



THURBER ENGINEERING LTD.

**DETAILED FOUNDATION INVESTIGATION AND DESIGN REPORT
McLEAN'S CREEK CULVERT REPLACEMENT
HIGHWAY 17, UNSURVEYED TERRITORY
THUNDER BAY DISTRICT, ONTARIO
LATITUDE: 48.839562°, LONGITUDE: -87.442991°**

G.W.P. 6809-14-00, W.P. 6809-14-01, SITE NO. 48C-178C

GEOCRES Number: 42D-059

Report

to

HATCH

Date: January 15, 2020
File: 15595



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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the detailed design of the proposed McLean's Creek Culvert on Highway 17, located west of Selim, in the District of Thunder Bay, Ontario. Thurber previously completed a preliminary foundation investigation at the culvert site in 2018.

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

Thurber carried out the investigation as a sub-consultant to Hatch under the Ministry of Transportation Ontario (MTO) Agreement Number 6016 -E-0008.

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

- Preliminary Foundation Investigation and Design Report, McLean's Creek Culvert Replacement, Highway 17, Unsurveyed Territory, Thunder Bay District, Ontario, GEOCRES Number 42D-53, prepared by Thurber Engineering Ltd.

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

2. SITE DESCRIPTION

The site is located along Highway 17, approximately 3 km west of the Selim area. The existing culvert allows McLean's Creek to flow south into Lake Superior. Highway 17 generally runs in an east-west direction at the culvert site.

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Based on the Ontario Structure Inspection Manual (OSIM) prepared by MTO on November 20, 2014 the existing culvert is a cast in place concrete box culvert that is 6.1 m wide, 2.8 m high and 36.7 m long. The culvert barrel is in fair condition with severe erosion along the bottom 0.3 m of both side walls and light scaling on the bottom 0.9 m of the side walls. There are several cracks in the walls that are up to 0.9 m in length as well as a crack at the midspan of the culvert with rust stains on both the walls and soffit. Delamination has also occurred along the soffit at the outlet of the culvert.

The estimated culvert invert is at approximate Elevation 186.6 m at the inlet (north) and 186.2 m at the outlet (south). The existing road grade at the culvert location is at approximate Elev. 192.0 m, and there is approximately 2.5 m of fill above the culvert. The elevation of the water flowing through the culvert in November of 2013 was recorded at approximately 187.5 m upstream of the inlet and 185.8 m downstream of the outlet.

The area on either side of the creek near the inlet and outlet of the culvert is vegetated with grass, shrubs and small trees. Rainbow Falls provincial park is located southwest of the culvert, with the entrance to the park approximately 80 m to the west of the culvert outlet. Photographs in Appendix D show the culvert and the surrounding area.

The site lies within the physiographic region known as the Wawa Subprovince of the Superior Province of the Canadian Shield. Based on Ontario Geological Survey (OGS) Map 2518, titled "Surficial Geology of Northern Ontario", dated 1987, the site is located in an area of "bare bedrock with thin glacial sediment cover". Based on OGS Map 2545, titled "Bedrock Geology of Ontario", dated 1991, the bedrock is of the Archean age and consists of intrusive rocks, mainly massive to foliated granodiorite and granite.

3. INVESTIGATION PROCEDURES

The current investigation and field testing program was carried out between June 23 and July 26, 2018, and consisted of drilling and sampling three (3) boreholes, designated as Boreholes 18-25 to 18-27, to depths of between 4.4 m to 15.8 m below the existing ground surface. Borehole 18-25 was drilled within the paved portion of Highway 17, approximately 16 m east of the existing culvert near the east end of the proposed roadway protection. Boreholes 18-26 and 18-27 were drilled near the inlet and outlet of the proposed culvert alignment to address cofferdam construction.

The previous preliminary investigation for this project was carried out between July 24 and 26, 2017, during which time four boreholes denoted as Boreholes 17-38 to 17-41 were drilled at



selected locations at the culvert site to depths of between 2.7 m to 15.8 m.

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

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from topographic drawings provided to Thurber by Hatch. The borehole drilled from the Highway platform from the current investigation was drilled using a truck-mounted drill rig using wash boring drilling techniques, Boreholes 18-26 and 18-27 were drilled using a portable Hilti drill and tripod equipment using wash boring techniques. Samples of the overburden soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

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

The boreholes were backfilled in general accordance with Ontario Regulation 903, as amended. A piezometer was installed in Borehole 17-38 drilled during the preliminary investigation.

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

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
18-25	15.8/175.9	None Installed	Borehole backfilled with bentonite holeplug and cuttings to 3.0 m, bentonite holeplug to 0.3 m, sand to 0.2 m, then asphalt to surface.
18-26	9.8/178.0	None Installed	Borehole backfilled with bentonite holeplug to surface.

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
18-27	4.4/182.5	None Installed	Borehole backfilled with bentonite holeplug to surface.
17-38	15.8/174.7	15.2/175.3	Sand from 15.8 m to 11.6 m, then bentonite holeplug to surface
17-38A (DCPT)	6.0/184.5	None Installed	Borehole backfilled with bentonite holeplug to surface
17-39	15.8/176.0	None Installed	Borehole backfilled with bentonite holeplug and cuttings to 0.2 m, then asphalt to surface
17-39A (DCPT)	9.2/182.6	None Installed	Borehole backfilled with bentonite holeplug to surface
17-40	14.8/174.1	None Installed	Borehole backfilled with bentonite holeplug to surface
17-41	2.7/188.9	None Installed	Borehole backfilled with bentonite holeplug and cuttings to 0.2 m, then asphalt to surface

4. LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (hydrometer and/or sieve) and Atterberg Limits testing, where appropriate. Point load tests were conducted on rock cores. Laboratory testing results are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, during the previous investigation, a sample of the fill, and a sample of the surface water from the creek upstream of the existing culvert were



collected and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters. The results of the analytical testing are summarized in this report and also presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

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

In general, the subsurface conditions encountered in these boreholes consisted of asphalt and sand and gravel fill overlying varying thicknesses of sand and silt layers, which were in turn underlain by silty clay and bedrock. Descriptions of the individual strata are presented below.

5.1 Surficial Boulders / Sand and Gravel / Topsoil

The creek bed and the creek banks near the proposed cofferdam locations were observed to contain boulders, as shown on Photos 4 to 6 in Appendix D. At Borehole 18-26, a 0.3 m thick boulder was encountered at the ground surface, which was underlain by topsoil with some gravel to a depth of 0.5 m (Elevation 187.2 m). At Borehole 18-27, a layer of sand and gravel with trace cobbles and trace organics was encountered at the ground surface and extended to a depth of 0.9 m (Elevation 186.0 m).

The surficial deposits were compact, based on SPT 'N' values of 16 to 27 blows per 0.3 m of penetration, with 70 blows per 0.2 m of penetration also recorded in Borehole 18-27, which is likely due to the presence of cobbles in the soil. The measured moisture content of the surficial materials ranged from 10 percent for the sand and gravel to 80 percent for the topsoil with some gravel.

The results of a grain size distribution analysis carried out on a sample of the sand and gravel are presented on the Record of Borehole sheets included in Appendix A and on Figure B1 in Appendix B. The results of the grain size distribution analysis are summarized below:



Soil Particle	Percentage (%)
Gravel	43
Sand	52
Silt and Clay	5

5.2 Asphalt

Boreholes 17-39, 17-41, and 18-25 were drilled through the paved portions of Highway 17 and encountered a 150 to 200 mm thick layer of asphalt. Borehole 17-38 was drilled on the east side of the culvert inlet near the base of the existing highway embankment and encountered 75 mm of asphalt, that may have been part of a former road bed.

5.3 Sand and Gravel Fill

Sand and gravel fill ranging to gravelly sand fill, and containing trace silt, was encountered below the asphalt in Boreholes 17-38, 17-39, 17-41, and 18-25, and at the ground surface in Borehole 17-40. The sand and gravel to gravelly sand fill had a thickness of between 2.8 m and 5.0 m and extended to depths of approximately 2.8 m to 5.2 m (Elevation 188.7 m to 186.1 m). Borehole 17-41 was terminated within the fill at a depth of 2.7 m (Elevation 188.9 m).

SPT 'N' values within the sand and gravel to gravelly sand fill ranged from 2 blows per 0.3 m of penetration to 50 blows for 0.15 m of penetration, indicating a very loose to very dense relative density. Moisture contents between 1 percent and 21 percent were measured in the cohesionless fill.

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

Soil Particle	Percentage (%)
Gravel	19 to 49
Sand	46 to 75
Silt and Clay	3 to 7



5.4 Silty Sand to Sand and Silt

Silty sand to sand and silt, containing trace clay and trace gravel was encountered in Boreholes 17-38 to 17-40 and 18-25 to 18-27 at depths of between 0.6 m to 5.5 m (Elevations 186.0 m to 187.4 m). The silty sand to sand and silt layer was between 0.9 m to 7.4 m thick and extended to depths of between 1.8 m and 11.2 m (Elevations 185.1 m to 178.7 m).

SPT 'N' values within the deposit ranged from 5 to 102 blows per 0.3 m of penetration, indicating a loose to very dense condition. Measured moisture contents within the deposit varied between 14 percent and 22 percent.

The DCPTs 17-38A and 17-39A were terminated within this deposit at depths of 6.0 m and 9.2 m (Elevation 184.5 m and 182.6 m) respectively upon refusal of 100 blows per 0.3 m of penetration.

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

Soil Particle	Percentage (%)
Gravel	0 to 7
Sand	44 to 77
Silt	25 to 48
Clay	3 to 10
Silt and Clay	21 to 23

5.5 Sand

Sand, with trace to some silt and trace gravel, was encountered in Boreholes 17-39, 18-25, and 18-26 at depths of between 7.3 m and 11.2 m (Elevations 181.9 m to 180.5 m). Where fully penetrated the sand layer was between 2.5 m and 4.9 m thick and extended to depths of between 13.7 m and 14.8 m (Elevations 178.0 m and 177.0 m). Borehole 18-26 was terminated in the sand at a depth of 9.8 m (Elevation 178.0 m).

