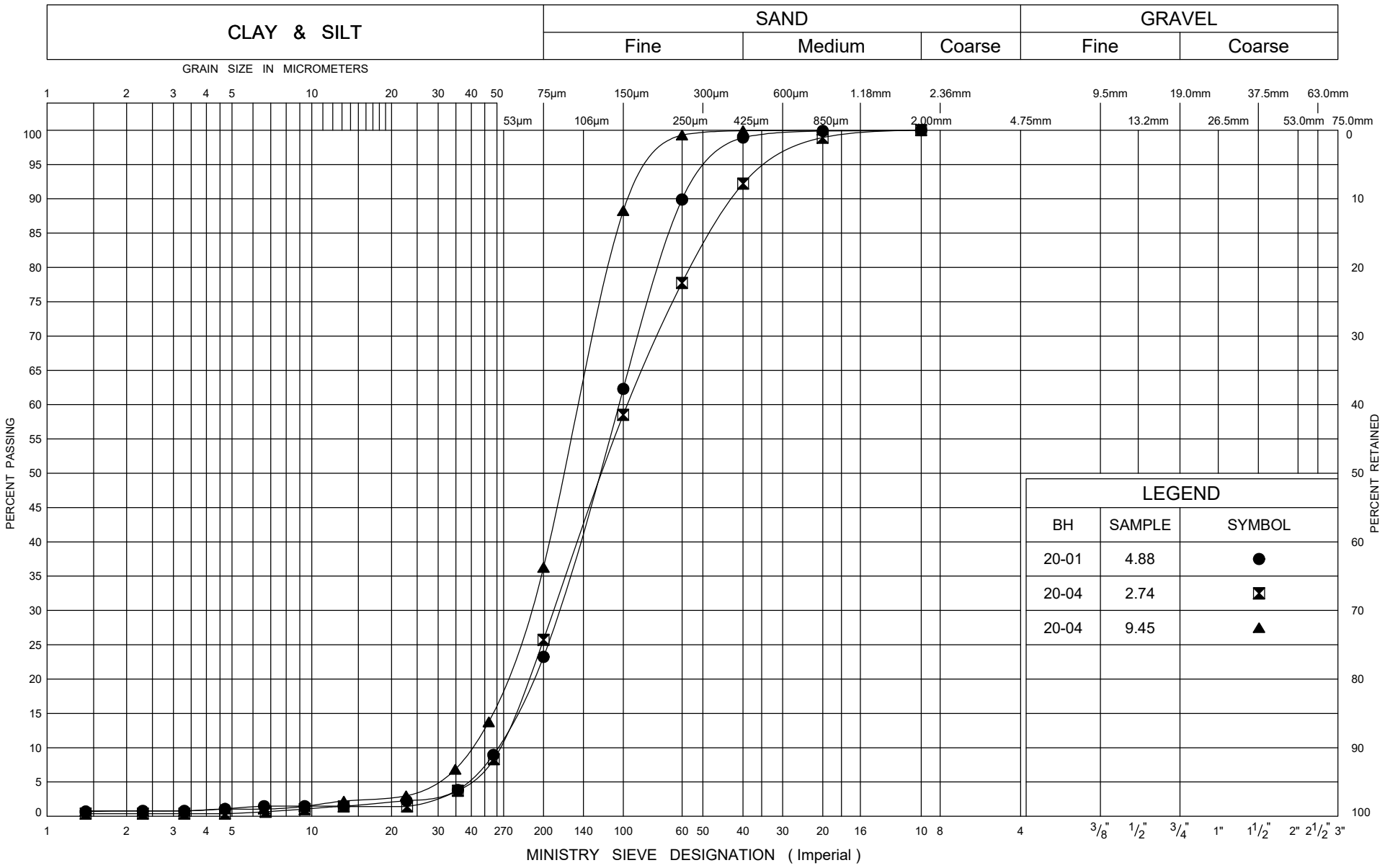
GRAIN SIZE DISTRIBUTION

SAND

FIG No B3

W P 6336-14-00

Baker Creek



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GRAIN SIZE DISTRIBUTION

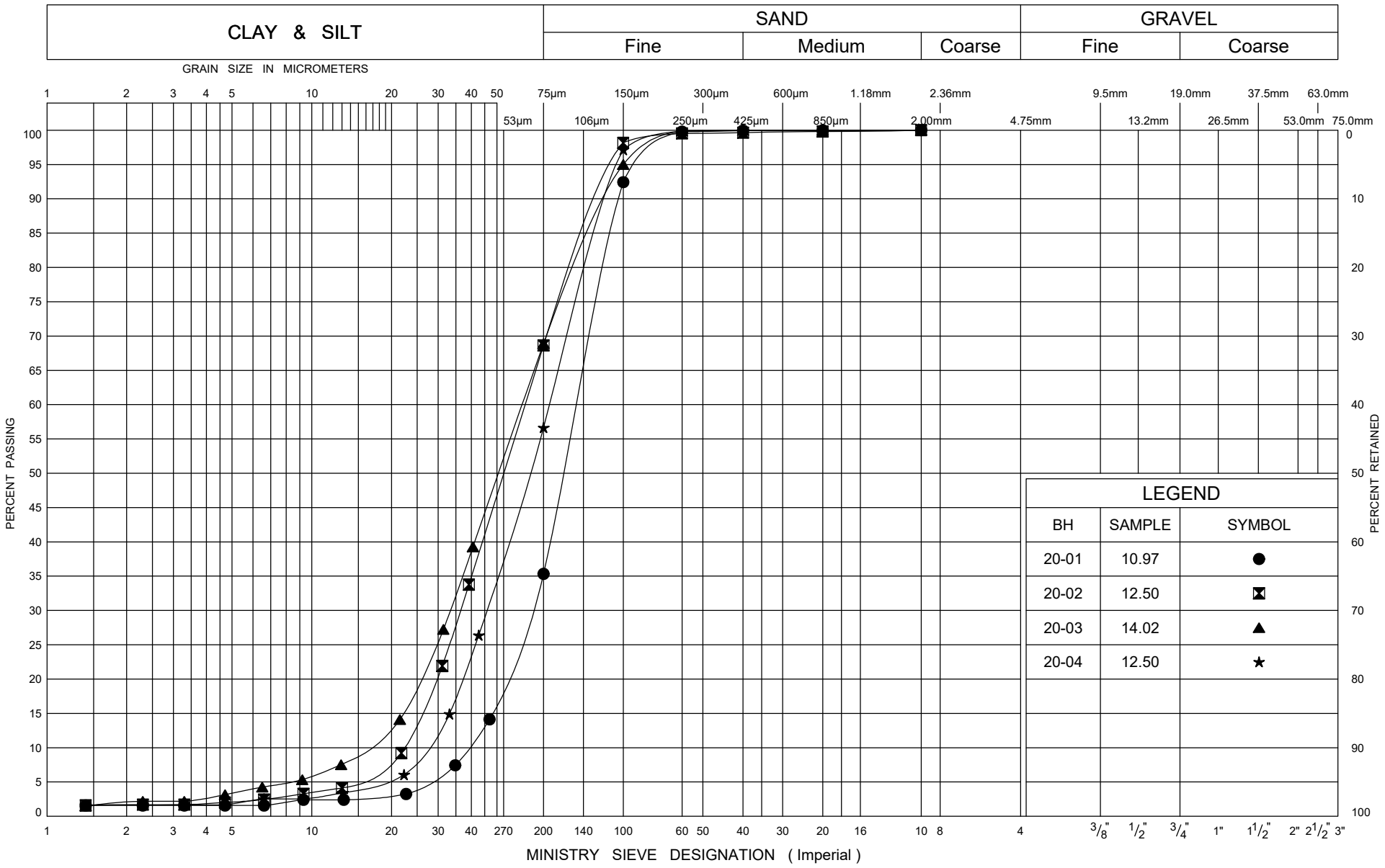
Silty SAND

FIG No B4

W P 6336-14-00

Baker Creek

ONTARIO MOT GRAIN SIZE 2 MTO-29181.GPJ ONTARIO MOT.GDT 9/18/20



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GRAIN SIZE DISTRIBUTION

Sandy SILT to SAND and SILT

FIG No B5

W P 6336-14-00

Baker Creek

ONTARIO MOT GRAIN SIZE 2 MTO-29181.GPJ ONTARIO MOT.GDT 9/18/20

THURBER ENGINEERING LTD.

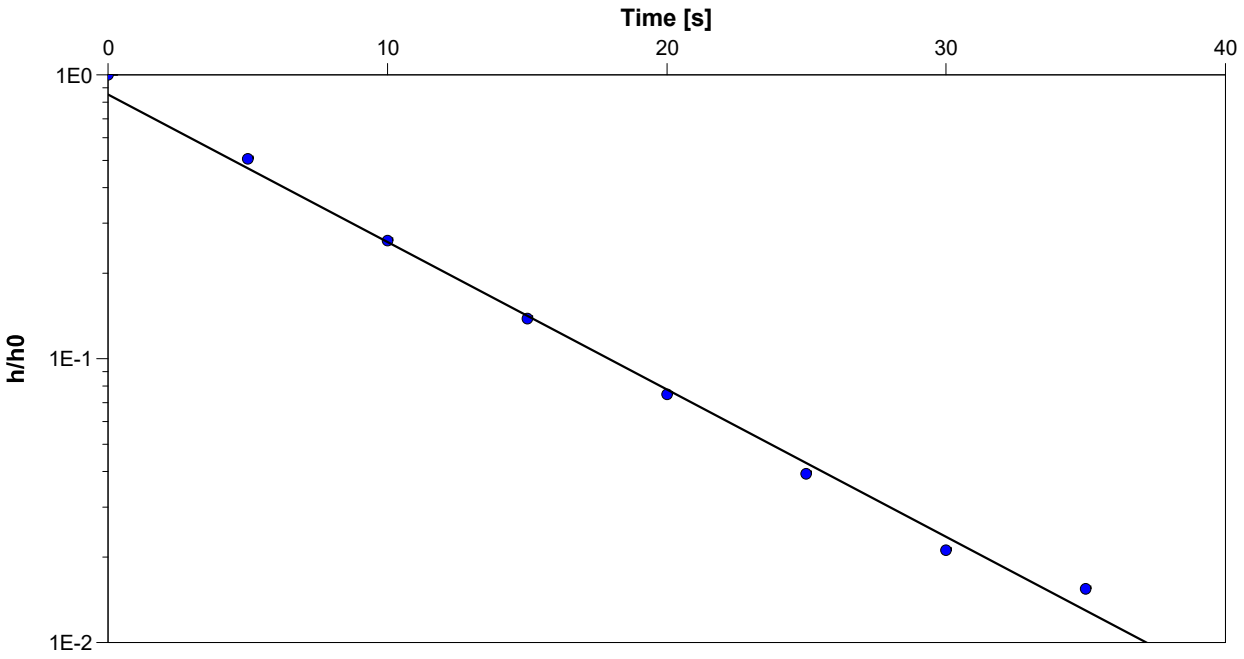
Slug Test Analysis Report

Project: Baker Creek Culvert

Number: 29181

Client: Hatch

Location: Baker Creek Culvert	Slug Test: 20-02	Test Well: 20-02
Test Conducted by: GS		Test Date: 2020-08-21
Analysis Performed by: PC	20-02 SWRT Analysis	Analysis Date: 2020-09-18
Aquifer Thickness:		
Checked by: DH		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
20-02	1.0×10^{-4}	

THURBER ENGINEERING LTD.

