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FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 579 CULVERT REPLACEMENT AT STA 18+519
SITE NO. 39E-0316/C0
DISTRICT OF COCHRANE, ONTARIO
MTO ASSIGNMENT NO. 5021-E-0027
G.W.P. 5212-18-00, W.P. 5233-18-02

GEOCRES Number 42H00-093

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PART A: FACTUAL INFORMATION

1. INTRODUCTION

Thurber Engineering (Thurber) has been retained by McIntosh Perry Consulting Engineers Ltd. (McIntosh Perry) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the replacement of Clute Creek culvert on Highway 579 under Assignment No. 5021-E-0027.

This report presents the results of the foundation investigation carried out for the proposed culvert replacement at STA 18+519 on Highway 579 (Site No. 39E-0316/C0), referred as Culvert 2, in the District of Cochrane, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the culvert site by borehole drilling and laboratory testing and to prepare a borehole location plan, stratigraphic profiles, records of boreholes, laboratory test results, and a description of the subsurface conditions. The results of the foundation investigations at other culvert locations are presented in separate reports.

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.

2. SITE DESCRIPTION

The existing culvert is located on Highway 579, approximately 12.9 km north of the intersection with Highway 11 near Cochrane, Ontario. Details of the existing culvert are as follows:

Township and Station	Culvert Size and Type	Length of Culvert (m)	Invert Elevation at Inlet (m)	Invert Elevation at Outlet (m)
Clute and Glackmeyer STA 18+519	4.25 m wide by 2.5 m high Twin-Cell Timber Box Culvert	16.4	235.5 (East)	235.5 (West)

The existing culvert allows flow in an east to west direction under an embankment with approximately 1.4 m of fill above the culvert obvert. The surface of the highway is at approximately Elev. 238.9 m. Locally at the culvert, the embankment slopes have a gradient of about 1.5H:1V.

Based on visual observation, no signs of slope instability were observed near the inlet and outlet of the culvert site; however, erosion of the embankment was observed along the north edge of the culvert near the inlet. Both the culvert inlet and outlet were surrounded by ponded water, grass, and other low vegetation. In addition, overhead wires are present along the west side of the highway. Site photographs taken during the foundation investigation are presented in Appendix A.

Highway 579 is comprised of two paved lanes and narrow, partially paved shoulders. There are entrances to private properties located approximately 750 m and 960 m to the north and south of the culvert, respectively.

3. INVESTIGATION PROCEDURES

The foundation investigation was carried out between May 6 and May 26, 2023, and consisted of drilling and sampling five boreholes, designated as Boreholes C2-01 to C2-05, to depths of between 11.3 m and 13.4 m (Elev. 226.2 m and 225.3 m). Boreholes C2-02, C2-04, and C2-05 were advanced through the existing highway embankment, while Boreholes C2-01 and C2-03 were advanced near the toe of the embankment near the existing inlet and outlet, respectively.

The Record of Borehole sheets for the boreholes are included in Appendix B.

Utility clearances were obtained prior to mobilization to site. The ground surface elevation at the as-drilled borehole locations were surveyed using a rod and level and is referenced to temporary benchmarks at the top of the culvert inlet and outlet at Elev. 237.5 m. The borehole coordinates were based on offset measurements against the highway centerline and existing culvert. The coordinate system MTM NAD 83, Zone 12 was used for the boreholes. The survey was carried out with accuracy consistent with MTO's Guideline for Foundation Engineering Services (version 3.0), date April 2022.

Boreholes C2-02, C2-04, and C2-05 were advanced using a truck-mounted CME 55 drill rig using 205 mm outside diameter hollow stem augers. Boreholes C2-01 and C2-03 were advanced using portable drilling equipment and BW casing employing wash boring technique. Soil samples were obtained at selected intervals using split-spoon samplers in general accordance with ASTM D1586.

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

Groundwater conditions observed in open boreholes are not considered stabilized due to the introduction of water throughout the drilling operations. Groundwater level readings observed upon completion of drilling are shown on the Record of Borehole sheets. The borehole completion details are summarized below.

Borehole	Borehole Depth / Borehole Termination Elevation (m)	Northing and Easting MTM NAD83 Zone 12	Completion Details
C2-01	11.3 / 226.2	N 5,446,503.2 E 299,391.4	Borehole backfilled with bentonite to surface.
C2-02	13.4 / 225.3	N 5,446,494.2 E 299,380.6	Monitoring well decommissioned and borehole backfilled with bentonite and asphalt patch at surface.
C2-03	11.3 / 225.9	N 5,446,495.2 E 299,369.4	Borehole backfilled with bentonite to surface.
C2-04	12.8 / 226.0	N 5,446,489.1 E 299,380.5	Borehole backfilled with bentonite and asphalt patch at surface.
C2-05	12.8 / 225.9	N 5,446,508.6 E 299,378.5	Borehole backfilled with bentonite to surface.

All recovered soil samples were subjected to visual identification and natural moisture content determination. Selected samples were subjected to grain size distribution analysis and/or Atterberg Limits testing. The results of this testing program are summarized on the Record of Borehole sheets in Appendix B and are shown on the figures in Appendix C.

Testing was carried out on a sample of the native soil to assess the potential for sulphate attack on buried concrete structures, as well as the potential for corrosion associated with buried steel elements of the structures. The results of the analytical testing are summarized in this report and presented in Appendix C.

4. SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Site Geology

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS) mapping, the site lies near a transition between an outwash plain and ground moraine, which are comprised of tills, clays, and sands.

4.2 Subsurface Conditions

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and interpreted stratigraphic profile and section are presented on the Borehole Locations and Soil Strata Drawings in Appendix D. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following sections. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. Classification and descriptions of coarse- and fine-grained soils are made in accordance with ASTM D2487, and MTO's Soil Classification Manual (as amended), respectively.

The results of in-situ testing (i.e., standard penetration testing and shear vane testing) as presented in the record of boreholes and in the following sections are uncorrected. The boundaries between soil deposits on the record of boreholes have been inferred from non-continuous sampling, observation of the progress of drilling, and the results of Standard Penetration Testing. Therefore, the boundaries represent the transitions between soil deposits rather than exact planes of geological change. Variation on the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In general, the subsurface conditions encountered consisted of embankment fill comprised of sand to silty sand, underlain by native deposits of organic silt, which in turn is underlain by clayey silt to silty clay, and sand and gravel to silty sand.

4.3 Asphalt

Boreholes C2-02, C2-04, and C2-05 were advanced through the paved portion of Highway 579, and the thickness of the asphalt was measured to be 25 mm at each borehole location.

4.4 Topsoil

A 65 mm thick layer of topsoil was encountered at ground surface at Borehole C2-01 and Borehole C2-03, respectively. The topsoil thickness may vary in other areas of the site.

4.5 Embankment Fill

Granular embankment fill was encountered below the asphalt in Boreholes C2-02, C2-04, and C2-05 and is generally comprised of sand, trace silt to silty, trace to some gravel. In Borehole C2-05, a layer of sandy silt, trace gravel containing wood fragments was encountered below the silty sand fill.

The embankment fill ranged in thickness from 3.0 m to 3.8 m and extends to depths of between 3.0 m and 3.8 m (Elev. 235.8 m and 234.9 m).

In general, SPT 'N' values recorded in the embankment fill ranged from 38 blows per 0.3 m penetration to 94 blows per 0.13 m of penetration, indicating a dense to very dense condition. However, SPT 'N' values between 9 blows and 22 blows per 0.3 m of penetration were also recorded in the fill immediately above the underlying organic silt, indicating the fill is loose to compact in places. The measured moisture contents generally ranged from 4 per cent to 41 per cent.

The results of grain size analyses carried out on samples of the embankment fill are shown on the Record of Borehole sheets in Appendix B and presented in Figure C1 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	3 to 20
Sand	46 to 83
Silt	12 to 33
Clay	2 to 12

4.6 Organic Silt

A 3.0 m to 4.5 m thick deposit of organic silt, some sand to sandy was encountered below the topsoil in C2-01 (Elev. 237.4 m) and C2-03 (Elev. 237.1 m), and below the embankment fill in Boreholes C2-02, C2-04, and C2-05 between depths of 3.0 m and 3.8 m (Elev. 235.8 m to 234.9 m).

SPT 'N' values recorded in the organic silt ranged from 1 blow to 9 blows per 0.3 m of penetration, indicating a very loose to loose condition. The measured moisture contents were typically between 35 per cent and 195 per cent, with moisture contents as low as 17 per cent to 23 per cent. Organic contents measured on two samples from this deposit are each about 23 per cent.

The results of grain size analyses carried out on samples of the organic silt are shown on the Record of Borehole sheets in Appendix B and presented in Figure C2 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	14 to 22
Silt	61 to 65
Clay	16 to 24

The results of the Atterberg Limits tests carried out on two samples of the organic silt are shown on the Record of Borehole logs in Appendix B and presented in Figure C3 of Appendix C. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	63 and 96
Plastic Limit	49 and 74
Plastic Index	14 and 22

The results of the Atterberg Limits testing indicate the material is organic silt of high plasticity (OH).

4.7 Silt

A 1.5 m thick layer of silt, some sand was encountered below the organic silt in Borehole C2-02 at a depth of 4.6 m (Elev. 234.1 m).

A SPT 'N' value of 10 blows per 0.3 m of penetration was recorded in the silt, indicating a loose condition. The measured moisture content was 21 per cent.

The result of grain size analysis carried out on a sample of the silt is shown on the Record of Borehole sheets in Appendix B and presented in Figure C4 of Appendix C. The result is summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	20
Silt	67
Clay	13

4.8 Clayey Silt to Silty Clay

A deposit of clayey silt to silty clay, trace sand, trace gravel was encountered below the organic silt or silt at depths ranging from 3.0 m to 6.1 m (Elev. 234.2 m to 232.6 m). Boreholes C2-01 and C2-05 were terminated in this deposit between depths of 11.3 m and 12.8 m (Elev. 226.2 m and 225.9 m), respectively. Where the deposit was fully penetrated, the thickness of the deposit ranged from 6.1 m to 7.2 m.

SPT 'N' values recorded in the clayey silt to silty clay ranged from 0 blows (i.e., weight of hammer) to 13 blows per 0.3 m of penetration. Shear vane testing carried out within clayey silt to silty clay recorded undrained shear strengths ranged from about 15 kPa to greater than 85 kPa, indicating a soft to stiff condition. The sensitivity of the clayey silt to silty clay was typically between 2.3 and 5.0; however, a sensitivity of 9.0 was recorded in Borehole C2-04. The measured moisture contents were typically between 19 per cent and 42 per cent.

The results of grain size analyses carried out on samples of the clayey silt to silty clay are shown on the Record of Borehole sheets in Appendix B and presented in Figure C5 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 3
Sand	1 to 5
Silt	58 to 84
Clay	15 to 40

The results of the Atterberg Limits tests carried out on samples of the clayey silt to silty clay are shown on the Record of Borehole logs in Appendix B and presented in Figure C6 of Appendix C. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	23 to 33
Plastic Limit	16 to 20
Plastic Index	4 to 16

The results of the Atterberg Limits testing indicate the material is clayey silt to silty clay of low plasticity (CL-ML to CL).

4.9 Sand and Gravel to Silty Sand

A layer of sand and gravel to silty sand, some gravel to gravelly, was encountered below the clayey silt to silty clay deposit at depths ranging from 10.2 m to 12.2 m in Boreholes C2-02 to C2-04 (Elev. 227.0 m to 226.5 m).

SPT 'N' values of 25 blows to 59 blows per 0.3 m penetration were recorded in the sand and gravel, indicating a compact to very dense condition, while SPT 'N' values recorded in the silty sand 23 blows and 29 blows per 0.3 m penetration, indicating a compact condition. The measured moisture contents ranged from 2 per cent to 10 per cent.