SPT 'N' values within the deposit ranged from 2 blows per 0.3 m of penetration to 50 blows per 0.125 mm of penetration, indicating a very loose to very dense condition. Measured moisture contents within the deposit varied between 17 percent and 28 percent.



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

Soil Particle	Percentage (%)
Gravel	0
Sand	88 to 96
Silt and Clay	4 to 12

5.6 Silt

Silt, containing some sand, some clay, and trace gravel was encountered in Borehole 17-38 at a depth of 10.1 m (Elevation 180.4 m). The silt was approximately 4.5 m thick and extended to a depth of 14.6 m (Elevation 175.9 m).

SPT 'N' values within the silt deposit ranged from 19 to 28 blows per 0.3 m of penetration, indicating a compact relative density. Measured moisture contents within the silt deposit varied between 19 percent and 23 percent.

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

Soil Particle	Percentage (%)
Gravel	0
Sand	11
Silt	75
Clay	14

5.7 Silty Clay

A 2.5 m thick upper layer of silty clay with trace sand was encountered below the fill in Borehole 18-25, which extended to a depth of 5.5 m (Elev. 186.2 m). A lower layer of silty clay with trace sand and gravel was also encountered in Boreholes 17-38 to 17-40, 18-25 and 18-27 below the sand and silt layers above the bedrock. Where fully penetrated, the lower silty clay layer was approximately 0.4 m to 1.1 m thick and extended to depths of 2.2 m to 11.3 m (Elevations 184.7 m to 177.6 m). Boreholes 17-38, 17-39, 18-25 were terminated within the silty clay layer at depths of 15.8 m (Elevation 176.0 m to 174.7 m).



In Borehole 18-25, artesian conditions were encountered within the upper silty clay layer at a depth of approximately 4.5 m (Elevation 187.4 m). The groundwater temporarily rose to approximately 0.6 m above ground surface (Elevation 192.3 m). After approximately 20 minutes the ground water level dissipated and upon completion of drilling no groundwater was observed in the open borehole.

SPT 'N' values of 6 to 31 blows per 0.3 m penetration indicated that the silty clay had a firm to hard consistency. The silty clay had a measured moisture content ranging from 20 to 36 percent.

The results of grain size distribution analyses and Atterberg Limits testing carried out on selected samples of the silty clay are presented on the Record of Borehole sheets included in Appendix A and on Figures B5 and B6 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	0 to 6
Silt	21 to 69
Clay	28 to 76

The results of Atterberg Limits testing are summarized below:

Index Property	Percentage (%)
Plastic Limit	14 to 23
Liquid Limit	24 to 55

The results of the Atterberg Limits testing indicate the layer to be of low to high plasticity with group symbol CH in the upper layer and CL in the lower layer.

5.8 Bedrock

Bedrock was encountered below the silty clay in Boreholes 17-40 and 18-27 at depths of 11.3 m and 2.2 m (Elevation 177.6 m and 184.7 m), respectively. The bedrock was proven by coring in both boreholes to depths of 14.8 m and 4.4 m (Elevation 174.1 m and 182.5 m), respectively. In Borehole 17-40 the bedrock consisted of moderately weathered grey basalt underlain by slightly weathered reddish brown granite, while in Borehole 18-27 only slightly weathered granite was encountered. The total core recovery, solid core recovery and rock quality index values recorded for the three runs of rock that were sampled in each borehole are shown below.



Borehole	Run Number	Total Core Recovery (%)	Solid Core Recovery (%)	Rock Quality Index (%)
17-40	1	100	100	89
	2	77	37	20
	3	97	70	40
18-27	1	90	90	24
	2	100	100	100
	3	18	18	18

The RQD results indicate very poor to good rock quality. Average unconfined compressive strengths (UCS) of the rock ranged between 70 MPa and 238 MPa based on correlations with the point load tests, indicating the rock was strong to very strong. The point load test results are included in Appendix B.

5.9 Groundwater Conditions

Groundwater conditions were observed during drilling operations, and groundwater levels were measured in the open boreholes upon completion of drilling. A standpipe piezometer was installed in Borehole 17-38 to monitor the groundwater level at the site. The groundwater levels measured in the open boreholes and in the standpipe piezometer are summarized below.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
18-25	June 23, 2018	Dry	Dry	Open borehole. Artesian condition in upper silty clay
18-26	July 24, 2018	0.6	187.2	Open borehole
18-27	July 26, 2018	0.2	186.7	Open borehole
17-38	July 26, 2017	2.6	187.9	Standpipe piezometer
17-39	July 24, 2017	2.1	189.7	Open borehole
17-40	July 26, 2017	1.0	187.9	Open borehole
17-41	July 24, 2017	Dry	Dry	Open borehole

In Borehole 18-25, artesian pressure of approximately 0.6 m above the ground surface (Elevation 192.3 m) was encountered during drilling at a depth of approximately 4.5 m. The artesian pressure dissipated after approximately 20 minutes, and no groundwater was observed in the open borehole upon completion of drilling.



The creek water level in November 2013 was reported to be Elev. 187.5 m upstream of the inlet and 185.8 m downstream of the outlet and was measured at Elevation 187.5 m and 187.2 m (at the inlet and outlet respectively) during the preliminary investigation.

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

6. CORROSIVITY AND SULPHATE TEST RESULTS

During the preliminary investigation, a sample of the sand and gravel fill from Borehole 17-39 and a sample of the creek water were submitted for analytical testing corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results	
			17-39, 3.0 m – 3.7 m	McLean's Creek
			(Sand and Gravel Fill)	(Creek Water)
Sulphide	%	mg/L	<0.02	<0.006
Chloride	mg/L	mg/L	1500	0.39
Sulphate	mg/L	mg/L	37	2
pH	No unit	No unit	6.17	7.17
Electrical Conductivity	µS/cm	µS/cm	1520	33
Resistivity	Ohms.cm	Ohms.cm	656	30300
Redox Potential	mV	mV	276	198

7. MISCELLANEOUS

Thurber marked the borehole locations in the field and obtained subsurface utility clearances prior to drilling.

Downing Drilling of Hawkesbury, Ontario, and OGS Drilling of Almonte, Ontario, supplied and operated the drilling, sampling and in-situ testing equipment for the current field investigation. The



current field investigation was supervised on a full-time basis by Mr. Liam Steers and Mr. Ryan McCourt of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. of Thurber.

Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field relative to the topographic plans provided by Hatch. The coordinate system MTM NAD83 Zone 14 was used for these boreholes.

Routine laboratory testing was carried out at Thurber's geotechnical laboratory. Interpretation of the field data and preparation of this report was carried out by Mr. Cory Zanatta, P.Eng. and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report provides an interpretation of the geotechnical data in the factual report and presents detailed foundation design recommendations for the proposed McLean's Creek Culvert replacement on Highway 17, located in the Unsurveyed District of Thunder Bay, Ontario. This detailed foundation report should be read in conjunction with the Preliminary Foundation Report dated September 11, 2018.

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

Information on the existing culvert site was obtained from the MTO Terms of Reference, and the Ontario Structure Inspection Manual (Inspection Form) prepared by MTO on November 20, 2014. The existing structure is a cast in place concrete box culvert. The culvert measures 6.1 m wide, 2.8 m high and is 36.7 m long. The estimated culvert invert is at approximate Elevation 186.6 m at the inlet (north) and 186.2 m at the outlet (south). The existing road grade at the culvert location is at approximate Elev. 192 m, and there is approximately 2.5 m of fill above the culvert.

The preliminary foundation report provided recommendations for both pipe culverts and box culverts. General Arrangement Drawings and discussions with Hatch indicate that twin Structural

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Plate Corrugated Steel Pipe (SPCSP) culverts are the preferred replacement option. The twin pipe culverts are to have an interior diameter of 3.99 m. The invert levels of the twin pipe culverts are at approximately Elevation 185.41 m and 185.34 m at the inlet and outlet, respectively.

The proposed twin pipe culvert replacements will be constructed on approximately the same alignment as the existing box culvert. No grade raise or embankment widening is proposed for the culvert replacement. No headwalls or wingwalls are proposed.

Temporary roadway protection will be used to construct the twin culverts in stages and a temporary diversion pipe will be used to divert creek flow. The proposed temporary diversion pipe will be approximately 12 m west of the existing culvert.

9. CULVERT FOUNDATION DESIGN

In general, the subsurface conditions encountered in the boreholes consisted of 150 to 200 mm of asphalt underlain by sand and gravel embankment fill overlying native firm silty clay, loose to very dense silty sand to sand and silt, very loose to very dense silt and stiff to hard silty clay layers. Bedrock was encountered in Boreholes 17-40 and 18-27, below the silty clay deposit. The groundwater level, as measured in the piezometer, was at approximately 187.9 m. Artesian groundwater conditions with a piezometric head of about 0.6 m above ground level was encountered in Borehole 18-25, which dissipated after approximately 20 minutes.

The founding soils encountered at the proposed invert level (Elevations 185.41 m to 185.34 m) generally consist of loose to very dense silty sand to sand and silt below the groundwater table. There is approximately 2.5 m of fill above the proposed culvert replacement.

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

9.1 Foundations

Replacement of the culvert with twin pipe culverts, located on approximately the same alignment as the existing culvert, is being considered for this site. It is anticipated that the foundation soils within the culvert footprint will not be subjected to any significant additional loading due to the culvert replacement.

The twin pipe culverts should be placed on uniform foundation subgrade consisting of a minimum of 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements as per OPSD 802.014 or 802.010. The bedding material should



be placed on the prepared subgrade as soon as practical, following its inspection and approval. The subgrade preparation, placement, and compaction of the bedding, should be carried out in the dry. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction. A separation layer consisting of a non-woven geotextile should be placed between the subgrade soils and the bedding material. The geotextile should meet the specifications for the OPSS Class II, and have a fabric opening size (FOS) not greater than 212 μm .

The underside of the bedding layer should be placed at or below Elevation 185.1 m, which corresponds to compact silts and sands subgrade. Any loose soil, large cobbles and boulders, and any organic or other detritus material encountered during subgrade preparation should be sub-excavated and replaced with compacted granular material to provide a uniformly competent subgrade condition.