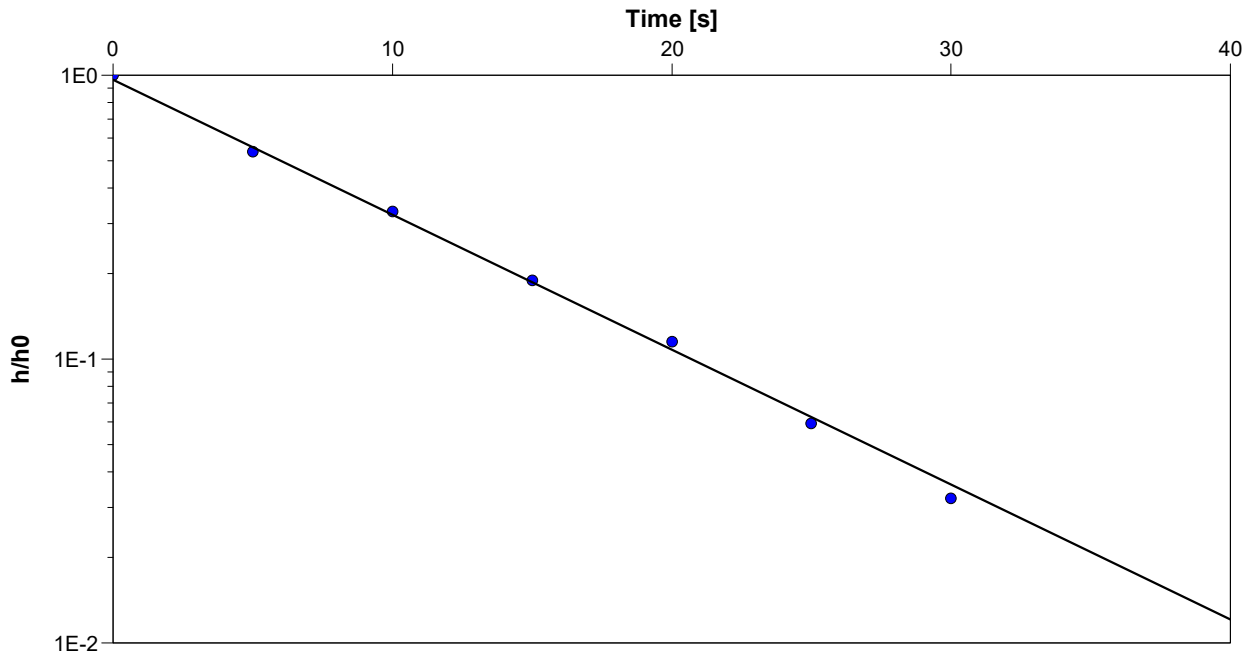
Slug Test Analysis Report

Project: Baker Creek Culvert

Number: 29181

Client: Hatch

Location: Baker Creek Culvert	Slug Test: 20-03	Test Well: 20-03
Test Conducted by: GS		Test Date: 2020-08-12
Analysis Performed by: PC	20-03 SWRT Analysis	Analysis Date: 2020-09-18
Aquifer Thickness:		
Checked by: DH		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
20-03	9.3×10^{-5}	

Your Project #: 29181
Site Location: BAKER CREEK CULVERT
Your C.O.C. #: n/a

Attention: Judy Mei

Thurber Engineering Ltd
2010 Winston Park Dr
Suite 103
Oakville, ON
CANADA L6H 5R7

Report Date: 2020/09/11
Report #: R6326370
Version: 2 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C0M0935
Received: 2020/08/27, 14:35

Sample Matrix: Soil
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (20:1 extract)	2	2020/09/01	2020/09/01	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	2	2020/09/01	2020/09/01	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 3)	2	N/A	2020/09/02	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	2	N/A	2020/09/02	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	2	2020/09/01	2020/09/01	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	2	2020/08/27	2020/09/01	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	2	2020/09/01	2020/09/02	CAM SOP-00464	EPA 375.4 m
Redox Potential (2, 4)	2	N/A	N/A		

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in BV Labs profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) This test was performed by BVLabs Calgary via Mississauga
(2) This test was performed by Sub from Campo to Env. Testing Canada (Eurofins)
(3) Offsite analysis requires that subcontracted moisture be reported.

Your Project #: 29181
Site Location: BAKER CREEK CULVERT
Your C.O.C. #: n/a

Attention: Judy Mei

Thurber Engineering Ltd
2010 Winston Park Dr
Suite 103
Oakville, ON
CANADA L6H 5R7

Report Date: 2020/09/11
Report #: R6326370
Version: 2 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C0M0935
Received: 2020/08/27, 14:35

(4) Oxidation-Reduction Potential (ORP) values are determined using a Ag/AgCl reference electrode.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Antonella Brasil, Senior Project Manager
Email: Antonella.Brasil@bvlabs.com
Phone# (905)817-5817

==========

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

BV Labs Job #: C0M0935
Report Date: 2020/09/11

Thurber Engineering Ltd
Client Project #: 29181
Site Location: BAKER CREEK CULVERT
Sampler Initials: JM

SOIL CORROSIVITY PACKAGE (SOIL)

BV Labs ID		NME948	NME949		
Sampling Date		2020/08/26 15:00	2020/08/26 15:00		
COC Number		n/a	n/a		
	UNITS	20-03, SS3 (5' - 7')	20-02, SS5B (10'6'' - 12'')	RDL	QC Batch
Calculated Parameters					
Resistivity	ohm-cm	2200	3700	N/A	6914206
Inorganics					
Soluble (20:1) Chloride (Cl-)	ug/g	280	190	20	6921178
Conductivity	umho/cm	448	269	2	6920713
Available (CaCl2) pH	pH	6.88	5.29	N/A	6920644
Soluble (20:1) Sulphate (SO4)	ug/g	<20	<20	20	6921183
Sulphide	mg/kg	<0.5 (1)	<0.5 (1)	0.5	6924474
Physical Testing					
Moisture-Subcontracted	%	12	17	0.30	6928285

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable
(1) Sample contained greater than 10% headspace at time of extraction.

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

BV Labs Job #: C0M0935
Report Date: 2020/09/11

Thurber Engineering Ltd
Client Project #: 29181
Site Location: BAKER CREEK CULVERT
Sampler Initials: JM

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	9.0°C

Sample NME948 [20-03, SS3 (5' - 7')] : Sample was analyzed past method specified hold time for Sulphide.

Sample NME949 [20-02, SS5B (10'6'' - 12'')] : Sample was analyzed past method specified hold time for Sulphide.

Results relate only to the items tested.

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BV Labs Job #: C0M0935
Report Date: 2020/09/11

Thurber Engineering Ltd
Client Project #: 29181
Site Location: BAKER CREEK CULVERT
Sampler Initials: JM

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
6920644	NYS	Spiked Blank	Available (CaCl2) pH	2020/09/01		100	%	97 - 103
6920644	NYS	RPD	Available (CaCl2) pH	2020/09/01	1.3		%	N/A
6920713	NYS	Spiked Blank	Conductivity	2020/09/01		102	%	90 - 110
6920713	NYS	Method Blank	Conductivity	2020/09/01	<2		umho/cm	
6920713	NYS	RPD	Conductivity	2020/09/01	2.4		%	10
6921178	KAD	Matrix Spike	Soluble (20:1) Chloride (Cl-)	2020/09/01		111	%	70 - 130
6921178	KAD	Spiked Blank	Soluble (20:1) Chloride (Cl-)	2020/09/01		104	%	70 - 130
6921178	KAD	Method Blank	Soluble (20:1) Chloride (Cl-)	2020/09/01	<20		ug/g	
6921178	KAD	RPD	Soluble (20:1) Chloride (Cl-)	2020/09/01	NC		%	35
6921183	DRM	Matrix Spike	Soluble (20:1) Sulphate (SO4)	2020/09/02		119	%	70 - 130
6921183	DRM	Spiked Blank	Soluble (20:1) Sulphate (SO4)	2020/09/02		98	%	70 - 130
6921183	DRM	Method Blank	Soluble (20:1) Sulphate (SO4)	2020/09/02	<20		ug/g	
6921183	DRM	RPD	Soluble (20:1) Sulphate (SO4)	2020/09/02	NC		%	35
6924474	SLL	Matrix Spike	Sulphide	2020/09/02		83	%	75 - 125
6924474	SLL	Spiked Blank	Sulphide	2020/09/02		90	%	75 - 125
6924474	SLL	Method Blank	Sulphide	2020/09/02	<0.5		mg/kg	
6924474	SLL	RPD	Sulphide	2020/09/02	11		%	30
6928285	ETS	Method Blank	Moisture-Subcontracted	2020/09/02	<0.30		%	

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

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BV Labs Job #: C0M0935
Report Date: 2020/09/11

Thurber Engineering Ltd
Client Project #: 29181
Site Location: BAKER CREEK CULVERT
Sampler Initials: JM

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Ashton Gibson, Project Manager

Anastassia Hamanov, Scientific Specialist

Gita Pokhrel, Senior Analyst

Maria Magdalena Florescu, Ph.D., P.Chem., QP, Inorganics Manager

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BUREAU VERITAS

6740 Campobello Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266
CAM FCD-01191/6

CHAIN OF CUSTODY RECORD

Page _____ of _____

Invoice Information	Report Information (if differs from invoice)	Project Information (where applicable)	Turnaround Time (TAT) Required
Company Name: Thurber Engineering Ltd.	Company Name:	Quotation #:	[X] Regular TAT (5-7 days) Most analyses
Contact Name: Judy Mei/Mark Farrant	Contact Name:	P.O. #/ AFE#:	PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS
Address: 2010 Winston Park Dr #103, Oakville, ON L6H 5R7	Address:	Project #: 29181	Rush TAT (Surcharges will be applied)
Phone: (905) 829-8666 Fax:	Phone: Fax:	Site Location: Baker Creek Culvert	[ ] 1 Day [ ] 2 Days [ ] 3-4 Days
Email: jmei@thurber.ca, mfarrant@thurber.ca	Email:	Site #:	Date Required:
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BUREAU VERITAS LABORATORIES' DRINKING WATER CHAIN OF CUSTODY		Site Location Province: ON Sampled By: JM	Rush Confirmation #:

Regulation 153	Other Regulations
[ ] Table 1 [ ] Res/Park [ ] Med/ Fine	[ ] CCME [ ] Sanitary Sewer Bylaw
[ ] Table 2 [ ] Ind/Comm [ ] Coarse	[ ] MISA [ ] Storm Sewer Bylaw
[ ] Table 3 [ ] Agri/ Other	[ ] PWQO Region
[ ] Table _____	[ ] Other (Specify)
FOR RSC (PLEASE CIRCLE) Y / N	[ ] REG 558 (MIN. 3 DAY TAT REQUIRED)
	[ ] REG 406 Table

Include Criteria on Certificate of Analysis: Y / N

SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS

	SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTEX/ PHC F1	PHCs F2 - F4	VOCs	REG 153 METALS & INORGANICS	REG 153 ICPMS METALS	REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B)	Soil Corrosivity								HOLD- DO NOT ANALYZE
Analysis Requested																					
1	20-03, SS3 (5' - 7')	2020-08-26	15:00	Soil	2								X								
2	20-02, SS5B (10'6" - 12')	2020-08-26	15:00	Soil	2								X								
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					

LABORATORY USE ONLY

CUSTODY SEAL Y / N		COOLER TEMPERATURES
Present	Intact	
N	N	8/9/10

COOLING MEDIA PRESENT: (Y) / N

COMMENTS

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)
Judy Mei	2020/08/27	13:40			
Judy Mei	2020/08/27	13:40		2020/08/27	14:35

27-Aug-20 14:35
Antonella Brasil
C0M0935

KVG ENV-971

Certificate of Analysis

Client: Bureau Veritas Canada (2019) Inc.
6740 Campobello Road
Mississauga, ON
L5N 2L8
Attention: Antonella Brasil
PO#:
Invoice to: Bureau Veritas Canada (2019) Inc.

Report Number: 1937765
Date Submitted: 2020-09-01
Date Reported: 2020-09-09
Project: C0M0935
COC #: 862181

Dear Antonella Brasil:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: _____
Sarah Horner, Inorganics Technician

All analysis is completed at Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) unless otherwise indicated.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on the scope of accreditation. The scope is available at: http://www.cala.ca/scopes/2602.pdf.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is licensed by the Ontario Ministry of the Environment, Conservation, and Parks (MECP) for specific tests in drinking water (license #2318). A copy of the license is available upon request.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by the Ontario Ministry of Agriculture, Food, and Rural Affairs for specific tests in agricultural soils.

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Eurofins recommends consulting the official provincial or federal guideline as required. Unless otherwise stated, measurement uncertainty is not taken into account when determining guideline or regulatory exceedances.

Certificate of Analysis

eurofins | Environment Testing

Client: Bureau Veritas Canada (2019) Inc.
6740 Campobello Road
Mississauga, ON
L5N 2L8
Attention: Antonella Brasil
PO#:
Invoice to: Bureau Veritas Canada (2019) Inc.

Report Number: 1937765
Date Submitted: 2020-09-01
Date Reported: 2020-09-09
Project: C0M0935
COC #: 862181

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1513958 Soil 2020-08-26 NME948-20-03 SS3 (5' - 7')	1513959 Soil 2020-08-26 NME949-20-02 SS5B (10'6" - 12")
Redox Potential	REDOX Potential		mV			210	317

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Certificate of Analysis

Client: Bureau Veritas Canada (2019) Inc.
6740 Campobello Road
Mississauga, ON
L5N 2L8
Attention: Antonella Brasil
PO#:
Invoice to: Bureau Veritas Canada (2019) Inc.

Report Number: 1937765
Date Submitted: 2020-09-01
Date Reported: 2020-09-09
Project: C0M0935
COC #: 862181

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 388927 **Analysis/Extraction Date** 2020-09-08 **Analyst** SKH **Method** C SM2580B			
REDOX Potential	212 mV	100	

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

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Your Project #: 29181
Site Location: BAKER CREEK CULVERT
Your C.O.C. #: 782317-01-01

Attention: Mark Farrant

Thurber Engineering Ltd
2010 Winston Park Dr
Suite 103
Oakville, ON
CANADA L6H 5R7

Report Date: 2020/11/13
Report #: R6409774
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

BV LABS JOB #: C0L6330
Received: 2020/08/24, 10:40

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Dissolved Aluminum (0.2 u, clay free)	1	N/A	2020/08/27	CAM SOP-00447	EPA 6020B m
Alkalinity	1	N/A	2020/08/26	CAM SOP-00448	SM 23 2320 B m
Chromium (VI) in Water	1	N/A	2020/08/27	CAM SOP-00436	EPA 7199 m
Free (WAD) Cyanide	1	N/A	2020/08/26	CAM SOP-00457	OMOE E3015 m
Dissolved Oxygen	1	2020/08/25	2020/08/25	CAM SOP-00427	SM 23 4500 O G m
Hardness (calculated as CaCO3)	1	N/A	2020/08/28	CAM SOP 00102/00408/00447	SM 2340 B
Mercury	1	2020/08/27	2020/08/27	CAM SOP-00453	EPA 7470A m
Dissolved Calcium and Magnesium	1	2020/08/26	2020/08/27	CAM SOP-00408	EPA 6010D m
Total Metals Analysis by ICPMS	1	N/A	2020/08/26	CAM SOP-00447	EPA 6020B m
Sulphide (as H2S) (1)	1	N/A	2020/08/27	AB WI-00065	Auto Calc.
Total Sulphide (1)	1	N/A	2020/08/27	AB SOP-00080	SM 23 4500 S2-A D Fm
Total Ammonia-N	1	N/A	2020/08/27	CAM SOP-00441	USGS I-2522-90 m
pH	1	2020/08/25	2020/08/26	CAM SOP-00413	SM 4500H+ B m
Phenols (4AAP)	1	N/A	2020/08/26	CAM SOP-00444	OMOE E3179 m
Total Phosphorus (Colourimetric)	1	2020/08/26	2020/08/28	CAM SOP-00407	SM 23 4500 P B H m
Turbidity	1	N/A	2020/08/26	CAM SOP-00417	SM 23 2130 B m

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

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BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Your Project #: 29181
Site Location: BAKER CREEK CULVERT
Your C.O.C. #: 782317-01-01

Attention: Mark Farrant

Thurber Engineering Ltd
2010 Winston Park Dr
Suite 103
Oakville, ON
CANADA L6H 5R7

Report Date: 2020/11/13
Report #: R6409774
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

BV LABS JOB #: C0L6330
Received: 2020/08/24, 10:40

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) This test was performed by BVLabs Calgary via Mississauga

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Antonella Brasil, Senior Project Manager
Email: Antonella.Brasil@bvlabs.com
Phone# (905)817-5817

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BV Labs Job #: C0L6330
Report Date: 2020/11/13

Thurber Engineering Ltd
Client Project #: 29181
Site Location: BAKER CREEK CULVERT

PWQO METALS AND INORGANICS (WATER)

BV Labs ID			NLE502	NLE502		
Sampling Date			2020/08/21 13:30	2020/08/21 13:30		
COC Number			782317-01-01	782317-01-01		
	UNITS	Criteria	BAKER CREEK, 20-02	BAKER CREEK, 20-02 Lab-Dup	RDL	QC Batch
Calculated Parameters						
Hardness (CaCO3)	mg/L	-	83	N/A	1.0	6905748
Sulphide (as H2S)	mg/L	**0.002**	**0.0053**	N/A	0.0020	6918194
Inorganics						
Total Ammonia-N	mg/L	-	13	N/A	0.050	6912563
Dissolved Oxygen	mg/L	-	0.820	0.800	N/A	6909534
pH	pH	**6.5:8.5**	6.73	N/A	N/A	6909103
Phenols-4AAP	mg/L	**0.001**	<0.0010	N/A	0.0010	6910166
Total Phosphorus	mg/L	**0.01**	**0.18**	N/A	0.02	6910791
Total Sulphide	mg/L	**0.002**	**0.0050**	N/A	0.0018	6918195
Turbidity	NTU	-	170	N/A	0.1	6909048
WAD Cyanide (Free)	ug/L	**5**	<1	<1	1	6910338
Alkalinity (Total as CaCO3)	mg/L	-	62	N/A	1.0	6909102
Metals						
Dissolved (0.2u) Aluminum (Al)	ug/L	**15**	**59**	N/A	5	6910907
Dissolved Calcium (Ca)	mg/L	-	24	N/A	0.050	6910917
Chromium (VI)	ug/L	**1**	<0.50	N/A	0.50	6910645
Dissolved Magnesium (Mg)	mg/L	-	5.6	N/A	0.050	6910917
Mercury (Hg)	ug/L	**0.2**	<0.10	N/A	0.10	6912601
Total Antimony (Sb)	ug/L	**20**	<0.50	N/A	0.50	6910169
Total Arsenic (As)	ug/L	**100**	<1.0	N/A	1.0	6910169
Total Beryllium (Be)	ug/L	**11**	<0.40	N/A	0.40	6910169
Total Boron (B)	ug/L	**200**	<10	N/A	10	6910169
Total Cadmium (Cd)	ug/L	**0.2**	<0.090	N/A	0.090	6910169
Total Chromium (Cr)	ug/L	-	<5.0	N/A	5.0	6910169
Total Cobalt (Co)	ug/L	**0.9**	<0.50	N/A	0.50	6910169
Total Copper (Cu)	ug/L	**5**	<0.90	N/A	0.90	6910169
Total Iron (Fe)	ug/L	**300**	**6100**	N/A	100	6910169
Total Lead (Pb)	ug/L	**5**	<0.50	N/A	0.50	6910169
Total Molybdenum (Mo)	ug/L	**40**	<0.50	N/A	0.50	6910169
Total Nickel (Ni)	ug/L	**25**	<1.0	N/A	1.0	6910169

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
Criteria: Ontario Provincial Water Quality Objectives
Ref. to MOEE Water Management document dated Feb.1999
N/A = Not Applicable

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

BV Labs Job #: C0L6330
Report Date: 2020/11/13

Thurber Engineering Ltd
Client Project #: 29181
Site Location: BAKER CREEK CULVERT

PWQO METALS AND INORGANICS (WATER)

BV Labs ID			NLE502	NLE502		
Sampling Date			2020/08/21 13:30	2020/08/21 13:30		
COC Number			782317-01-01	782317-01-01		
	UNITS	Criteria	BAKER CREEK, 20-02	BAKER CREEK, 20-02 Lab-Dup	RDL	QC Batch
Total Selenium (Se)	ug/L	**100**	<2.0	N/A	2.0	6910169
Total Silver (Ag)	ug/L	**0.1**	<0.090	N/A	0.090	6910169
Total Thallium (Tl)	ug/L	**0.3**	<0.050	N/A	0.050	6910169
Total Tungsten (W)	ug/L	**30**	<1.0	N/A	1.0	6910169
Total Uranium (U)	ug/L	**5**	<0.10	N/A	0.10	6910169
Total Vanadium (V)	ug/L	**6**	3.3	N/A	0.50	6910169
Total Zinc (Zn)	ug/L	**30**	5.0	N/A	5.0	6910169
Total Zirconium (Zr)	ug/L	**4**	<1.0	N/A	1.0	6910169

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
Criteria: Ontario Provincial Water Quality Objectives
Ref. to MOEE Water Management document dated Feb.1999
N/A = Not Applicable

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GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	10.7°C

Revised Report (2020/11/13): PWQO Criteria included as per client request .