The results of grain size analyses carried out on samples of the sand and gravel and silty sand are shown on the Record of Borehole sheets in Appendix B and presented in Figures C7 and C8 of Appendix C, respectively. The results are summarized as follows:

Soil Particle	Percentage (%) Sand and Gravel	Percentage (%) Silty Sand
Gravel	41	13 to 32
Sand	57	49 to 74
Silt	2	11 to 17
Clay		2

4.10 Groundwater Conditions

Details of the water level observed in the boreholes upon completion of drilling are presented on the record of boreholes and summarized below.

Borehole	Date of Measurement	Groundwater Level (m)		Remark
		Depth[1]	Elevation	
C2-01	--	--	--	Water level not measured upon completion of drilling due to the introduction of water for wash boring.
C2-02	May 8, 2023	2.6	236.1	Measured from monitoring well.
C2-03	May 26, 2023	-0.9	236.3	Artesian conditions within the silty sand deposit upon completion of drilling.[2,3]
C2-04	May 6, 2023	3.8	235.0	Upon completion of drilling.[2,3]
C2-05	May 5, 2023	2.7	236.0	Upon completion of drilling.[2,3]

Notes:

1. *Positive and negative depth values are used to represent water levels that are measured either below or above the ground surface, respectively.*
2. *Water level measured in casing / hollow stem augers.*
3. *Introduced water into borehole for drilling with wash boring methods and therefore, measured in casing may not be representative of the natural groundwater level.*

The water level in the culvert shown on the General Arrangement Drawing was at Elev. 236.9 m, which is about 1.4 m above the creek bed at the inlet and outlet. At the time of the investigation (May 2023), the water level in the creek was observed to be at about Elev. 237.2 m.

The water levels measured in the borehole upon completion of drilling, monitoring well, and creek are short-term observations and subject to seasonal fluctuations. In particular, the water levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.

5. ANALYTICAL LABORATORY TESTING

One sample of the native organic silt was submitted for analytical testing for corrosivity analysis and sulphide content. The analytical test results for the soil are presented in Appendix C and are summarized below.

Borehole	C2-02
Sample	**SS5**
Depth (m)	3.0 – 3.7
Elevation (m)	235.7 – 235.0
Sulphide (Na_2CO_3) %	<0.04
Chloride (µg/g)	16
Sulphate (µg/g)	21
pH	7.86
Conductivity (µS/cm)	230
Resistivity (Ohm-cm)	4,350

6. MISCELLANEOUS

Downing Drilling Ltd. of Hawkesbury, Ontario, and OGS of Almonte, Ontario supplied and operated the drilling, sampling, and in-situ testing equipment for the foundation investigation. The investigation was supervised on a full-time basis by Mr. Sergey Gladkiy, B.A.Sc. The overall management of the field program was conducted by Ms. Alysha Kobylinski, P.Eng.

Geotechnical laboratory testing on soil samples was carried out in Thurber's geotechnical laboratory. Organic content testing and corrosivity testing on the organic silt deposit was carried out by SGS Canada Inc., a CALA accredited analytical laboratory in Guelph, Ontario.

Interpretation of the field data and preparation of this report was carried out by Mr. Ian Ross, B.A.Sc., and Ms. Alysha Kobylinski, P.Eng., and was reviewed by Messrs. Christopher Ng, P.Eng., and Jason Lee, P.Eng.

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PART B: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This report provides an interpretation of the geotechnical data in the foundation investigation report and presents foundation design recommendations for the proposed culvert replacement at STA 18+519 on Highway 579 (Site No. 39E-0316/C0), referred to as Culvert 2, on Highway 579 in the District of Cochrane, Ontario.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, Ontario, and the designer to carry out the culvert replacement and shall not be used or relied upon for any other purposes or by any other parties including the constructor or design-build contractor. The constructor or contractor must make their own interpretation based on the data provided in factual portion of the report (Part A).

Where comments are made on construction, they are provided to highlight those aspects which could affect the design of the project. The constructor or contractor must make their own interpretation of the factual data as such interpretation may affect equipment selection, proposed construction methods, scheduling, and the like.

The highway embankment is up to about 3.4 m high at the existing culvert location (approximately 1.4 m of fill above the culvert obvert) and as such, the proposed replacement box culvert is intended to be installed by open cut methods. It is understood that Highway 579 will be under full closure from traffic during construction and therefore, temporary roadway protection systems will not be required.

The existing structure is 4.25 m wide by 2.5 m high Twin-Cell Timber Box Culvert, with inlet and outlet inverts at approximate Elev. 235.5 m. The existing highway grade at the culvert is at approximately Elev. 238.9 m. The local creek water level was reportedly measured at Elev. 236.9 m in November 2022.

Based on the General Arrangement (GA) Drawing dated May 2023, it is understood that the existing culvert will be replaced by a concrete box culvert generally along the same alignment. The proposed type, size, length, and invert elevations from the GA Drawing are summarized below.

Culvert Type	Culvert Size (m)	Invert Elevation at Inlet (m)	Invert Elevation at Outlet (m)
Precast Concrete Box	4.2 (wide) 3.0 (high) 20.9 (long)	235.4 (East)	235.4 (West)

8. SUB-EXCAVATION, AND BACKFILLING

The very loose to loose organic silt, loose silt, and soft to stiff clayey silt to silty clay deposit at and immediately below the invert level is not suitable for the support of the proposed culvert. As such, it is recommended that the materials be sub-excavated to Elev. 234.0 m and be replaced by granular backfill. Both the sub-excavation and backfilling operations should be carried out in accordance with OPSS.PROV 902, and in dry conditions.

As a minimum, the base of sub-excavation should extend 0.5 m beyond the edge of the proposed culvert. The base of the sub-excavation should be inspected and approved by qualified geotechnical personnel, and any softened/loosened or poorly performing areas of the subgrade should be removed and replaced with compacted granular fill as directed.

Prior to backfilling, non-woven geotextile meeting the specifications for the OPSS.PROV 1860 Class II and have a maximum fabric opening size (FOS) 75 µm should be placed at the base of the excavation.

The granular backfill meeting the specification of OPSS.PROV 1010 Granular ‘A’ or ‘B’ Type II should be placed and compacted in accordance with OPSS.PROV 501 as amended by Special Provision 105S22.

9. TEMPORARY EXCAVATIONS, AND PROTECTION SYSTEMS

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). The sand to sandy silt embankment fills above the groundwater level are classified as a Type 3. Below the groundwater level, the embankment fills and all native soils (i.e., very loose to loose organic silt, loose silt, and very soft to stiff clayey silt to silty clay) are classified as Type 4 soil. For Type 3 soils, temporary cut slopes should have a gradient of 1H:1V or flatter and while Type 4 soils should have a gradient of 3H:1V or flatter. Alternatively, temporary excavations could be supported with temporary protection systems.

Consideration should be given to protecting the temporary cut slopes from precipitation and runoffs during construction to avoid erosion and surficial instability. Stability of the highway embankment and temporary cut slopes are the responsibility of the contractor.

Excavated material must be stockpiled at a distance away from the excavation equal to or greater than the depth of the open cut excavation. The selection and operation of heavy construction equipment near the open cut excavation are the contractor's responsibility. Stockpiling of excavated material and the operation of construction equipment must not destabilize the embankment.

Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539, as amended by Special Provision 105S09. The lateral movement of the temporary protection systems shall meet Performance Level 2 as specified in OPSS.PROV 539, provided that any existing adjacent utilities (where present) can tolerate the associated magnitude of deformation. The selection, design, installation, and maintenance of protection systems are the responsibility of the contractor.

The soil parameters presented below may apply for the design of temporary roadway protection systems with horizontal backfill.

Stratigraphic Unit	Unit Weight of Material, γ' (kN/m^3)	Angle of Internal Friction, φ (kN/m^3)	Coefficient of Static Lateral Earth Pressure	
			Active, K_a	Passive, K_p
Existing Embankment Fill	21	32	0.31	3.3
Organic Silt	16	20	0.49	2.0
Silt	19	29	0.35	2.9
Clayey Silt to Silty Clay	19	29	0.35	2.9
Gravelly Silty Sand to Sand and Gravel (underlying Silt to Clayey Silt to Silty Clay)	19	35	0.27	3.7

Notes:

1. The lateral earth pressure coefficients presented above are based on static loading conditions and level backfill/ground surface behind the protection system. Where there is sloping ground behind the protection system, the coefficient of lateral earth pressure must be adjusted to account for the slope.
2. The total passive resistance below the base of excavation, if required, may be calculated based on the values of K_p indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.27 of the Canadian Highway Bridge Design Code (CHBDC, 2019) to account for the fact that a large strain would be required for mobilization of the full passive resistance.
3. It is important to note that artesian pressures were encountered in the silty sand deposit underlying the silt to silty clay deposit.

In accordance with OPSS.PROV 539, should the temporary protection systems be left in place after completion of construction, the top shall be removed to at least 1.2 m below the finished grade or ground level, or at least 0.6 m below the streambed.

10. SUBGRADE PREPARATION, BEDDING, COVER, AND BACKFILL

Upon the completion of the removal of unsuitable foundation soils, the subgrade should be inspected and approved by qualified geotechnical personnel. Protection of the clayey silt to silty clay subgrade should include installation of a non-woven geotextile on the subgrade prior to the placement of bedding material. The geotextile should meet the specifications for the OPSS.PROV 1860 Class II and have a maximum fabric opening size (FOS) of 75 µm.

The bedding, cover, and backfill should be placed in loose lifts not exceeding 200 mm, and compacted in accordance with OPSS.PROV 501, as amended by Special Provision 105S22. For a precast concrete box culvert, a minimum 75 mm thick uncompacted levelling course should be placed over a 300 mm thick layer of prepared bedding. In accordance with OPSS.PROV 902, backfill should be placed and compacted in simultaneous equal lifts on both sides of the culvert and the top of backfill elevations should be within 500 mm on both sides of the culvert during backfilling. The bedding material should be placed and compacted as soon as practical following inspection and approval of the final subgrade. Construction equipment should not be allowed to travel on the prepared subgrade, which should be protected from disturbance during construction.

The bedding, levelling, cover, and backfill materials should consist of OPSS.PROV 1010 Granular ‘A’ or ‘B’ Type II with 100% passing the 26.5 mm sieve.

In accordance with OPSD 3090.100, the depth of frost penetration at this site is approximately 2.5 m.

11. GEOTECHNICAL RESISTANCES

The following geotechnical resistances may be used for the design of the proposed culvert, and have been estimated considering sub-excavation and replacement of material with granular to Elev. 234.0 m:

Structure	Founding Condition	Factored Ultimate Geotechnical Resistance (kPa)	Factored Serviceability Geotechnical Resistance for 25 mm of Settlement (kPa)
4.2 m wide Pre-Cast Concrete Box Culvert at STA 18+519	OPSS.PROV 1010 Granular 'A' or 'B' Type II subbase	125	100

The factored geotechnical resistances provided above are based on the following factors from Canadian Highway Bridge Design Code (CHBDC) 2019, Section 6.9:

Factor	Value for Typical Consequence Level and Degree of Understanding
Consequence Factor, Ψ	1.0
Ultimate Geotechnical Resistance Factor, φ_{gu}	0.5
Serviceability Geotechnical Resistance Factor, φ_{gs}	0.8

It should be noted that the factored ultimate and serviceability geotechnical resistances are dependent on the width of the culvert and the foundation elevation and as such, the geotechnical resistances should be reviewed if the culvert dimensions or founding conditions differ from those specified.

