



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 579 CULVERT REPLACEMENT AT STA 15+994
SITE NO. 39E-0315/C0
DISTRICT OF COCHRANE, ONTARIO
MTO ASSIGNMENT NO. 5021-E-0027
G.W.P. 5212-18-00, W.P. 5232-18-02**

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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 15+994 on Highway 579 (Site No. 39E-0315/C0), referred as Culvert 1, 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 10.5 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 15+994	2 m high x 3 m wide CSPA	20.9	252.9 (East)	252.8 (West)

The existing culvert allows flow in an east to west direction under an embankment with approximately 1.6 m of fill above the culvert obvert. The surface of the highway is at approximately Elev. 256.4 m. Locally at the culvert, the east- and west-facing slope has a gradient of about 1.5H:1V, and 2H:1V, respectively.

Based on visual observation, no signs of slope instability were observed near the inlet and outlet of the culvert site. Both the culvert inlet and outlet were surrounded by ponded water, brushes, 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 430 m and 500 m to the north and south of the culvert, respectively.

3. INVESTIGATION PROCEDURES

The foundation investigation was carried out between May 2 and May 25, 2023, and consisted of drilling and sampling five boreholes, designated as Boreholes C1-01 to C1-05, to depths of between 11.3 m and 13.0 m (Elev. 243.7 m and 243.3 m). Boreholes C1-02, C1-04, and C1-05 were advanced through the existing highway embankment, while Boreholes C1-01 and C1-03 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. 255.0 m and 254.9 m, respectively. 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 C1-02, C1-04, and C1-05 were advanced using a truck-mounted CME 55 drill rig using 205 mm outside diameter hollow stem augers. Boreholes C1-01 and C1-03 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
C1-01	11.3 / 243.5	N 5 444 003.8 E 299 389.0	Borehole backfilled with bentonite to surface.
C1-02	13.0 / 243.4	N 5 443 992.2 E 299 378.9	Monitoring well decommissioned, and borehole backfilled with bentonite and asphalt patch at surface.
C1-03	11.3 / 243.3	N 5 443 991.0 E 299 365.4	Borehole backfilled with bentonite to surface.
C1-04	13.0 / 243.5	N 5 444 006.3 E 299 378.3	Borehole backfilled with bentonite and asphalt patch at surface.
C1-05	13.0 / 243.5	N 5 443 984.8 E 299 374.5	Borehole backfilled with bentonite and asphalt patch at 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 gravelly sand to silty sand, underlain by native deposits of organic silt, which is in turn is underlain by silt to silty clay, and silty sand to sandy silt.

4.3 Asphalt

Boreholes C1-02, C1-04, and C1-05 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 50 mm thick layer of topsoil was encountered at ground surface at Borehole C1-03. The topsoil thickness may vary in other areas of the site.

4.5 Embankment Fill

Granular embankment fill comprised of sand, some gravel to gravelly, to silty sand, trace gravel, was encountered below the asphalt in Boreholes C1-02, C1-04, and C1-05.

The embankment fill ranged in thickness from 2.3 m to 2.7 m and extends to depths of between 2.3 m and 3.6 m (Elev. 254.2 m to 252.8 m).

In general, SPT 'N' values recorded in the embankment fill ranged from 24 blows per 0.3 m penetration to 87 blows per 0.25 m of penetration, indicating a compact to very dense condition. However, SPT 'N' values of 6 and 8 blows per 0.3 m of penetration were also recorded between the transition from the embankment fill to the underlying sandy organic silt in Boreholes C1-05 and C1-02, respectively. The measured moisture contents generally ranged from 5 per cent to 43 per cent.

The results of grain size analyses carried out on selected 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	4 to 24
Sand	65 to 79
Silt	7 to 14
Clay	3

4.6 Organic Silt and Sand to Organic Silt

A 1.0 m to 2.8 m thick deposit of organic silt and sand to organic silt, trace sand was encountered at ground surface in C1-01 (Elev. 254.8 m), below the embankment fill in Boreholes C1-02, C1-04, and C1-05 between depths of 2.3 m and 3.6 m (Elev. 254.2 m to 252.8 m), and below the topsoil in Borehole C1-03 (Elev. 254.6 m).

SPT 'N' values recorded in the organic silt and sand to organic silt ranged from 1 blow to 6 blows per 0.3 m of penetration, indicating a very loose to loose condition. The measured moisture contents were typically between 42 per cent and 92 per cent. Organic contents measured on two samples from this deposit are 7 per cent and 12 per cent.

The results of grain size analyses carried out on samples of the organic silt sand to 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	5 to 39
Silt	42 to 72
Clay	19 to 23

The result of the Atterberg Limits test carried out on a sample of the organic silt deposit is shown on the Record of Borehole logs in Appendix B and presented in Figure C3 of Appendix C. The result is summarized as follows:

Index Property	Percentage (%)
Liquid Limit	50
Plastic Limit	33
Plastic Index	17

The results of the Atterberg Limits testing indicate material is silt of intermediate plasticity (OI).

4.7 Silty Sand

A 1.5 m thick layer of silty sand, some gravel, trace clay, containing wood fragments was encountered below the organic silt in Borehole C1-02 at a depth of 4.6 m (Elev. 251.8 m).

A SPT 'N' value of 13 blows per 0.3 m of penetration was recorded in the silty sand, indicating a compact condition. The measured moisture content was 26 per cent.

The result of grain size analysis carried out on a sample of the silty sand 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	19
Sand	34
Silt	39
Clay	8

The result of the Atterberg Limits test carried out on the fines portion of a silty sand sample is shown on the Record of Borehole logs in Appendix B and presented in Figure C5 of Appendix C. The result is summarized as follows:

Index Property	Percentage (%)
Liquid Limit	18
Plastic Limit	15
Plastic Index	3

The results of the Atterberg Limits testing indicate the material is of low plasticity (ML).

4.8 Silt to Silty Clay

A deposit of silt to silty clay was encountered below the organic silt in Boreholes C1-01, C1-03, C1-04, and C1-05 (Elev. 252.8 m and 251.0 m), and below the layer of silty sand in Borehole C1-02 at depths ranged from about 2.1 m to 6.1 m (Elev. 250.3 m). Boreholes C1-02, C1-04, and C1-05 were terminated in this deposit at a depth of 13.0 m (Elev. 243.5 m to 243.4 m). Where the deposit was fully penetrated in Boreholes C1-01 and C1-03, the thickness of the deposit was about 8.1 m and 9.0 m, respectively. The deposit is generally clayey silt to silty clay, with a zone of non-plastic silt between about Elev. 248 m and 245 m.

SPT 'N' values recorded in the silt to silty clay ranged from 0 blows (i.e., weight of hammer) to 22 blows per 0.3 m of penetration. Shear vane testing carried out within clayey silt to silty clay portions of the deposit recorded undrained shear strengths ranged from 16 kPa to greater than 100 kPa, indicating a soft to very stiff condition. The sensitivity of the clayey silt to silty clay was typically between 2.5 and 3.3; however, a sensitivity of 7.3, and 12.5 was recorded in Boreholes C1-05, and C1-02, respectively. The measured moisture contents were typically between 18 per cent and 50 per cent.