Shallow bedrock was encountered at a depth of 2.2 m (Elevation 184.7 m) in Borehole 18-27 near the culvert outlet. Based on the available information, at this location the bedrock is below the culvert invert level. However, there is a potential that bedrock may be encountered at higher elevations in the vicinity of the culvert outlet, and therefore bedrock excavation may be required to place sufficient bedding material below the pipes. A tender item for rock excavation is recommended.

9.2 Frost Cover

The depth of frost penetration at this site is approximately 2.2 m based on OPSD 3090.100. The twin SPCSPs do not require frost cover protection.

Based on the results of the field investigation, the existing embankment fill at the culvert location comprises sand and gravel material to below the frost penetration depth; therefore, construction of new frost tapers does not appear warranted as part of the culvert replacement.

9.3 Subgrade Preparation

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



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

Shallow bedrock was encountered near the outlet of the culvert. In the event that bedrock is encountered in the culvert excavations near the outlet, the bedding thickness in the rock areas should be increased to 500 mm in order to reduce the potential for non-uniform and abrupt settlement and associated deformation of the culvert (i.e. hard point effect) between the variable materials. The bedrock should be excavated sufficiently to accommodate the increased bedding thickness.

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

9.4 Settlement

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

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

10. EXCAVATION AND GROUNDWATER CONTROL

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



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

Excavations for culvert replacement will be carried out through the existing embankment fill, and native silty clay and silty sand to sand and silt below the groundwater table.

Installation of the culvert must be carried out in the dry. Excavations for the culvert replacement will be carried out at or below the creek water level, and diversion of the creek flow will be required. The groundwater table is high at this site and there is evidence of artesian conditions. Seepage should be anticipated from the embankment fill and the sand layer adjacent to the creek. Depending on the time of construction, a combination of cofferdam enclosures and creek diversion along with pumping from filtered sumps within an enclosure surrounding all sides of the excavation will be required to maintain dry excavations during the course of staged construction. Recommendations for cofferdam design are provided in Sections 14 and 15 below. The dewatering scheme must be in place prior to excavation below the groundwater level, and must be effective to lower the groundwater level at least 0.5 m below the final subgrade level. The contractor must submit a dewatering plan to the CA two (2) weeks prior to construction. If dewatering is not in place prior to excavation, the subgrade will be susceptible to base boiling and the culvert may be susceptible to future settlement.

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

In accordance with SP FOUN0003, the dewatering system is to be designed in accordance with OPSS.PROV 517. A preconstruction survey is required, thus Designer Fill-In ** in SP FOUN0003 should be "100 m". It is recommended that a Professional Engineer with greater than 5 years of experience in designing dewatering systems be retained. The dewatering plan must be signed/sealed by the P.Eng.

Dewatering must remain operational and effective until the culvert is installed and backfilled. Suggesting wording for an NSSP in this regard is included in Appendix E. Further assessment of dewatering requirements and the need for an Environmental Activity and Sector Registry (EASR) or Permit to Take Water (PTTW) should be carried out by specialists experienced in the field. It is anticipated that dewatering pumping systems for staged construction at this site will generate flows between 50,000 and 400,000 L/day, which indicates that an EASR may be applicable.



11. STREAM DIVERSION PIPE

A temporary CSP stream diversion pipe is proposed to accommodate creek water flow during culvert replacement. Based on the preliminary general arrangement drawings, the invert of the diversion pipe is at approximate Elevation 186.5 m, which corresponds to native sand and silt.

The temporary 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.

Based on the presence of shallow bedrock found near the culvert outlet, there is a potential for bedrock to be encountered during excavation for the diversion pipe trench. Accordingly, a tender item for rock excavation is recommended.

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

12. CULVERT BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the culvert should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 802.010 or 802.014, as appropriate. Backfilling for the culvert should be in accordance with OPSS PROV 401 for SPCSP culverts. All fills should be placed in regular lifts and be compacted in accordance with OPSS PROV 501. The backfill should be placed and compacted in simultaneous lifts on both sides of the culvert, and the top of backfill elevation should not differ more than 500 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used adjacent to the walls and on the roof of the culvert. Compaction equipment to be used adjacent to the culvert should be restricted in accordance with OPSS PROV 501.

Lateral earth pressures acting on any culvert walls or retaining walls, if employed, may be assumed to be a triangular distribution. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC 2014, but are generally given by the expression:



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

where

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

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

Table 12.1 – Lateral Earth Pressure Coefficients (K)

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

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

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

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

13. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2014, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy. Based on the stratigraphy of the site, this area corresponds to a Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2% in 50-year probability of



exceedance at this site is 0.033 g as per the National Building Code of Canada (NBCC), and a Site Class D would be amplified to 0.043 g.

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

Table 13.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I or Type III $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$
Active (K_{AE})*	0.29	0.32
Passive (K_{PE})	3.6	3.2
At Rest (K_{OE})**	0.48	0.53

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

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

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

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

14. COFFERDAMS

Construction of cofferdams will be required to construct the culvert replacement in the dry. It is recommended that the temporary culvert excavations be carried out within a water tight enclosure surrounding all sides of the excavations. Both sand bag cofferdams systems and interlocking sheet piles with pumping from sumps are considered to be feasible for cofferdam construction at this site. However, due to the presence of dense to very dense native soils, as well as shallow bedrock at the culvert outlet encountered in Borehole 18-27, it may be difficult to drive sheet piles to a sufficient embedment depth. Bracing may be required for sheet piles that cannot be driven deep enough. If sheet pile cofferdams are considered for this site, the recommendations provided in Section 15 below for Temporary Protection Systems are also applicable to sheet pile cofferdams, however a Professional Engineer experienced in design must check that the appropriate lateral resistance can be achieved. Surficial boulders in the creek bed and along the creek banks may impede the driving of sheet piles, and therefore should be removed prior to driving sheet piles.

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Design\FINAL\McLean's Creek Culvert Detail FIDR - FINAL.docx



Design of a suitable and effective dewatering system is the responsibility of the Contractor as indicated in Section 10.

15. TEMPORARY PROTECTION SYSTEM

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

Options for roadway protection are a soldier pile-lagging system or interlocking sheet piles. However, the presence of occasional boulders in the fill and dense to very dense fill and native soils may impede the driving of sheet piles.

The soil parameters in Table 15.1 may apply for the design of the temporary roadway protection system with horizontal backfill.

Table 15.1 –Soil Parameters for Temporary Protection System Design

Soil Parameter	Existing Fill	Native Silt Clay	Native Sand and Silt
Φ (angle of internal friction)	32°	25°	30°
γ (total unit weight)	20 kN/m ³	19 kN/m ³	20 kN/m ³
γ_w (Submerged unit weight)	10 kN/m ³	9 kN/m ³	10 kN/m ³
K_a	0.31	0.41	0.33
K_p	3.3	2.5	3.0

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

The temporary protection system may be removed or partially removed upon completion of the work. Care must be taken when removing the sheet piles or soldier piles as to not incur damage or settlement of the newly installed culvert. In particular, vibratory extraction methods may cause settlement of the existing sands and silts. An NSSP to this effect is included in Appendix E.

The design of temporary protection system is the responsibility of the Contractor. The actual pressure distribution acting on the protection/shoring system is a function of the construction



sequence and the relative flexibility of the wall, and these factors have to be considered when designing the shoring system. All protection systems should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system.

16. EMBANKMENT RESTORATION

Provided that the embankment is reconstructed with side slopes inclined not steeper than 2H:1V, the restored embankment slope should remain stable. As discussed in Section 9.4, and if there is no grade raise or embankment widening, settlement of the embankment under the existing culvert footprint should be less than 25 mm. Fill placement for temporary embankment widening for construction staging purposes may lead to minor settlement of the existing embankment prior to replacement of the culvert. The embankment may need to be regraded during construction as necessary. The temporary widening fill must be removed and the slopes reinstated to the new permanent grade level prior to opening the embankment to live traffic.

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

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

17. SCOUR AND EROSION PROTECTION

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

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

A clay seal (only at the inlet) should be used to minimize the potential for erosion or piping around the culvert. The clay seal should extend to approximately 0.3 m above the high water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The



material requirements should be in accordance with OPSS PROV 1205. A geosynthetic clay liner may be used in place of a compacted clay seal.

18. CORROSION AND SULPHATE ATTACK POTENTIAL

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

- The potential for corrosion on concrete foundations from the surrounding surface water is considered to be negligible. However, the high chloride content of the soil indicates that the surrounding soil may be corrosive to concrete elements. The risk of sulphate attack on concrete from the native soil or surface water is negligible. The effect of road deicing salt should also be considered while selecting the class of concrete.
- The potential for surface water corrosion on metal is considered to be mild. However, due to the low resistivity of the soil, the potential for corrosion on steel, cast iron and other metals is considered to be very severe.
- Appropriate protection measures are recommended for concrete and metal structural elements. The effect of road deicing salt should be considered while selecting the corrosion protection measures.

19. CONSTRUCTION CONCERNS

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

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



may limit the type of equipment suitable for use during construction. The design and safety of any temporary works is the responsibility of the Contractor.

20. CLOSURE

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

Thurber Engineering Ltd.

