



THURBER ENGINEERING LTD.

**FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 118 CULVERT AT STATION 17+698
OAKLEY TOWNSHIP, ONTARIO
ASSIGNMENT NO.: 5017-E-0003
GWP 5011-19-00**

GEOCRES NO.: 31E03-002

Location: Lat: 45.002614°, Long: -79.039471°

Client Name: McIntosh Perry Consulting Engineers

Date: February 7, 2024

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PART 1. FACTUAL INFORMATION

1. INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation completed by McIntosh Perry Consulting Engineers (MPCE) at the Centreline Culvert located on Highway 118 near Station 17+698 within Oakley Township in the District of Muskoka, Ontario. MPCE carried out the foundation investigation under Agreement No. 5017-E-0003. Thurber Engineering Ltd. (Thurber) carried out the preparation of the foundation investigation and design report on behalf of MPCE. It must be noted that MPCE is solely responsible for the accuracy of the subsurface information in their borehole logs and the field and the laboratory results provided during the preparation of this report.

The purpose of this investigation carried out by MPCE was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results, and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction was developed during the investigation.

A historical foundation investigation report was not available for this site within the online Geocres Library. In addition to the borehole records and laboratory test results, background information provided by MPCE included the DCP Contract Drawings of August 2023, the Centreline Culvert Inspection Summary Report provided by MPCE on October 27, 2023 and emails summarizing the existing and proposed culvert and embankment characteristics provided on October 27, 2023 and November 24, 2023.

It is a condition of this report that Thurber' performance of its professional services will be subject to the attached Statement of Limitations and Conditions.



2. SITE DESCRIPTION

2.1 General

The culvert crosses Highway 118 approximately 12.8 km east of the intersection between Highway 118 and Highway 20 and is within Oakley Township in the District of Muskoka. For project orientation purposes, Highway 118 is herein described as oriented east-west, and the culvert is described as oriented north-south.

At the location of the culvert, Highway 118 is a two-lane highway with a posted speed limit of 80 km/hr. The road surface is near elevation 292.1 m (MPCE email dated October 27, 2023) with the highway profile increasing east of the culvert. Traffic volumes on this section of Highway 118 are understood to have been 1,600 AADT in 2016. The shoulders are partially paved.

The existing culvert is reported in the email dated October 27, 2023 to be a 2,700 mm in diameter, 28.0 m long corrugated steel pipe (CSP) culvert. The culvert has a gradient of approximately -0.46% with the invert of the culvert near elevations 288.2 m and 288.4 m at the inlet and outlet, respectively. The soil cover above the existing culvert is approximately 1.2 m near the highway centerline. Water flows through the culvert from north to south. The culvert has a skew of approximately 70 degrees to the highway. The surface water elevation north and south of the highway was measured to be 289.9 m and 290.0 m in May 2018 as shown in the Centreline Culvert Inspection Summary provided by MPCE. An existing beaver dam was noted just east of the culvert outlet, which may cause unforeseen fluctuations in the surface water elevations.

The highway embankment side slopes near the culvert are generally sloped at approximately 1.2H:1V to 1.6H:1V. MPCE examined the slopes in the field and did not observe any indications of slope instability (email of November 24, 2023). In the area of the culvert, the embankment slopes and ditch line are mainly grass covered with small shrubs. The lands surrounding the site are heavily vegetated with coniferous and deciduous trees. Overhead utility lines are present near the northern embankment toe and run parallel to the highway. A single-family dwelling, with an entrance from Highway 118 is located approximately 100 m west of the culvert.

Photographs of the project area are included in Appendix D. These photographs were taken by MPCE and show the existing condition of the highway embankment and the culvert at the time of the field investigation.



2.2 Site Geology

According to Crins et al. 2009¹ the project area is described as Ecoregion 5E (Georgian Bay Ecoregion) within the Ontario Shield Ecozone. According to Wester et al. 2018² the ecoregion is subdivided into Ecodistrict 5E-8 (Huntsville Ecodistrict). The area is characterized by shallow layers of morainal material and pockets of deeper glaciolacustrine sediment overlying Precambrian bedrock.

Bedrock Geology Map (MRD126)³ indicates the site is underlain by derived gneisses or felsic igneous rocks such as tonalite, granodiorite, monzonite, and syenite.

2.3 Existing Information

A historical foundation investigation report was not available for this site within the online Geocres Library. However, Geocres Report 31E00-399 for a foundation investigation conducted 4.9 km east of the culvert was reviewed for regional information only but has not been used further in the report.

3. SITE INVESTIGATION AND FIELD TESTING

The foundation investigation and field-testing program was carried out between July 27th, 2023, and August 31st, 2023, and consisted of three off-road boreholes identified as 68-1, 68-2 and 68-3. The off-road boreholes were advanced with portable drilling (tripod) equipment. MPCE has confirmed that utility clearances were acquired in the vicinity of the borehole locations prior to commencement of drilling.

A summary of the borehole coordinates, elevations, and termination depths is provided within Table 3-1. The as-drilled borehole elevations were surveyed by MPCE with a geodetic optical survey with centimeter accuracy (vertical datum of CGVD28). Horizontal locations were measured by MPCE relative to existing site features with centimeter accuracy. The borehole coordinates and elevations are shown on the Borehole Location and Soil Strata drawing included in Appendix A and on the individual Record of Borehole sheets included in Appendix B. The borehole coordinates are referenced to MTM Zone 10.

¹ <https://files.ontario.ca/mnrf-ecosystemspart1-accessible-july2018-en-2020-01-16.pdf>

² <https://files.ontario.ca/ecosystems-ontario-part2-03262019.pdf>

³ <http://www.geologyontario.mndm.gov.on.ca/mines/data/google/mrd126/doc.kml>



Table 3-1 Borehole Summary

BOREHOLE NO.	DRILLED LOCATION	NORTHING (m)	EASTING (m)	GROUND SURFACE ELEVATION (m)	TERMINATION DEPTH (m)
68-1	Southeast of Culvert Outlet	4 984 842.6	341 122.1	290.0	9.0
68-2	Northwest of Culvert Inlet	4 984 839.6	341 089.7	290.6	11.7
68-3	Northwest of Culvert Inlet	4 984 841.4	341 086.7	290.2	8.1

The boreholes were advanced to depths ranging from 8.1 to 11.7 m below the existing ground surface (base elev. 282.1 to 278.9 m). Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in general accordance with ASTM D 1586. A third weight hammer was used in the upper samples of Boreholes 68-2 and 68-3. A full weight hammer was used in the deeper samples of Boreholes 68-2 and 68-3 and all samples in Borehole 68-1. The SPT N-values reported on the borehole logs utilizing a third weight hammer have been adjusted accordingly. It is noted that an automatic hammer could not be used with the portable drill thus the SPT N-values from the portable drilling equipment are considered to be less reliable.

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

MPCE has confirmed that following completion of the field investigation, the boreholes were decommissioned in general in accordance with O.Reg. 903, as amended.

4. LABORATORY TESTING

Laboratory testing was selected by MPCE in accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. MPCE has confirmed that geotechnical laboratory testing included a visual identification of all retained soil samples. Select soil samples were tested for moisture content, grain size distribution in accordance with MTO and ASTM standards. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B.

MPCE selected four soil samples and submitted for analytical testing of corrosivity parameters.

All laboratory test results from the investigation are provided in Appendix C.



5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing 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 for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions will vary between and beyond borehole locations. Soil classification is in general accordance with ASTM D2487 with the description of secondary components as outlined in the MTO Guideline for Foundation Engineering Services Manual (April 2022). It must be noted that MPCE is solely responsible for the accuracy of the subsurface information in their borehole logs.

In general terms, the encountered stratigraphy consisted of surficial topsoil and organics over a non-cohesive deposit varying in composition from silt to sandy silt to silty sand to sand underlain by cobbles and boulders. Bedrock was not proven within the depth of investigation.

5.1 Topsoil

Surficial topsoil was encountered at the ground surface in Boreholes 68-1 and 68-3 with a recorded thickness of 0.1 and 0.6 m (base elev. 289.9 and 289.6 m). An SPT N-value of 2 blows was obtained within this layer indicating a very loose relative density. The recorded moisture content was 36%.

5.2 Organic Sand to Organic Sandy Silt

A deposit of organic sand to sandy silt with trace gravel was encountered below topsoil in Boreholes 68-1 and 68-3 and at ground surface in Borehole 68-2. The organic deposit ranged in thickness from approximately 0.6 to 1.8 m thick (base elev. 289.0 to 288.8 m). SPT N-values obtained in the organic sand to sandy silt deposit ranged from 1 to 19 blows indicating a very loose to compact relative density. The recorded moisture contents ranged from 15 to 55%.

5.3 Silt to Sandy Silt

A non-cohesive deposit varying in composition from silt to sandy silt to silty sand was encountered below the organic material in all boreholes. Varying amounts of clay and gravel were noted in the layer. Frequent coarse sand seams were noted throughout the silt deposit in Borehole 68-3. Running sands approximately 1.8 m thick (base elev. 282.9 m) were noted at the base of this deposit in Borehole 68-3. The silty to sandy silt deposit extends to an underside depth of 7.3 to



9.0 m (base elev. 282.9 to 281.0 m). SPT N-values ranging from 11 and 93 blows were obtained in the silt to sandy silt deposit indicating a loose to very dense relative density.

The recorded moisture contents ranged from 21 to 28%. Atterberg Limit tests were attempted; the soil samples were found to be non-plastic. The results of gradation analyses completed on nine samples of the silt are illustrated on Figures C1 to C9 of Appendix C. The results of the tests are summarized below and on the Record of Boreholes sheets in Appendix B.