The results of grain size analyses carried out on samples of the silt to silty clay are shown on the Record of Borehole sheets in Appendix B and presented in Figures C6A and C6B of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	0 to 5
Silt	62 to 86
Clay	13 to 33

The results of the Atterberg Limits tests carried out on samples of the clayey silt to silty clay portions of the deposit are shown on the Record of Borehole logs in Appendix B and presented in Figure C7 of Appendix C. Atterberg Limits testing was also attempted on selected samples of the silt zone but were determined to be non-plastic. Samples which are determined to be non-plastic are noted on the record of boreholes. The results are summarized as follows:

Index Property	Percentage (%) Clayey Silt to Silty Clay	Percentage (%) Silt Zone
Liquid Limit	15 to 25	Non-Plastic
Plastic Limit	4 to 17	
Plastic Index	5 to 11	

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

4.9 Silty Sand to Sandy Silt

A layer of silty sand, some gravel to sandy silt, trace gravel was encountered below the clayey silt deposit in Boreholes C1-01 and C1-03 at depths of 10.2 m and 11.3 m (Elev. 244.6 m and 243.4 m), respectively. The silty sand to sandy silt was at least 1.1 m and 0.1 m thick in Boreholes C1-01 and C1-03, respectively, prior to borehole termination.

A SPT 'N' value of 24 blows per 0.3 m penetration was recorded in the silty sand, indicating a compact condition. The measured moisture content is 18 per cent.

The result of grain size analysis carried out on a sample of the silty sand is shown on the Record of Borehole sheets in Appendix B and presented in Figure C8 of Appendix C. The result is summarized as follows:

Soil Particle	Percentage (%)
Gravel	11
Sand	59
Silt	25
Clay	5

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	
C1-01	May 24, 2023	-1.8	256.6	Artesian pressure within the silty sand deposit upon completion of drilling. ²
C1-02	May 8, 2023	2.0	254.4	In monitoring well.
C1-03	May 25, 2023	3.9	250.7	Upon completion of drilling. ^{2,3}
C1-04	May 3, 2023	11.3	245.2	Upon completion of drilling. ²
C1-05	May 4, 2023	7.3	249.2	Upon completion of drilling. ²

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.

At the time of the investigation (May 2023), the water level in the creek was observed to be at about Elev. 252.2 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	C1-02
Sample	SS6
Depth (m)	3.8 – 4.4
Elevation (m)	252.6 – 252.0
Sulphide (Na ₂ CO ₃) %	0.04
Chloride (µg/g)	12
Sulphate (µg/g)	66
pH	7.66
Conductivity (µS/cm)	209
Resistivity (Ohm-cm)	4,780

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 Ms. Alysha Kobylinski, P.Eng., and was reviewed by Messrs. Christopher Ng, P.Eng., and Jason Lee, P.Eng.

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Date: **February 1, 2024**
File: **33730-C1**

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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 15+994 on Highway 579 (Site No. 39E-0315/C0), referred to as Culvert 1, 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 3.8 m high at the existing culvert location (approximately 1.6 m of fill above the culvert obvert) and as such, the proposed replacement culvert pipe 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 a 2 m high by 3 m wide Corrugated Steel Pipe-Arch (CSPA), with inlet and outlet inverts at approximate Elev. 252.9 m and 252.8 m, respectively. The existing highway grade at the culvert is at approximately Elev. 256.4 m. The local creek water level was reportedly measured at Elev. 254.3 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) 22.4 (long)	252.7 (East)	252.7 (West)

8. SUB-EXCAVATION, AND BACKFILLING

The organic silt and soft to firm clayey silt 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. 251.5 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 gravelly sand to silty sand embankment fills above the groundwater level are classified as a Type 3. Below the groundwater level, the embankment fill, and all native soils (i.e., compact silty sand, very loose to loose organic silt and sand to organic 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, 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
Silty Sand (underlying Organic Silt)	19	31	0.32	3.1
Silt to Silty Clay	19	29	0.35	2.9
Silty Sand (underlying Silt to Silty Clay)	19	31	0.32	3.1

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 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. 251.5 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 15+994	OPSS.PROV 1010 Granular 'A' or 'B' Type II subbase	225	150

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, $\tan\phi'$
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. 252.9 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 4,780 ohm-cm, which indicates the soil has a low corrosion potential ($6,000 \text{ ohm-cm} > R > 4,500 \text{ ohm-cm}$) according to Table 3.2 of the MTO Gravity Pipe Design Guideline.
- The sulphate concentration of the organic silt was measured to be 66 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 7.66, 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 silt to clayey silt 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.

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-C1**

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

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.



APPENDIX A SITE PHOTOGRAPHS



Photograph #1 – Culvert inlet at the east embankment toe, surrounded by wetland brushes and grass, facing west. (May 2023)



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



Photograph #3 – East embankment slope, facing west. The inlet at the base of the embankment slope is surrounded by wetland brushes, and grass. (May 2023)



Photograph #4 – West embankment slope, facing east. The outlet at the base of the embankment slope is surrounded by wetland brushes, and grass. (May 2023)



Photograph #5 – East embankment slope, approximately 6 m north of the culvert, facing west. Culvert is located at the bottom left of the photograph. (May 2023)



Photograph #6 – East embankment slope, approximately 10 m south of the culvert, facing west. Culvert is not visible. (May 2023)



Photograph #7 – West embankment slope, approximately 8 m north of the culvert, facing east. Culvert is located near the center right of the photograph. (May 2023)



Photograph #8 – West embankment slope, approximately 7 m south of the culvert, facing east. Culvert is located at the center left of the photograph. (May 2023)



Photograph #9 – Clute Creek beyond culvert inlet, facing east. Culvert is located at the bottom right of the photograph. (May 2023)



Photograph #10 – Clute Creek beyond culvert outlet, facing west. (May 2023)



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
 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			

METRIC[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No C1-01

2 OF 2

METRIC

WP# 5232-18-02 LOCATION MTM 83-12: N 5 444 003.8 E 299 389.0 ORIGINATED BY SG
DIST Cochrane HWY 579 BOREHOLE TYPE Continuous Sampling; Wash Boring with 'B' Casing COMPILED BY AK
DATUM Geodetic DATE 2023.05.24 - 2023.05.24 LATITUDE 49.134141 LONGITUDE -81.074156 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
244.6																	
10.2	Silty SAND , some gravel Compact Grey Wet		11	SS	24	244										11 59 25 5	
243.5																	
11.3	END OF BOREHOLE AT 11.3 m. NOTES: 1. Artesian conditions observed below a depth of 11.3 m below ground surface. Water level in casing measured at 1.8 m above ground surface upon completion of drilling.																