Resistance to lateral loads (i.e., sliding resistance) between the concrete footing and the subgrade should be calculated in accordance with Section 6.10.4 of the CHBDC (2019). The following unfactored coefficient of friction that may be used for design.

Culvert and Subgrade Interface	Coefficient of Friction, $tan\varphi'$
Pre-Cast Concrete Box Culvert on Compacted Granular 'A' Bedding	0.50

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

12. CONTROL OF GROUNDWATER AND SURFACE WATER

Observations of water level in the monitoring well indicates the groundwater table will be above the invert of the proposed culvert. It should also be noted that artesian water pressure was noted in the silty sand deposit underlying the silt to silty clay deposit.

If conditions at the time of construction are similar to those observed during the investigation, pumping from filtered sumps within a temporary cofferdam may be adequate to maintain groundwater from entering the excavations. The dewatering system must be effective to maintain the water level at a minimum of 0.5 m below the base of the excavation to allow for the compaction of backfill, bedding, and cover in dry conditions. In addition, the dewatering system must remain operational until the culvert is installed and backfilled. The design and implementation of the dewatering system is the responsibility of the contractor.

The dewatering system is to be designed in accordance with OPSS.PROV 517, as amended by Special Provision 517F01. Considering the excavation will extend down below the observed groundwater level, a design Engineer and design-checking Engineer with a minimum of 5 years of experience in designing systems of similar nature and scope to the required work is required, and thus Designer Fill-In ***** in Special Provision 517F01 should be “Yes”. This recommendation is based on the groundwater conditions observed during the investigation. As noted above, groundwater levels change and should be checked prior to and during the work.

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

If the water taking rate for this project will be greater than 50,000 L/day and less than 400,000 L/day, registration on the Environmental Activity and Sector Registry (EASR) is required. If the water taking rate will be greater than 400,000 L/day, a Category 3 Permit-To-Take Water (PTTW) is required. The rate of water taking should be assessed by a qualified hydrogeologist once the preferred culvert installation method has been selected.

The groundwater level will fluctuate and the minimum groundwater elevation for the site at the time of the proposed works should be taken as the water level from the design storm period defined by the Contract Documents.

13. STREAM DIVERSION PIPE AND COFFERDAMS

A temporary stream diversion pipe will be required during construction to divert the flow of creek water away from the area of the new culvert to allow for construction in dry conditions. It is anticipated that the invert level of the diversion pipe, will be at or below Elev. 235.5 m.

The temporary diversion pipe should be installed in accordance with OPSD 802.010 and be placed on a minimum 300 mm thick layer of bedding material meeting the specification of OPSS.PROV 1010 Granular 'A' or 'B' Type II in dry conditions. The bedding material should be placed on the prepared subgrade as soon as practical, following inspection and approval by qualified geotechnical personnel. The prepared subgrade should be protected from disturbance during construction.

Due to the required depth of sub-excavation for the replacement of unsuitable foundation soils, interlocking sheet piles cofferdam is likely the preferred option for a temporary cofferdam system. The temporary cofferdams that may be used at the site should be designed and constructed in accordance with OPSS.PROV 539, as amended by Special Provision 105S09. The lateral movement of temporary cofferdam systems should include an evaluation of base stability and hydraulic uplift as defined in the Canadian Foundation Engineering Manual (CFEM, 2006). The contractor is responsible for the design and construction of temporary cofferdam systems.

Refer to Section 9, for engineering parameters that may be used for the design of temporary cofferdams.

14. SCOUR AND EROSION PROTECTION

The contractor shall provide silt fences and erosion control blankets as per OPSS.PROV 805 and OPSD 219.110 throughout the duration of construction to prevent transport of silt/sediment from entering the creek.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. A vegetation cover shall be established on exposed earth surfaces to protect against surficial erosion in accordance with OPSS.PROV 803.

Scour and erosion control should be provided at the new culvert inlet and outlet areas. Design of the scour and erosion protection measures must consider hydrologic and hydraulic concerns and should be carried out by a specialist experienced in this field. In accordance with OPSS.PROV 511, rock protection should be provided over all surfaces subjected to flowing water.

Treatment at the outlets should be in accordance with OPSD 810.010.

It is recommended that a clay seal or a concrete cut-off wall be used to ensure that water is channelled through the culvert, reducing the potential for piping and erosion around the culvert. The clay seal should be continuous and have a minimum compacted thickness of 500 mm, constructed to approximately 300 mm above the high water level, and extend laterally for the width of the granular backfill. The material used for the clay seal should conform to the requirements stipulated in OPSS 1205. Alternatively, a geosynthetic clay liner could be considered for use as a clay seal.

15. EMBANKMENT REINSTATEMENT

Embankment reinstatement after construction of the proposed culvert should be carried out in accordance with OPSS.PROV 206 with embankment side slope reconstructed to 2H:1V or flatter provided that OPSS.PROV 1010 Granular B Type I or II is used for the reinstatement. The fill placement and compaction should be carried out in accordance with OPSS.PROV 501.

It is understood that the embankment envelope will require a minor reprofiling of the embankment slopes but will remain essentially unchanged (i.e., without the need for grade raise or embankment widening). As a result, foundation settlement is expected to be less than 25 mm.

The magnitude of the embankment self-compression constructed with granular materials is in the order of 0.5% of the newly reconstructed embankment height and is expected to occur predominantly during fill placement.

16. CORROSION POTENTIAL

Based on results of corrosivity testing on a sample of the organic silt, the following statements can be made in reference to the MTO Gravity Pipe Design Guideline. However, it should be noted that effects of road de-icing salts/chemicals should be considered when selecting pipe material and/or corrosion mitigation measures.

- The resistivity of the organic silt was measured to be 4,350 ohm-cm, which indicates the soil has a moderate corrosion potential (4,500 ohm-cm > R > 2,000 ohm-cm) according to Table 3.2 of the MTO Gravity Pipe Design Guideline.
- The sulphate concentration of the organic silt was measured to be 21 µg/g, which is considered to have a negligible degree of sulphate attack on concrete according to Table 7.2 of the MTO Gravity Pipe Design Guideline.

- The pH level of the organic silt was measured to be 7.86, and according to Section 7.1.1 of the MTO Gravity Pipe Design Guideline, pH levels between 5.5 and 8.5 in soil or water are not considered detrimental to the durability of the culvert.

17. CONSTRUCTION CONCERNS

During construction, qualified geotechnical personnel should be retained to observe activities related to the culvert replacement and advise the Contract Administrator on construction concerns related to performance of the embankment and instability of slopes.

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

- The complete removal and replacement of unsuitable foundation soils with compacted granular backfill as outlined in the preceding sections.
- A dewatering system must be implemented to avoid the instability/boiling of the base of the excavation, particularly with artesian pressure at depth. In addition, the dewatering system must be effective to maintain the water level at a minimum of 0.5 m below the base of the excavation to provide a dry subgrade for the proper compaction of backfill and bedding.
- Disturbance of subgrade soil. Where fine-grained soils are exposed at the culvert subgrade, these areas will become softened and moisture sensitive and may become heavily disturbed when subjected to construction traffic. Construction traffic must not be allowed on the final clayey silt to silty clay subgrade. The final subgrade should be protected with geotextile and granular bedding materials.
- Buried obstructions may be encountered during construction and interfere with excavations, installation of temporary protection systems and cofferdams.

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18. CLOSURE

Preparation of the design report and engineering analysis was carried out by Ms. Alysha Kobylinski, P.Eng., and Mr. Christopher Ng, P.Eng., which was reviewed by Mr. Jason Lee, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Alysha Kobylinski, P. Eng.
Geotechnical Engineer

Christopher Ng, P. Eng.
Associate, Senior Geotechnical Engineer

Date: ***February 1, 2024***
File: ***33730-C2***

Jason Lee, P. Eng., M.Sc.
Partner, Senior Geotechnical Engineer
Designated MTO Contact

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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.

3. BASIS OF REPORT

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
SITE PHOTOGRAPHS

Photograph #1 – Culvert inlet at the east embankment toe, surrounded by a ponded water, facing west. (May 2023)

Photograph #2 – Culvert outlet at the west embankment toe, surrounded by ponded water, facing east. (May 2023)

Photograph #3 – Highway 579, approximately 3 m south of the culvert centerline, facing north. (May 2023)

Photograph #4 – Highway 579, approximately 3 m south of the culvert centerline, facing south. (May 2023)

Photograph #5 – Clute Creek beyond culvert inlet, facing east. Culvert inlet is located near center of the photograph. (May 2023)

Photograph #6 – Clute Creek beyond outlet, facing west. Culvert outlet is located at the bottom left corner of the photograph. (May 2023)

Photograph #7 – Erosion along the north edge of the culvert near the inlet, facing east. (May 2023)

Photograph #8 – Erosion along the north edge of the culvert near the inlet, facing west. (May 2023)

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APPENDIX B
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			

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RECORD OF BOREHOLE No C2-01 1 OF 2 METRIC

WP# 5233-18-02 LOCATION MTM 83-12: N 5 446 503.2 E 299 391.4 ORIGINATED BY SG

DIST Cochrane HWY 579 BOREHOLE TYPE Portable Drilling: Continuous sampling; Washboring with B-casing COMPILED BY AK

DATUM Geodetic DATE 2023.05.27 - 2023.05.27 LATITUDE 49.156617 LONGITUDE -81.074157 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
237.5	GROUND SURFACE										
0.0 / 0.1	**TOPSOIL**: (65 mm)										
	Organic **SILT**, some sand Very Loose to Loose Dark Brown Moist to Wet		1	SS	5		237				
			2	SS	2						
	Wet below a depth of 1.1 m		3	SS	5		236		>98		0 15 61 24
			4	SS	3				117		
			5	SS	4		235		90		
			6	SS	7				81		
233.0			7	SS	3		234				
4.5	Clayey **SILT** (CL-ML) to silty **CLAY** (CL), trace sand, trace gravel Very Soft to Stiff Grey Wet		8	SS	13		233				3 5 72 20
							232				
			9	SS	13		231				
							230				
			10	SS	1						0 2 67 31
							229	2.3			
			11	SS	8		228				

Continued Next Page

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

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

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RECORD OF BOREHOLE No C2-01 2 OF 2 METRIC

WP# 5233-18-02 LOCATION MTM 83-12: N 5 446 503.2 E 299 391.4 ORIGINATED BY SG

DIST Cochrane HWY 579 BOREHOLE TYPE Portable Drilling: Continuous sampling; Washboring with B-casing COMPILED BY AK

DATUM Geodetic DATE 2023.05.27 - 2023.05.27 LATITUDE 49.156617 LONGITUDE -81.074157 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Clayey **SILT** (CL-ML) to silty **CLAY** (CL), trace sand, trace gravel Very Soft to Stiff Grey Wet						227				
226.2			12	SS	2				o		
11.3	END OF BOREHOLE AT 11.3 m. NOTES: 1. Water level not measured upon completion of drilling due to introduction of water for wash boring.										