Results relate only to the items tested.

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BV Labs Job #: C0L6330
Report Date: 2020/11/13

Thurber Engineering Ltd
Client Project #: 29181
Site Location: BAKER CREEK CULVERT

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
6909048	GTO	Spiked Blank	Turbidity	2020/08/26		109	%	85 - 115
6909048	GTO	Method Blank	Turbidity	2020/08/26	<0.1		NTU	
6909048	GTO	RPD	Turbidity	2020/08/26	NC		%	20
6909102	SAU	Spiked Blank	Alkalinity (Total as CaCO3)	2020/08/26		96	%	85 - 115
6909102	SAU	Method Blank	Alkalinity (Total as CaCO3)	2020/08/26	<1.0		mg/L	
6909102	SAU	RPD	Alkalinity (Total as CaCO3)	2020/08/26	0.17		%	20
6909103	SAU	Spiked Blank	pH	2020/08/26		101	%	98 - 103
6909103	SAU	RPD	pH	2020/08/26	0.12		%	N/A
6910166	BMO	Matrix Spike	Phenols-4AAP	2020/08/26		97	%	80 - 120
6910166	BMO	Spiked Blank	Phenols-4AAP	2020/08/26		98	%	80 - 120
6910166	BMO	Method Blank	Phenols-4AAP	2020/08/26	<0.0010		mg/L	
6910166	BMO	RPD	Phenols-4AAP	2020/08/26	NC		%	20
6910169	N_R	Matrix Spike	Total Antimony (Sb)	2020/08/26		103	%	80 - 120
			Total Arsenic (As)	2020/08/26		102	%	80 - 120
			Total Beryllium (Be)	2020/08/26		103	%	80 - 120
			Total Boron (B)	2020/08/26		99	%	80 - 120
			Total Cadmium (Cd)	2020/08/26		102	%	80 - 120
			Total Chromium (Cr)	2020/08/26		99	%	80 - 120
			Total Cobalt (Co)	2020/08/26		100	%	80 - 120
			Total Copper (Cu)	2020/08/26		101	%	80 - 120
			Total Iron (Fe)	2020/08/26		97	%	80 - 120
			Total Lead (Pb)	2020/08/26		99	%	80 - 120
			Total Molybdenum (Mo)	2020/08/26		101	%	80 - 120
			Total Nickel (Ni)	2020/08/26		95	%	80 - 120
			Total Selenium (Se)	2020/08/26		102	%	80 - 120
			Total Silver (Ag)	2020/08/26		95	%	80 - 120
			Total Thallium (Tl)	2020/08/26		98	%	80 - 120
			Total Tungsten (W)	2020/08/26		101	%	80 - 120
			Total Uranium (U)	2020/08/26		99	%	80 - 120
			Total Vanadium (V)	2020/08/26		101	%	80 - 120
			Total Zinc (Zn)	2020/08/26		100	%	80 - 120
			Total Zirconium (Zr)	2020/08/26		104	%	80 - 120
6910169	N_R	Spiked Blank	Total Antimony (Sb)	2020/08/26		100	%	80 - 120
			Total Arsenic (As)	2020/08/26		101	%	80 - 120
			Total Beryllium (Be)	2020/08/26		102	%	80 - 120
			Total Boron (B)	2020/08/26		98	%	80 - 120
			Total Cadmium (Cd)	2020/08/26		99	%	80 - 120
			Total Chromium (Cr)	2020/08/26		97	%	80 - 120
			Total Cobalt (Co)	2020/08/26		100	%	80 - 120
			Total Copper (Cu)	2020/08/26		101	%	80 - 120
			Total Iron (Fe)	2020/08/26		98	%	80 - 120
			Total Lead (Pb)	2020/08/26		98	%	80 - 120
			Total Molybdenum (Mo)	2020/08/26		98	%	80 - 120
			Total Nickel (Ni)	2020/08/26		98	%	80 - 120
			Total Selenium (Se)	2020/08/26		104	%	80 - 120
			Total Silver (Ag)	2020/08/26		95	%	80 - 120
			Total Thallium (Tl)	2020/08/26		97	%	80 - 120
			Total Tungsten (W)	2020/08/26		100	%	80 - 120
			Total Uranium (U)	2020/08/26		100	%	80 - 120
			Total Vanadium (V)	2020/08/26		100	%	80 - 120
			Total Zinc (Zn)	2020/08/26		105	%	80 - 120
			Total Zirconium (Zr)	2020/08/26		100	%	80 - 120

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
6910169	N_R	Method Blank	Total Antimony (Sb)	2020/08/26	<0.50		ug/L	
			Total Arsenic (As)	2020/08/26	<1.0		ug/L	
			Total Beryllium (Be)	2020/08/26	<0.40		ug/L	
			Total Boron (B)	2020/08/26	<10		ug/L	
			Total Cadmium (Cd)	2020/08/26	<0.090		ug/L	
			Total Chromium (Cr)	2020/08/26	<5.0		ug/L	
			Total Cobalt (Co)	2020/08/26	<0.50		ug/L	
			Total Copper (Cu)	2020/08/26	<0.90		ug/L	
			Total Iron (Fe)	2020/08/26	<100		ug/L	
			Total Lead (Pb)	2020/08/26	<0.50		ug/L	
			Total Molybdenum (Mo)	2020/08/26	<0.50		ug/L	
			Total Nickel (Ni)	2020/08/26	<1.0		ug/L	
			Total Selenium (Se)	2020/08/26	<2.0		ug/L	
			Total Silver (Ag)	2020/08/26	<0.090		ug/L	
			Total Thallium (Tl)	2020/08/26	<0.050		ug/L	
			Total Tungsten (W)	2020/08/26	<1.0		ug/L	
			Total Uranium (U)	2020/08/26	<0.10		ug/L	
			Total Vanadium (V)	2020/08/26	<0.50		ug/L	
			Total Zinc (Zn)	2020/08/26	<5.0		ug/L	
			Total Zirconium (Zr)	2020/08/26	<1.0		ug/L	
6910169	N_R	RPD	Total Iron (Fe)	2020/08/26	0.82		%	20
6910338	LHA	Matrix Spike [NLE502-06]	WAD Cyanide (Free)	2020/08/26		102	%	80 - 120
6910338	LHA	Spiked Blank	WAD Cyanide (Free)	2020/08/26		101	%	80 - 120
6910338	LHA	Method Blank	WAD Cyanide (Free)	2020/08/26	<1		ug/L	
6910338	LHA	RPD [NLE502-06]	WAD Cyanide (Free)	2020/08/26	NC		%	20
6910645	LLE	Matrix Spike	Chromium (VI)	2020/08/27		103	%	80 - 120
6910645	LLE	Spiked Blank	Chromium (VI)	2020/08/27		103	%	80 - 120
6910645	LLE	Method Blank	Chromium (VI)	2020/08/27	<0.50		ug/L	
6910645	LLE	RPD	Chromium (VI)	2020/08/27	NC		%	20
6910791	SSV	Matrix Spike	Total Phosphorus	2020/08/27		95	%	80 - 120
6910791	SSV	QC Standard	Total Phosphorus	2020/08/27		99	%	80 - 120
6910791	SSV	Spiked Blank	Total Phosphorus	2020/08/27		97	%	80 - 120
6910791	SSV	Method Blank	Total Phosphorus	2020/08/27	<0.004		mg/L	
6910791	SSV	RPD	Total Phosphorus	2020/08/27	NC		%	20
6910907	ADA	Matrix Spike	Dissolved (0.2u) Aluminum (Al)	2020/08/27		103	%	80 - 120
6910907	ADA	Spiked Blank	Dissolved (0.2u) Aluminum (Al)	2020/08/27		101	%	80 - 120
6910907	ADA	Method Blank	Dissolved (0.2u) Aluminum (Al)	2020/08/27	<5		ug/L	
6910907	ADA	RPD	Dissolved (0.2u) Aluminum (Al)	2020/08/27	3.1		%	20
6910917	SUK	Matrix Spike	Dissolved Calcium (Ca)	2020/08/27		NC	%	80 - 120
			Dissolved Magnesium (Mg)	2020/08/27		95	%	80 - 120
6910917	SUK	Spiked Blank	Dissolved Calcium (Ca)	2020/08/27		101	%	80 - 120
			Dissolved Magnesium (Mg)	2020/08/27		97	%	80 - 120
6910917	SUK	Method Blank	Dissolved Calcium (Ca)	2020/08/27	<0.050		mg/L	
			Dissolved Magnesium (Mg)	2020/08/27	<0.050		mg/L	
6912563	ASP	Matrix Spike	Total Ammonia-N	2020/08/27		100	%	75 - 125
6912563	ASP	Spiked Blank	Total Ammonia-N	2020/08/27		101	%	80 - 120
6912563	ASP	Method Blank	Total Ammonia-N	2020/08/27	<0.050		mg/L	
6912563	ASP	RPD	Total Ammonia-N	2020/08/27	1.0		%	20
6912601	MPD	Matrix Spike	Mercury (Hg)	2020/08/27		92	%	75 - 125
6912601	MPD	Spiked Blank	Mercury (Hg)	2020/08/27		92	%	80 - 120
6912601	MPD	Method Blank	Mercury (Hg)	2020/08/27	<0.10		ug/L	
6912601	MPD	RPD	Mercury (Hg)	2020/08/27	NC		%	20

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
6918195	éBS	Matrix Spike	Total Sulphide	2020/08/27		89	%	80 - 120
6918195	éBS	Spiked Blank	Total Sulphide	2020/08/27		83	%	80 - 120
6918195	éBS	Method Blank	Total Sulphide	2020/08/27	<0.0018		mg/L	
6918195	éBS	RPD	Total Sulphide	2020/08/27	NC		%	20

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

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BV Labs Job #: C0L6330
Report Date: 2020/11/13

Thurber Engineering Ltd
Client Project #: 29181
Site Location: BAKER CREEK CULVERT

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Anastassia Hamanov, Scientific Specialist

Maria Magdalena Florescu, Ph.D., P.Chem., QP, Inorganics Manager

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports.
For Service Group specific validation please refer to the Validation Signature Page.