SOIL PARTICLE	PERCENTAGE (%)
Gravel	0
Sand	0 – 2
Silt	89 – 95
Clay	5 – 11

5.4 Cobbles and Boulders

Cobbles and Boulders were inferred below the silt in Borehole 68-1, observed below the sandy silt in Borehole 68-2 and observed beneath the running sands in Borehole 68-3. All three boreholes were terminated on or within the cobbles and boulders layer at depths ranging from 11.7 to 8.1 m (base elev. 278.9 to 282.1 m). Two SPT N-value of greater than 50 blows were obtained within the cobbles and boulders. Inferred sand was noted within the boulder deposit in Borehole 68-3.

5.5 Groundwater Level

The measured groundwater levels from within the open boreholes are as summarized in Table 5-1. It is noted that water levels in open boreholes have not had sufficient time to stabilize and could have been affected by drilling techniques. These values should be used with caution.

Table 5-1 Measured Water Levels

Borehole	Groundwater Level		Date of Measurement	Comments
	Depth (mbgs)	Elevation (m)		
68-1	1.5	288.5	2023-07-27	Open Borehole
68-2	2.4	288.2	2023-08-31	Open Borehole
68-3	1.5	288.7	2023-08-28	Open Borehole

As per the centerline culvert inspection summary report provided by MPCE on October 27, 2023, the surface water level was measured in May 2018 at 1.0 and 1.1 m below the existing culvert



obvert (water level at elev. 289.9 and 290.0 m) at the upstream and downstream of culvert, respectively.

It should be noted that the values shown above are considered short-term readings and may not reflect groundwater levels or surface water levels at the time of construction. Seasonal fluctuations of the water levels are to be expected. In particular, the level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

5.6 Analytical Testing

Four soil sample was submitted for analytical testing. The analysis results are included in Appendix C and are summarized in Table 5-2.

Table 5-2 Analytical Test Results

BOREHOLE	68-2	68-2	68-3	68-3
SAMPLE	SS5	SS8	SS4	SS9
DEPTH (ft/m)	8' – 10' 2.4 – 3.0	14' – 16' 4.3 – 4.9	6' – 8' 1.8 – 2.4	16' – 18' 4.9 – 5.5
ELEVATION (m)	287.9	286.0	288.1	285.0
SOIL TYPE	Silt	Silt	Silt	Silt
pH	7.91	8.14	7.53	8.68
RESISTIVITY (Ohm-cm)	14,700	13,700	18,200	17,300
CHLORIDE (µg/g)	10	<10	<10	<10
SULPHATE (µg/g)	24	27	25	25



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6. MISCELLANEOUS

The as-drilled locations and ground surface elevation were measured by MPCE following completion of the field program. Ohlmann Geotechnical Services Inc. of Almonte, Ontario, supplied and operated the drill rigs used to drill, test, sample, and decommission the boreholes. Traffic control was performed in accordance with Ontario Book 7 and was provided by Robinson Haulage of Kilworthy, Ontario. The field investigation was supervised on a full-time basis by Mr. Jay Patel, Field Technician.

Interpretation of the data and preparation of this report were carried out by I. Khan, EIT and K. Walker, P.Eng. The report was reviewed by S. Peters, P. Eng and F. Griffiths, P.Eng. the Designated Principal Contact for MTO Foundation Projects.

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PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This section of the report provides an interpretation of the factual data from Part 1 of this report and presents foundation design recommendations to assist the project team in the design of the rehabilitation of the culvert located on Highway 118 near Station 17+698 within Oakley Township in the District of Muskoka, Ontario. McIntosh Perry Consulting Engineers (MPCE) carried out the field and laboratory investigations under Agreement No. 5017-E-0003. Thurber Engineering Ltd. (Thurber) prepared the foundation investigation and design report on behalf of MPCE. The discussion and recommendations presented in this report are based on information provided by MPCE and the factual data obtained during the field investigation. It must be noted that MPCE is solely responsible for the accuracy of the subsurface information in their borehole logs and the field information provided to aid in the preparation of this report.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation Ontario and their designer, McIntosh Perry Consulting Engineers, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. 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. Those requiring information on aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, and scheduling and the like.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.



7.1 Background Information

In addition to the borehole records and laboratory test results, background information provided by MPCE included the DCP Contract Drawings of August 2023, the Centreline Culvert Inspection Summary Report provided by MPCE on October 27, 2023 and emails summarizing the existing and proposed culvert and embankment characteristics provided on October 27, 2023 and November 24, 2023.

The culvert crosses Highway 118 approximately 12.8 km east of the intersection between Highway 118 and Highway 20 and is within Oakley Township in the District of Muskoka. For project orientation purposes, Highway 118 is herein described as oriented east-west, and the culvert is described as oriented north-south.

At the location of the culvert, the road surface is near elevation 292.1 m with the highway profile increasing east of the culvert. The existing culvert is reported to be a 2,700 mm diameter, 28.0 m long corrugated steel pipe (CSP) culvert. The culvert has a gradient of approximately -0.46% with the invert of the culvert near elevations 288.2 m and 288.4 m at the inlet and outlet, respectively. The soil cover above the existing culvert is approximately 1.2 m near the highway centerline. Water flows through the culvert from north to south. The water depth near the upstream and downstream ends of the culvert was reported to be 1.0 and 1.1 m, respectively.

In general terms, the encountered stratigraphy consisted of surficial topsoil and organics over a non-cohesive deposit varying in composition from silt to sandy silt to silty sand to sand underlain by cobbles and boulders. Bedrock was not proven within the depth of investigation.

7.2 Proposed Work

The proposed works for this culvert is indicated in the MPCE Foundation Engineering request for services dated October 5, 2023, with the approach recommended by MPCE to be culvert rehabilitation by slip lining.

As per Sheet 24 of the DCP Drawings, the existing culvert will be lined with a new Tunnel Plate Liner. As per email from MPCE dated October 27, 2023, the proposed invert of the rehabilitated lined culvert is at elevation 288.5 and 288.6 m at the inlet and outlet, respectively. The cover above the existing culvert will remain unchanged at approximately 1.2 m at the highway centerline.

8. CEMENT TYPE AND CORROSION POTENTIAL

Analytical tests were completed to determine the potential for degradation of concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel used in buried



infrastructure. The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. Soluble sulphate concentrations less than 1000 $\mu\text{g/g}$ generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. The sulphate content in the soils ranges from 24 to 27 $\mu\text{g/g}$, see Section 5.6. The selection for class of concrete should include consideration of the effects of road de-icing salts.

The pH, resistivity, and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The tests results provided in Section 5.6 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. The corrosive effects of road de-icing salts should also be considered.

9. CONSTRUCTION CONSIDERATIONS

9.1 Excavation

If required, all excavation must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The sand and silt may be classified as Type 3 soils. Organic sediment and very loose to loose sand, gravel and organic materials may be classified as Type 4 soils. *Where an excavation is within more than one soil type, the entire excavation must be completed in accordance with the more stringent requirement as per the requirements of the regulation.*

Excavations, if needed, must be planned and carried out in a manner that does not impact on the stability of the existing roadway. Where present, temporary cut slopes may have to be protected from precipitation and runoff to avoid surficial instabilities. The duration of temporary open excavations and cut slopes should be minimized to reduce the likelihood of causing instability concerns. Temporary embankment and cut slope stability is the responsibility of the Contractor.

Material stockpiling is a temporary construction measure and the associated stability implications are the responsibility of the Contractor. The selection and placement of construction equipment (such as cranes) and construction of temporary construction access roads are also the Contractor's responsibility. Placement of the crane or temporary stockpiling must not destabilize the embankment slopes (existing, temporary, or new).

At locations where there are space restrictions or where a slope has to be retained, the excavations will need to be carried out within a protection system. Further discussion on temporary protection systems (TPS) is presented in Section 9.2.



If existing embankments are disturbed during construction, embankment reinstatement after installation of the culvert liner should be carried out in accordance with OPSS.PROV 206 with materials similar to the existing. If constructed using Select Subgrade Material (SSM) or Granular B Type I, the embankment should be constructed with side slopes of 2H:1V (or flatter). The granular fill should be placed and compacted in accordance with OPSS.PROV 501. Where newly placed embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, benching of the existing slope should be carried out in accordance with OPSD 208.010.

9.2 Temporary Protection Systems

If required, Temporary Protection Systems (TPS) must be implemented in accordance with OPSS.PROV 539 as amended by SP 105S09. Performance Level 2 (maximum 25 mm horizontal deflection) is considered appropriate where the protection supports the existing highway. More stringent performance levels may be required if the protection system is intended to support existing structures or utilities. The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall, and these factors must be considered when designing the shoring system.

The measured surface water level observed during the investigation was approximately elevation 289.9 and 290.0 m near the upstream and downstream ends of the culvert, respectively. The water level will fluctuate and the minimum groundwater elevation for the site at the time of the excavation should be taken as the expected highwater level defined in SP 517F01 and SP FOUN0003.

For conceptual design purposes, driven sheet piles are recommended for TPS at this site. It is anticipated that sheet piles will be suitable for use at this site, however, this approach will be limited by the presence of a deposit of cobbles and boulders beneath the silt and sand soils. The selection and design of temporary protection is the responsibility of the Contractor. All protection systems should be designed by a licensed Professional Engineer experienced in such designs and retained by the Contractor. The design of the temporary protection system must incorporate surcharge loading due to traffic, construction equipment and operations. An anchoring and/or internal bracing system may need to be incorporated into the temporary protection design to resist lateral earth pressure loadings.

The lateral earth pressure coefficients for the native soils are given below for a vertical wall and a horizontal backslope. Unit weights provided herein are to be adjusted for applications below the groundwater level. Unbalanced hydrostatic pressures must be considered in the design of the protection systems.



Table 9-1 Static Earth Pressure Coefficients for Existing Soils

MATERIAL	UNIT(*) WEIGHT (kN/m³)	K_A (-)	K_p (-)	S_u (kPa)	GROUND SURFACE BEHIND WALL
Native Organic Soils	18	0.36	2.8	-	Horizontal
Native Sand	20	0.33	3.0	-	Horizontal
Native Silt	19	0.36	2.8	-	Horizontal

Note: (*) to be adjusted when below water level

It is recommended that the protection systems in the vicinity of the culvert (within 3 m from the edge of the culvert) should be left in place and cut off in accordance with OPSS.PROV 539.