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Geotechnical Engineer



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Geotechnical Engineer



P.K. Chatterji, P.Eng., Ph.D.
Review Principal, Designated MTO Contact



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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


4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level


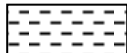



C_{pen} Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION

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

EXPLANATION OF ROCK LOGGING TERMS

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

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

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

RECORD OF BOREHOLE No 18-25

1 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 342.1 E 272 301.3 ORIGINATED BY BRM
DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing COMPILED BY MP
DATUM Geodetic DATE 2018.06.23 - 2018.06.23 LATITUDE 48.839590 LONGITUDE -87.442767 CHECKED BY MEF



SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
191.7	GROUND SURFACE															
0.0	ASPHALT (200mm)															
0.2	SAND and GRAVEL, trace silt Very Dense Brown Moist (FILL)		1	SS	77		191									
			2	SS	77											
	Boulders from 1.5m to 2.3m		3	SS	66		190									
			4	SS	50/ 0.150		189									
188.7	Silty CLAY, trace sand Firm Brown Wet (CH)		5	SS	6		188									
3.0																
	Artesian condition encountered at 4.5m						187									
	Water level rose to 0.6m above ground level, Dissipated after 20 minutes		6	SS	7											
186.2							186									
5.5	SAND and SILT, trace clay, trace gravel Compact to Very Dense Grey Moist to Wet		7	SS	20		185									
			8	SS	41		184									
							183									
	boulder at 9.1m		9	SS	50/ 0.125		182									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

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

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
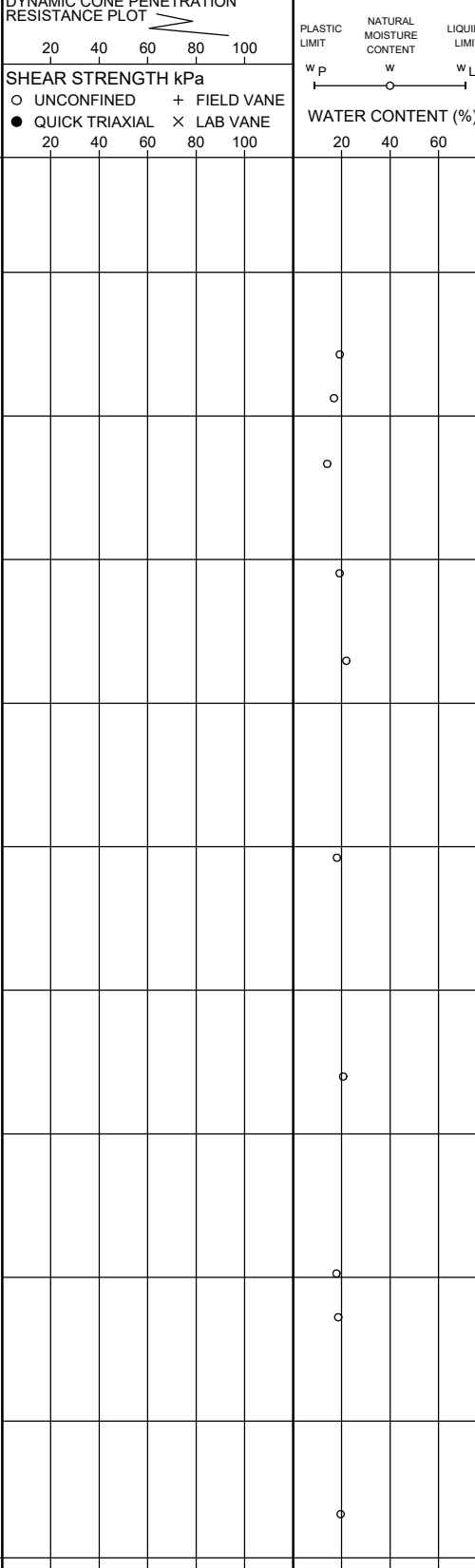
+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 18-26

1 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 363.8 E 272 278.5 ORIGINATED BY LS
DIST Thunder Bay HWY 17 BOREHOLE TYPE Wash Boring COMPILED BY MP
DATUM Geodetic DATE 2018.07.23 - 2018.07.24 LATITUDE 48.839784 LONGITUDE -87.443080 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
187.8	GROUND SURFACE														80		
0.0	BOULDER																
187.5			1	SS	16												
0.3	TOPSOIL, some rootlets, some gravel																
187.2	Compact Brown Moist		2	SS	15												
0.6	Silty SAND, trace gravel, occasional cobbles		3	SS	11												
	Compact to Very Dense Brown to Grey Wet		4	SS	61												
			5	SS	65												
			6	SS	102												
			7	SS	42												
		8	SS	100													
180.5																	
7.3	SAND, some silt, trace gravel																
	Very Dense Grey Wet	9	SS	88													
		10	SS	70													
178.0																	
9.8	END OF BOREHOLE AT 9.8m.																

Continued Next Page

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

RECORD OF BOREHOLE No 18-26

2 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 363.8 E 272 278.5 ORIGINATED BY LS
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Wash Boring COMPILED BY MP
 DATUM Geodetic DATE 2018.07.23 - 2018.07.24 LATITUDE 48.839784 LONGITUDE -87.443080 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Continued From Previous Page																
	BOREHOLE OPEN TO 0.6m AND WATER LEVEL AT 0.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																

RECORD OF BOREHOLE No 18-27

1 OF 1

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 316.3 E 272 275.6 ORIGINATED BY LS
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Wash Boring COMPILED BY MP
 DATUM Geodetic DATE 2018.07.25 - 2018.07.26 LATITUDE 48.839357 LONGITUDE -87.443115 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
186.9	GROUND SURFACE							<div>20406080100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div>							
0.0	SAND and GRAVEL , trace cobbles, trace organics, trace silt Compact Brown Moist		1	SS	27										
186.0			2	SS	70/ 0.200								○		43 52 5 (SI+CL)
0.9	Silty SAND , trace gravel, ocasional cobbles Compact Brown Wet						186								
185.1			3	SS	18								○		
1.8	Silty CLAY		4	SS	11		185						○		
184.7	Stiff Grey Wet														
2.2	Spoon refusal at 2.2m		1	RUN											
	BEDROCK (GRANITE) , slightly weathered, pink sub vertical fracture (125mm) at 2.3m mechanical fracture (200mm) at 2.3m vertical fracture (200mm) at 2.4m sub horizontal fracture (50mm) at 2.7m		2	RUN			184								RUN #1 TCR=90% SCR=90% RQD=24% UCS=223MPa RUN #2 TCR=100% SCR=100% RQD=100% UCS=238MPa RUN #3 TCR=18% SCR=18% RQD=18% UCS=191MPa
182.5			3	RUN			183								
4.4	END OF BOREHOLE AT 4.4m. WATER LEVEL AT 0.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.														

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

RECORD OF BOREHOLE No 17-38

1 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 354.2 E 272 288.6 ORIGINATED BY JZ
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2017.07.25 - 2017.07.25 LATITUDE 48.839698 LONGITUDE -87.442941 CHECKED BY NLB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20	40	60	80			100
190.5	GROUND SURFACE													
0.0	ASPHALT: (75mm) Gravelly SAND to SAND and GRAVEL , trace silt, occasional cobbles Very Loose to Loose Dark Brown Moist to Wet (FILL)		1	AS										
0.1			1	SS	2									
			2	SS	7									
			3	SS	5									
187.4	Silty SAND , trace gravel, trace clay Loose to Very Dense Grey Wet		4	SS	9									
3.1														
			5	SS	35									
			6	SS	53									
			7	SS	26									
			8	SS	43									

Continued Next Page

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

RECORD OF BOREHOLE No 17-38

2 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 354.2 E 272 288.6 ORIGINATED BY JZ
DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY AN
DATUM Geodetic DATE 2017.07.25 - 2017.07.25 LATITUDE 48.839698 LONGITUDE -87.442941 CHECKED BY NLB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
	Continued From Previous Page							20 40 60 80 100				○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
180.4 10.1	SILT, some sand, some clay, trace gravel Compact Grey Wet							20 40 60 80 100				20 40 60					0 11 75 14
		9	SS	28													
		10	SS	19													
		11	SS	24													
175.9																	
14.6	Silty CLAY, trace sand, trace gravel Stiff Grey Moist (CL)														0 6 66 28		
		12	SS	9													
174.7																	
15.8	END OF BOREHOLE AT 15.8m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.07.26 2.6 187.9																

ONTMT452 MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 8/29/19

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 17-39

1 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 336.2 E 272 274.3 ORIGINATED BY JZ
DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid & Hollow Stem Augers/NW Casing COMPILED BY AN
DATUM Geodetic DATE 2017.07.24 - 2017.07.24 LATITUDE 48.839536 LONGITUDE -87.443135 CHECKED BY NLB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _P w w _L				GR	SA	SI	CL	
191.8	GROUND SURFACE					▽		20	40	60	80	100								
0.0	ASPHALT: (150mm)							20	40	60	80	100								
0.2	SAND and GRAVEL, trace silt Compact Brown Moist (FILL)		1	AS																
			1	SS	23															
			2	SS	29															
			3	SS	22															
			4	SS	25															
	Dark Brown Wet		5	SS	26															
186.6																				
5.2	SAND and SILT, trace clay, trace gravel Compact Grey Wet		6	SS	28															
			7	SS	14															
			8	SS	14															
181.9																				

Continued Next Page



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

RECORD OF BOREHOLE No 17-39

2 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 336.2 E 272 274.3 ORIGINATED BY JZ
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid & Hollow Stem Augers/NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2017.07.24 - 2017.07.24 LATITUDE 48.839536 LONGITUDE -87.443135 CHECKED BY NLB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page						20	40	60	80	100						
9.9	SAND , trace to some silt, trace gravel Very Loose to Dense Grey Saturated																
			9	SS	2		181							○			0 96 4 (SI+CL)
			10	SS	41		180										
	No recovery						179										
			11	SS	40		178										
177.0																	
14.8	Silty CLAY , trace sand, trace gravel Very Stiff Grey Moist (CL)						177										
			12	SS	15									⊢			0 0 69 31
176.0																	
15.8	END OF BOREHOLE AT 15.8m. WATER LEVEL AT 2.1m FROM SURFACE UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.						176										

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

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 17-40

1 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 323.6 E 272 294.2 ORIGINATED BY JZ
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2017.07.26 - 2017.07.26 LATITUDE 48.839423 LONGITUDE -87.442863 CHECKED BY NLB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE										
188.9	GROUND SURFACE																		
0.0	SAND and GRAVEL , trace silt, occasional cobbles, trace organics Dense to Compact Brown Moist (FILL)		1	AS															
	No recovery			1	SS	40												49 48 3 (SI+CL)	
				2	SS	17													
	Grey Wet			3	SS	16													
186.1																			
2.8	SAND and SILT , trace clay, trace gravel Loose to Very Dense Grey Wet		4	SS	5														
				5	SS	8												4 47 43 6	
				6	SS	54													
				7	SS	52													
				8	SS	60												0 52 38 10	