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Page of

CHAIN OF CUSTODY RECORD

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#5843 Thurber Engineering Ltd	Company Name:		Quotation #:	B90187	BV Labs Job #:	Bottle Order #: 782317
Attention:	Mark Farrant	Attention:	Same as Invoice	P.O. #:			
Address:	2010 Winston Park Dr Suite 103 Oakville ON L6H 5R7	Address:		Project:	29181	COC #: C#782317-01-01	Project Manager: Antonella Brasil
Tel:	(905) 829-8666 Ext: 528 Fax: (905) 829-1166	Tel:	Fax:	Project Name:			
Email:	mfarrant@thurber.ca	Email:		Site #:	Baker Creek Culvert		
				Sampled By:	Greg Stanhope		

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BV LABS DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011): ☑ Table 1 ☐ Res/Park ☐ Medium/Fine ☐ Table 2 ☐ Ind/Comm ☐ Coarse ☐ Table 3 ☐ Agri/Other ☐ For RSC ☐ Table ___

Other Regulations: ☐ CCME ☐ Sanitary Sewer Bylaw ☐ Reg 558 ☐ Storm Sewer Bylaw ☐ MISA Municipality ☐ PWQO ☐ Reg 406 Table ☐ Other

Special Instructions

Include Criteria on Certificate of Analysis (Y/N)? ___

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

Regular (Standard) TAT: ☑
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests..
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: ___ Time Required: ___ ☐
Rush Confirmation Number: ___ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	ANALYSIS REQUESTED (PLEASE BE SPECIFIC): PWQO Metals and Inorganics	Dissolved Al, Antimony, Dissolved Cat Mg, pH, Turbidity	Dissolved Oxygen	Free (WAD) Cyanide	Total Sulphide	Cr (VI) in water	Field temp, total chlorine, UNIONIZED AMMONIA	total ammonia-N	total metals analysis by ICPMS	Phenols (4AAP)	# of Bottles	Comments
1	22533, 22833	Baker creek, 20-02	Aug. 21	1:30, 1:45	water			✓	✓	✓							4	
2	22612	Baker Creek, 20-02	Aug. 21	1:30, 1:45	water				✓								2	
3	22308	Baker creek, 20-02	Aug. 21	1:30, 1:45	water.					✓							2	
4	22612 (DUP2)	Baker creek, 20-02	Aug-21	1:30, 1:45	water					✓	✓						2	
5	22526	Baker creek, 20-02	Aug. 21	1:30, 1:45	water	yes					✓		✓				2	
6	22709	Baker creek, 20-02	Aug-21	1:30, 1:45	water	yes						✓					2	
7	22786	Baker creek, 20-02	Aug-21	1:30, 1:45	water								✓		✓		2	
8	22526 (red)	Baker creek, 20-02	Aug-21	1:30, 1:45	water	yes.									✓		2	
9	22623	Baker creek, 20-02	Aug-21	1:30, 1:45	water	yes.	✓									✓	2	
10	22654	Baker creek, 20-02	Aug-21	1:30, 1:45	water											✓	2	

24-Aug-20 10:40
Antonella Brasil
C0L6330
HGR ENV-1219

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
Greg Stanhope GS.	Aug. 24, 2020	10:30AM		20/08/24	1040	

Laboratory Use Only
Time Sensitive | Temperature (°C) on Recei: 10 | 11 | 11 | Custody Seal: Present ☑ Intact ☑ Yes ☑ No ☐

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BV LABS' STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVLABS.COM/TERMS-AND-CONDITIONS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT WWW.BVLABS.COM/RESOURCES/CHAIN-OF-CUSTODY-FORMS.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BV LABS

White: BV Labs Yellow: Client

Bureau Veritas Canada (2019) Inc.

Exceedance Summary Table – Prov. Water Quality Obj.

Result Exceedances

Sample ID	BV Labs ID	Parameter	Criteria	Result	DL	UNITS
BAKER CREEK, 20-02	NLE502-01	Dissolved (0.2u) Aluminum (Al)	15	59	5	ug/L
BAKER CREEK, 20-02	NLE502-02	Total Iron (Fe)	300	6100	100	ug/L
BAKER CREEK, 20-02	NLE502-08	Total Phosphorus	0.01	0.18	0.02	mg/L
BAKER CREEK, 20-02	NLE502-04	Total Sulphide	0.002	0.0050	0.0018	mg/L
BAKER CREEK, 20-02	NLE502-04	Sulphide (as H2S)	0.002	0.0053	0.0020	mg/L

The exceedance summary table is for information purposes only and should not be considered a comprehensive listing or statement of conformance to applicable regulatory guidelines.

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THURBER

Appendix C

Site Photographs

Figure 1: Looking east at east approach on Highway 17 (August 2020)

Figure 2: Looking west at west approach on Highway 17 (August 2020)

Figure 3: Upstream of Baker Creek from top of culvert inlet (August 2020)

Figure 3: Downstream of Baker Creek from top of culvert outlet (August 2020)

Figure 5: Looking northeast at culvert inlet (August 2020)

Figure 6: Looking east at culvert outlet (August 2020)

Figure 7: Looking east along north slope of Highway 17 embankment (August 2020)

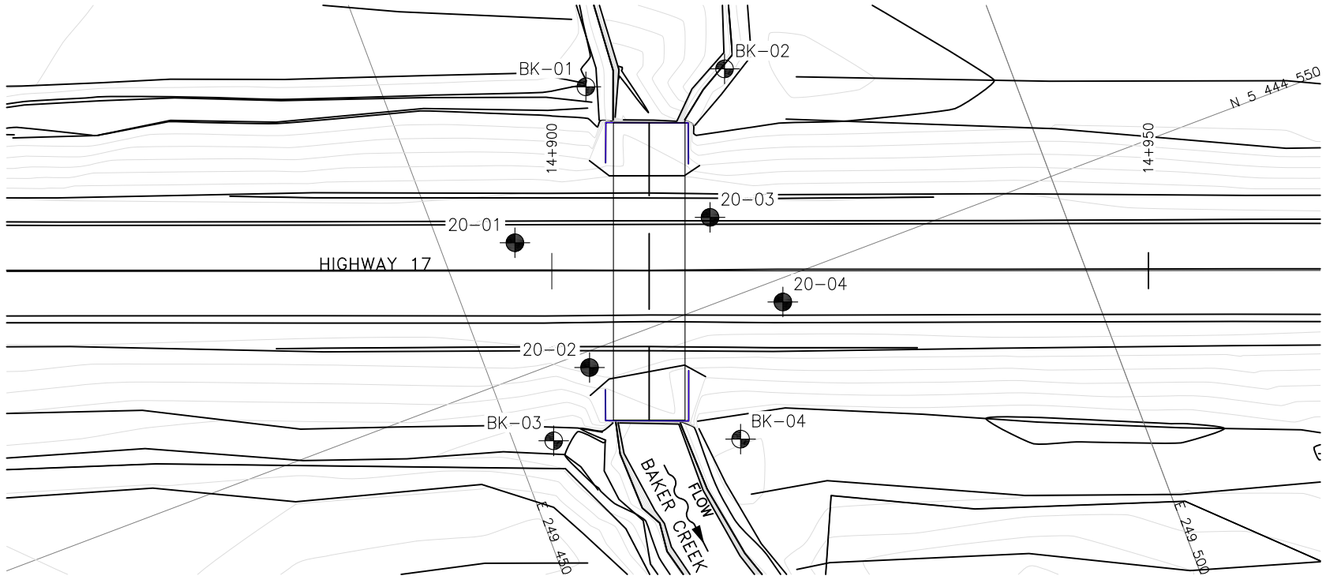
Figure 8: Looking east along south slope of Highway 17 embankment (August 2020)

THURBER

Appendix D

Borehole Locations and Soil Strata Drawing

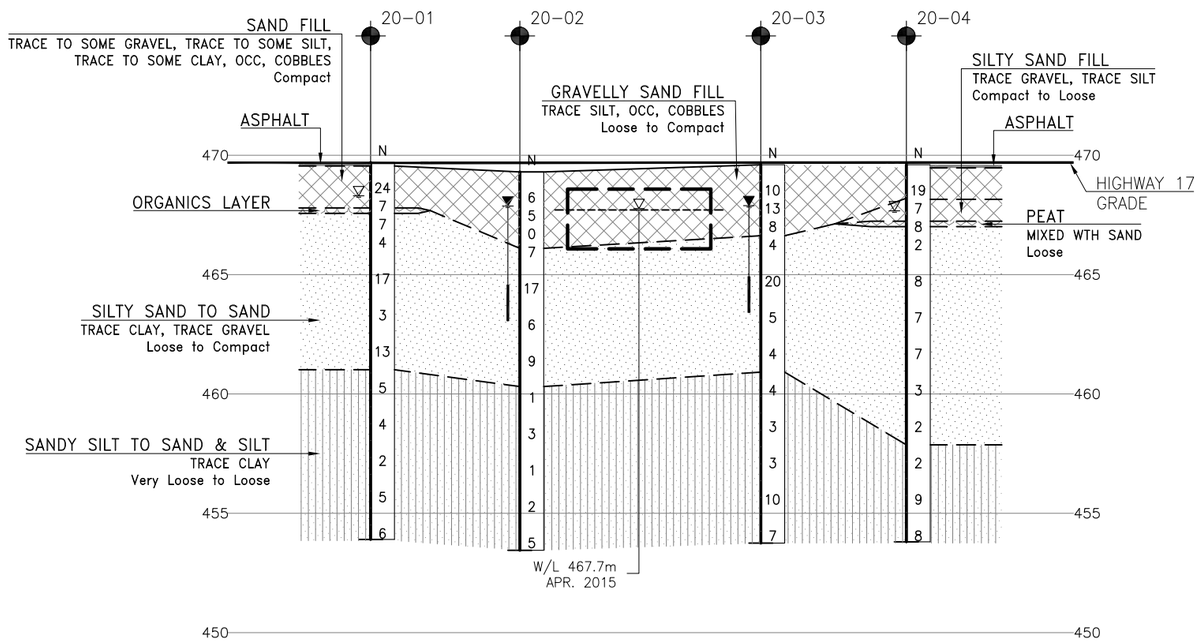
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