9.3 Surface and Groundwater Control

The measured surface water level observed during the investigation was approximately elevation 289.9 and 290.0 m near the upstream and downstream ends of the culvert, respectively. The water level will fluctuate and the minimum groundwater elevation for the site at the time of the excavation should be taken as the expected highwater level defined in SP 517F01 and SP FOUN0003. It is proposed to rehabilitate the existing 2.7 m diameter CSP culvert by inserting a new 2.3 m diameter liner and grouting the annulus. The proposed culvert inverts at the inlet and outlet are at approximate elevation 288.4 and 288.6 m, respectively. The liner installation must be completed in a dry and stable environment.

It is noted that organic soils were encountered at ground surface in all three off-road boreholes drilled at this site. It is anticipated that these materials will not provide a suitable working surface. Design and preparation of an appropriate temporary work surface is the responsibility of the contractor. Consideration could be given to placement of a clear stone pad. The contract should include a notice to the contractor of the potential need for this preparatory work.

Based on the conditions at the time of the investigation, the work will require flow passage and dewatering systems to control surface water and groundwater and may include cofferdams, flow diversion, pumping etc. The Contract Documents must alert the Contractor to this responsibility and to design the systems in accordance with SP 517F01 which amends OPSS.PROV 517.

It is anticipated that flow passage will be achieved by pumping around the culvert. The design of flow passage systems is the responsibility of the Contractor. Given the site conditions and anticipated works, the Designer Fill-In ***** in SP 517F01 Table A for flow passage systems



should be **“No**; the design Engineer and design-checking Engineer do not need a minimum of 5 years of experience in designing similar flow passage systems.

The dewatering system will be required to remain operational and effective throughout the culvert liner insertion and grout installation and then should be decommissioned and removed. The design of dewatering systems is the responsibility of the Contractor. Given the site conditions and anticipated works, the Designer Fill-In ***** in SP 517F01 Table A for dewatering systems should be **“Yes”**; the design Engineer and design-checking Engineer need a minimum of 5 years of experience in designing similar dewatering systems. The possibility of basal heave due to unbalanced hydrostatic pressures must be considered in the dewatering design due to the presence of coarse sand seams and running sands observed during drilling. The dewatering plan must also be designed to support the temporary excavation slope assumptions, where needed. A preconstruction survey is not recommended, thus Designer Fill-In ** in SP 517F01 should be **“N/A”**.

For conceptual design purposes, watertight sheet piles or sandbags are recommended for cofferdams. The lateral earth pressure coefficients and relevant design recommendations provided in Section 9.2 for Temporary Protection Systems are also applicable to Cofferdams. It is anticipated that sump pumps will likely be sufficient to extract water from the work area isolated with sheet pile or sandbag cofferdams installed near the culvert inlet and outlet. Pumping should continue until control of inflow is achieved and the liner is installed and grouted in a dry, stable environment. More than one pump may be required.

Additional recommendations can be provided concerning dewatering should deeper excavations be required.

Further assessment of dewatering requirements and the need for registration on the Environmental Activity and Sector Registry (EASR) or a Permit to take Water (PTTW) should be carried out by specialists experienced in this field.

10. CONSTRUCTION CONCERNS

All work, including the grouting of the annulus, shall be carried out in dry conditions. It will be necessary to divert flow around the work area, to isolate the work area with coffer dams and dewater the work area. It is noted that some preparatory work may be required to create a temporary work surface at either end of the culvert.

The successful performance of the project will depend largely upon good workmanship and quality control during construction.



11. CLOSURE

As noted above, McIntosh Perry Consulting Engineers (MPCE) carried out the field and laboratory investigations under Agreement No. 5017-E-0003. Thurber Engineering Ltd. (Thurber) prepared the foundation investigation and design report on behalf of MPCE. The discussion and recommendations presented in this report are based on information provided by MPCE and the factual data obtained during the field investigation and laboratory testing. It must be noted that MPCE is solely responsible for the accuracy of the subsurface information in their borehole logs and the field and laboratory information provided to aid in the preparation of this report.

Engineering analysis and preparation of this report were carried out by K. Walker, P.Eng. The report was reviewed by S. Peters, P.Eng. and F. Griffiths, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

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Associate | Geotechnical Engineer



Fred Griffiths, Ph.D., P.Eng.
Designated Principal Contact
Senior Geotechnical Engineer

LIMITATIONS OF REPORT

McIntosh Perry Consulting Engineers Ltd. (McIntosh Perry) carried out the geotechnical field investigation. This document is an integral part of the Foundation Investigation and Design report presented.

The conclusions and recommendations provided in this report are based on the information obtained at the borehole locations where the tests were conducted. Subsurface and groundwater conditions between and beyond the boreholes may differ from those encountered at the specific locations where tests were conducted and conditions may become apparent during construction, which were not detected and could not be anticipated at the time of the site investigation. The benchmark level used and borehole elevations presented in this report are primarily to establish relative differences in elevations between the borehole locations and should not be used for other purposes such as to establish elevations for grading, depth of excavations or for planning construction.

The recommendations presented in this report for design are applicable only to the intended structure and the project described in the scope of the work, and if constructed in accordance with the details outlined in the report. Unless otherwise noted, the information contained in this report does not reflect on any environmental aspects of either the site or the subsurface conditions.

The comments or recommendation provided in this report on potential construction problems and possible construction methods are intended only to guide the designer. The number of boreholes advanced at this site may not be sufficient or adequate to reveal all the subsurface information or factors that may affect the method and cost of construction. The contractors who are undertaking the construction shall make their own interpretation of the factual data presented in this report and make their conclusions, as to how the subsurface conditions of the site may affect their construction work.

The boundaries between soil strata presented in the report are based on information obtained at the borehole locations. The boundaries of the soil strata between borehole locations are assumed from geological evidences. If differing site conditions are encountered, or if the Client becomes aware of any additional information that differs from or is relevant to the McIntosh Perry findings, the Client agrees to immediately advise McIntosh Perry so that the conclusions presented in this report may be re-evaluated.

Under no circumstances shall the liability of McIntosh Perry for any claim in contract or in tort, related to the services provided and/or the content and recommendations in this report, exceed the extent that such liability is covered by such professional liability insurance from time to time in effect including the deductible therein, and which is available to indemnify McIntosh Perry. Such errors and omissions policies are available for inspection by the Client at all times upon request, and if the Client desires to obtain further insurance to protect it against any risks beyond the coverage provided by such policies, McIntosh Perry will co-operate with the Client to obtain such insurance.

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STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

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The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.



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APPENDIX A

Borehole Locations and Strata Drawing

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

CONT No 2022-5007
GWP No 5011-19-00



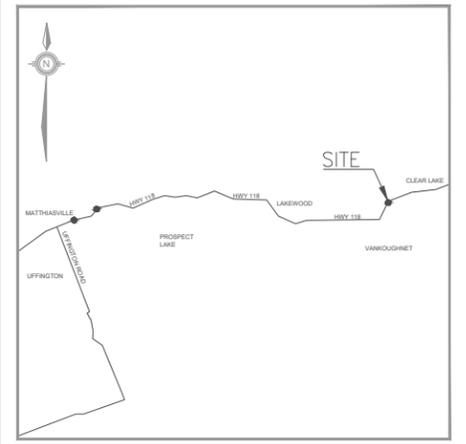
HIGHWAY 118
TOWNSHIP OF OAKLEY
CULVERT AT 17+698
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

McINTOSH PERRY



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

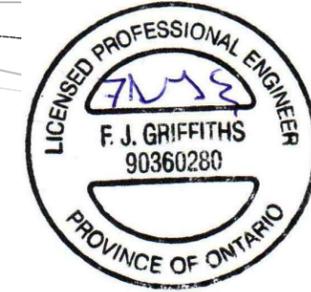
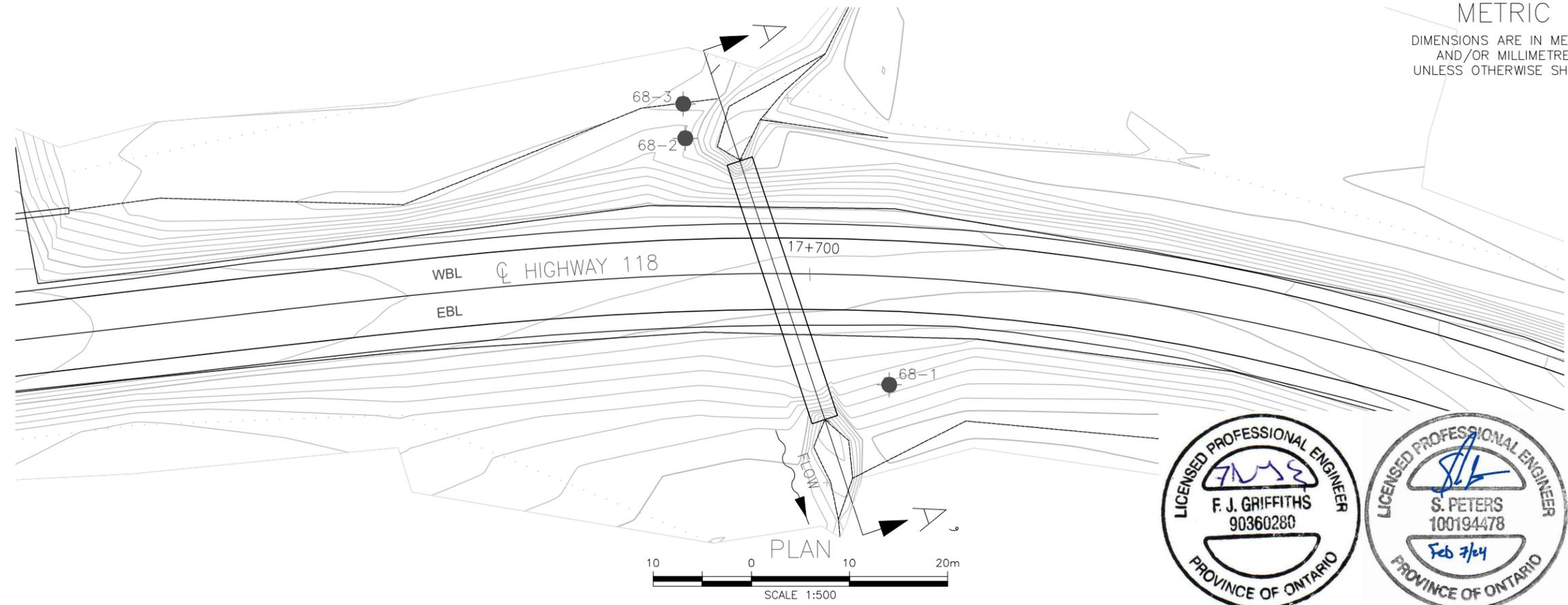
	Current Borehole by MPCE
	Previous Borehole by Others (Approx.)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
68-1	290.0	4 984 842.6	341 122.1
68-2	290.6	4 984 839.6	341 089.7
68-3	290.2	4 984 841.4	341 086.7