Continued Next Page

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

RECORD OF BOREHOLE No 17-40

2 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 323.6 E 272 294.2 ORIGINATED BY JZ
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2017.07.26 - 2017.07.26 LATITUDE 48.839423 LONGITUDE -87.442863 CHECKED BY NLB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page													
178.7														
10.2	Silty CLAY , trace sand, trace gravel Very Stiff Grey Wet		9	SS	19		178							
177.6														
11.3	BEDROCK (BASALT), moderately weathered, very strong to strong, grey		1	RUN			177							
			2	RUN			176							
	Becoming granite, slightly weathered, very strong, reddish brown		3	RUN			175							
174.1														
14.8	END OF BOREHOLE AT 14.8m. WATER LEVEL AT 1.0m FROM SURFACE AT COMPLETION. BOREHOLE CAVED TO 4.6m AND BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													


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

RECORD OF BOREHOLE No 17-41

1 OF 1

METRIC

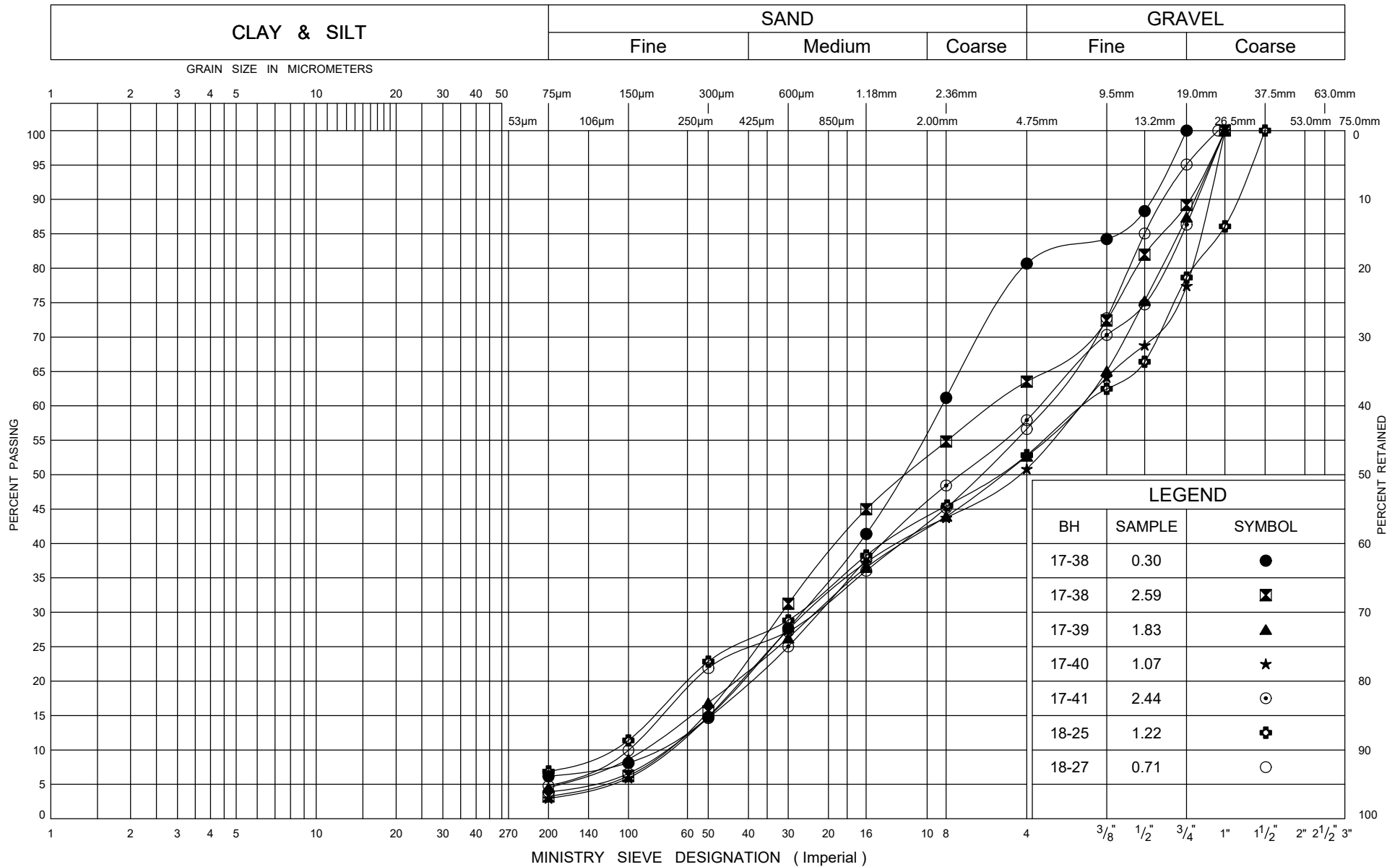
W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 335.2 E 272 289.9 ORIGINATED BY JZ
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.07.24 - 2017.07.24 LATITUDE 48.839527 LONGITUDE -87.442922 CHECKED BY NLB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
191.6	GROUND SURFACE							20	40	60	80	100						
0.0	ASPHALT: (150mm)																	
0.2	SAND and GRAVEL, trace silt Brown Moist (FILL)		1	AS														
188.9	Loose		1	SS	5												42 54 4 (SI+CL)	
2.7	END OF BOREHOLE AT 2.7m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.																	



Appendix B

Laboratory Test Results



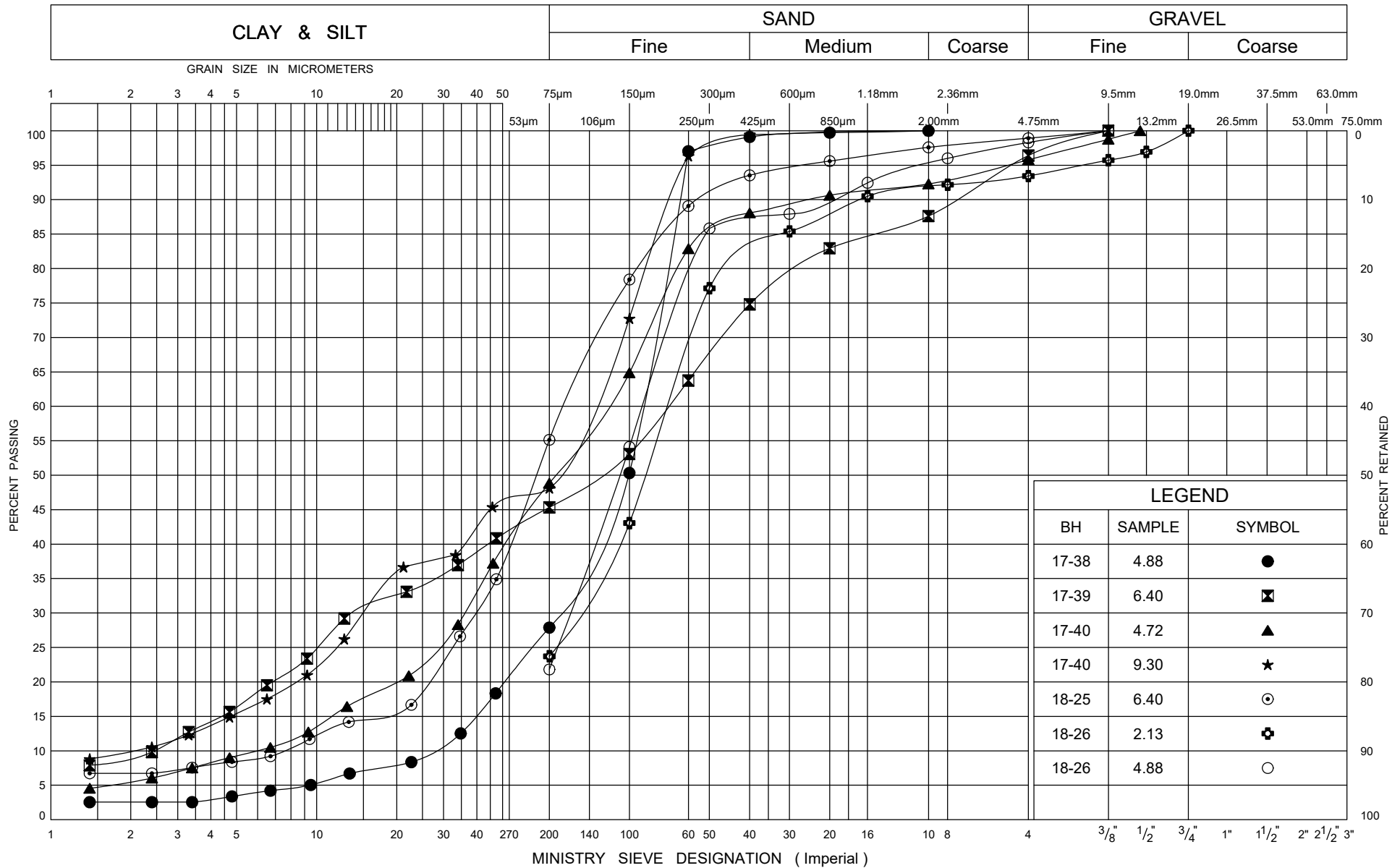
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION SAND and GRAVEL FILL and NATIVE