RECORD OF BOREHOLE No C1-02

1 OF 2

METRIC

WP# 5232-18-02 LOCATION MTM 83-12: N 5 443 992.2 E 299 378.9 ORIGINATED BY SG
DIST Cochrane HWY 579 BOREHOLE TYPE 205mm I.D. Hollow Stem Augers COMPILED BY AK
DATUM Geodetic DATE 2023.05.02 - 2023.05.02 LATITUDE 49.134036 LONGITUDE -81.074294 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
256.4	GROUND SURFACE							20 40 60 80 100							GR SA SI CL
0.0	ASPHALT: (25 mm)		1	SS	52		256								
	SAND, some gravel, trace fines Compact to Very Dense Brown Moist to Wet (FILL)		2	SS	52										
			3	SS	26										13 77 7 3
254.1															
2.3	SAND, trace silt, containing wood fragments Loose to Compact Brown Wet (FILL)		4	SS	24		254								
			5	SS	8										
252.8															
3.6	Organic SILT, and sand, containing wood fragments Loose Brown Wet		6	SS	6										OC=12.1%
251.8															
4.6	Silty SAND, some gravel, containing wood fragments Compact Greyish Brown Wet		7	SS	13										19 34 39 8
250.3															
6.1	Silty CLAY (CL), trace sand Soft to Very Stiff Brown Wet		8	SS	5		250								
							249								
			9	SS	3										0 5 62 33
247.6							248								
8.8	SILT Very Loose to Loose Brown Wet														
			10	SS	4		247								

Continued Next Page

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

RECORD OF BOREHOLE No C1-02

2 OF 2

METRIC

WP# 5232-18-02 LOCATION MTM 83-12: N 5 443 992.2 E 299 378.9 ORIGINATED BY SG
DIST Cochrane HWY 579 BOREHOLE TYPE 205mm I.D. Hollow Stem Augers COMPILED BY AK
DATUM Geodetic DATE 2023.05.02 - 2023.05.02 LATITUDE 49.134036 LONGITUDE -81.074294 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
							20	40	60	80	100					
	Continued From Previous Page															
244.8	SILT Very Loose to Loose Brown Wet		11	SS	1											
11.6	Silty CLAY (CL), trace sand Soft to Firm Grey Wet															
	Auger refusal at a depth of 13.0 m		12	SS	2											
243.4																
13.0	END OF BOREHOLE AT 13.0 m. NOTES: 1. Monitoring well installed 1.0 m south of sampled borehole. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.05.08 2.0 254.4															

RECORD OF BOREHOLE No C1-03

1 OF 2

METRIC

WP# 5232-18-02 LOCATION MTM 83-12: N 5 443 991.0 E 299 365.4 ORIGINATED BY SG
DIST Cochrane HWY 579 BOREHOLE TYPE Continuous Sampling; Wash Boring with 'B' Casing COMPILED BY AK
DATUM Geodetic DATE 2023.05.25 - 2023.05.25 LATITUDE 49.134026 LONGITUDE -81.074479 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
254.6	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL: (50 mm) Organic SILT and sand Very Loose to Loose Dark Brown Moist		1	SS	1		254										
			2	SS	2												
			3	SS	6		253										
252.4			4	SS	3												
2.2	Clayey SILT (CL-ML), trace sand Soft to Stiff Grey Wet		5	SS	10		252										
			6	SS	7		251										
			7	SS	5												
			8	SS	3		250										
							249										
			9	SS	5		248										
247.1							247										
7.5	SILT Loose to Compact Grey Wet		10	SS	4												
							246										
			11	SS	22		245										

Continued Next Page


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

RECORD OF BOREHOLE No C1-03

2 OF 2

METRIC

WP# 5232-18-02 LOCATION MTM 83-12: N 5 443 991.0 E 299 365.4 ORIGINATED BY SG
DIST Cochrane HWY 579 BOREHOLE TYPE Continuous Sampling; Wash Boring with 'B' Casing COMPILED BY AK
DATUM Geodetic DATE 2023.05.25 - 2023.05.25 LATITUDE 49.134026 LONGITUDE -81.074479 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT							UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
	Continued From Previous Page							20 40 60 80 100											
244.5 10.1	Silty CLAY (CL) Stiff Grey Wet						244												
243.4			12	SS	10														
243.3 11.3	Sandy SILT , trace gravel Compact Grey Wet END OF BOREHOLE AT 11.3 m. NOTES: 1. Water level in casing measured at a depth of 3.9 m below ground surface upon completion of drilling; however, it is not representative of the natural groundwater level due to the introduction of water from wash boring.																		

RECORD OF BOREHOLE No C1-04

1 OF 2

METRIC

WP# 5232-18-02 LOCATION MTM 83-12: N 5 444 006.3 E 299 378.3 ORIGINATED BY SG
DIST Cochrane HWY 579 BOREHOLE TYPE 205mm O.D. Hollow Stem Augers COMPILED BY AK
DATUM Geodetic DATE 2023.05.03 - 2023.05.03 LATITUDE 49.134164 LONGITUDE -81.074302 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
							WATER CONTENT (%)							
							20 40 60							
256.5	GROUND SURFACE													
0.0	ASPHALT: (25 mm)													
	Gravelly SAND Dense to Very Dense Brown Moist to Wet (FILL)		1	SS	42		256							
			2	SS	41									
			3	SS	68		255							
	Wet below a depth of 1.9 m													
254.2														
2.3	Organic SILT , and sand Loose Dark Brown Moist		4	SS	6		254							
			5	SS	6		253							
252.8														
3.7	Clayey SILT (CL-ML), trace sand Soft to Stiff Grey Wet		6	SS	3		252							
	Brown below a depth of 4.5 m		7	SS	12									
	100mm thick gravelly sand layer at a depth of 4.9 m						251							
			8	SS	8		250							
	65mm thick gravel layer at a depth of 6.3 m													
			9	SS	2		249							
							248							
247.8														
8.7	SILT Very Loose to Loose Brown Wet		10	SS	2		247							

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C1-04

2 OF 2

METRIC

WP# 5232-18-02 LOCATION MTM 83-12: N 5 444 006.3 E 299 378.3 ORIGINATED BY SG
DIST Cochrane HWY 579 BOREHOLE TYPE 205mm O.D. Hollow Stem Augers COMPILED BY AK
DATUM Geodetic DATE 2023.05.03 - 2023.05.03 LATITUDE 49.134164 LONGITUDE -81.074302 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page																
244.8	SILT Very Loose to Loose Brown Wet		11	SS	7		246										
							245										
11.7	Silty CLAY (CL), trace sand Very Soft Brown Wet		12	SS	1		244										
243.5	Vane refusal at a depth of 13.0 m																
13.0	END OF BOREHOLE AT 13.0 m. NOTES: 1. Water level in hollow stem augers measured at a depth of 11.3 m below ground surface upon completion is not considered stabilized.																