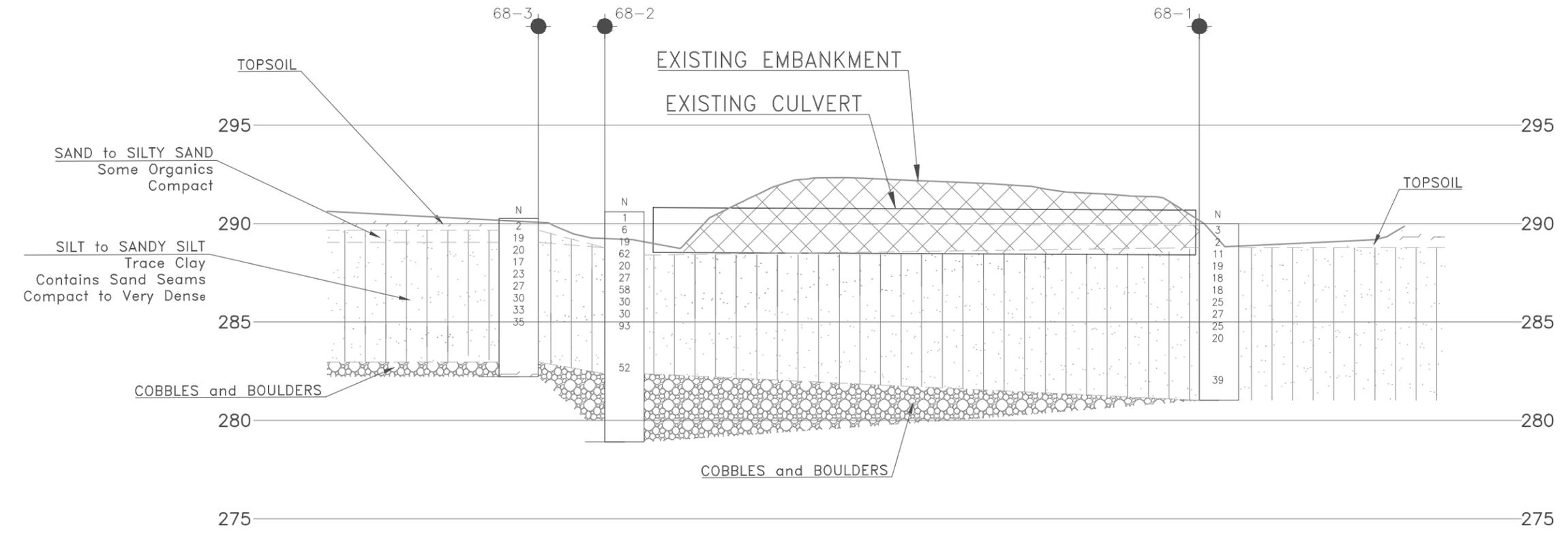
-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.
- Locations and elevations for boreholes are approximate.

GEOCRES No.



PLAN
SCALE 1:500



SECTION A-A'
H 1:250
V 1:250

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	AO	CHK	KW	CODE	LOAD	DATE	NOV. 2023
DRAWN	JEM	CHK	KW	STRUCT	DWG	1	



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APPENDIX B

Symbols and Terms

Record of Boreholes Sheets (MPCE)

EXPLANATION OF TERMS USED IN REPORT

N-VALUE: THE STANDARD PENETRATION TEST (SPT) N-VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N-VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N-VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 – 5	5 – 10	10 – 30	30 – 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0 – 25	25 – 50	50 – 75	75 – 90	90 – 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINT AND BEDDING:

SPACING	50mm	50 – 300mm	0.3m – 1m	1m – 3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
c_c	1	COMPRESSION INDEX
c_s	1	SWELLING INDEX
c_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{v0}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
Φ_i	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
Φ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

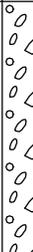
ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(W_L - W_L)$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(W - W_p) / I_p$	i	1	HYDAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_c	1	CONSISTENCY INDEX = $(W_L - W) / I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 68-2

2 OF 2

METRIC

W.P. 5011-19-00 / MP: OKM-17-7060-11 LOCATION E341089.7 N4984839.6 / 45.002615 -79.039677 ORIGINATED BY JP-MPCE
 DIST NER HWY Hwy 118 BOREHOLE TYPE Portable SPT COMPILED BY JP-MPCE
 DATUM Geodetic(Opt Lev BM=DS Inv 288.37m) DATE 2023-07-28 - 2023-08-31 CHECKED BY MA-MPCE

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W _p	W		
278.9 11.7	Cobbles/boulders (continued)															
	End of Borehole Water level observed observed during drilling operations = 2.44 m															

MP MTO_GINT HWY118 CL 68_BRACEBRIDGE.GPJ_MP_OTTAWA_FOUNDATIONS.GDT 24/27

RECORD OF BOREHOLE No 68-3

1 OF 1

METRIC

W.P. 5011-19-00 / MP: OKM-17-7060-11 LOCATION E341086.7 N4984841.4 / 45.002632 -79.039715 ORIGINATED BY JP-MPCE
 DIST NER HWY Hwy 118 BOREHOLE TYPE Portable SPT COMPILED BY JP-MPCE
 DATUM Geodetic(Opt Lev BM=DS Inv 288.37m) DATE 2023-07-28 - 2023-08-28 CHECKED BY MA-MPCE

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W _p	W			W _L	GR	SA
290.2 0.0	Soil surrounded by grass Topsoil , sand, sandy silt, some organics, brown, very loose, moist to dry		1	SS	2														
289.6 0.6	Sand , some silt, some organics, trace gravel, brown, compact, moist to wet		2	SS	19														
289.0 1.2	Silt , grey, compact, wet		3	SS	20	∇													
288.4 1.8	Silt , coarse sand seams, grey, compact, wet		4	SS	17														
287.1 3.1	Coarse sand seams encountered at depths of 2.6, 3.3 and 3.9 m		5	SS	23														
286.0 4.3	Silt , trace sand, grey, compact to dense, wet		6	SS	27														
285.1 5.1	Coarse sand seams encountered at depths of 5.1 m		7	SS	30														
284.7 5.5	Inferred sandy silt, silty sand		8	SS	33														
282.9 7.3	Boulders Inferred Sand		9	SS	35														
282.1 8.1	"Borehole terminated due to running sands entering casing at depth" Water level observed during drilling operations = 1.52 m																		