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

(%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No C2-02 1 OF 2 METRIC

WP# 5233-18-02 LOCATION MTM 83-12: N 5 446 494.2 E 299 380.6 ORIGINATED BY SG

DIST Cochrane HWY 579 BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers COMPILED BY AK

DATUM Geodetic DATE 2023.06.05 - 2023.06.05 LATITUDE 49.156536 LONGITUDE -81.074305 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
238.7	GROUND SURFACE										
0.0 / 0.0	**ASPHALT:** (25 mm)										
	SAND, trace silt, trace gravel Loose to Very Dense Brown Moist to Wet (FILL)		1	SS*	39						
			2	SS*	53		238				
			3	SS*	38		237				
			4	SS*	9		236				
			5	SS*	22		235				9 46 33 12
234.9											
3.8	Sandy Organic **SILT** Loose Brown Wet		6	SS*	6				124		OC= 22.9%
234.1							234				
4.6	**SILT**, some sand Compact Brown Wet		7	SS*	10						0 20 67 13
232.6							233				
6.1	Clayey **SILT** (CL-ML) to Silty **CLAY** (CL), trace sand, trace gravel Very Soft to Stiff Grey Wet		8	SS	2		232	4.3			
			9	SS	2		231				1 2 60 37
			10	SS	2		230				
							229				

Continued Next Page

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

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

Ministry of Transportation
Ontario

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RECORD OF BOREHOLE No C2-02 2 OF 2 METRIC

WP# 5233-18-02 LOCATION MTM 83-12: N 5 446 494.2 E 299 380.6 ORIGINATED BY SG

DIST Cochrane HWY 579 BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers COMPILED BY AK

DATUM Geodetic DATE 2023.06.05 - 2023.06.05 LATITUDE 49.156536 LONGITUDE -81.074305 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Clayey **SILT** (CL-ML) to Silty **CLAY** (CL), trace sand, trace gravel Very Soft to Stiff Grey Wet							+ 3.5			
			11	SS	2		228		○		
226.5							227				
12.2	**SAND** and **GRAVEL**, trace fines Compact to Very Dense Brown Wet		12	SS	25		226		○		41 57 2 (SI+CL)
225.3			13	SS	59				○		
13.4	END OF BOREHOLE AT 13.4 m.										

NOTES:

1. SS* denotes a 63.5 mm inside diameter split-spoon sampler was used for Standard Penetration Testing and the recovery of soil samples.

2. Water level in hollow stem augers measured at a depth of 3.4 m below ground upon completion of drilling.

Monitoring well installation consists of 31.8mm diameter schedule 40 PVC pipe with 3.0m slotted screen

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2023.05.08	2.6	236.1

+ 3, × 3: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No C2-03 1 OF 2 METRIC

WP# 5233-18-02 LOCATION MTM 83-12: N 5 446 495.2 E 299 369.4 ORIGINATED BY SG

DIST Cochrane HWY 579 BOREHOLE TYPE Continuous sampling; Washboring with B-casing COMPILED BY AK

DATUM Geodetic DATE 2023.05.26 - 2023.05.26 LATITUDE 49.156546 LONGITUDE -81.074459 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
237.2	GROUND SURFACE						237				
0.0 / 0.1	**TOPSOIL**: (65 mm)										
	Organic **SILT**, some sand Very Loose to Loose Dark Brown Moist to Wet		1	SS	1						
			2	SS	2		236				
	Wet below a depth of 1.0 m		3	SS	2						OC =22.5%
			4	SS	2		235				0 14 65 21 Non-Plastic
234.2			5	SS	5						
3.0	Clayey **SILT** (CL-ML) to Silty **CLAY** (CL), trace sand Soft to Stiff Grey Wet		6	SS	6		234				
			7	SS	4		233				
			8	SS	4						
							232	4.5			
			9	SS	2		231				0 2 58 40
								3.2			
			10	SS	6		230				
							229				
			11	SS	7		228				

Continued Next Page

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

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

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Ontario

THURBER

RECORD OF BOREHOLE No C2-03 2 OF 2 METRIC

WP# 5233-18-02 LOCATION MTM 83-12: N 5 446 495.2 E 299 369.4 ORIGINATED BY SG

DIST Cochrane HWY 579 BOREHOLE TYPE Continuous sampling; Washboring with B-casing COMPILED BY AK

DATUM Geodetic DATE 2023.05.26 - 2023.05.26 LATITUDE 49.156546 LONGITUDE -81.074459 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
227.0	Continued From Previous Page										
10.2	Silty **SAND**, some gravel Compact Brown Wet		12	SS	23		227		○		13 74 11 2
225.9							226				
11.3	END OF BOREHOLE AT 11.3 m. NOTES: 1. Artesian conditions observed at a depth of 11.3 m below ground surface. Water level in casing measured at 0.9 m above ground surface upon completion of drilling.										

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C2-04 1 OF 2 METRIC

WP# 5233-18-02 LOCATION MTM 83-12: N 5 446 489.1 E 299 380.5 ORIGINATED BY SG

DIST Cochrane HWY 579 BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers COMPILED BY AK

DATUM Geodetic DATE 2023.06.05 - 2023.06.05 LATITUDE 49.156491 LONGITUDE -81.074307 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
238.8	GROUND SURFACE										
0.0	**ASPHALT:** (25 mm)										
	Silty **SAND**, some gravel Dense to Very Dense Brown to Dark Brown Moist to Wet (FILL)		1	SS*	45				○		20 66 12 2
			2	SS*	48		238		○		
	Wet below a depth of 1.5 m		3	SS*	94/ 0.254		237		○		
			4	SS*	94/ 0.127		236				
235.8											
3.0	Organic **SILT**, some sand to sandy, containing wood fragments Loose Dark Brown Wet		5	SS*	9	▽			○		
			6	SS*	5		235		○ 183		
			7	SS*	6		234		○		
233.6											
5.2	Clayey **SILT** (CL-ML) to Silty **CLAY** (CL), trace sand Very Soft to Firm Grey Wet										
			8	SS	2		233		○		
							232	3.2 +			
			9	SS	1		231		⊢○		0 2 67 31
							230	3.3 +			
			10	SS	WH		229		○		

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C2-04 2 OF 2 METRIC

WP# 5233-18-02 LOCATION MTM 83-12: N 5 446 489.1 E 299 380.5 ORIGINATED BY SG

DIST Cochrane HWY 579 BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers COMPILED BY AK

DATUM Geodetic DATE 2023.06.05 - 2023.06.05 LATITUDE 49.156491 LONGITUDE -81.074307 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Clayey **SILT** (CL-ML) to Silty **CLAY** (CL), trace sand Very Soft to Firm Grey Wet							9.0 +			
			11	SS	WH		228		H ○		0 3 76 21
226.6							227				
12.2	Gravelly Silty **SAND** Compact Brown		12	SS	29				○		32 49 17 2
226.0	Wet						226				
12.8	END OF BOREHOLE AT 12.8 m.										

NOTES:

1. SS* denotes a 63.5 mm inside diameter split-spoon sampler was used for Standard Penetration Testing and the recovery of soil samples.

2. Water level in hollow stem augers measured at a depth of 3.8 m below ground surface upon completion of drilling.

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C2-05 1 OF 2 METRIC

WP# 5233-18-02 LOCATION MTM 83-12: N 5 446 508.6 E 299 378.5 ORIGINATED BY SG

DIST Cochrane HWY 579 BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers COMPILED BY AK

DATUM Geodetic DATE 2023.05.05 - 2023.05.05 LATITUDE 49.156665 LONGITUDE -81.074334 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
238.7	GROUND SURFACE										
0.0 / 0.0	**ASPHALT:** (25 mm)										
	Silty **SAND**, trace gravel Very Dense Brown Moist to Wet (FILL)		1	SS	65				○		
			2	SS	68		238		○		
	Wet below a depth of 1.5 m		3	SS	94/ 0.279		237		○		3 83 12 2
236.3											
2.4	Sandy **SILT**, trace gravel, containing wood fragments Compact Brown		4	SS	11	▽	236		○		
235.7											
3.0	Moist (FILL)		5	SS	4				○		0 22 62 16
	Organic **SILT**, some sand to sandy Very Loose to Loose Dark Brown Moist		6	SS	5		235		○		
			7	SS	3		234		○		
232.6											
6.1	Clayey **SILT** (CL-ML) to Silty **CLAY** (CL), trace sand Firm to Very Stiff Brown Wet		8	SS	5		233		○		
			9	SS	10		232		○		0 1 84 15
			10	SS	2		231		○		
							230				
							229				

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C2-05 2 OF 2 METRIC

WP# 5233-18-02 LOCATION MTM 83-12: N 5 446 508.6 E 299 378.5 ORIGINATED BY SG

DIST Cochrane HWY 579 BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers COMPILED BY AK

DATUM Geodetic DATE 2023.05.05 - 2023.05.05 LATITUDE 49.156665 LONGITUDE -81.074334 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	Clayey **SILT** (CL-ML) to Silty **CLAY** (CL), trace sand Firm to Very Stiff Brown Wet							5.0 +			
			11	SS	2		228		○		
							227				
225.9			12	SS	1		226		○		
12.8	END OF BOREHOLE AT 12.8 m.										
	NOTES: 1. SS* denotes a 63.5 mm inside diameter split-spoon sampler was used for Standard Penetration Testing and the recovery of soil samples. 2. Water level in hollow stem augers measured at a depth of 2.7 m below ground surface upon completion of drilling.										

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

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

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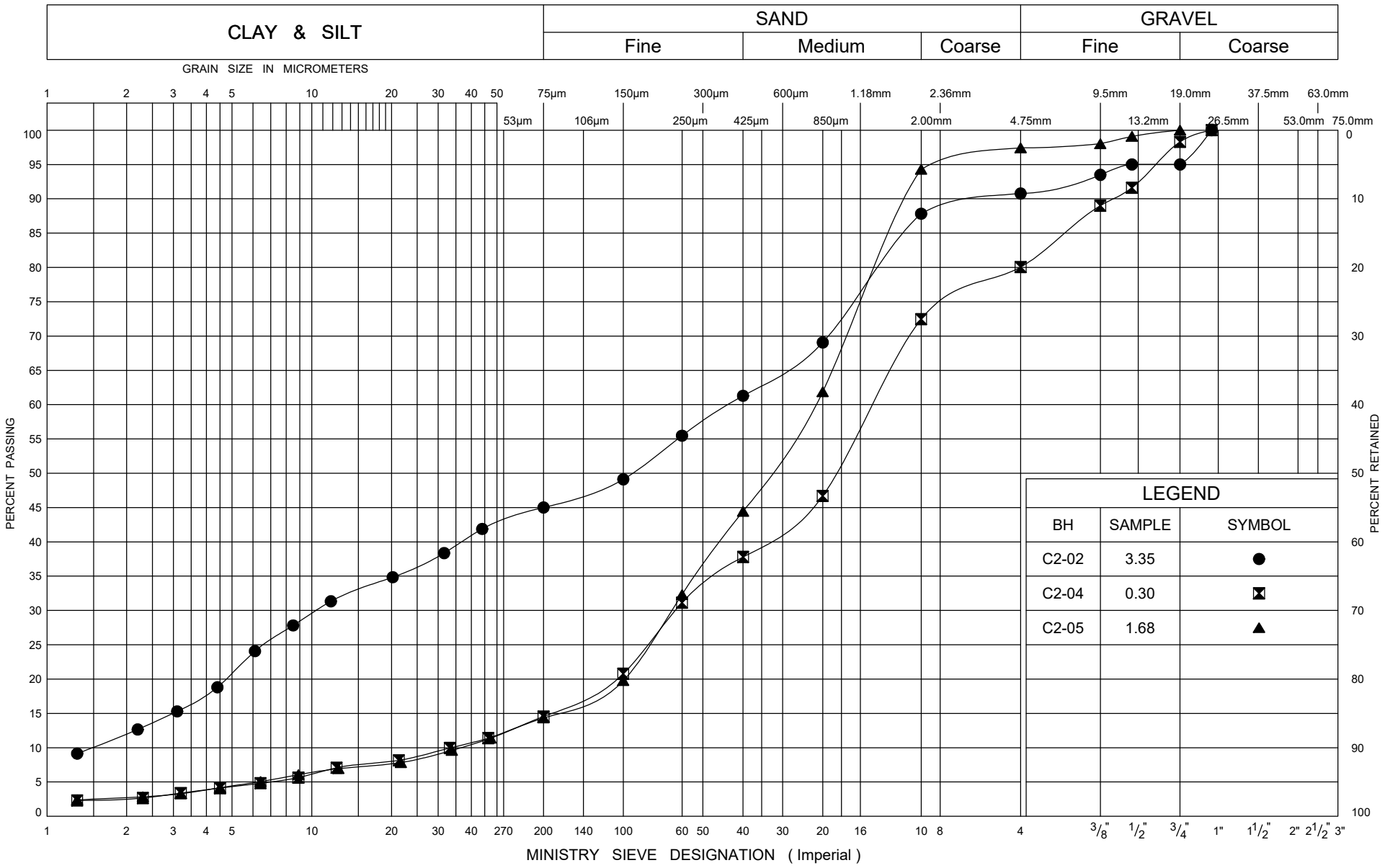
THURBER ENGINEERING LTD.