RECORD OF BOREHOLE No C1-05

1 OF 2

METRIC

WP# 5232-18-02 LOCATION MTM 83-12: N 5 443 984.8 E 299 374.5 ORIGINATED BY SG
DIST Cochrane HWY 579 BOREHOLE TYPE 205mm O.D. Hollow Stem Augers COMPILED BY AK
DATUM Geodetic DATE 2023.05.04 - 2023.05.04 LATITUDE 49.133970 LONGITUDE -81.074355 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W P		W		W L			GR SA SI CL				
								20	40	60	80	100									
256.5	GROUND SURFACE																				
0.8	ASPHALT: (25 mm)																				
	Silty SAND , trace gravel Very Dense Brown Moist (FILL)		1	SS	54																
			2	SS	54																
			3	SS	87/ 0.254																
	Wet below a depth of 1.8 m																				
253.8			4	SS	6																
2.7	Sandy Organic SILT , containing wood fragments Very Loose to Loose Dark Brown Moist																				
			5	SS	4																
			6	SS	2																
			7	SS	2																
251.0																					
5.5	Clayey SILT (CL-ML), trace gravel Very Soft to Stiff Brown Wet																				
			8	SS	1																
			9	SS	WH																
248.0																					
8.5	SILT Very Loose to Loose Brown Wet																				
			10	SS	6																

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C1-05

2 OF 2

METRIC

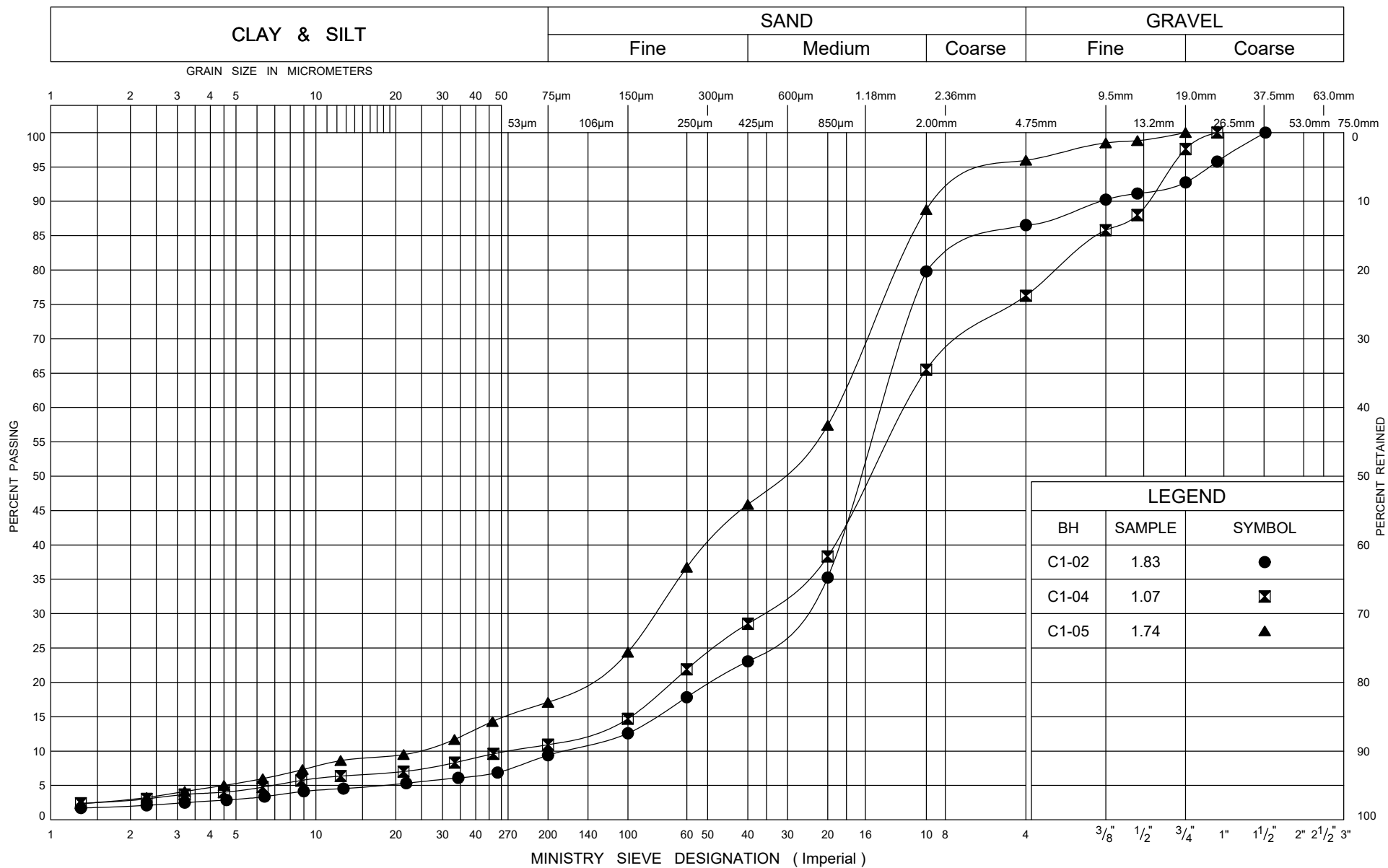
WP# 5232-18-02 LOCATION MTM 83-12: N 5 443 984.8 E 299 374.5 ORIGINATED BY SG
DIST Cochrane HWY 579 BOREHOLE TYPE 205mm O.D. Hollow Stem Augers COMPILED BY AK
DATUM Geodetic DATE 2023.05.04 - 2023.05.04 LATITUDE 49.133970 LONGITUDE -81.074355 CHECKED BY CN