10 0 10 20m

SCALE 1:500



PROFILE ALONG HWY 17

5 0 5 10m

SCALE 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Feb. 24, 2021
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
C. A. MURRAY
100206832
Feb 24/2021
PROVINCE OF ONTARIO

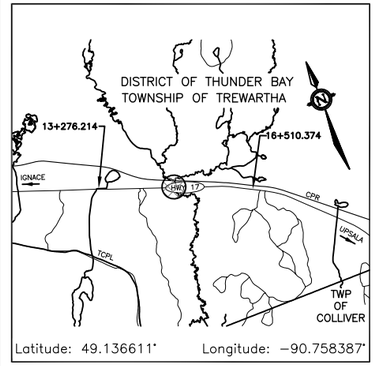
CONT No
WP No 6336-14-00

SHEET

HIGHWAY 17
BAKER CREEK
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
20-01	469.7	5 444 560.7	249 456.0
20-02	469.3	5 444 548.7	249 458.2
20-03	469.6	5 444 556.9	249 472.1
20-04	469.6	5 444 548.1	249 475.3
BK-01	468.3	5 444 570.8	249 466.2
BK-02	467.8	5 444 568.1	249 477.6
BK-03	468.2	5 444 544.0	249 453.2
BK-04	468.3	5 444 538.6	249 467.9

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 15.

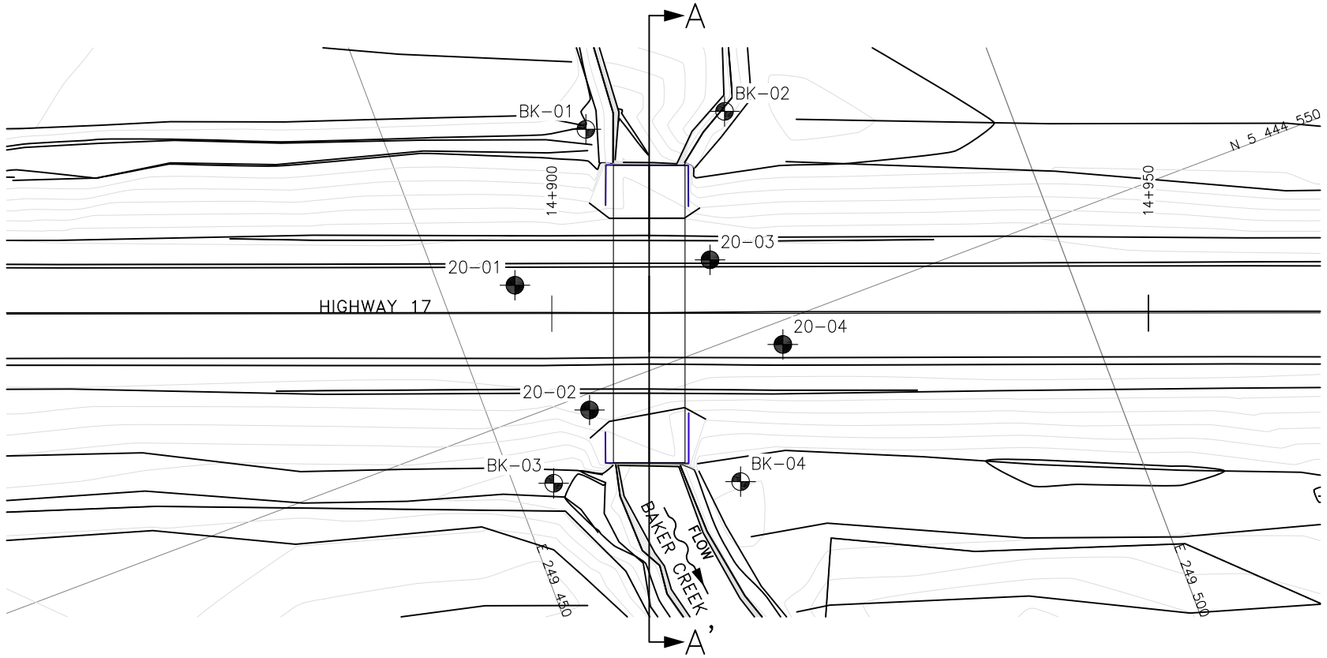
GEOCRES No. 40P8-274

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	JM	CHK MEF	CODE	LOAD	DATE FEB 2021
DRAWN	AN	CHK JM	SITE	STRUCT	DWG 1

FILENAME: H:\Drafting\29000\29181\TES-29181-PLPR-BC.dwg
PLOTDATE: 2/25/2021 9:28 AM

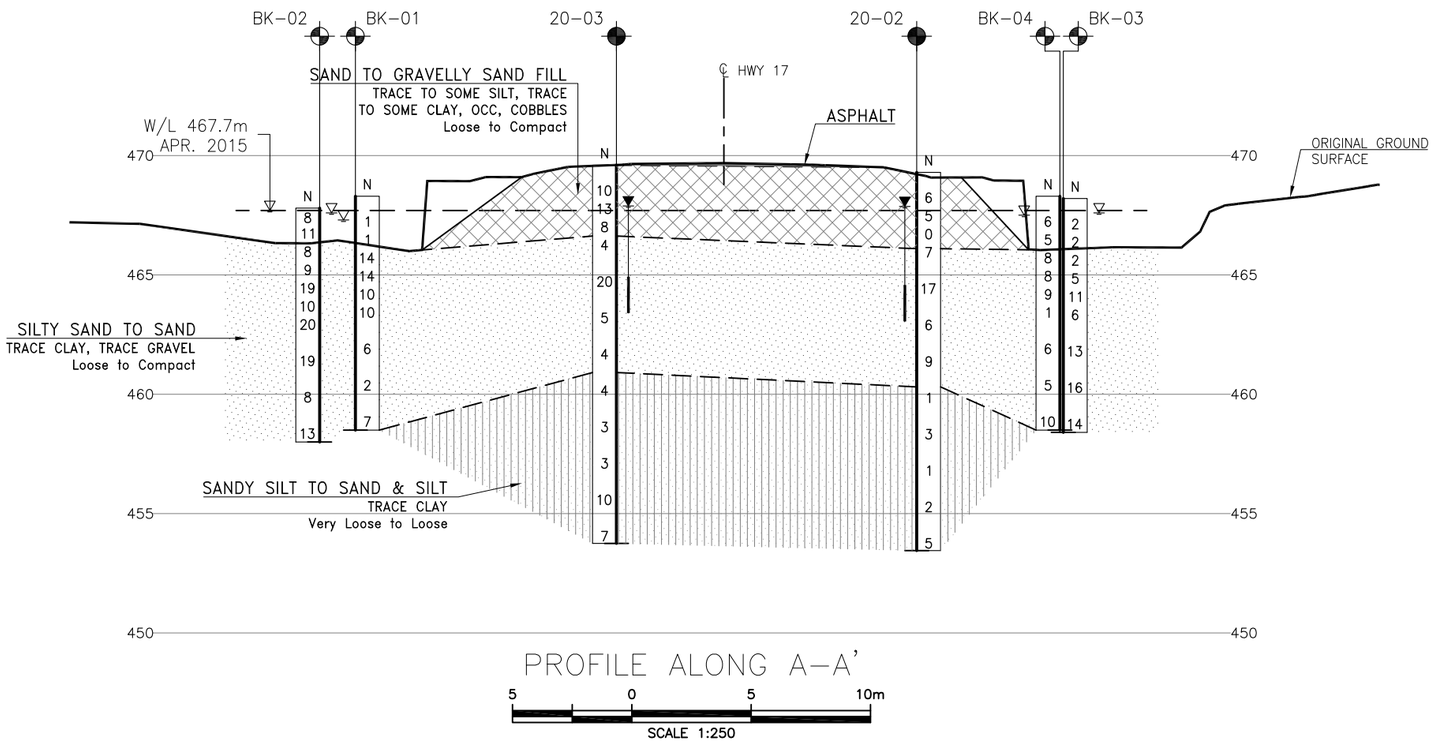
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

10 0 10 20m

SCALE 1:500



PROFILE ALONG A–A'

5 0 5 10m

SCALE 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Feb. 24, 2021
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
C. A. MURRAY
100206832
Feb 24/2021
PROVINCE OF ONTARIO

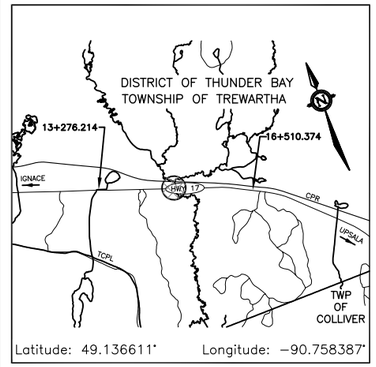
CONT No
WP No 6336-14-00

SHEET

HIGHWAY 17
BAKER CREEK
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH

THURBER ENGINEERING LTD.



KEYPLAN

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

NO	ELEVATION	NORTHING	EASTING
20-01	469.7	5 444 560.7	249 456.0
20-02	469.3	5 444 548.7	249 458.2
20-03	469.6	5 444 556.9	249 472.1
20-04	469.6	5 444 548.1	249 475.3
BK-01	468.3	5 444 570.8	249 466.2
BK-02	467.8	5 444 568.1	249 477.6
BK-03	468.2	5 444 544.0	249 453.2
BK-04	468.3	5 444 538.6	249 467.9

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 15.