APPENDIX C
GEOTECHNICAL AND ANALYTICAL LABORATORY TEST RESULTS



ONTARIO MOT GRAIN SIZE 2 MTO-33730.GPJ ONTARIO MOT.GDT 8/18/23

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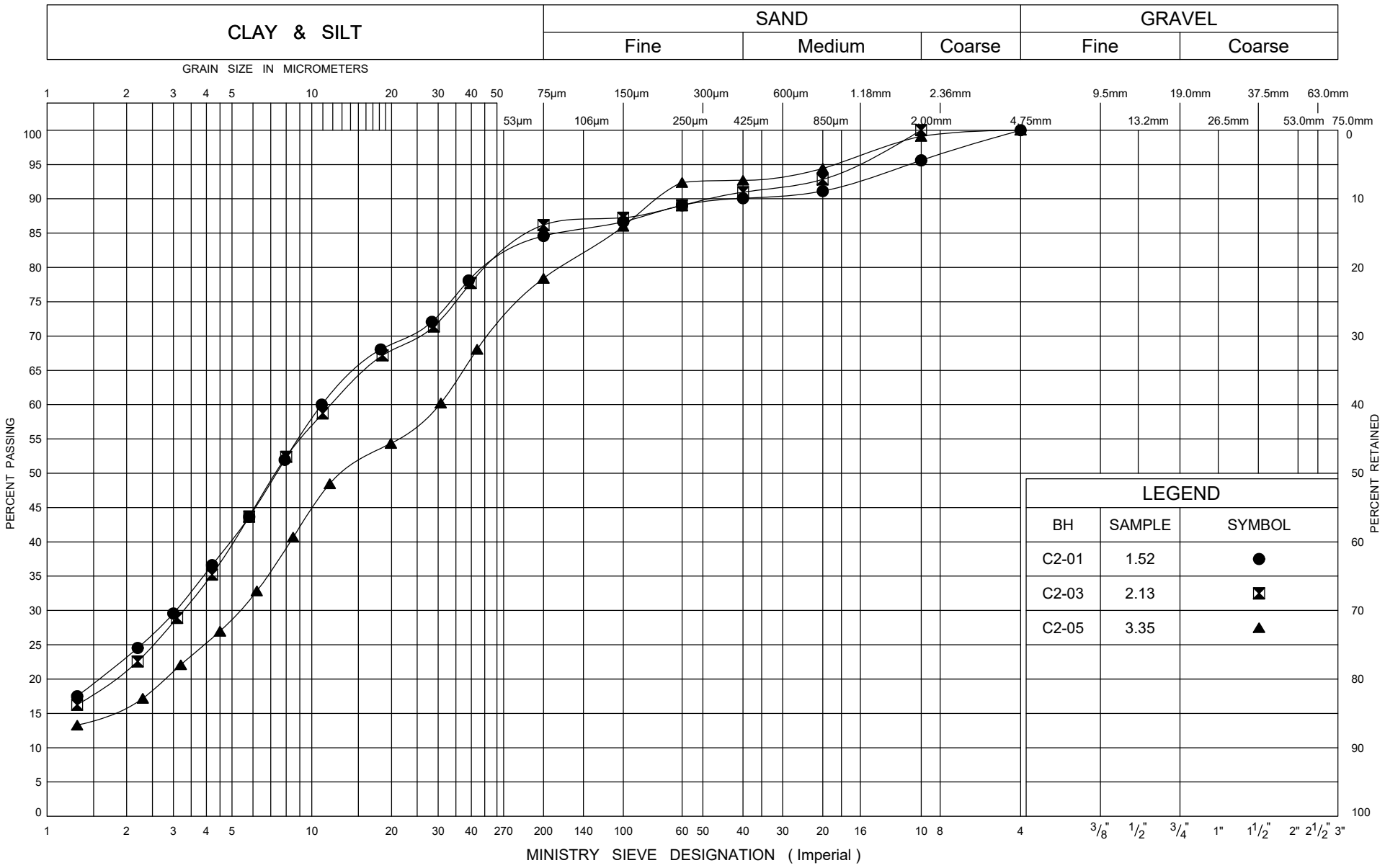
Ontario

GRAIN SIZE DISTRIBUTION

SAND to Silty SAND FILL

FIG No C1

WP# 5233-18-02



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GRAIN SIZE DISTRIBUTION

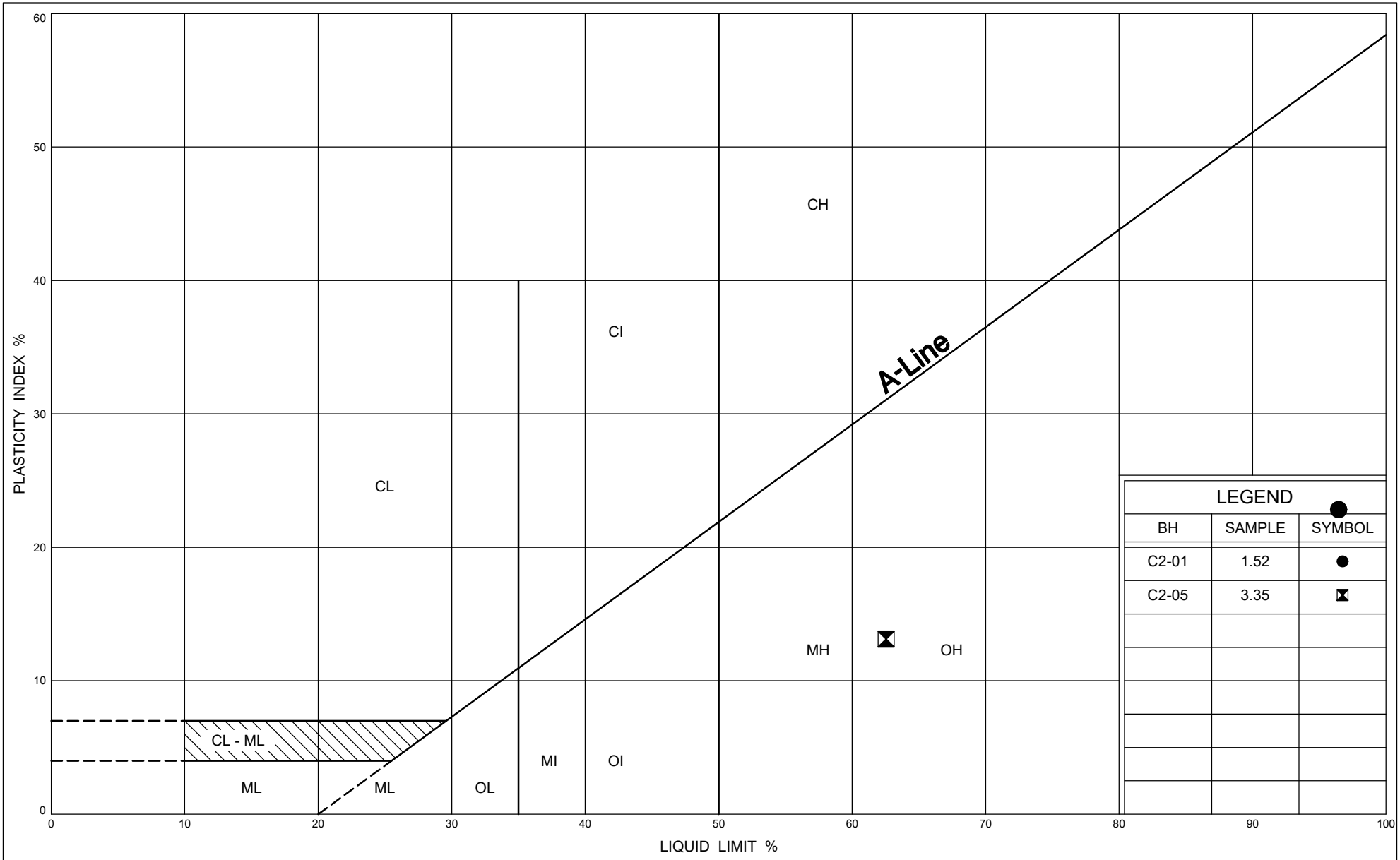
Organic SILT

FIG No C2

WP# 5233-18-02

ONTARIO MOT GRAIN SIZE 2 MTO-33730.GPJ ONTARIO MOT.GDT 8/18/23

Oct 75, FF - S - 21



ONTARIO MOT PLASTICITY CHART MTO-33730.GPJ ONTARIO MOT.GDT 8/18/23

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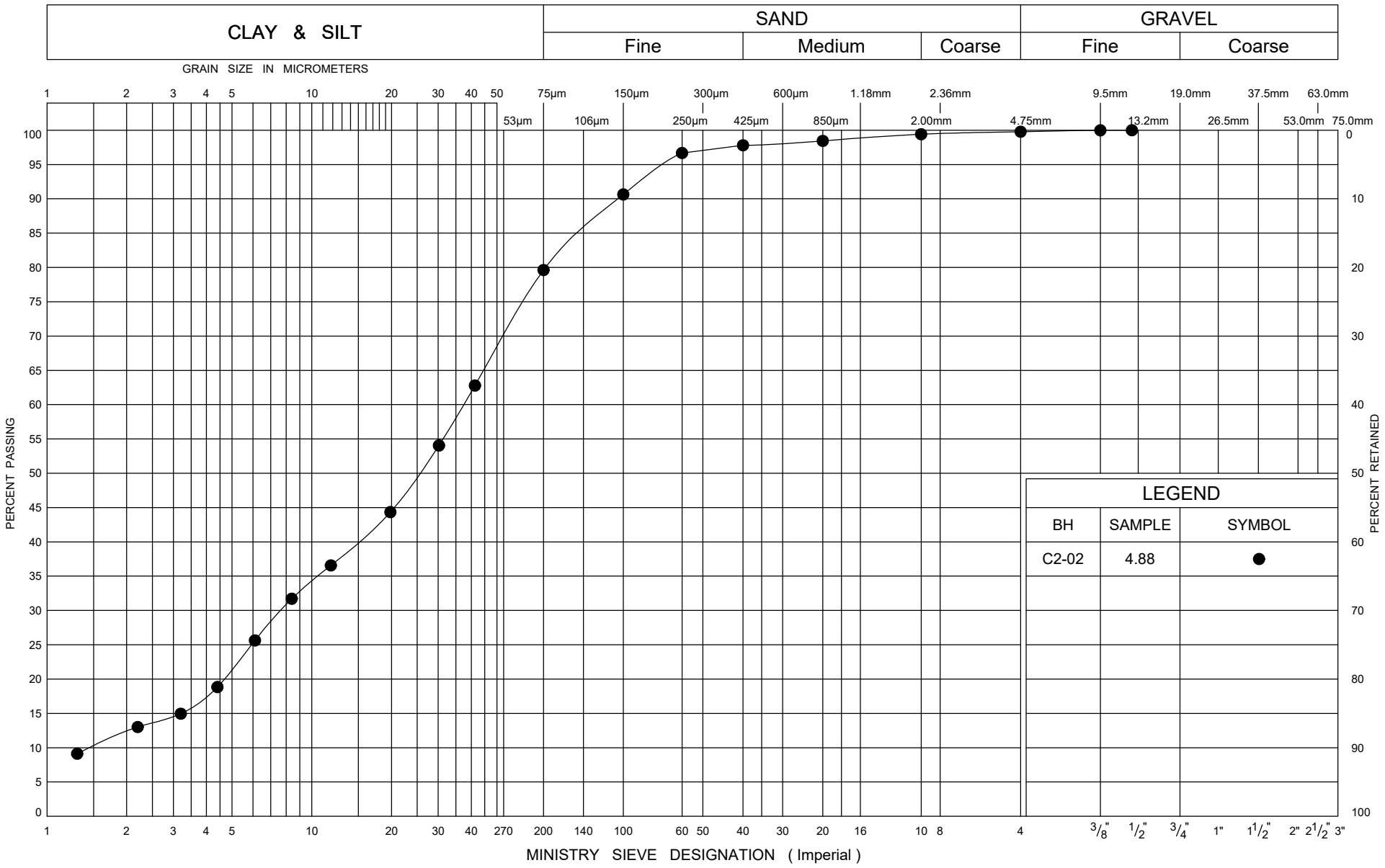
Ontario