FIG No B1

W P 6809-14-01

McLean's Creek Culvert



Ministry of
Transportation

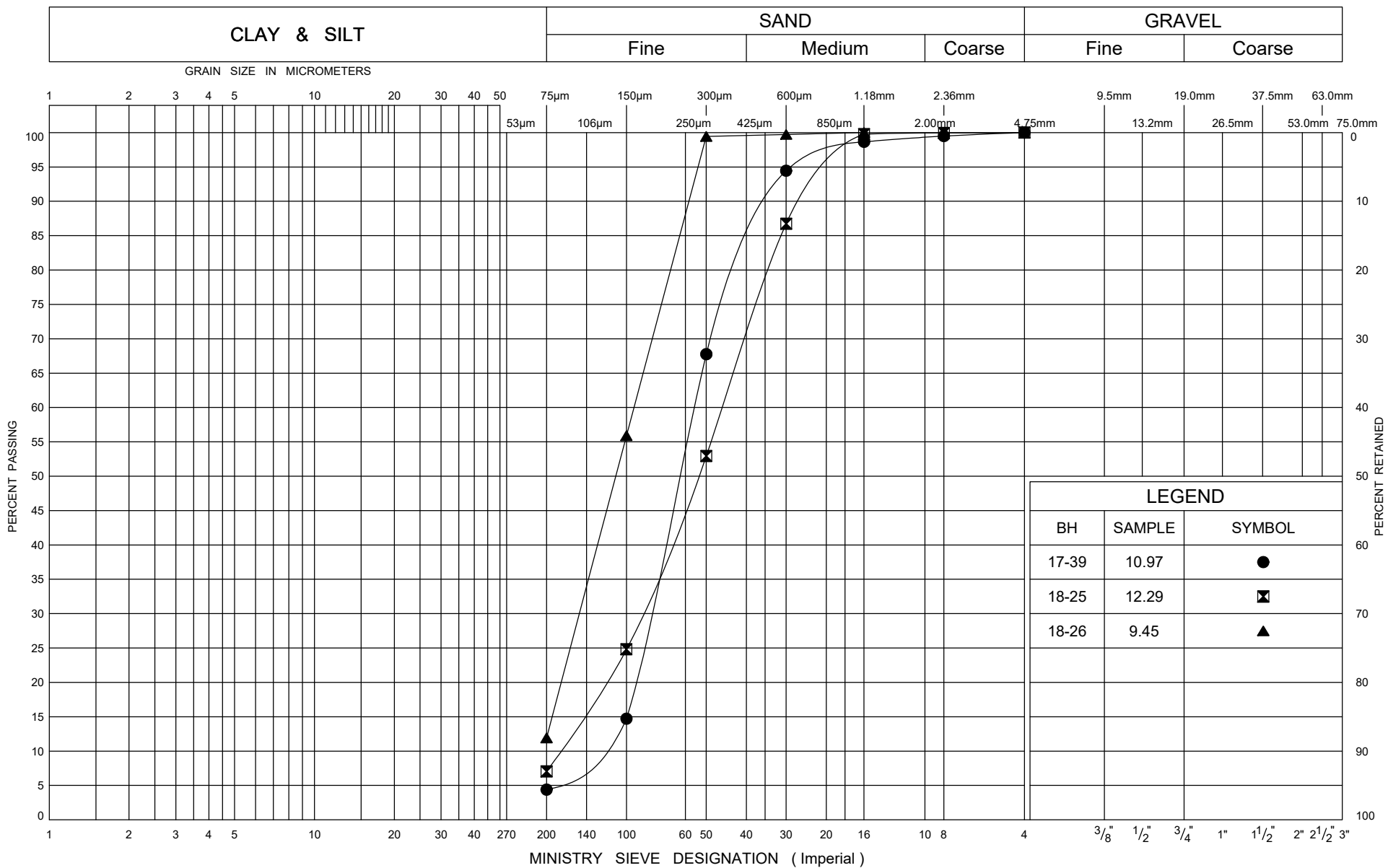
GRAIN SIZE DISTRIBUTION

Silty SAND to SAND and SILT

FIG No B2

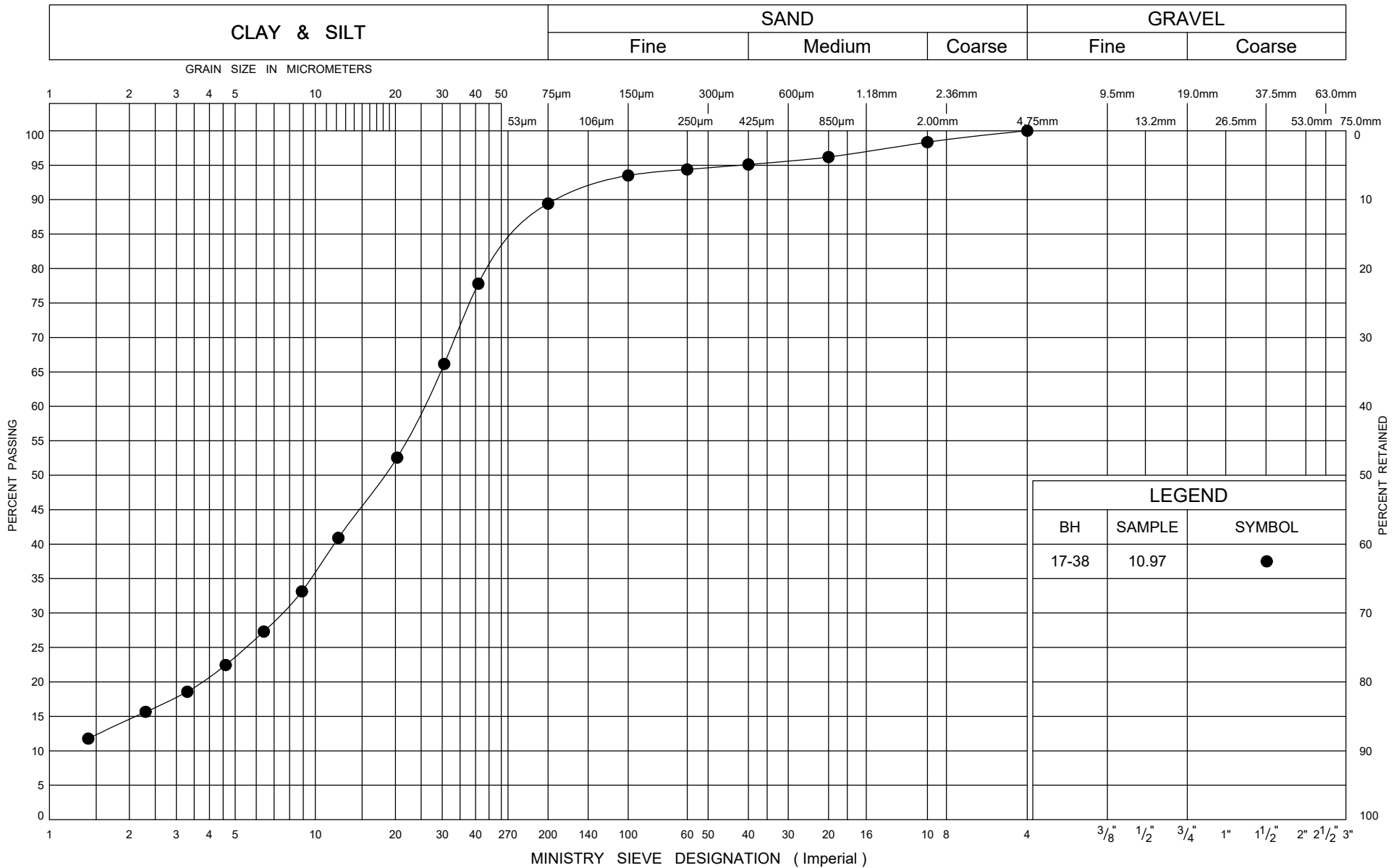
W P 6809-14-01

McLean's Creek Culvert



GRAIN SIZE DISTRIBUTION
SAND

FIG No B3
W P 6809-14-01
McLean's Creek Culvert



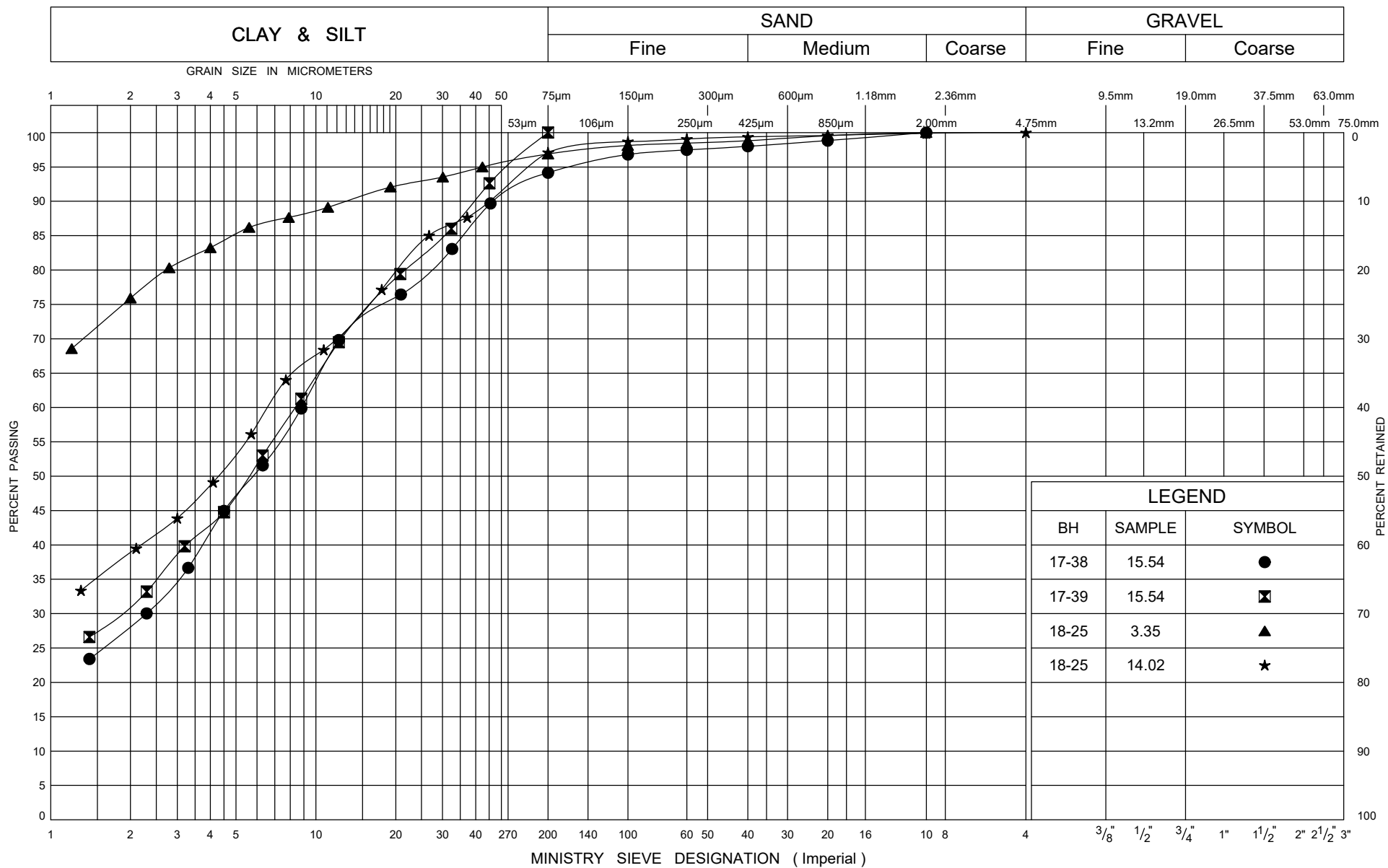
Ministry of
Transportation

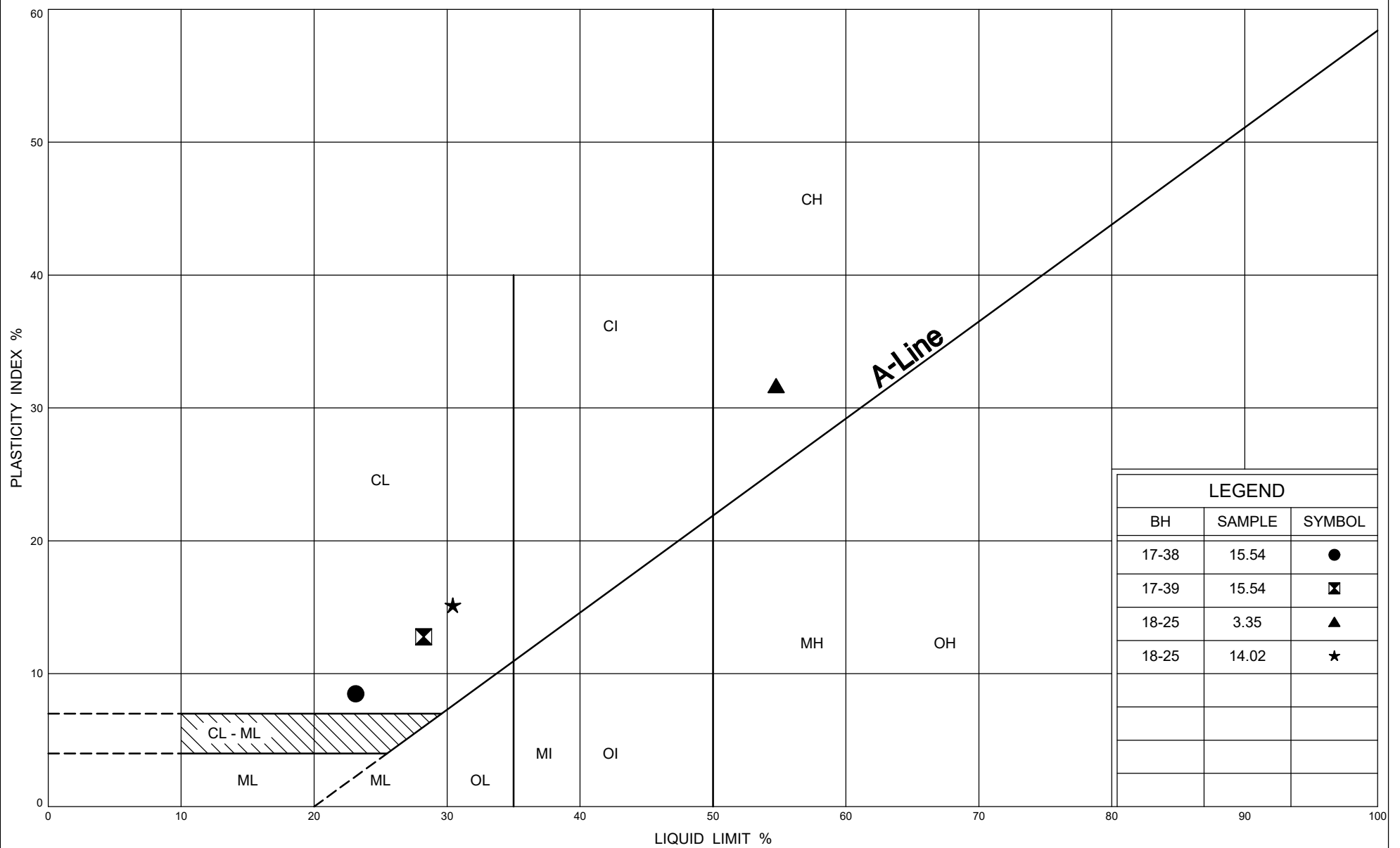
GRAIN SIZE DISTRIBUTION SILT

FIG No B4

W P 6809-14-01

McLean's Creek Culvert







ASTM D5731-08

Date Drilled:	July 26/18
Date Tested:	August 17/18
Tester:	BS
Reviewed by:	MEF

[illegible]



ASTM D5731-08

Date Drilled:	July 26/17
Date Tested:	Aug 23/17
Tester:	ISP
Reviewed by:	MEF

[illegible]

Certificate of Analysis

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



Client
SGS LIMS Number
Analysis Package:

Attention: Mark Farrant
Project#: 15595
Thurber Engineering Ltd.
CA14253-SEP17
Corrosivity (Soil)

Sample ID	Unit	BH-39, SS#5, 10'-12'
Sample Date/Time		24-Jul-17
Moisture	%	9.9
pH	no unit	6.17
Corrosivity Index	none	11.0
Soil Redox Potential	mV	276
Sulphide	mg/L	<0.02
Chloride	mg/L	1500
Sulphate	mg/L	37
Conductivity	uS/cm	1520
Resistivity (calculated)	ohms.cm	656

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

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

Data reported represents the sample submitted to SGS. Reproduction of this analytical report in full or in part is prohibited without prior written approval. Please refer to SGS General Conditions of Services located at http://www.sgs.com/terms_and_conditions_service.htm.
(Printed copies are available upon request.). Test Method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.



FINAL REPORT

CA12892-JUL17 R

Prepared for

Thurber Engineering Ltd.

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Deanna Edwards, B.Sc, C.Chem
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7.	Laboratory	SGS Canada Inc.
Contact	Mark Farrant	Address	185 Concession St., Lakefield ON, K0L 2H0
Telephone	905-829-8666 x 228	Telephone	705-652-2000
Facsimile		Facsimile	705-652-6365
Email	mfarrant@thurber.ca	Email	deanna.edwards@sgs.com
Project		SGS Reference	CA12892-JUL17
Order Number		Received	07/28/2017
Samples	Water (2)	Approved	01/23/2018
		Report Number	CA12892-JUL17 R
		Date Reported	01/23/2018

COMMENTS

Temperature of Sample upon Receipt: 23 degrees C