MP MTO_GINT HWY118 CL 68_BRACEBRIDGE.GPJ_MP_OTTAWA_FOUNDATIONS.GDT 24/2/7

\bullet \times \times : Numbers refer to Sensitivity \circ 3% STRAIN AT FAILURE

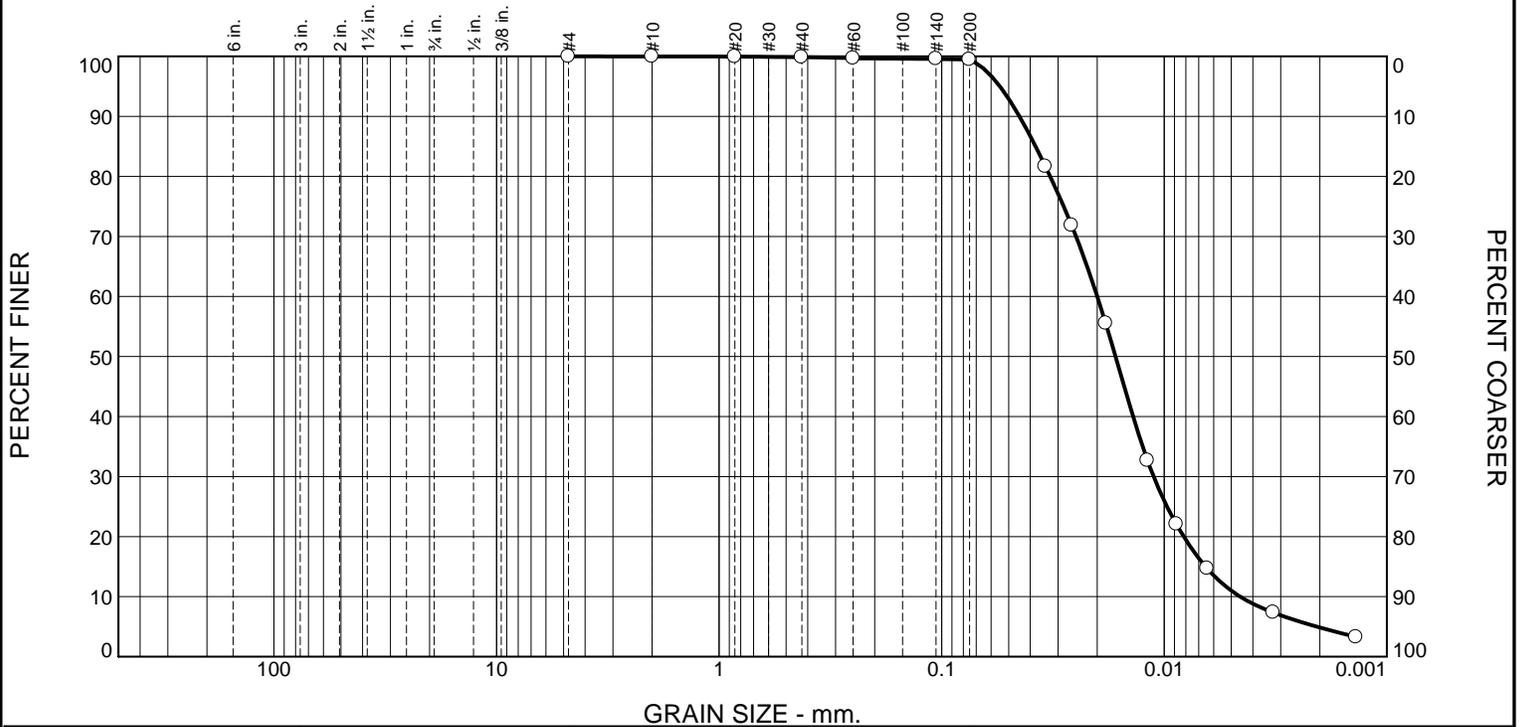


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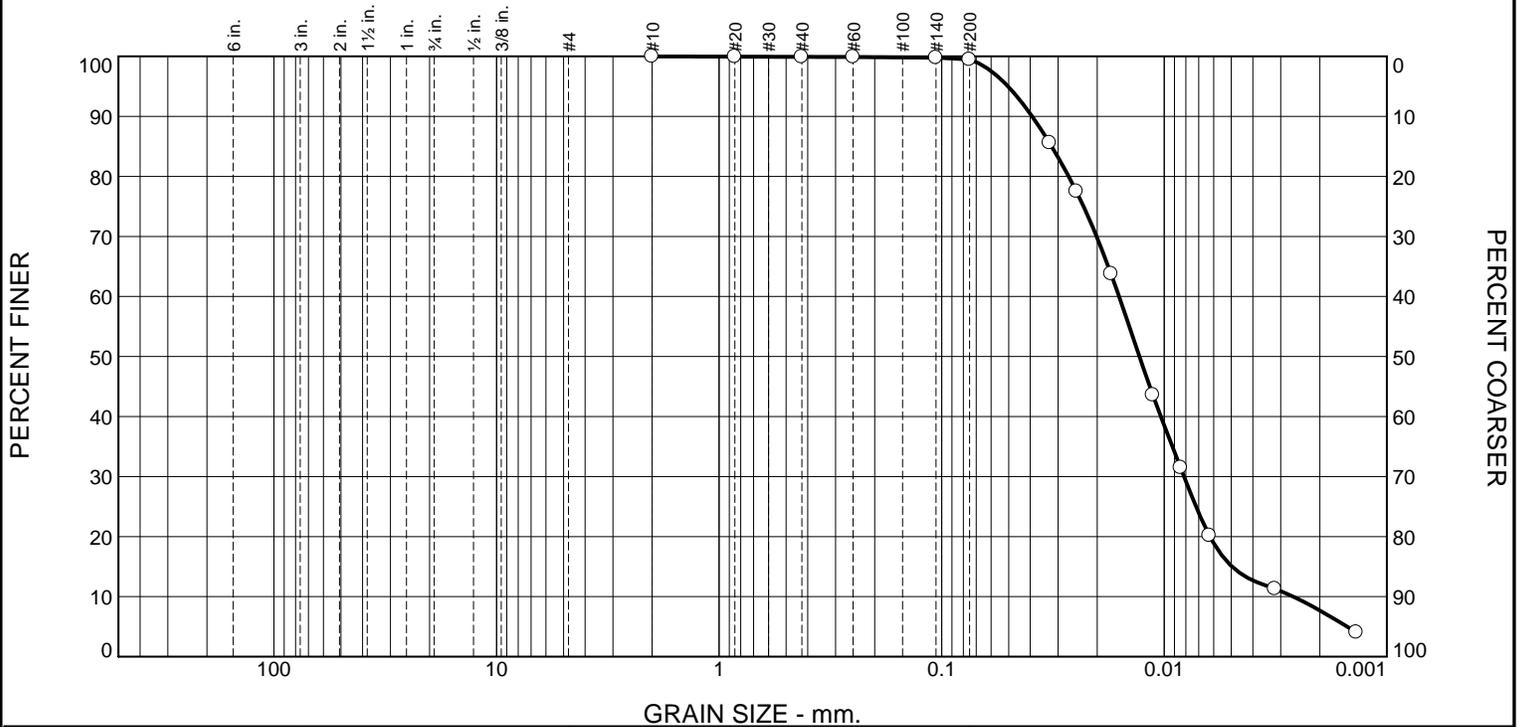
APPENDIX C

Particle Size Analysis Figures
Analytical Testing Results

Particle Size Distribution Report



Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	0.4	91.8	7.7

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2.00mm	100.0		
0.850mm	100.0		
0.425mm	99.9		
0.250mm	99.9		
0.106mm	99.8		
0.075mm	99.5		
0.0328 mm.	85.6		
0.0248 mm.	77.5		
0.0173 mm.	63.8		
0.0113 mm.	43.6		
0.0084 mm.	31.5		
0.0063 mm.	20.2		
0.0032 mm.	11.3		
0.0014 mm.	4.0		

* (no specification provided)

Material Description

Silt trace Clay trace Sand

Atterberg Limits (ASTM D 4318)

PL= _____ LL= _____ PI= _____

Classification

USCS (D 2487)= _____ AASHTO (M 145)= _____

Coefficients

D ₉₀ = 0.0392	D ₈₅ = 0.0321	D ₆₀ = 0.0160
D ₅₀ = 0.0129	D ₃₀ = 0.0081	D ₁₅ = 0.0050
D ₁₀ = 0.0026	C _u = 6.06	C _c = 1.58

Remarks

Specific gravity of soil is assumed.
F.M.=0.00

Date Received: August 2,2023 Date Tested: Aug 10,2023

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

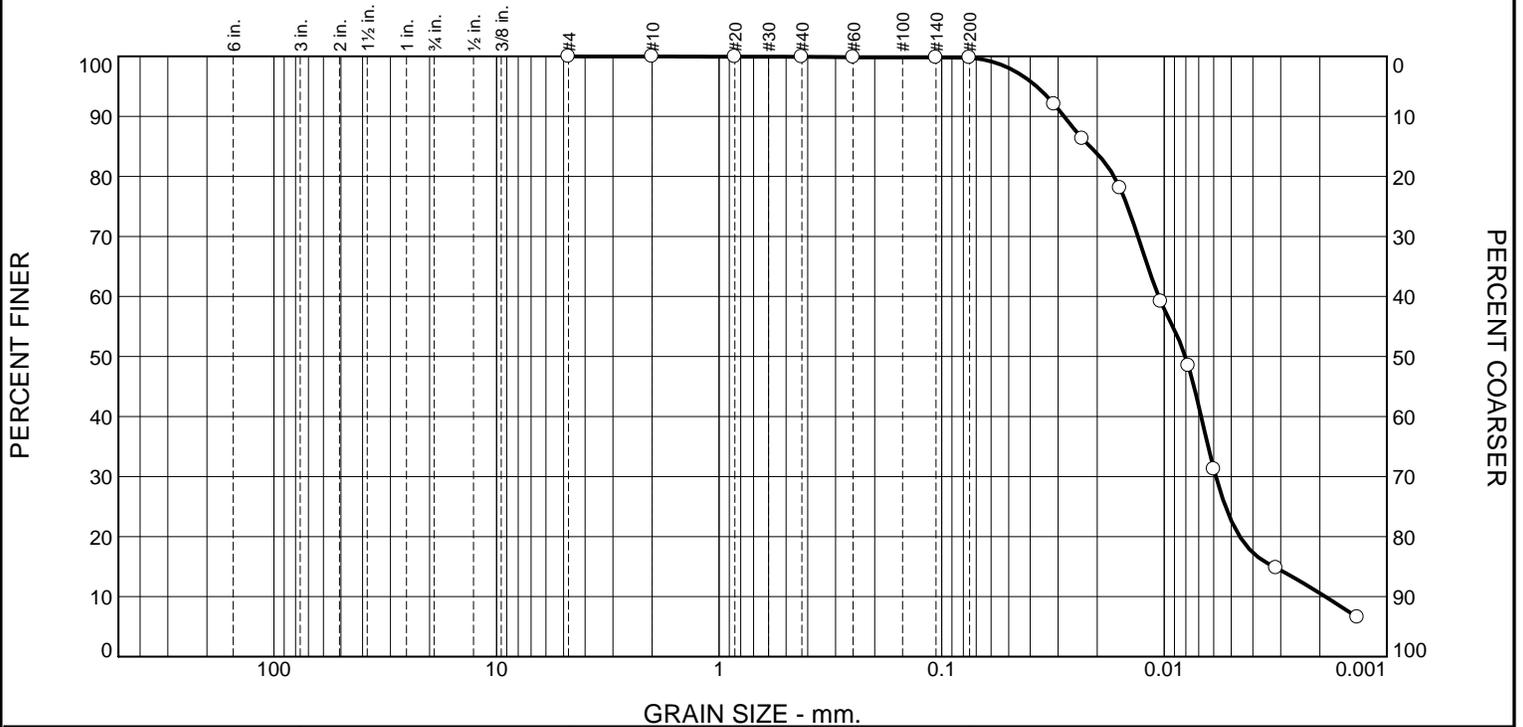
Location: Culvert 68-1 SS-9 Date Sampled: July 28,2023
 Sample Number: SS-9 Depth: 16'-18'