PLASTICITY CHART

Organic SILT

FIG No C3

WP# 5233-18-02



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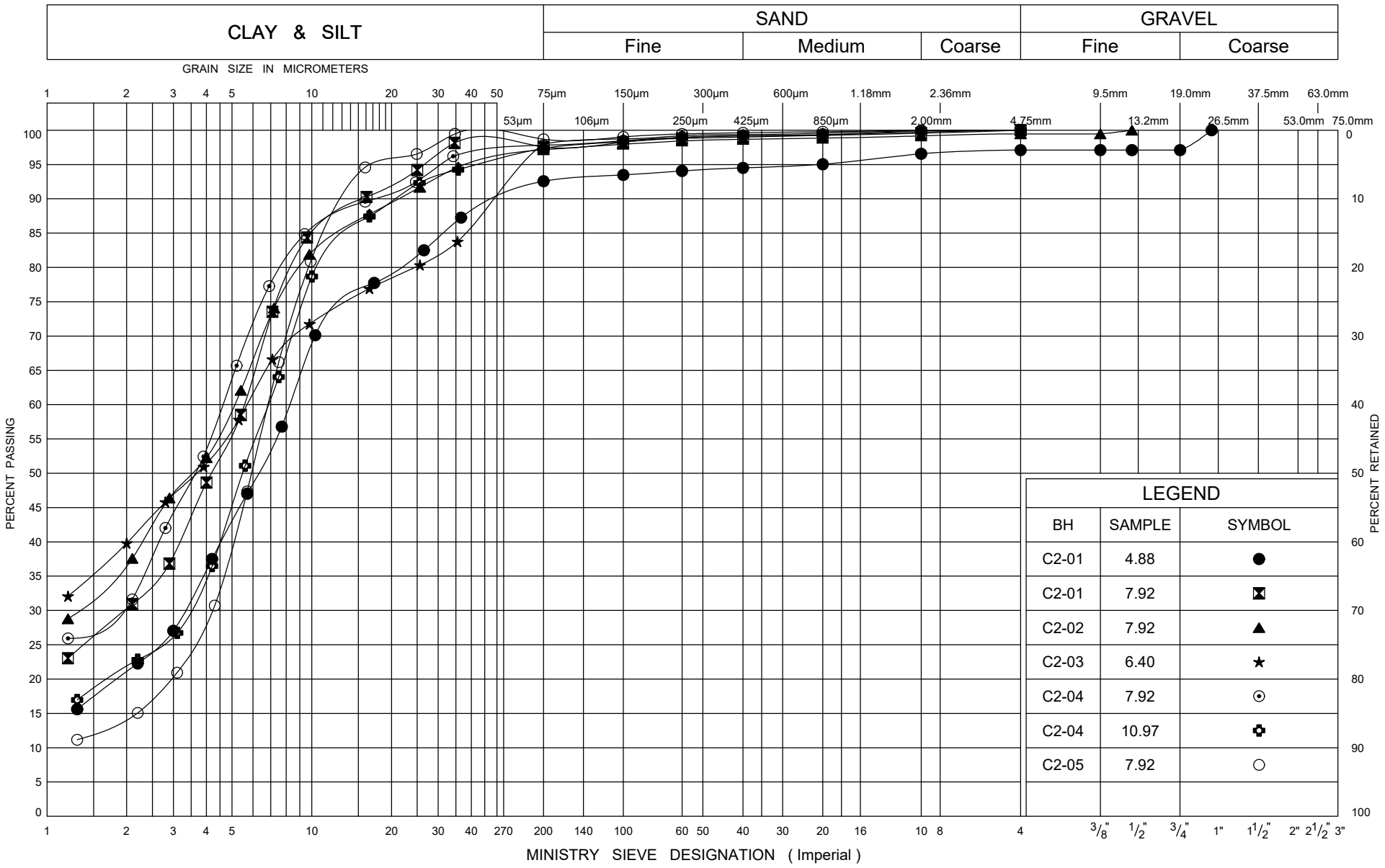
GRAIN SIZE DISTRIBUTION

SILT

FIG No C4

WP# 5233-18-02



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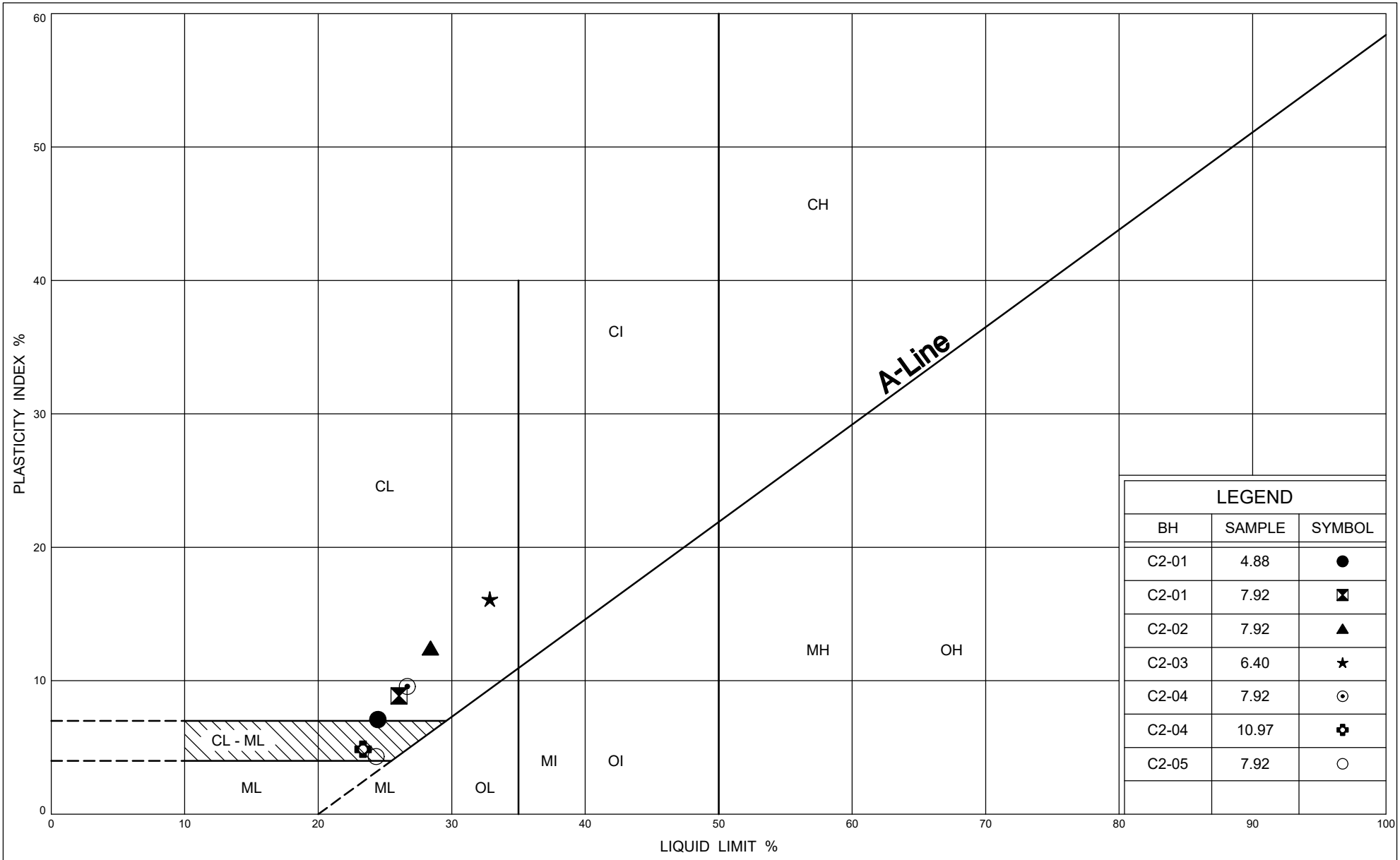
GRAIN SIZE DISTRIBUTION

Clayey SILT to Silty CLAY

FIG No C5

WP# 5233-18-02

Oct 75, FF - S - 21



ONTARIO MOT PLASTICITY CHART MTO-33730.GPJ ONTARIO MOT.GDT 8/18/23

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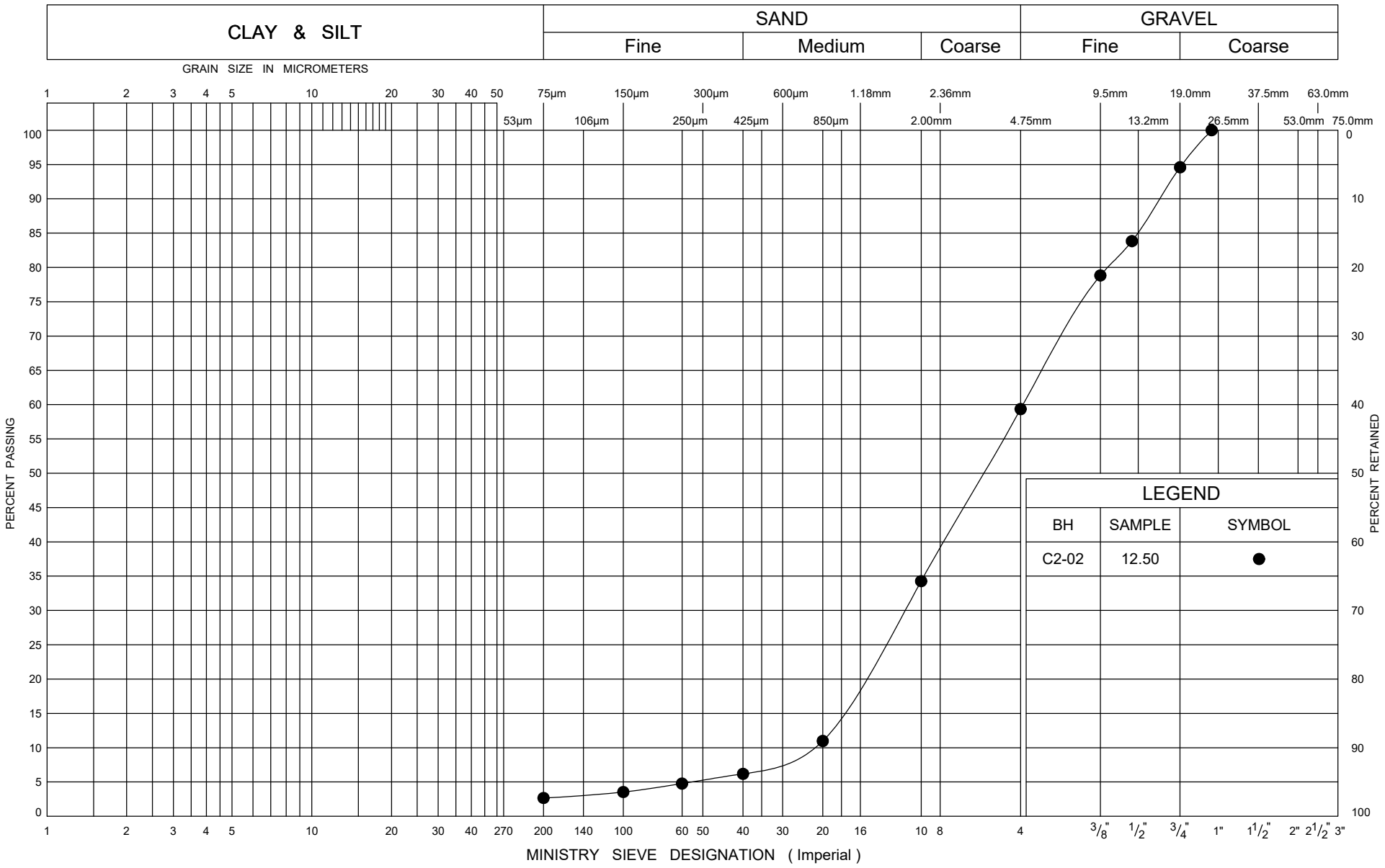
PLASTICITY CHART