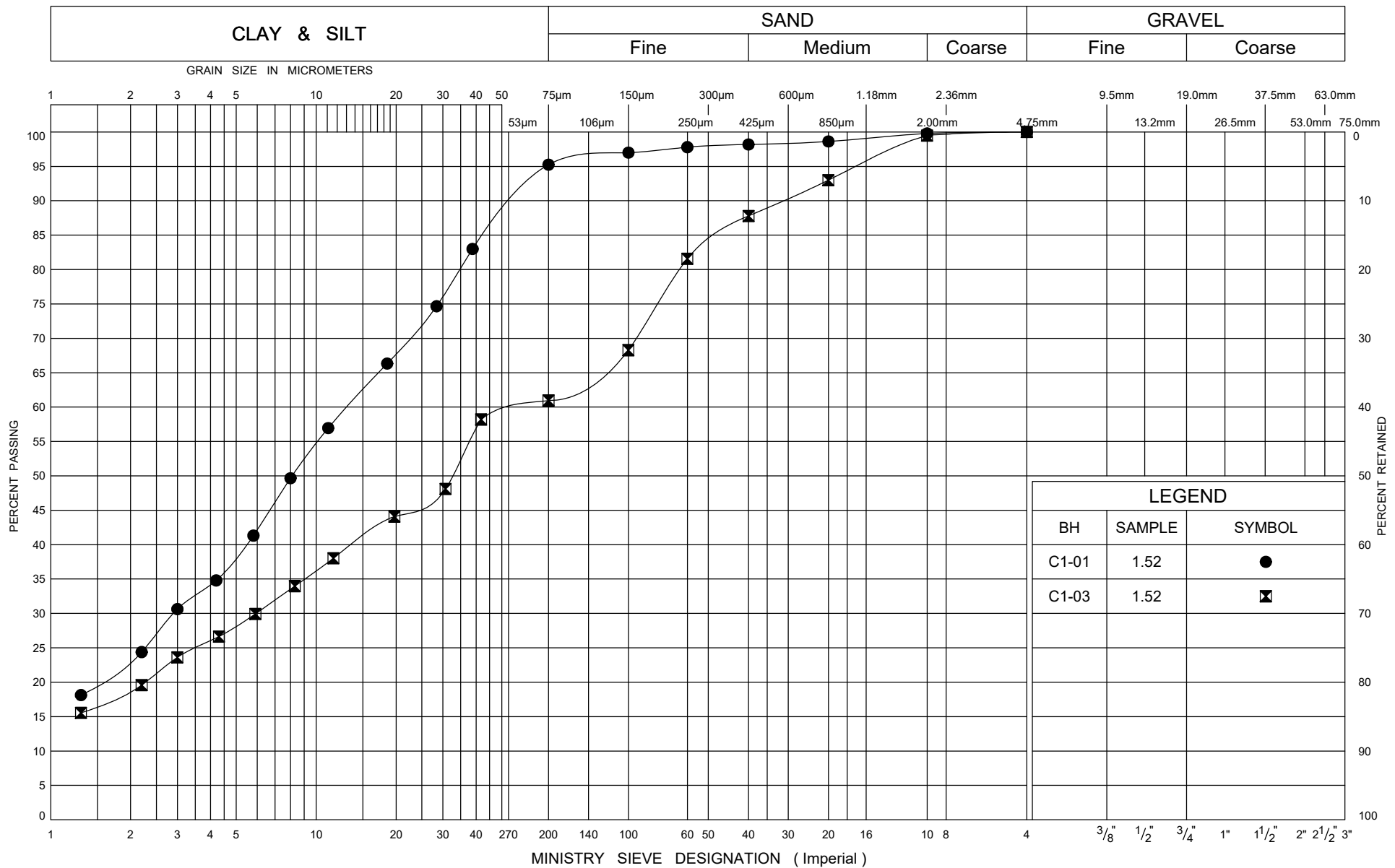
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
	Continued From Previous Page							<div>20406080100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>20406080100</div>						<div>PLASTIC LIMIT</div> <div>NATURAL MOISTURE CONTENT</div> <div>LIQUID LIMIT</div> <div>W P W W L</div> <div>WATER CONTENT (%)</div> <div>204060</div>				
244.9	SILT Very Loose to Loose Brown Wet		11	SS	1		246											
11.6	Clayey SILT (CL-ML) Firm Brown Wet		12	SS	4		245	3.3 +										
243.5	Vane refusal at a depth of 13.0 m						244										0 0 77 23	
13.0	END OF BOREHOLE AT 13.0 m. NOTES: 1. Water level in hollow stem augers measured at a depth of 7.3 m below ground surface upon completion is not considered stabilized.																	

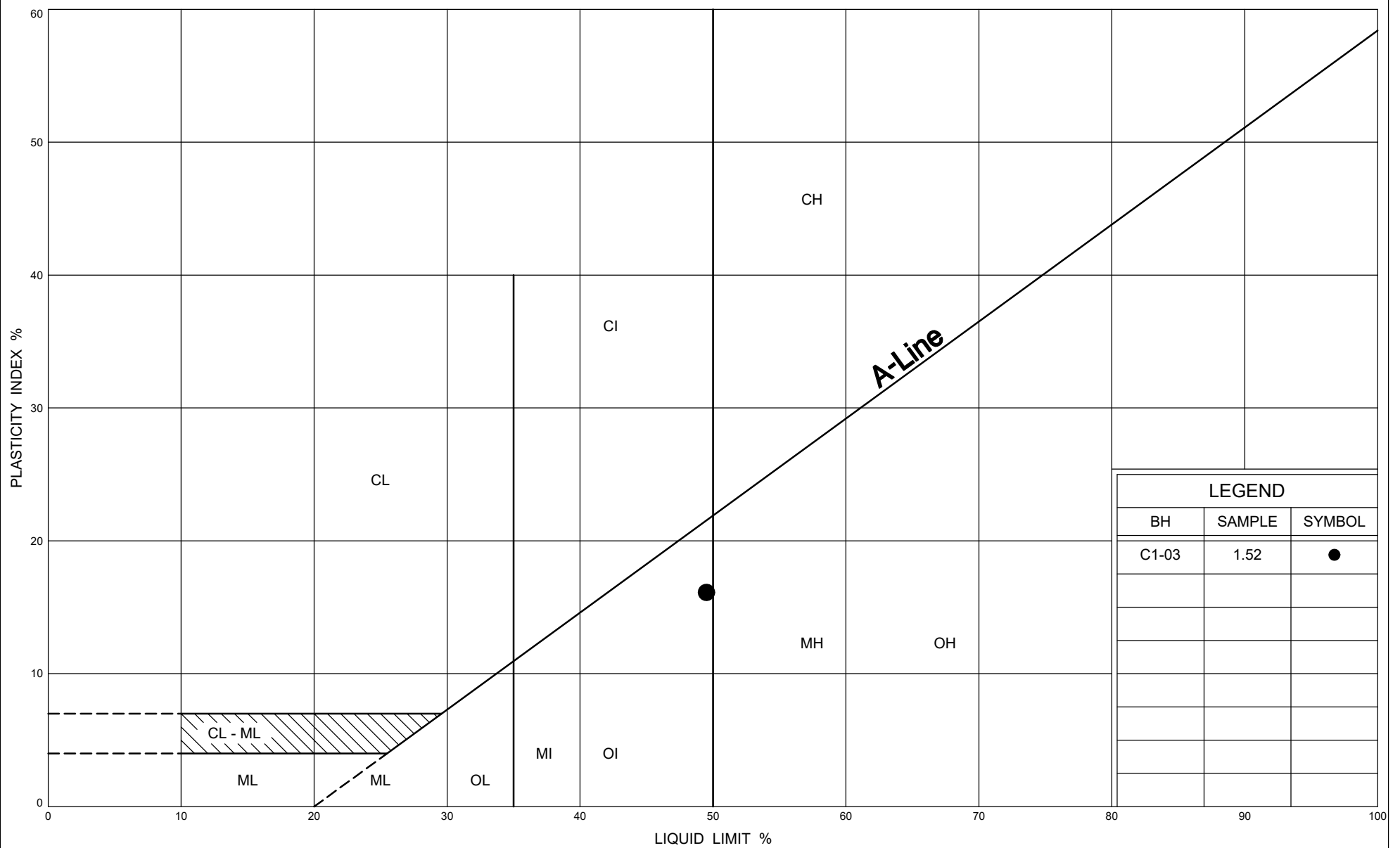
+³, X³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