McINTOSH PERRY

Client: MTO Northeastern
Project: MTO NER-CO#11-Additional Drilling
 Hwy 118 Culverts
Project No: CCO-177060-11

Figure C3

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	0.1	89.2	10.6

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
4.75mm	100.0		
2.00mm	100.0		
0.850mm	99.9		
0.425mm	99.9		
0.250mm	99.8		
0.106mm	99.8		
0.075mm	99.8		
0.0313 mm.	92.1		
0.0233 mm.	86.3		
0.0158 mm.	78.1		
0.0104 mm.	59.2		
0.0078 mm.	48.5		
0.0060 mm.	31.2		
0.0031 mm.	14.8		
0.0014 mm.	6.6		

* (no specification provided)

Material Description

Silt some Clay

Atterberg Limits (ASTM D 4318)

PL= _____ LL= _____ PI= _____

Classification

USCS (D 2487)= _____ AASHTO (M 145)= _____

Coefficients

D₉₀= 0.0282 D₈₅= 0.0216 D₆₀= 0.0106
D₅₀= 0.0080 D₃₀= 0.0059 D₁₅= 0.0032
D₁₀= 0.0019 C_u= 5.60 C_c= 1.72

Remarks

Specific gravity of soil is assumed.
F.M.=0.00

Date Received: August 2, 2023 Date Tested: Aug 10, 2023

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: Culvert 68-1 SS-11 Depth: 25'-27'

Date Sampled: July 28, 2023

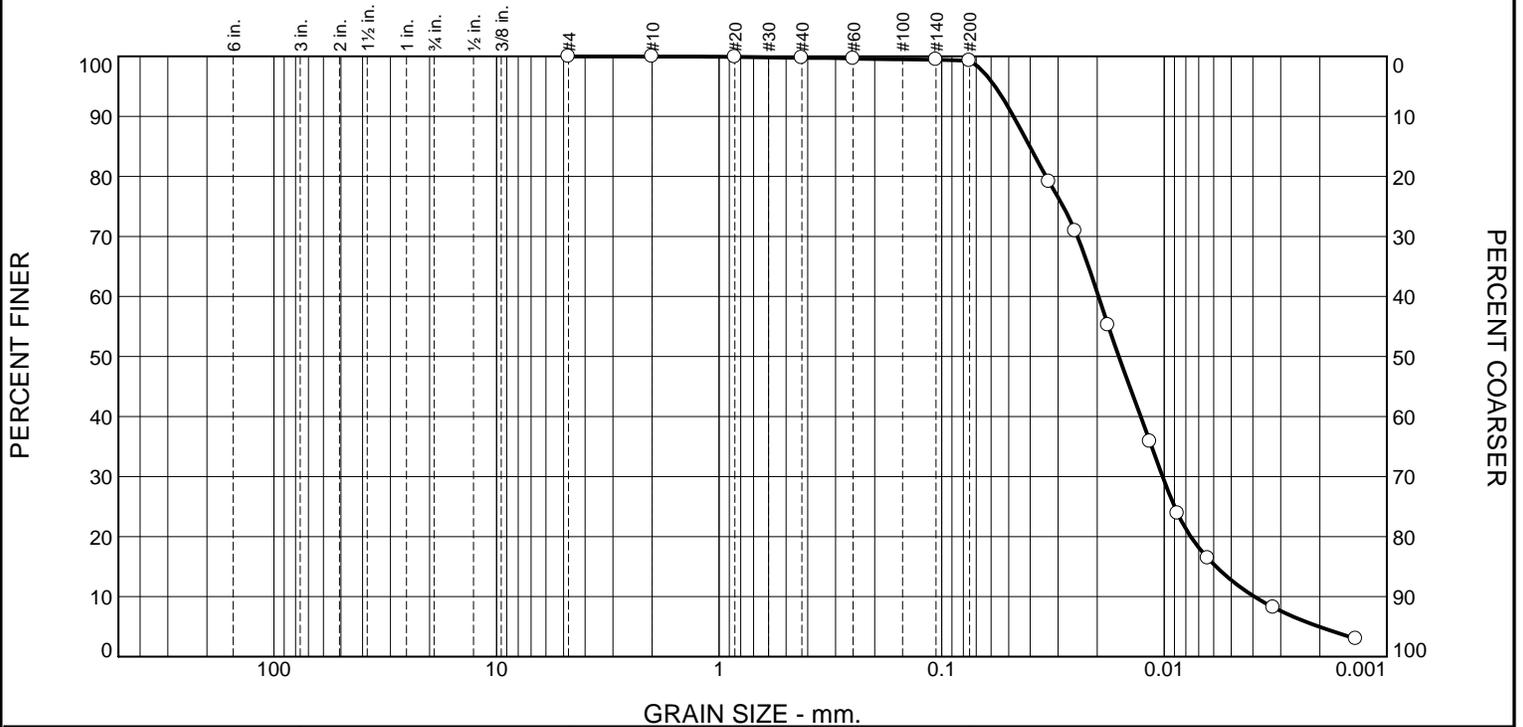
McINTOSH PERRY

Client: MTO Northeastern
Project: MTO NER-CO#11-Additional Drilling
Hwy 118 Culverts

Project No: CCO-177060-11

Figure C4

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.2	0.5	94.4	4.9

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
4.75mm	100.0		
2.00mm	100.0		
0.850mm	99.9		
0.425mm	99.8		
0.250mm	99.6		
0.106mm	99.5		
0.075mm	99.3		
0.0330 mm.	79.1		
0.0251 mm.	70.9		
0.0179 mm.	55.2		
0.0116 mm.	35.8		
0.0087 mm.	23.9		
0.0064 mm.	16.4		
0.0032 mm.	8.2		
0.0014 mm.	3.0		

* (no specification provided)

Material Description

Silt trace Clay trace fine Sand

Atterberg Limits (ASTM D 4318)

PL= _____ LL= _____ PI= _____

Classification

USCS (D 2487)= _____ AASHTO (M 145)= _____

Coefficients

D₉₀= 0.0476 D₈₅= 0.0402 D₆₀= 0.0197
D₅₀= 0.0160 D₃₀= 0.0102 D₁₅= 0.0059
D₁₀= 0.0039 C_u= 5.01 C_c= 1.33

Remarks

Note: Specific Gravity of Soils is Assumed.
F.M.=0.01

Date Received: Sept 13,2023 Date Tested: Sept 19,2023

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL68-2 SS-6
Sample Number: SS-6

Depth: 10'-12'

Date Sampled: Aug 31,2023

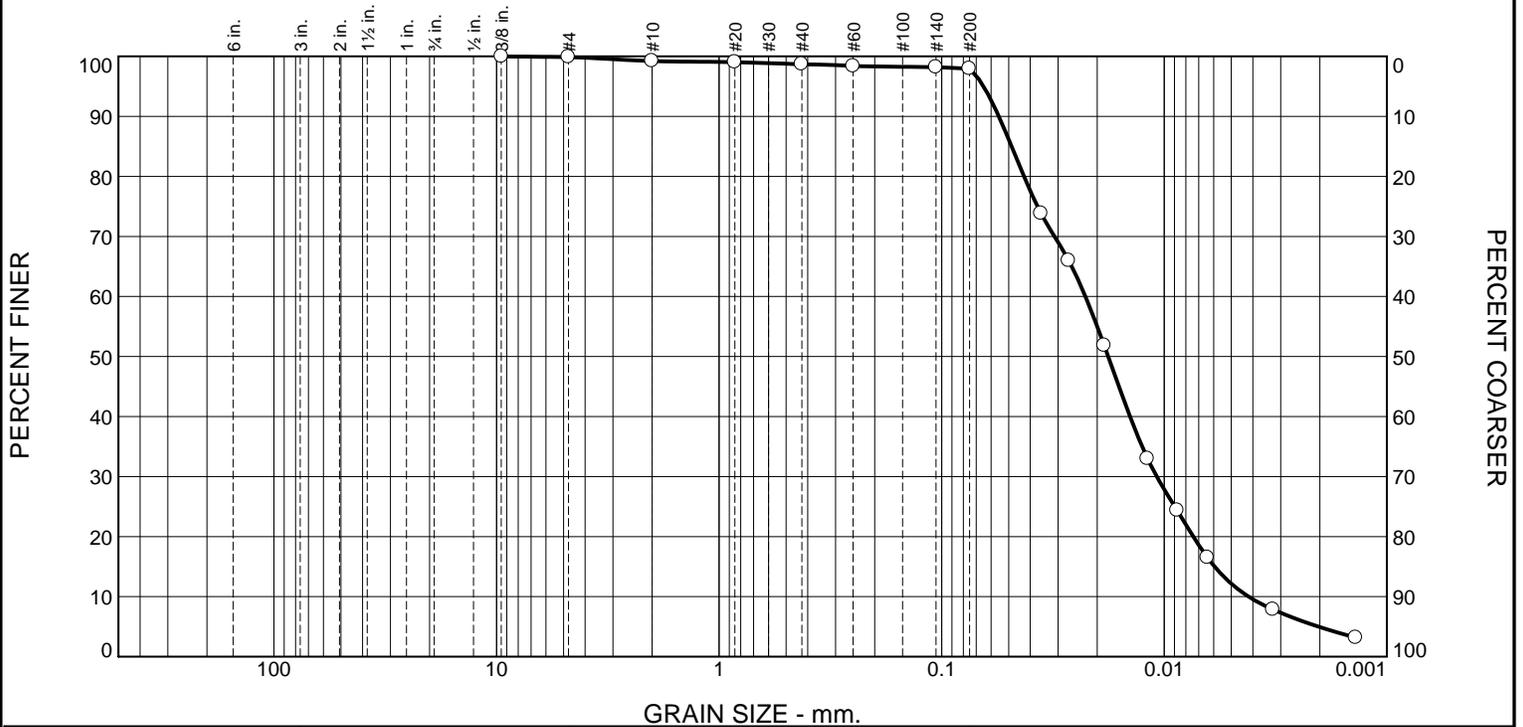
McINTOSH PERRY

Client: MTO - Northeastern Region
Project: Hwy 118 - Culvert 68

Project No: CCO-177060-11

Figure C5

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.7	0.5	0.8	93.0	4.9

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
9.5mm	100.0		
4.75mm	99.9		
2.00mm	99.2		
0.850mm	99.0		
0.425mm	98.7		
0.250mm	98.4		
0.106mm	98.2		
0.075mm	97.9		
0.0358 mm.	73.8		
0.0269 mm.	66.0		
0.0186 mm.	51.8		
0.0119 mm.	33.0		
0.0087 mm.	24.3		
0.0064 mm.	16.5		
0.0032 mm.	7.9		
0.0014 mm.	3.1		