Clayey SILT to Silty CLAY

FIG No C6

WP# 5233-18-02



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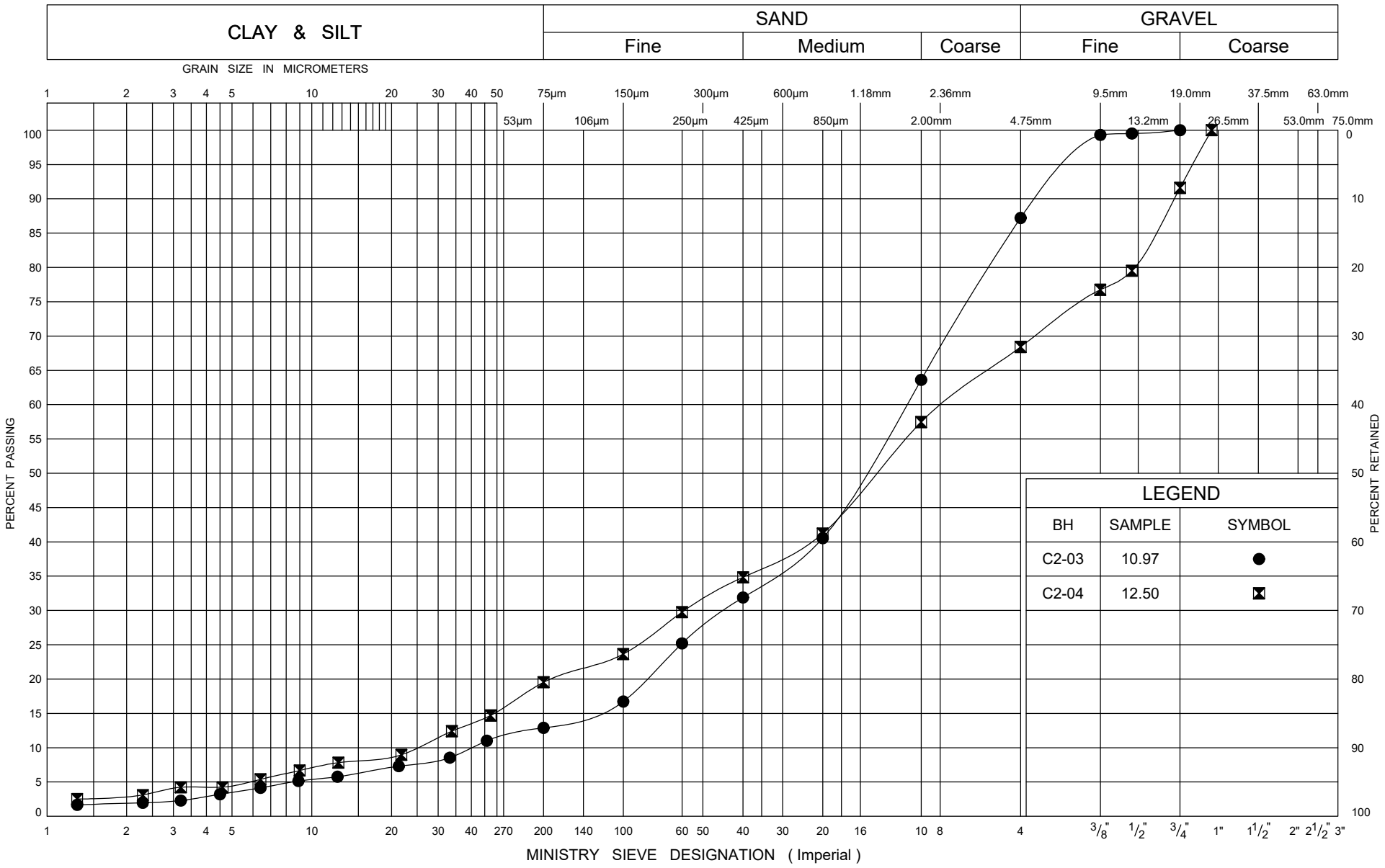
GRAIN SIZE DISTRIBUTION

SAND and GRAVEL

FIG No C7

WP# 5233-18-02

ONTARIO MOT GRAIN SIZE 2 MTO-33730.GPJ ONTARIO MOT.GDT 8/18/23



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GRAIN SIZE DISTRIBUTION

Gravelly SILTY SAND to Silty SAND

FIG No C8

WP# 5233-18-02

FINAL REPORT

CA40305-MAY23 R1

33730, Highway 579 Culverts

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS

Client	Thurber Engineering Ltd.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7. Canada
Contact	Ali Rajaei
Telephone	
Facsimile	
Email	arajaei@thurber.ca; jzoldy@thurber.ca
Project	33730, Highway 579 Culverts
Order Number	
Samples	Soil (3)

LABORATORY DETAILS

Project Specialist	Maarit Wolfe, Hon.B.Sc
Laboratory	SGS Canada Inc.
Address	185 Concession St., Lakefield ON, K0L 2H0
Telephone	705-652-2000
Facsimile	705-652-6365
Email	Maarit.Wolfe@sgs.com
SGS Reference	CA40305-MAY23
Received	05/25/2023
Approved	06/05/2023
Report Number	CA40305-MAY23 R1
Date Reported	06/05/2023

COMMENTS

Temperature of Sample upon Receipt: 12 degrees C
Cooling Agent Present: Yes
Custody Seal Present: Yes

Chain of Custody Number: n/a

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SIGNATORIES

Maarit Wolfe, Hon.B.Sc

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FINAL REPORT

CA40305-MAY23 R1

Client: Thurber Engineering Ltd.
Project: 33730, Highway 579 Culverts
Project Manager: Ali Rajaei
Samplers: Ali Rajaei

MATRIX: SOIL

Sample Number	5	6	7
Sample Name	C1-02/SS6	C2-02/SS5	C3-02/SS6A
Sample Matrix	Soil	Soil	Soil
Sample Date	23/05/2023	23/05/2023	23/05/2023

Parameter	Units	RL		Result	Result	Result
Corrosivity Index						
Corrosivity Index	none	1		6	2	4
Soil Redox Potential	mV	no		117	132	155
Sulphide (Na2CO3)	%	0.04		0.04	< 0.04	0.12
pH	pH Units	0.05		7.66	7.86	7.92
Resistivity (calculated)	ohms.cm	-9999		4780	4350	4760
General Chemistry						
Conductivity	uS/cm	2		209	230	210
Metals and Inorganics						
Moisture Content	%	0.1		32.8	31.6	13.0
Sulphate	µg/g	0.4		66	21	180
Other (ORP)						
Chloride	µg/g	0.4		12	16	7.1

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-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	DIO0723-MAY23	µg/g	0.4	<0.4	1	35	98	80	120	116	75	125
Sulphate	DIO0723-MAY23	µg/g	0.4	<0.4	1	35	96	80	120	103	75	125

Carbon/Sulphur

Method: ASTM E1915-07A | Internal ref.: ME-CA-[ENV]ARD-LAK-AN-020

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 (Na2CO3)	ECS0068-MAY23	%	0.04	< 0.04	ND	20	113	80	120			

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-[ENV]EWL-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	EWL0655-MAY23	uS/cm	2	< 2	1	20	101	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-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
pH	EWL0655-MAY23	pH Units	0.05	NA	0		100			NA		

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

Results relate only to the sample tested.
Data reported represent the sample as submitted to SGS. 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.
Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the "Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act and Excess Soil Quality" published by the Ministry and dated March 9, 2004 as amended.

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.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

This report supersedes all previous versions.

-- End of Analytical Report --

SGS Request for Laboratory Services and CHAIN OF CUSTODY

Environment, Health & Safety - Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Fax: 705-652-6365 Web: www.sgs.com/environment
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361

No:

Laboratory Information Section - Lab use only

Received By: KM
Received Date (mm/dd/yy): 05/25/23
Received Time: 13:45
Received By (signature): KMcKinnon
Custody Seal Present: ☑
Custody Seal Intact: ☑
Cooling Agent Present: ☑
Temperature Upon Receipt (°C): 12°C x3
LAB LIMS #: May-40305

REPORT INFORMATION	INVOICE INFORMATION	PROJECT INFORMATION
Company: Thurber Engineering Ltd.	☑ (same as Report Information)	Quotation #: P.O. #: 33730
Contact: Ali Rajaei	Company:	Project #: 33730 Site Location/ID: Highway 579 Culverts
Address: 1815 Ironstone Manor Suite 11, Pickering, ON L1W 3W9	Contact:	**TURNAROUND TIME (TAT) REQUIRED**
Phone: 4165759069	Address:	☑ Regular TAT (5-7days) TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 6pm or on weekends: TAT begins next business day
Email: arajaei@thurber.ca	Phone:	**RUSH TAT (Additional Charges May Apply):** ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days
Email: akobylinski@thurber.ca	Email:	**PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION**
		Specify Due Date: Rush Confirmation ID:

REGULATIONS

Regulation 153/04: ☐ Table 1 ☐ Table 2 ☐ Table 3 ☐ Table ____ ☐ R/P/I ☐ I/C/C ☐ A/O Soil Texture: ☐ Coarse ☐ Medium ☐ Fine

Other Regulations: ☐ Reg 347/558 (3 Day min TAT) ☐ PWQO ☐ MMER ☐ CCME ☐ Other: ☐ MISA

Sewer By-Law: ☐ Sanitary ☐ Storm Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☑ NO

NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Field Filtered (Y/N)	Metals & Inorganics	PAH ☐ ABN ☐ SVOC(all) ☐	PCB Total ☐ Aroclor ☐	PHC F1-F4 ☐ BTEX ☐ VOC ☐ BTEX/F1 ☐ F2-F4 ☐	VOC ☐ BTEX ☐ THM ☐	Pesticides OC ☐ OP ☐	TCLP M&I ☐ VOC ☐ PCB ☐ B(a)P ☐ ABN ☐ Ignit. ☐	Water Pkg Gen. ☐ Ext. ☐	Sewer Use:	Corrosivity/Resistivity					COMMENTS:
1	C1-02/SS6	5/23/23	16:00	1	Soil		☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	Please include Sulphide as well
2	C2-02/SS5	5/23/23	16:15	1	Soil		☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	Please include Sulphide as well
3	C3-02/SS6A	5/23/23	16:30	1	Soil		☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	Please include Sulphide as well
4							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
5							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
6							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
7							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
8							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
9							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
10							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
11							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
12							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Observations/Comments/Special Instructions

Sampled By (NAME): Ali Rajaei	**Signature:** AR	Date: 05/23/23	(mm/dd/yy)	Pink Copy - Client
Relinquished by (NAME): Czarlene Pontejos	**Signature:** C.P.	Date: 5/24/23	(mm/dd/yy)	Yellow & White Copy - SGS

THURBER ENGINEERING LTD.