GEOCRES No. 40P8-274

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN JM	CHK MEF	CODE	LOAD	DATE FEB 2021	
DRAWN AN	CHK JM	SITE	STRUCT	DWG 2	

FILENAME: H:\Drafting\29000\29181\TES-29181-PLPR-BC.dwg
PLOTDATE: 2/25/2021 9:29 AM

THURBER

Appendix E

Record of Borehole Sheets and Laboratory Test Results (Previous Investigation)

Golder Associates

RECORD OF BOREHOLE No BK-1

1 OF 1 **METRIC**

PROJECT 1533879 | 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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
468.3	GROUND SURFACE										
0.0	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.		1	SS	1	▽	467				
			2	SS	1		466		○		
			3	SS	14						
			4	SS	14		465				
			5	SS	10				○		0 80 (20)
	Approximately 0.1 m of heave below 4.6 m depth.		6	SS	10		464				
			7	SS	6		463				
			8	SS	2		462				
			9	SS	7		461		○		0 67 32 1
458.5							460				
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.						459				

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

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

Golder Associates

RECORD OF BOREHOLE No BK-2

1 OF 1 **METRIC**

PROJECT 1533879

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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
467.8	GROUND SURFACE										
0.0	ICE (200 mm)					▽					
0.2	SILTY SAND to SAND, trace gravel Loose to compact Brown to grey Wet		1	SS	8						
	Trace organics in Sample 1.		2	SS	11		467				
			3	SS	8		466		○		0 99 (1)
			4	SS	9		465				
			5	SS	19						
			6	SS	10		464		○		1 86 (13)
			7	SS	20		463				
							462				
	Approximately 0.2 m of heave at 6.1 m depth.		8	SS	19						
							461				
			9	SS	8		460		○		0 77 (23)
							459				
458.0			10	SS	13						
458							458				
9.8	END OF BOREHOLE Note: 1. Water level at a depth of 0.2 m below ground surface (Elev. 467.6 m) upon completion of drilling.										

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

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

Golder Associates

RECORD OF BOREHOLE No BK-3

1 OF 1 **METRIC**

PROJECT 1533879 | 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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
468.2	GROUND SURFACE										
0.0	PEAT (Amorphous) Very soft Black Wet		1	AS	-	▽	468		222.3		
			2	SS	2						
466.8							467				
1.4	ORGANIC SAND, trace to some silt, trace gravel, trace wood Very loose Dark brown to black Wet		3	SS	2						1 90 (9)
466.0							466				
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						
			5	SS	5		465				
			6	SS	11						
			7	SS	6		464				0 99 (1)
							463				
			8	SS	13		462				
							461				
			9	SS	16						0 97 (3)
							460				
			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.										

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

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

Golder Associates

RECORD OF BOREHOLE No BK-4

1 OF 1 **METRIC**

PROJECT 1533879 | G.W.P. 6336-14-00 | LOCATION N 5444538.6; E 249467.9 | ORIGINATED BY MR

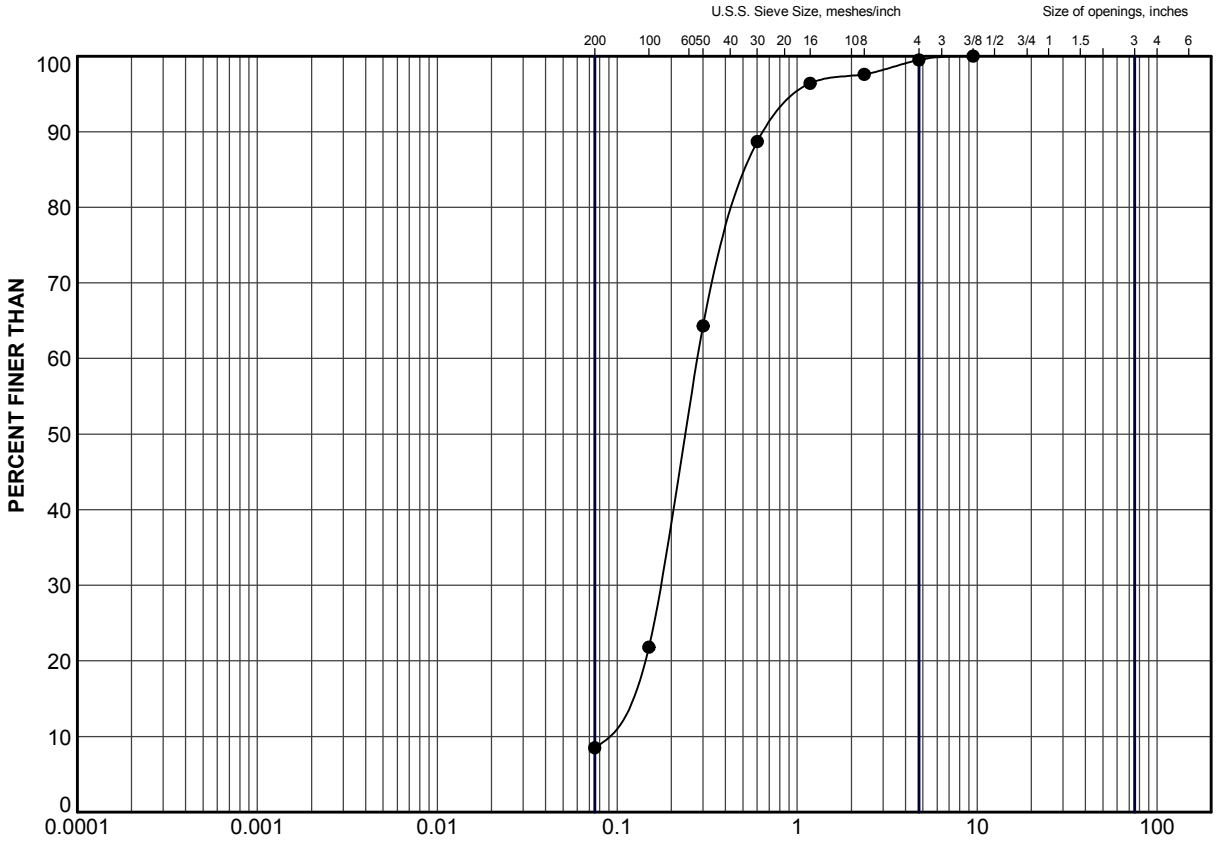
DIST _____ HWY 17 | BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers | COMPILED BY AC

DATUM GEODETIC | DATE January 19, 2016 | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
468.3	GROUND SURFACE										
0.0	Sandy PEAT (Amorphous), some silt Brown Frozen*		1	AS	-*		468				
467.6						▽					
0.7	SAND, trace to some silt, trace gravel Very loose to compact Brown to grey Wet		2	SS	6				○		1 92 (7)
	Trace organics encountered in Sample 2.						467				
			3	SS	5						
	Approximately 0.2 m to 1.4 m of heave below 2.3 m depth.		4	SS	8		466				
			5	SS	8		465		○		0 98 (2)
			6	SS	9		464				
			7	SS	1						
							463				
			8	SS	6		462				
							461				
			9	SS	5				○		0 94 (6)
							460				
			10	SS	10		459				
458.5											
9.8	END OF BOREHOLE Note: 1. Water level at a depth of 0.8 m below ground surface (Elev. 467.5 m) upon completion of drilling.										

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

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



LEGEND

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

PROJECT

HIGHWAY 17
BAKER CREEK CULVERT STA 14+907

TITLE

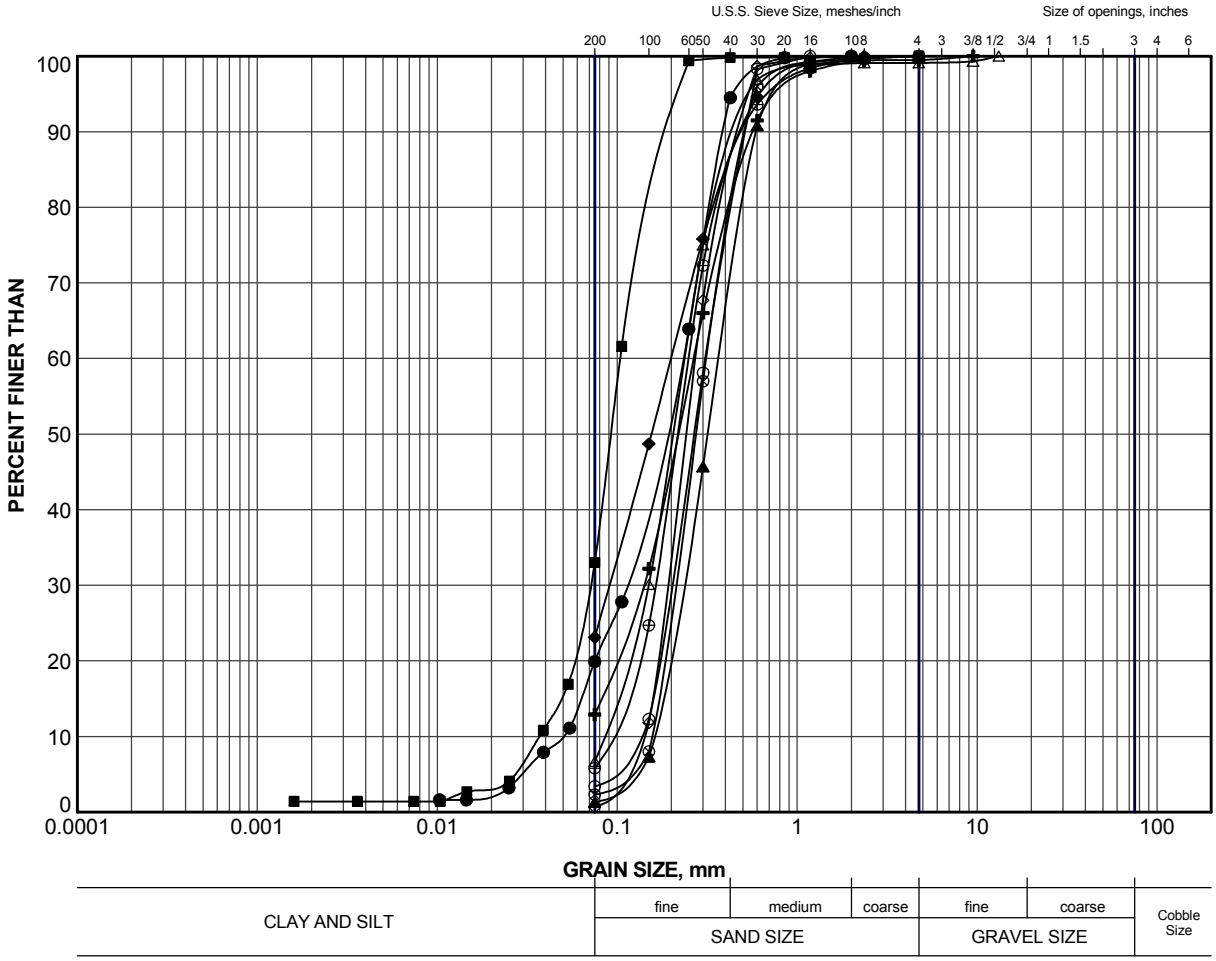
GRAIN SIZE DISTRIBUTION

SAND

Golder Associates
SUDBURY, ONTARIO

PROJECT No.	1533879		FILE No.	1533879.GPJ
DRAWN	JJL	Aug 2016	SCALE N/A	REV.
CHECK	DAM	Aug 2016		
APPR	JMAC	Aug 2016	**FIGURE C1**	