* (no specification provided)

Material Description

Silt trace Clay trace Sand

Atterberg Limits (ASTM D 4318)

PL= _____ LL= _____ PI= _____

Classification

USCS (D 2487)= _____ AASHTO (M 145)= _____

Coefficients

D₉₀= 0.0554 D₈₅= 0.0485 D₆₀= 0.0226
D₅₀= 0.0179 D₃₀= 0.0108 D₁₅= 0.0059
D₁₀= 0.0042 C_u= 5.40 C_c= 1.23

Remarks

Note: Specific Gravity of Soils is Assumed.
F.M.=0.06

Date Received: Sept 13,2023 Date Tested: Sept 19,2023

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL68-3 SS-3 Depth: 4'-6'

Date Sampled: Aug 31,2023

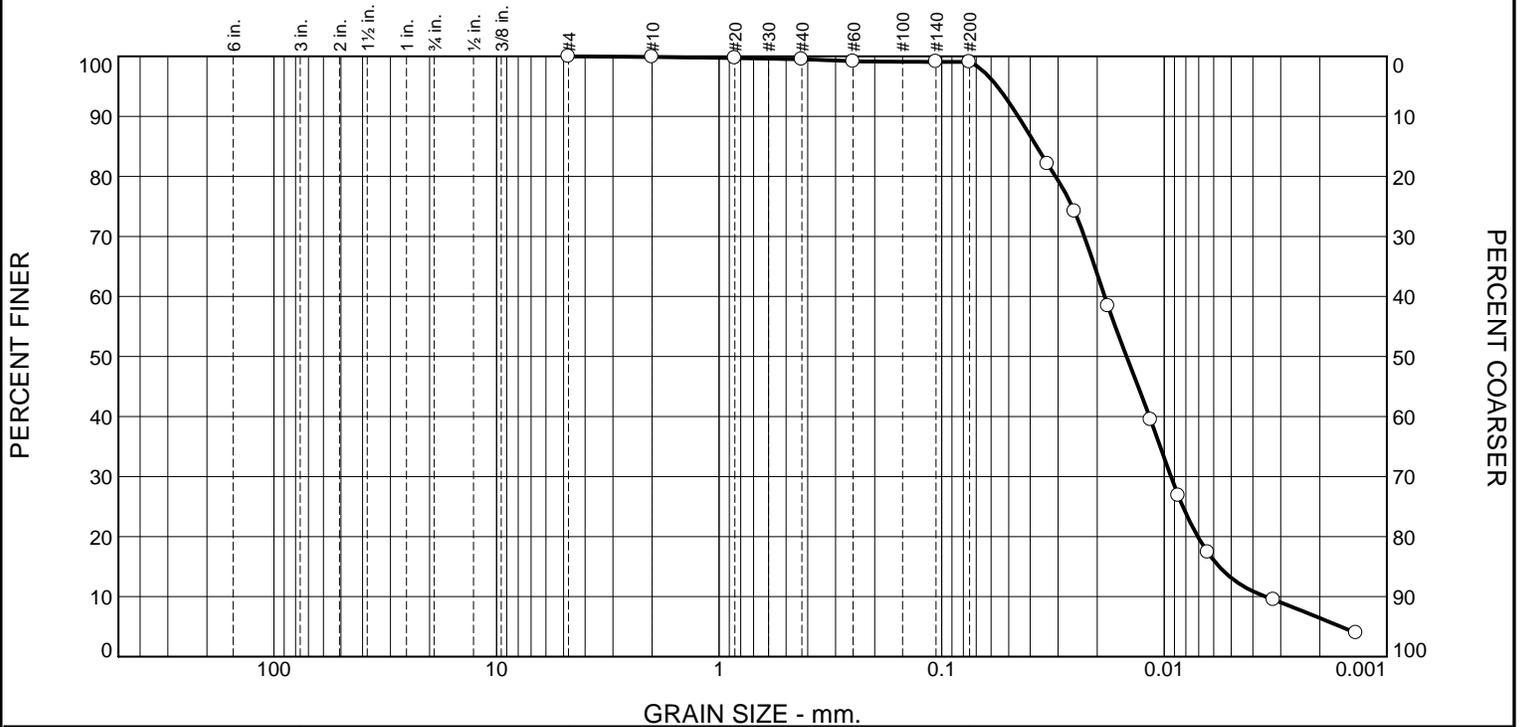
McINTOSH PERRY

Client: MTO - Northeastern Region
Project: Hwy 118 - Culvert 68

Project No: CCO-177060-11

Figure C7

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	0.4	0.4	92.7	6.4

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
4.75mm	100.0		
2.00mm	99.9		
0.850mm	99.7		
0.425mm	99.5		
0.250mm	99.2		
0.106mm	99.1		
0.075mm	99.1		
0.0335 mm.	82.1		
0.0253 mm.	74.2		
0.0179 mm.	58.4		
0.0115 mm.	39.5		
0.0087 mm.	26.8		
0.0064 mm.	17.4		
0.0032 mm.	9.5		
0.0014 mm.	3.9		

* (no specification provided)

Material Description

Silt trace Clay trace Sand

Atterberg Limits (ASTM D 4318)

PL= _____ LL= _____ PI= _____

Classification

USCS (D 2487)= _____ AASHTO (M 145)= _____

Coefficients

D₉₀= 0.0454 D₈₅= 0.0375 D₆₀= 0.0185
D₅₀= 0.0148 D₃₀= 0.0093 D₁₅= 0.0057
D₁₀= 0.0035 C_u= 5.27 C_c= 1.34

Remarks

Note: Specific Gravity of Soils is Assumed.
F.M.=0.02

Date Received: Sept 13,2023 Date Tested: Sept 19,2023
Tested By: R.C
Checked By: J.Hopwood-Jones
Title: Lab Manager

Location: CL68-3 SS-6
Sample Number: SS-6

Depth: 10'-12'

Date Sampled: Aug 31,2023

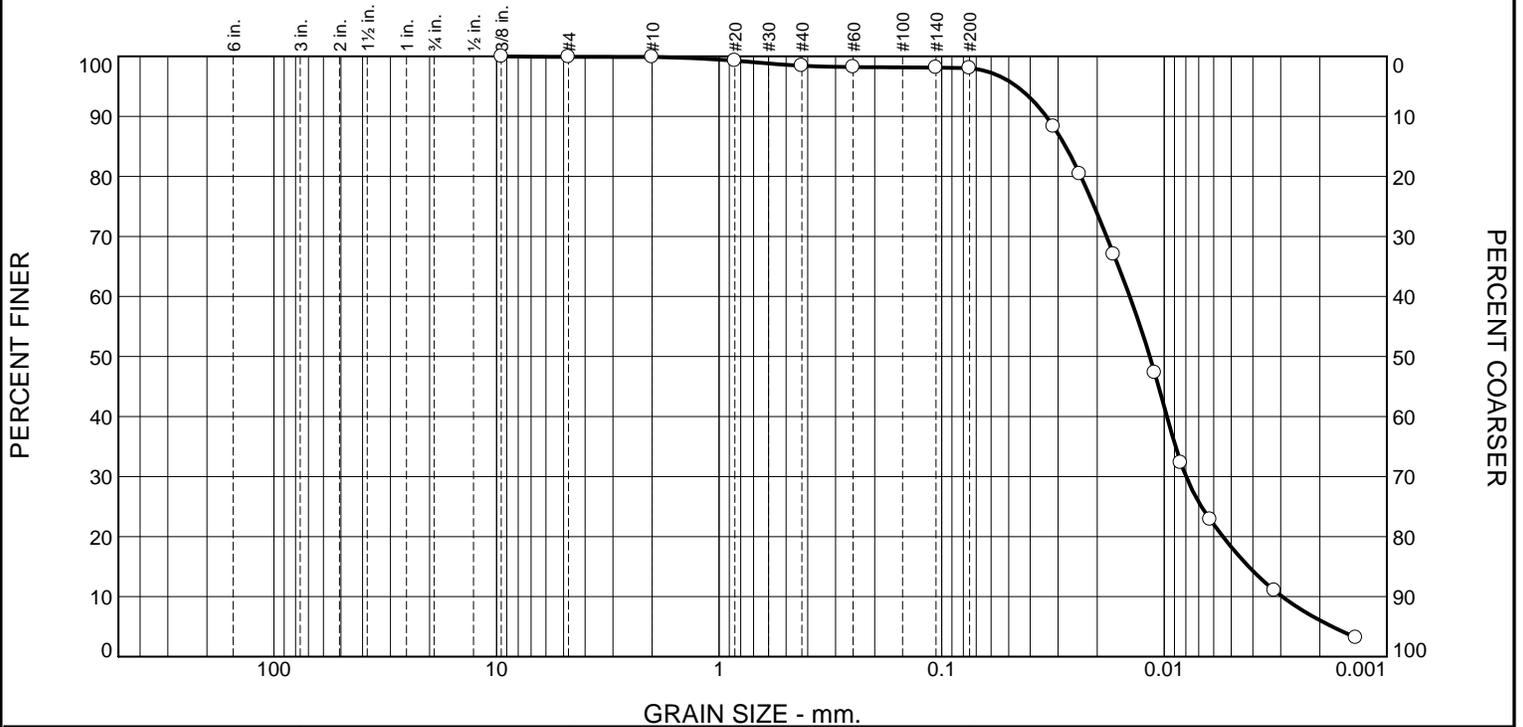
McINTOSH PERRY

Client: MTO - Northeastern Region
Project: Hwy 118 - Culvert 68

Project No: CCO-177060-11

Figure C8

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.0	1.5	0.3	92.0	6.1

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
9.5mm	100.0		
4.75mm	99.9		
2.00mm	99.9		
0.850mm	99.3		
0.425mm	98.4		
0.250mm	98.2		
0.106mm	98.1		
0.075mm	98.1		
0.0315 mm.	88.3		
0.0240 mm.	80.4		
0.0169 mm.	67.0		
0.0110 mm.	47.3		
0.0084 mm.	32.3		
0.0062 mm.	22.9		
0.0032 mm.	11.0		
0.0014 mm.	3.2		