APPENDIX D
BOREHOLE LOCATION PLAN AND SOIL STRATA DRAWINGS

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

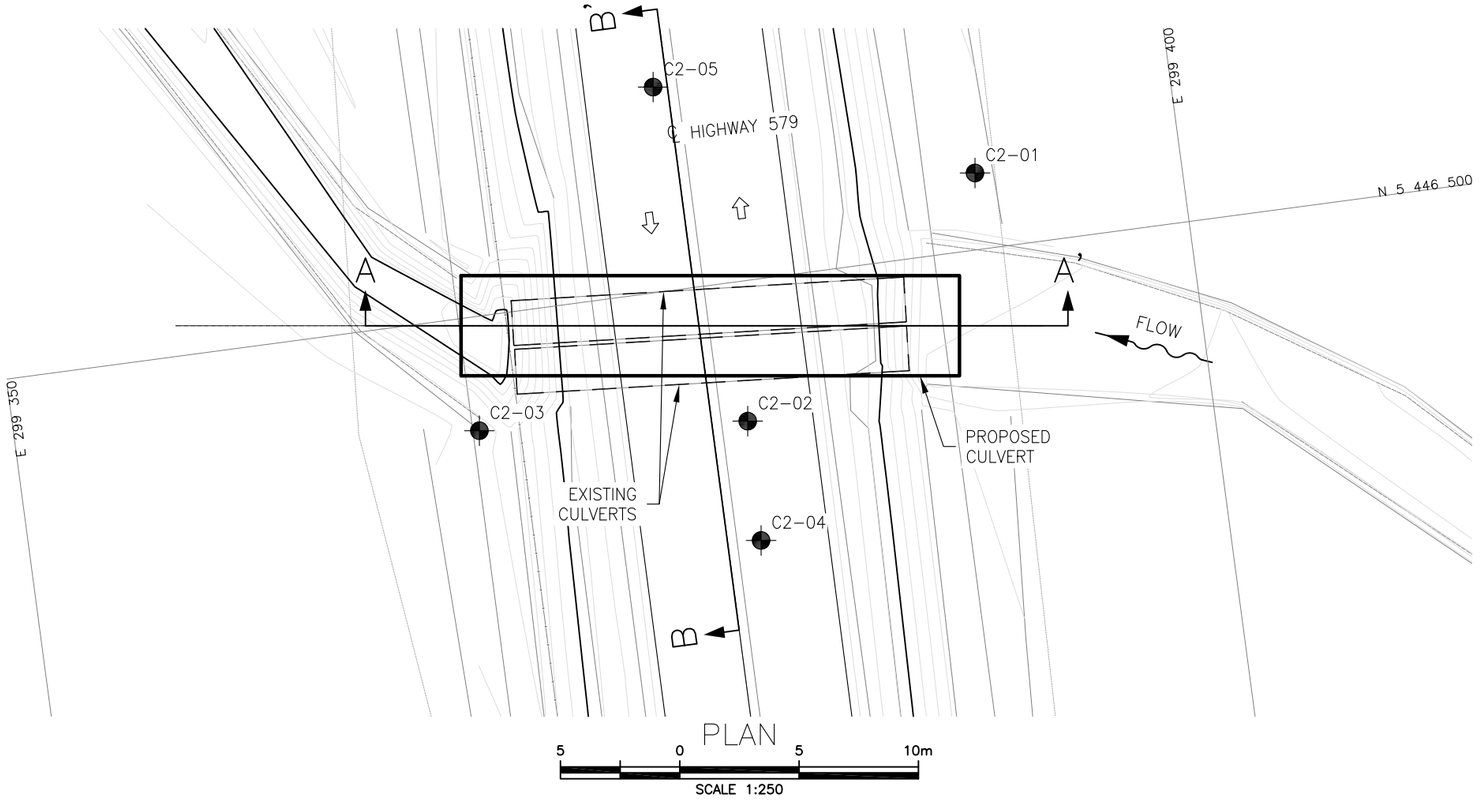
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

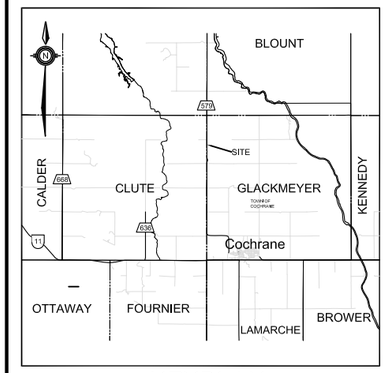
CONT No
WP No. 5233-18-02

SHEET

HIGHWAY 579
CULVERT REPLACEMENT
STA. 18+519 (CLUTE CREEK)
BOREHOLE LOCATIONS AND SOIL STRATA

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 Upon Completion of Drilling
▼	Water Level in Monitoring Well/Piezometer
▮	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
C2-01	237.5	5 446 503.2	299 391.4
C2-02	238.7	5 446 494.2	299 380.6
C2-03	237.2	5 446 495.2	299 369.4
C2-04	238.8	5 446 489.1	299 380.5
C2-05	238.7	5 446 508.6	299 378.5

-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 12.

GEOCRES No. 42H00-093

LICENSED PROFESSIONAL ENGINEER
J. P. K. LEE
100086735
2024/02/01
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
C.C. NG
100085170
2024/02/01
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN AK	CHK	CODE	LOAD	DATE JAN 2024	
DRAWN AN	CHK AK	SITE	STRUCT	DWG 1	

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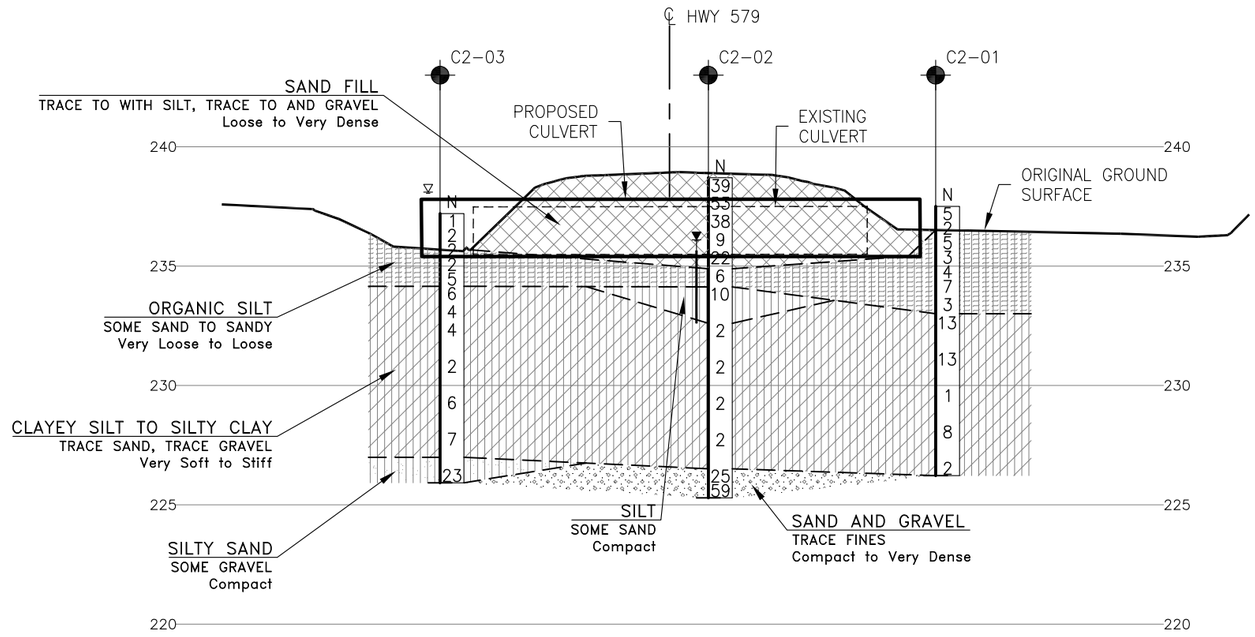
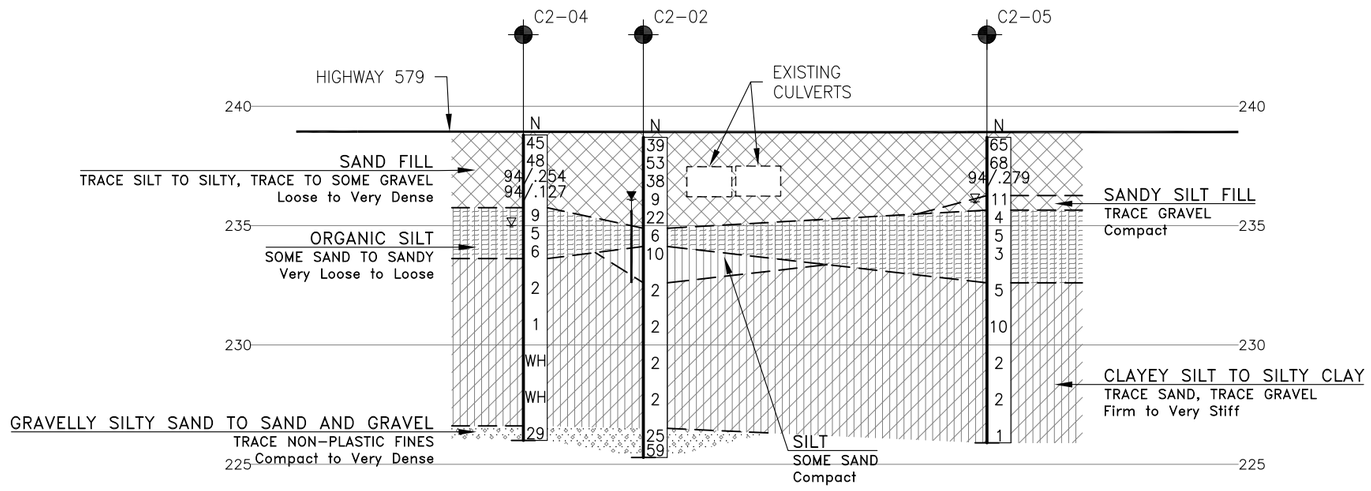


PROFILE ALONG CULVERT AT STA. 18+519 (A–A')

5 0 5 10m

SCALE 1:250



PROFILE ALONG HIGHWAY 579 (B–B')

5 0 5 10m

SCALE 1:250

METRIC

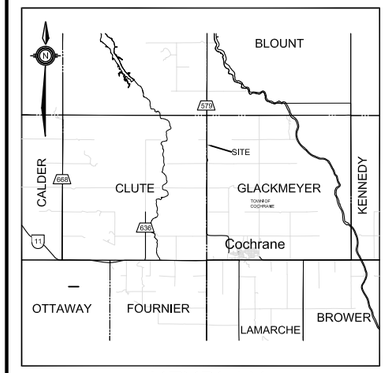
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No. 5233-18-02

HIGHWAY 579
CULVERT REPLACEMENT
STA. 18+519 (CLUTE CREEK)
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.



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C.C. NG
100086170
2024/02/01
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN AK	CHK	CODE	LOAD	DATE JAN 2024
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