SUD-MTO GSD (2016) GLDR_LDN.GDT



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		
APPR	JMAC	Aug 2016	**FIGURE C2**	

SUD-MTO GSD (2016) GLDR_LDN.GDT

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Appendix F

Foundation Comparison

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GEOTECHNICAL COMPARISON OF ALTERNATIVE FOUNDATION TYPES

Type	Circular Pipe Culvert	Closed Box Culvert	Open Bottom Culvert
Advantages	• Can tolerate larger magnitude of settlement than concrete (rigid frame) culverts. • Relatively expedient installation. • Concrete or steel pipes are likely to be more cost effective than concrete box or open footing culverts.	• Relatively expedient installation if precast units are used. • Typically smaller magnitude of settlement than open footing foundation due to lower bearing stress on subgrade. • Minimized differential settlement between culvert and approach fills.	• Limits disturbance to streambed. Typically favourable from an aquatic habitat perspective. • Relatively expedient installation if precast units are used. • Likely will not require offline diversion at this site.
Disadvantages	• Feasibility also depends on flow capacity and other hydraulic properties. May need multiple pipes. • Requires large excavation. • Roadway protection or temporary widening will be required. • Groundwater control is required.	• Requires large excavation. • Roadway protection or temporary widening will be required. • Groundwater control is required.	• Requires deeper excavation for frost protection increasing excavation volume and dewatering efforts. • Requires higher soil geotechnical resistances to support strip footings. • Cannot tolerate differential settlement. • Roadway protection or temporary widening will be required.
Risks/ Consequences	• May be difficult to dewater excavation	• May be difficult to dewater excavation	• Differential settlement is likely at this site and the underlying soils have low geotechnical capacity.
Relative Cost	Low	Low	Moderate
Recommendation	**Feasible**	**Feasible**	**Not Recommended**

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Appendix G

GSC Seismic Hazard Calculation

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 49.137N 90.758W **User File Reference:** Baker Creek Culvert 2020-11-12 18:33 UT

Requested by: C. Murray, Thurber Engineering

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.059	0.028	0.014	0.002
Sa (0.1)	0.079	0.040	0.021	0.004
Sa (0.2)	0.071	0.037	0.021	0.004
Sa (0.3)	0.055	0.030	0.017	0.004
Sa (0.5)	0.039	0.022	0.013	0.003
Sa (1.0)	0.019	0.010	0.006	0.001
Sa (2.0)	0.008	0.004	0.002	0.000
Sa (5.0)	0.002	0.001	0.001	0.000
Sa (10.0)	0.001	0.000	0.000	0.000
PGA (g)	0.043	0.021	0.011	0.002
PGV (m/s)	0.027	0.014	0.007	0.001

Notes: Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

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Appendix H

List of Referenced OPSS and OPSD Documents and Suggested Wording for NSSP

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1. The following Special Provisions and OPSS Documents are referenced in this report:

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 209	Embankments over Swamps and Compressible Soils
OPSS.PROV 401	Construction Specification for Trenching, Backfilling, and Compacting
OPSS.PROV 421	Construction Specification for Pipe Culvert Installation in Open Cut
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS 805	Construction Specification for Temporary Erosion and Sediment Control Measures
OPSS 902	Construction Specification for Excavating and Backfilling Structures
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
OPSS.PROV 1205	Material Specification for Clay Seal
OPSS.PROV 1860	Material Specification for Geotextiles
OPSD 208.010	Benching of Earth Slopes
OPSD 802.010	Flexible Pipe Embedment and Backfill Earth Excavation
OPSD 802.014	Flexible Pipe Embedment in Embankment, Original Ground: Earth or Rock
OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m
OPSD 803.031	Frost Treatment – Pipe Culverts
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets

OPSD 812.010	Cut Off Wall for Structural Plate Pipe Arch and Circular CSP
OPSD 3090.100	Foundation Frost Penetration Depths for Northern Ontario

2. Suggested Wording for NSSP

- **Suggested Text for NSSP on Dewatering**

Dewatering may be required to construct the replacement culvert in the dry. The design of an effective dewatering system is the responsibility of the contractor. The dewatering system must be effective to lower the groundwater table at least 0.5 m below the base of the excavations to avoid basal heave and base boiling. The dewatering system is to be designed in accordance with SP FOUN0003 and OPSS.PROV. 517. A preconstruction survey is not required, thus Designer Fill-In ** in SP FOUN0003 should be “N/A”. Special Provision FOUN0003 is included below. Considering the conditions on site, it is recommended that a dewatering engineer with a minimum of 5 years of experience in designing dewatering systems should be retained by the contractor for design of an effective dewatering system.

- **Suggested Text for NSSP on Obstructions**

“Excavations and installation of roadway protection systems could encounter obstructions such as cobbles and boulders embedded in the embankment fill. Such obstructions may impede excavation progress and/or sheetpile installation. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths. Vibrating equipment is not permitted for installation of sheet piles”

DEWATERING STRUCTURE EXCAVATIONS - Item No.

Special Provision No. FOUN0003 March 8, 2018

Amendment to OPSS 902, November 2010

OPSS 902, November 2010, Construction Specification for Excavating and Backfilling - Structures is amended as follows:

902.02 REFERENCES

Section 902.02 of OPSS 902 is amended by the addition of the following:

Ontario Provincial Standard Specifications, Construction

OPSS 517 Dewatering
OPSS 805 Temporary Erosion and Sediment Control Measures

902.03 DEFINITIONS

Section 903.03 of OPSS 902 is amended by the addition of the following:

Automatic Transfer Switch means as defined in OPSS 517.

Cofferdam means as defined in OPSS 539.

Cut-Off Wall means as defined in OPSS 517.

Design Storm Return Period means as defined in OPSS 517.

Dewatering System means as defined in OPSS 517.

Groundwater Control System means as defined in OPSS 517.

Plug means as defined in OPSS 517.

Sediment means as defined in OPSS 517.

Sediment Control Measure means as defined in OPSS 517.

Temporary Flow Passage System means as defined in OPSS 517.

Unwatering means as defined in OPSS 517.

Vegetated Discharge Area means as defined in OPSS 517.

Waterbody means as defined in OPSS 517.

Watercourse means as defined in OPSS 517.

902.04 DESIGN AND SUBMISSION REQUIREMENTS

902.04.01 Design Requirements

902.04.01.01 Dewatering

Clause 902.04.01.01 of OPSS 902 is deleted in its entirety and replaced with the following:

A dewatering system shall be designed to control water and the flow of water into the excavation, prevent disturbance of the foundation, permit the placing of concrete in the dry, and complete the excavating and backfilling for structures work.

When the system includes temporary flow passage system, the system shall be designed, as a minimum, for a [* Designer Fill-In, See Notes to Designer] year design storm return period, and groundwater discharge. A longer return period shall be used when determined appropriate for the work.

The dewatering system shall be according to the design requirements specified in OPSS 517.

902.04.02 Submission Requirements

Subsection 902.04.02 of OPSS 902 is deleted in its entirety and replaced with the following:

902.04.02.01 Working Drawings

Working Drawings for the dewatering system shall be according to OPSS 517.

902.04.02.02 Preconstruction Survey

When a groundwater control system by wells or a well point system will be used, a condition survey of property and structures that may be affected by the work shall be carried out. The condition survey shall include the location and condition of adjacent properties, buildings, underground structures, water wells, Utilities, and structures, within a distance of [** Designer Fill-In, See Notes to Designer] metres from the groundwater control system. In addition, all water wells used as a supply of drinking water and located within this distance shall be tested for compliance with Ontario Drinking Water Quality Standards.

Water wells within the preconstruction survey distance can be located using the website https://www.ontario.ca/environment-and-energy/map-well-records or its successor site.

Copies of the condition survey and water quality test results shall be submitted to the Contract Administrator prior to the operation of the groundwater control system.

902.04.02.03 Milestone Inspections

Clause 902.04.02.03 of OPSS 902 is deleted in its entirety.

902.07 CONSTRUCTION

Subsection 902.07.04 of OPSS 902 is deleted in its entirety and replaced with the following:

902.07.04 Dewatering Structure Excavation

902.07.04.01 General

The dewatering systems shall be constructed and operated according to the Working Drawings.

Activation and deactivation of a temporary flow passage system, if applicable, shall be according to OPSS 517.

The dewatering system shall be continuously operational to control buoyancy forces until such forces can be resisted by backfill and structure self-weight, to keep excavations stable, to avoid erosion impacts from the release of accumulated water, and to keep the work area in the condition required to complete the associated work as specified in the Contract Documents.

When a temporary flow passage system is to remain operational through a seasonal shutdown period, the Contractor shall be responsible for any maintenance or repair costs due to the system during the seasonal shutdown period.

Temporary erosion and sediment control measures, including controlling the discharge of water, shall be according to OPSS 805. Measures not specified in OPSS 805 shall be according to the Working Drawings. Temporary erosion and sediment control measures and cover material to protect exposed soils, as required by the Working Drawings, shall be installed as soon as is practical.

Stranded fish shall be managed as specified in the Contract Documents.

Unwatering shall be carried out as necessary.

Water suspected of being contaminated as indicated by visual or olfactory observations shall be reported to the Contract Administrator.

Dewatering and temporary flow passage systems shall be discontinued in a manner that does not disturb any structure, pipeline, or flow channel. Operation of the dewatering system shall be shut down according to the procedures specified in the Working Drawings, where applicable.

902.07.04.02 Discharge of Water

The discharge of water shall be according to OPSS 517.

902.07.04.03 Monitoring

Monitoring shall be according to OPSS 517.

902.07.04.04 System Amendments

Amendments to stop any displacement, damage, soil loss or erosion due to the operation of the dewatering system shall be according to OPSS 517.

902.07.04.05 Removal

Removal of dewatering system and temporary flow passage system components shall be according to OPSS 517.

NOTES TO DESIGNER:

Designer Fill-Ins

* Fill in the design storm return period according to MTO Drainage Design Standard TW-1.

** Fill in the preconstruction survey distance as recommended by the foundation engineer.

WARRANT: Include with this standard tender item **only** on the recommendation of a foundation engineer.

CUSTODIAN: Tony Sangiuliano, MERO - Foundation Group.