Cooling Agent Present: Yes
Custody Seal Present: Yes

SIGNATORIES

Deanna Edwards, B.Sc, C.Chem





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FINAL REPORT

CA12892-JUL17 R

Client: Thurber Engineering Ltd.

Project:

Project Manager: Mark Farrant

Samplers: John Zoldy

PACKAGE: REG153 - 1.3 Other (ORP) (WATER)

Sample Number 6
Sample Name 15595 McLeans
Creek
Sample Matrix Water
Sample Date 26/07/2017

Parameter	Units	RL	Result
1.3 Other (ORP)			
pH	units	0.05	7.17

PACKAGE: REG153 - Corrosivity Index (WATER)

Sample Number 6
Sample Name 15595 McLeans
Creek
Sample Matrix Water
Sample Date 26/07/2017

Parameter	Units	RL	Result
Corrosivity Index			
Resistivity (calculated)	ohms.cm	-9999	30300

PACKAGE: REG153 - Metals and Inorganics (WATER)

Sample Number 6
Sample Name 15595 McLeans
Creek
Sample Matrix Water
Sample Date 26/07/2017

Parameter	Units	RL	Result
Metals and Inorganics			
Conductivity	µS/cm	2	33
Chloride	mg/L	0.04	0.39
Sulphate	mg/L	0.04	2.0



FINAL REPORT

CA12892-JUL17 R

Client: Thurber Engineering Ltd.

Project:

Project Manager: Mark Farrant

Samplers: John Zoldy

PACKAGE: REG153 - UNDEFINED (WATER)

Sample Number 6
Sample Name 15595 McLeans
Creek
Sample Matrix Water
Sample Date 26/07/2017

Parameter	Units	RL	Result
UNDEFINED			
Redox Potential	mV	-	198
Sulphide	mg/L	0.006	< 0.006



FINAL REPORT

CA12892-JUL17 R

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0425-JUL17	mg/L	0.04	<0.04	11	20	97	80	120	99	75	125
Sulphate	DIO0425-JUL17	mg/L	0.04	<0.04	0	20	99	80	120	98	75	125
Chloride	DIO0438-JUL17	mg/L	0.04	<0.04	1	20	99	80	120	111	75	125
Sulphate	DIO0438-JUL17	mg/L	0.04	<0.04	1	20	94	80	120	103	75	125

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0430-JUL17	µS/cm	2	< 2	0	10	100	90	110	NA		



FINAL REPORT

CA12892-JUL17 R

QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0431-JUL17	no unit	0.05	NA	0		100			NA		

Redox Potential
Method: SM 2580 |

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Redox Potential	EWL0428-JUL17	mV	no	NA	5	20	109	80	120	NA		

Sulphide by SFA
Method: SM 4500 | Internal ref.: ME-CA-IENVISFA-LAK-AN-008

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	SKA0007-AUG17	mg/L	0.006	<0.006	ND	20	98	80	120	102	75	125

QC SUMMARY

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

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

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.