* (no specification provided)

Material Description

Silt trace Clay trace Sand

Atterberg Limits (ASTM D 4318)

PL= _____ LL= _____ PI= _____

Classification

USCS (D 2487)= _____ AASHTO (M 145)= _____

Coefficients

D₉₀= 0.0339 D₈₅= 0.0278 D₆₀= 0.0143
D₅₀= 0.0116 D₃₀= 0.0080 D₁₅= 0.0042
D₁₀= 0.0030 C_u= 4.84 C_c= 1.51

Remarks

Note: Specific Gravity of Soils is Assumed.
F.M.=0.05

Date Received: Sept 13,2023 Date Tested: Sept 19,2023

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL68-3 SS-8
Sample Number: SS-8

Depth: 14'-16'

Date Sampled: Aug 31,2023

McINTOSH PERRY

Client: MTO - Northeastern Region
Project: Hwy 118 - Culvert 68

Project No: CCO-177060-11

Figure C9

Certificate of Analysis

McIntosh Perry Consulting Eng. (Nepean)

215 Menten Place, Unit 104

Nepean, ON K2H 9C1

Attn: Jason Hopwood-Jones

Client PO:

Project: CCO-17-7060-11

Custody: 140469

Report Date: 22-Sep-2023

Order Date: 15-Sep-2023

Order #: 2338037

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Parcel ID	Client ID
2338037-01	CL 68-2 SS5
2338037-02	CL 68-2 SS8
2338037-03	CL 68-3 SS4
2338037-04	CL 68-3 SS9

Approved By:



Mark Foto, M.Sc.

Lab Supervisor

Certificate of Analysis

Report Date: 22-Sep-2023

Client: **McIntosh Perry Consulting Eng. (Nepean)**

Order Date: 15-Sep-2023

Client PO:

Project Description: CCO-17-7060-11

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	21-Sep-23	21-Sep-23
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	19-Sep-23	19-Sep-23
Resistivity	EPA 120.1 - probe, water extraction	19-Sep-23	20-Sep-23
Solids, %	CWS Tier 1 - Gravimetric	18-Sep-23	19-Sep-23

Certificate of Analysis

Report Date: 22-Sep-2023

Client: McIntosh Perry Consulting Eng. (Nepean)

Order Date: 15-Sep-2023

Client PO:

Project Description: CCO-17-7060-11

Client ID:	CL 68-2 SS5	CL 68-2 SS8	CL 68-3 SS4	CL 68-3 SS9	-	-
Sample Date:	31-Aug-23 09:00	31-Aug-23 09:00	31-Aug-23 09:00	31-Aug-23 09:00	-	-
Sample ID:	2338037-01	2338037-02	2338037-03	2338037-04	-	-
Matrix:	Soil	Soil	Soil	Soil	-	-
MDL/Units						

Physical Characteristics

% Solids	0.1 % by Wt.	80.3	79.1	81.0	80.6	-	-
----------	--------------	------	------	------	------	---	---

General Inorganics

pH	0.05 pH Units	7.91	8.14	7.53	8.68	-	-
Resistivity	0.1 Ohm.m	147	137	182	173	-	-

Anions

Chloride	10 ug/g	10	<10	<10	<10	-	-
Sulphate	10 ug/g	24	27	25	25	-	-

Certificate of Analysis

Report Date: 22-Sep-2023

Client: McIntosh Perry Consulting Eng. (Nepean)

Order Date: 15-Sep-2023

Client PO:

Project Description: CCO-17-7060-11

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions								
Chloride	ND	10	ug/g					
Sulphate	ND	10	ug/g					
General Inorganics								
Resistivity	ND	0.1	Ohm.m					

Certificate of Analysis

Report Date: 22-Sep-2023

Client: McIntosh Perry Consulting Eng. (Nepean)

Order Date: 15-Sep-2023

Client PO:

Project Description: CCO-17-7060-11

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	10.2	10	ug/g	10.9			6.6	35	
Sulphate	ND	10	ug/g	ND			NC	35	
General Inorganics									
pH	7.40	0.05	pH Units	7.45			0.7	2.3	
Resistivity	4.22	0.1	Ohm.m	4.20			0.4	20	
Physical Characteristics									
% Solids	73.7	0.1	% by Wt.	73.2			0.6	25	

Certificate of Analysis

Report Date: 22-Sep-2023

Client: McIntosh Perry Consulting Eng. (Nepean)

Order Date: 15-Sep-2023

Client PO:

Project Description: CCO-17-7060-11

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	112	10	ug/g	10.9	101	82-118			
Sulphate	108	10	ug/g	ND	108	80-120			

Certificate of Analysis

Report Date: 22-Sep-2023

Client: McIntosh Perry Consulting Eng. (Nepean)

Order Date: 15-Sep-2023

Client PO:

Project Description: CCO-17-7060-11

Qualifier Notes:

Sample Data Revisions:

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

NC: Not Calculated

Soil results are reported on a dry weight basis unless otherwise noted.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Any use of these results implies your agreement that our total liability in connection with this work, however arising, shall be limited to the amount paid by you for this work, and that our employees or agents shall not under any circumstances be liable to you in connection with this work.



Parcel Order Number (Lab Use Only) 2338037	Chain Of Custody (Lab Use Only) No 140469
---	--

Client Name: McIntosh Perry	Project Ref: CCO-17-7060-11	Page 1 of 1
Contact Name: Jason Hopwood-Jones	Quote #:	Turnaround Time <input type="checkbox"/> 1 day <input type="checkbox"/> 3 day <input type="checkbox"/> 2 day <input checked="" type="checkbox"/> Regular
Address: 215 Meriten Place Nepean, ON	PO #:	
Telephone: 613-453-0751	E-mail: j.hopwood-jones@mcintoshperry.com	
Date Required: _____		

REG 153/04 <input type="checkbox"/> REG 408/19 <input type="checkbox"/> Other Regulation		Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)		Required Analysis									
<input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/Fine	<input type="checkbox"/> REG 558 <input type="checkbox"/> PWOOD	Matrix	Air Volume	# of Containers	Sample Taken	PHCs F1-F4+BTEX	VOCs	PAHs	Metals by ICP	Hg	CrVI	B (HWS)	Corrosivity Package
<input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse	<input type="checkbox"/> CCME <input type="checkbox"/> MISA												
<input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other	<input type="checkbox"/> U - Sani <input type="checkbox"/> SU - Storm												
Mun: _____													
For RSC: <input type="checkbox"/> Yes <input type="checkbox"/> No													
Sample ID/Location Name		Date	Time										
1	CL 68-2 SS5	08/31/2023											X
2	CL 68-2 SS8	08/31/2023											X
3	CL 68-3 SS4	08/31/2023											X
4	CL 68-3 SS9	08/31/2023											X
5													
6													
7													
8													
9													
10													

Comments:		Method of Delivery: Walkin	
Relinquished By (Sign): R. Patel	Received At: 2:35	Received at Lab: SO	Verified By: Hina
Relinquished By (Print): R. Patel	Date/Time: Sept 15/23	Date/Time: Sept 18, 2023 9:35am	Date/Time: Sept 18, 23 / 11:24
Date/Time: 09/15/2023 2:40PM	Temperature: 21.1 °C	Temperature: 7.3 °C	pH Verified: <input type="checkbox"/> By: _____



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APPENDIX D

Site Photographs



THURBER ENGINEERING LTD.



Photo 1: Looking at inlet. STA 17+698 (taken by MPCE) [Summer 2023]



Photo 2: Looking at outlet. STA 17+698 taken by MPCE) [Summer 2023]



THURBER ENGINEERING LTD.



Photo 3: Looking upstream. STA 17+698 taken by MPCE) [Summer 2023]



Photo 4: Looking downstream. STA 17+698 taken by MPCE) [Summer 2023]



THURBER ENGINEERING LTD.



Photo 5: Looking West at road over culvert. STA 17+698 taken by MPCE) [Summer 2023]



Photo 6: Looking West at interior of the culvert. STA 17+698 taken by MPCE) [Summer 2023]



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APPENDIX E

List of Referenced Specifications and Contract Provisions



THURBER ENGINEERING LTD.

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

- OPSS.PROV 206
- OPSS.PROV 501
- OPSS.PROV 517
- OPSS.PROV 539
- OPSS.PROV 1004
- OPSS.PROV 1860
- SP 105S09
- SP 517F01
- OPSD 208.010

2. Notice to Contractor – Presence of Soft Organic Soils in Temporary Work Areas

Soft, organic soils were encountered at ground surface in all three off-road boreholes drilled at this site. The Contractor is advised that the thickness and presence of organic deposits may extend to greater depths or be encountered at other locations between and beyond boreholes. It is anticipated that these materials will not provide a suitable temporary working surface. The Contractor may have to adjust his operations in areas with soft, organic soils.