RL Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

NA The sample was not analysed for this analyte

ND Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

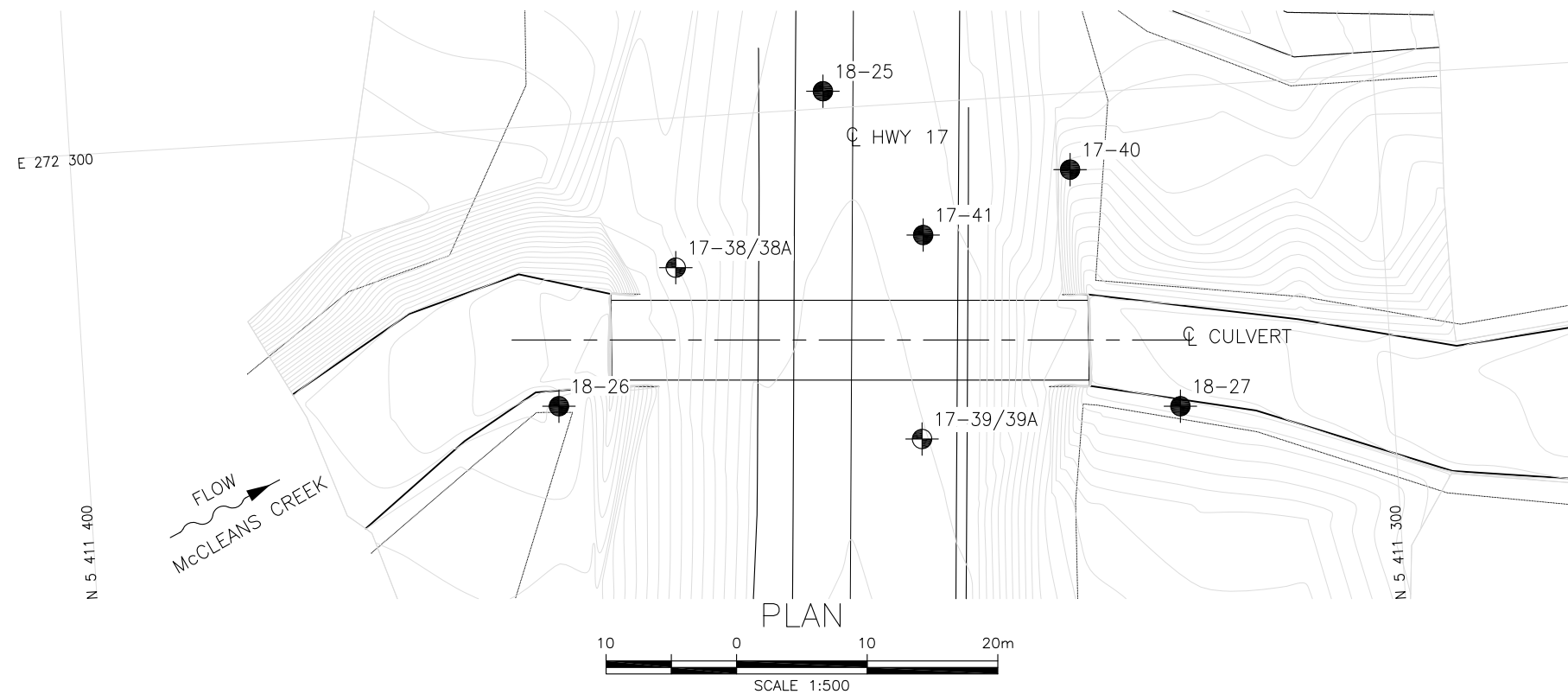
This report must not be reproduced, except in full. This report supersedes all previous versions.

-- End of Analytical Report --

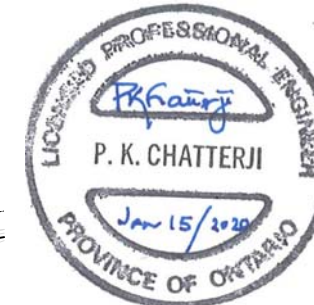


Appendix C

Borehole Locations and Soil Strata Drawing



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



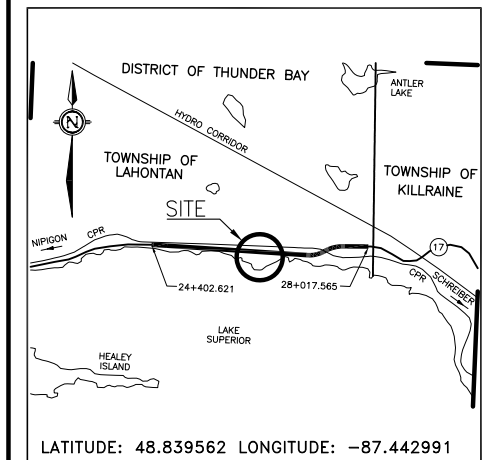
CONT No
WP No 6809-14-01

HIGHWAY 17
MCLEAN'S CREEK
CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH








THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
17-38/38A	190.5	5 411 354.2	272 288.6
17-39/39A	191.8	5 411 336.2	272 274.3
17-40	188.9	5 411 323.6	272 294.2
17-41	191.6	5 411 335.2	272 289.9
18-25	191.6	5 411 342.1	272 301.3
18-26	187.8	5 411 363.8	272 278.5
18-27	186.6	5 411 316.3	272 275.6

-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 14

GEOCRES No. 42D-059

SECTION ALONG C HWY 17

SECTION ALONG \mathbb{C}_L CULVERT

H 1:500

V 1:250

REVISIONS										
	DATE	BY	DESCRIPTION							
DESIGN	CZ		CHK	MEF		CODE		LOAD	DATE	JAN 2020
DRAWN	AN		CHK	CZ		SITE 48C-178C	STRUCT	DWG 1		



Appendix D

Site Photographs



Photo 1: Road approach looking east (May 18, 2017)



Photo 2: Road approach looking west (May 18, 2017)



Photo 3: Culvert Inlet looking south (July 24, 2017)



Photo 4: Boulders near Culvert Inlet looking north (July 23, 2018)



Photo 5: Culvert outlet looking north, showing delamination of soffit and scaling and spalling of lower wall (June 14, 2013)



Photo 6: Boulders in creek bed near Culvert Outlet looking south (July 25, 2018)



Photo 7: Looking east at north side of road (inlet) (July 24, 2017)



Photo 8: Looking west at north side of road (inlet) (July 24, 2017)



Photo 9: Looking east on south side of road (outlet) (July 26, 2017)



Photo 10: Looking west on south side of road (outlet) (July 26, 2017)



Appendix E

List of Specifications and Suggested Wording for NSSPs



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

- OPSS PROV 206 (Construction Specification for Grading)
- OPSS PROV 401 (Construction Specification for Trenching, Backfilling and Compacting)
- OPSS 421 (Pipe Culvert Installation in Open Cut)
- OPSS PROV 501 (Construction Specification for Compacting)
- OPSS 511 (Construction Specification for Rip-Rap, Rock Protection, And Granular Sheeting)
- OPSS 517 (Construction Specification for Dewatering)
- OPSS PROV 539 (Construction Specification for Temporary Protection Systems)
- OPSS PROV 804 (Construction Specification for Seed and Cover)
- OPSS 902 (Construction Specification for Excavating and Backfilling – Structures)
- Special Provision No. FOUN0003 to OPSS 902 (Dewatering Structure Excavations)
- OPSS PROV 1004 (Material Specification for Aggregates – Miscellaneous)
- OPSS PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material)
- OPSS PROV 1205 (Material Specification for Clay Seal)
- OPSS 1860 (Material Specification for Geotextiles)
- OPSD 208.010 (Benching of Earth Slopes)
- OPSD 802.010 (Flexible Pipe Embedment and Backfill, Earth Excavation)
- OPSD 802.014 (Flexible Pipe Embedment in Embankment)
- OPSD 803.031 (Frost Treatment – Pipe Culverts, Frost Penetration Line Between Top of Pipe and Bedding Grade)
- OPSD 810.010 (General Rip-Rap Layout for Sewer and Culvert Outlets)
- OPSD 3090.100 (Foundation Frost Depths for Northern Ontario)



2. Suggested Wording for NSSPs

- **Suggested Text for Notice to Contractor on “Dewatering”**

The ground water table at this site is high and there is evidence of artesian conditions. Dewatering will be required to install the new culvert and the diversion pipe 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 a minimum of 0.5 m below the final subgrade level to avoid basal heave and base boiling. If dewatering is not in place prior to excavation, the subgrade will be susceptible to base boiling and the culvert may be susceptible to future settlement.

The dewatering system is to be designed in accordance with Special Provision SP FOUN0003 and OPSS.PROV. 517. A preconstruction survey is required, thus Designer Fill-In ** in SP FOUN0003 should be “100 m”. SP FOUN0003 is included below. The dewatering system must be designed by a Professional Engineer with greater than 5 years of experience in designing dewatering systems. The Contractor must submit a dewatering plan to the Contract Administrator (CA) two (2) weeks prior to construction for information purposes only. The dewatering plan must be signed/sealed by the dewatering engineer.

It is anticipated that dewatering pumping systems for staged construction at this site will generate flows between 50,000 and 400,000 L/day, which indicates that an Environmental Activity and Sector Registry (EASR) may be required.

- **Suggested Text for Notice to Contractor on “Obstructions”**

Excavations and installation of cofferdams and roadway protection systems may encounter obstructions such as cobbles and boulders embedded in the fill or native soils, as well as dense to very dense fill and native soils, with Standard Penetration Test (SPT) ‘N’ values of 50 to greater than 100 blows per 0.3 m penetration in some locations. Such obstructions may impede excavation progress and/or sheet pile installation. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths. Alternatively, the Contractor shall design and provide alternate methods for roadway protection and cofferdams.



- **Suggested Text for Notice to Contractor on “Use of Vibratory Methods for Sheet Piles”**

The Contractor is alerted that the use of vibratory methods to extract sheet piles may cause settlement of the newly installed replacement culvert and the sand and silt foundation soils. The Contractor is responsible for monitoring the replacement culvert during sheet pile extraction for any signs of settlement due to vibration. If any settlement of the replacement culvert is noted during the sheet pile extraction process, the Contractor must stop the vibratory process and switch to the static mode of extraction.

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.