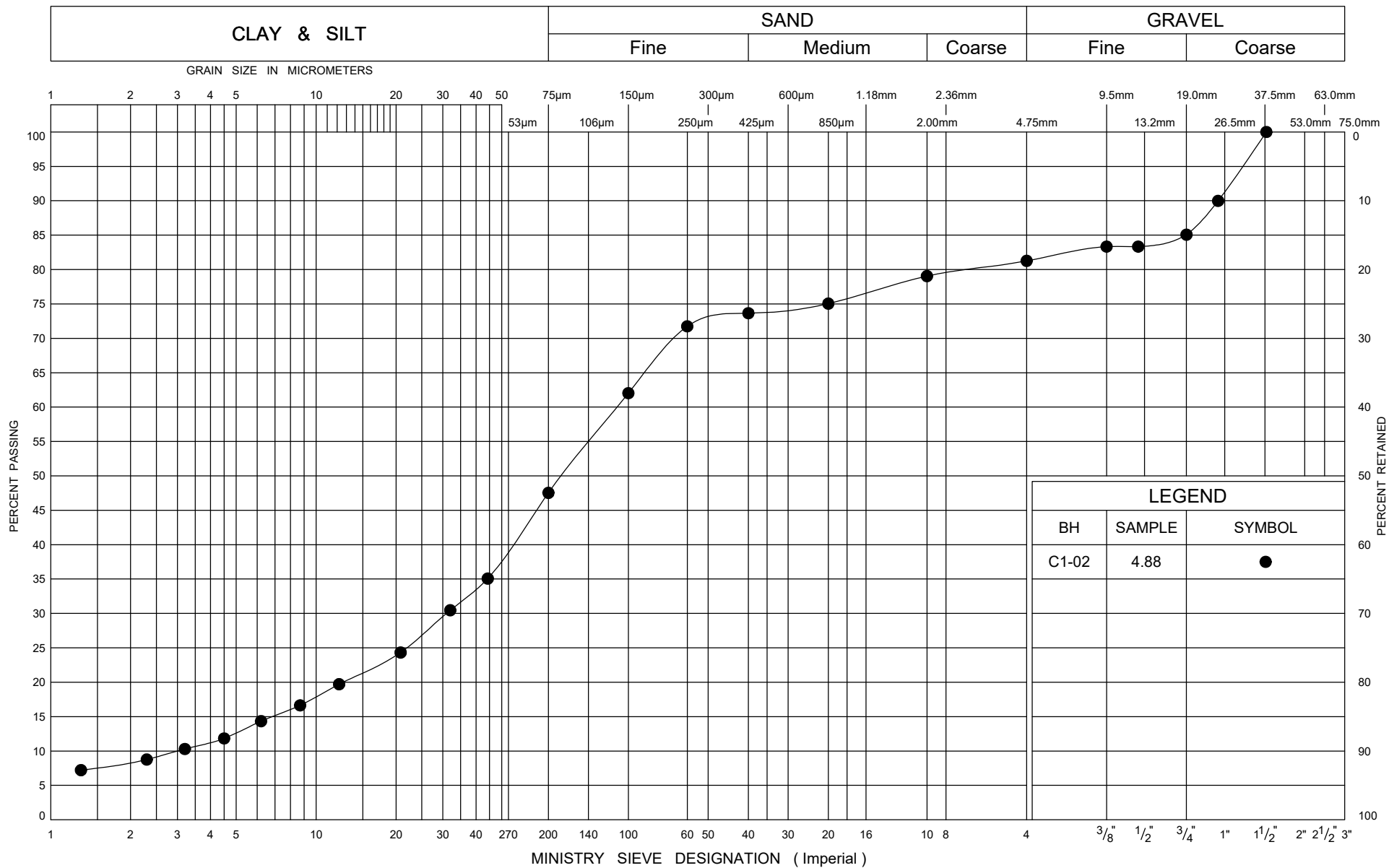
APPENDIX C

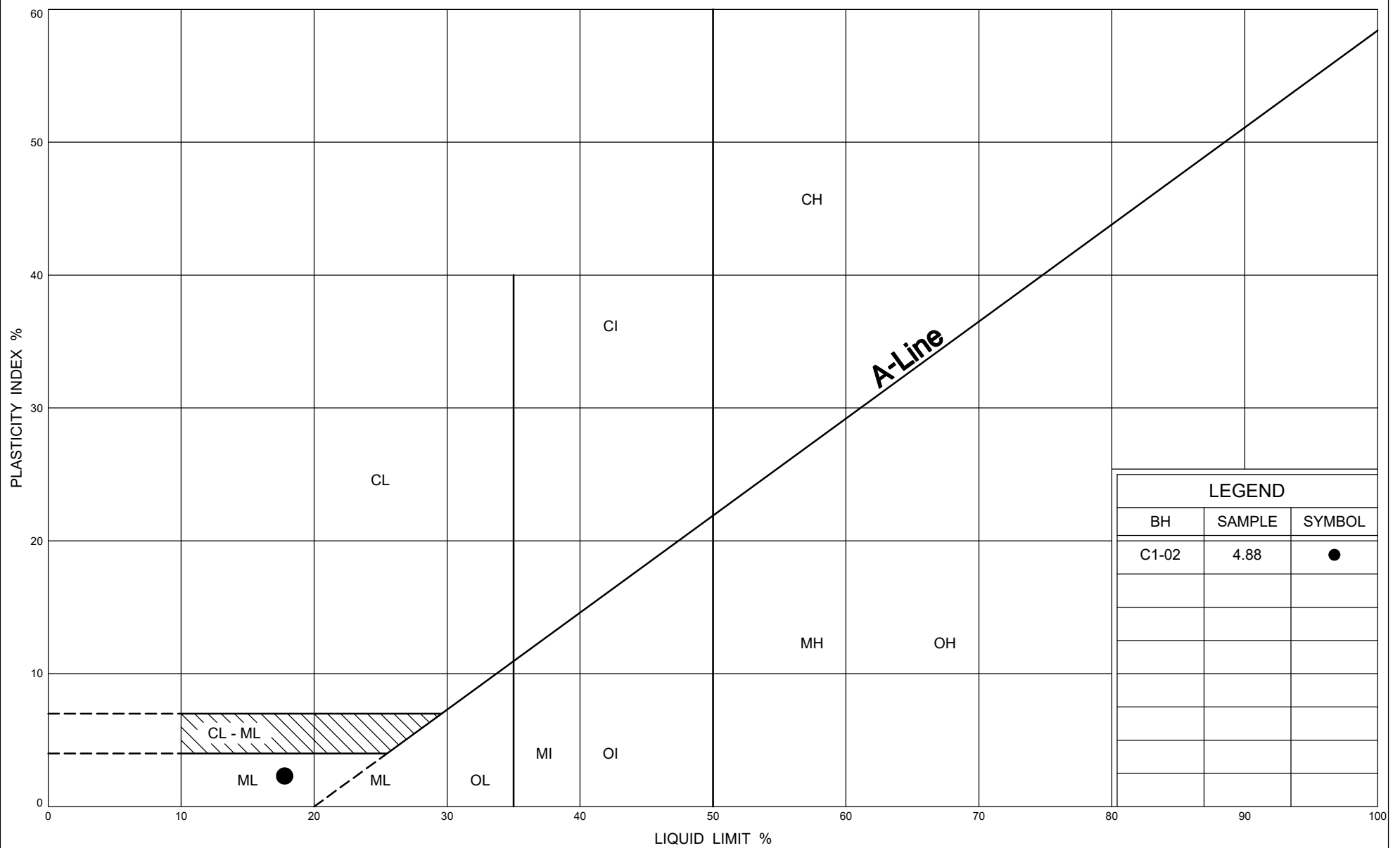
GEOTECHNICAL AND ANALYTICAL LABORATORY TEST RESULTS

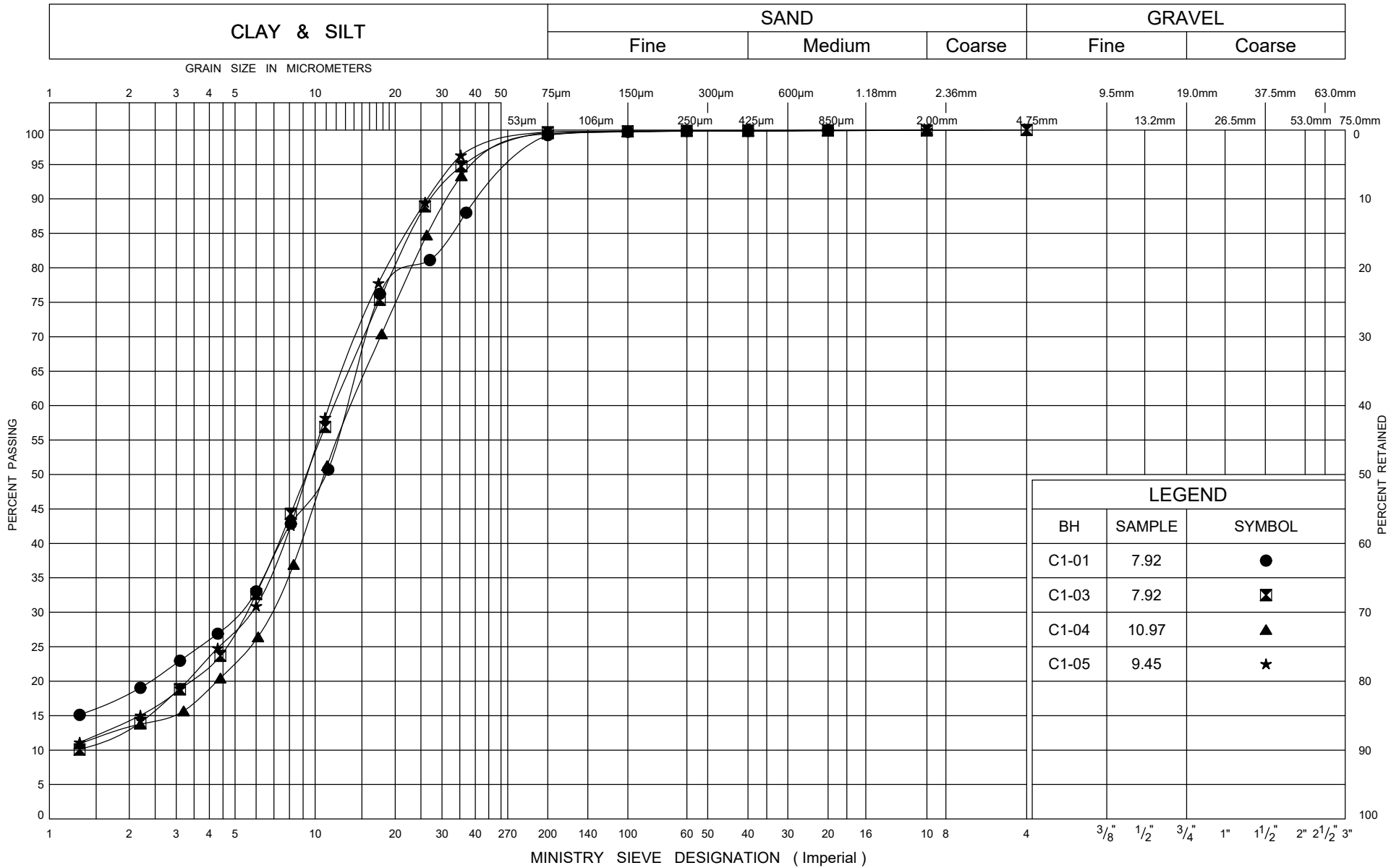


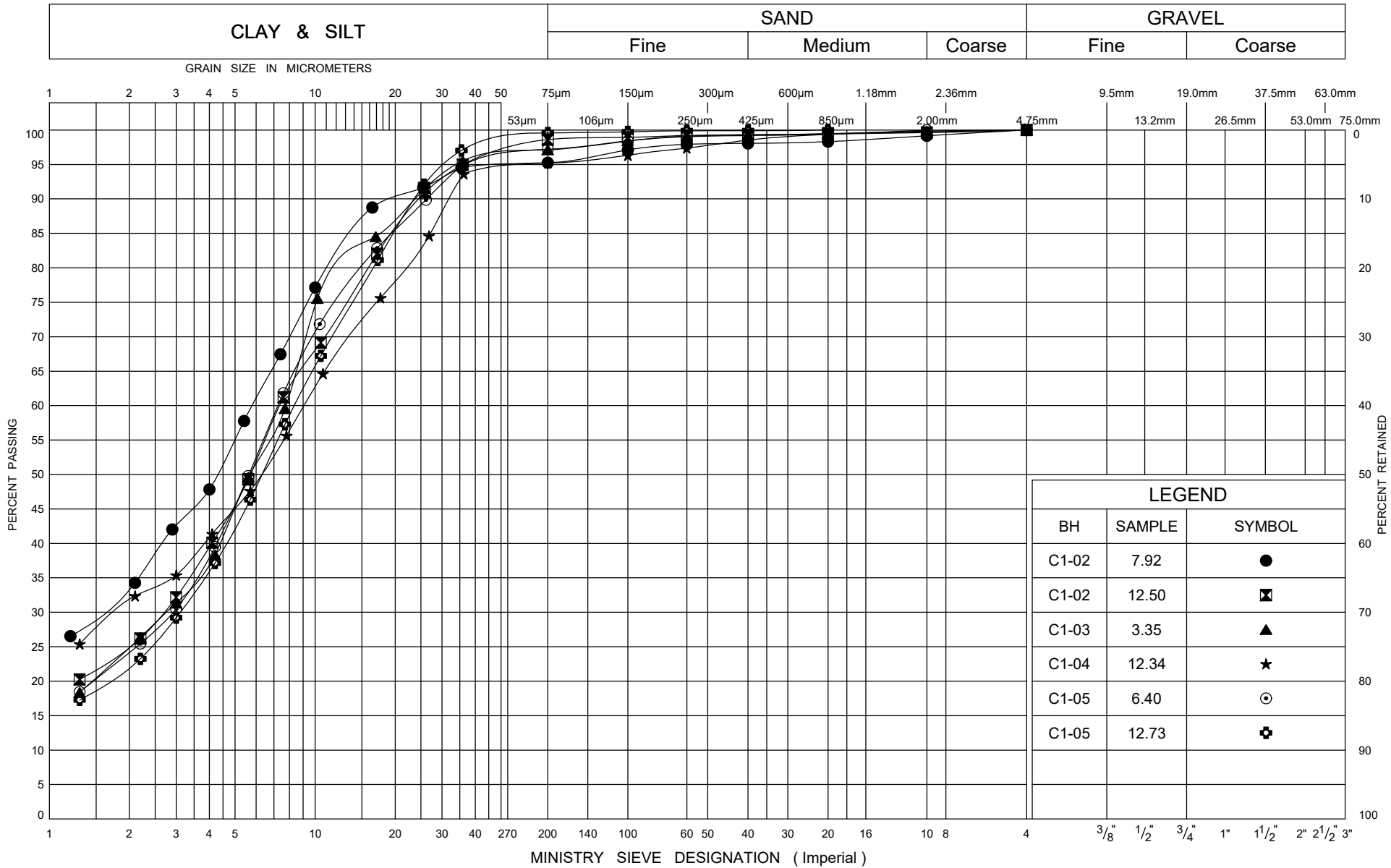


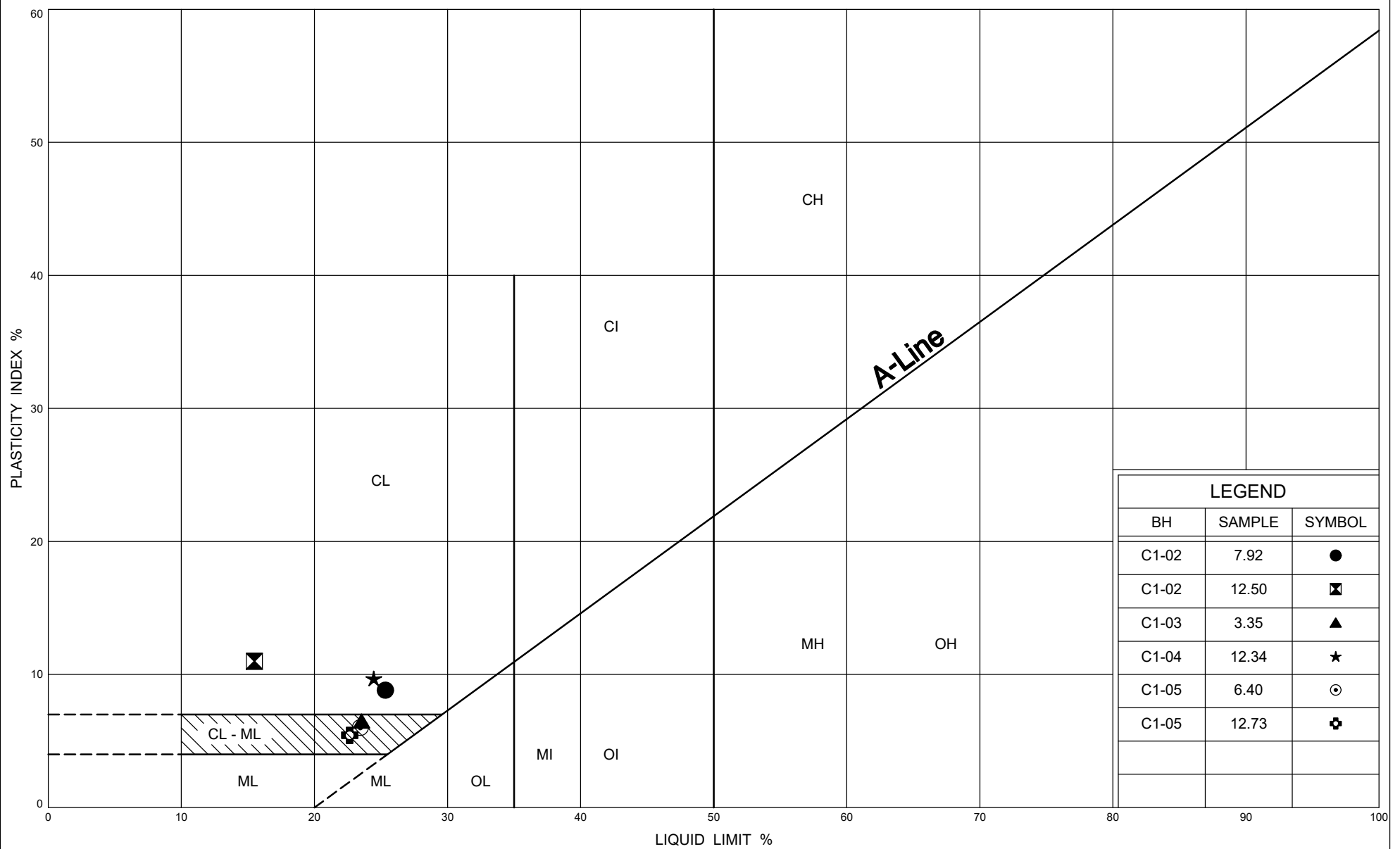












Ministry of
Transportation

PLASTICITY CHART

CLAYEY SILT to SILTY CLAY

FIG No C7

W.P. 5232-18-02



FIG No C8

W.P. 5232-18-02



FINAL REPORT

CA40305-MAY23 R1

33730, Highway 579 Culverts

Prepared for

Thurber Engineering Ltd.



FINAL REPORT

CA40305-MAY23 R1

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Maarit Wolfe, Hon.B.Sc
Address	103, 2010 Winston Park Drive	Laboratory	SGS Canada Inc.
	Oakville, ON	Address	185 Concession St., Lakefield ON, K0L 2H0
	L6H 5R7, Canada		
Contact	Ali Rajaei	Telephone	705-652-2000
Telephone		Facsimile	705-652-6365
Facsimile		Email	Maarit.Wolfe@sgs.com
Email	arajaei@thurber.ca; jzoldy@thurber.ca	SGS Reference	CA40305-MAY23
Project	33730, Highway 579 Culverts	Received	05/25/2023
Order Number		Approved	06/05/2023
Samples	Soil (3)	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 



TABLE OF CONTENTS

First Page..... 1

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Results..... 3

QC Summary..... 4-5

Legend..... 6

Annexes..... 7



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 (Na ₂ CO ₃)	%	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
----------	------	-----	--	----	----	-----



FINAL REPORT

CA40305-MAY23 R1

QC SUMMARY

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	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-IENVIARD-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-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0655-MAY23	uS/cm	2	< 2	1	20	101	90	110	NA		



FINAL REPORT

CA40305-MAY23 R1

QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-1ENVIEWL-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.

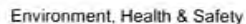
SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm.

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This report supersedes all previous versions.

-- End of Analytical Report --



No:

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

Page 1 of 1

Laboratory Information Section - Lab use only

Received By: 7/11
Received Date (mm/dd/yy): 05/25/23
Received Time: 13:45

Received By (signature): KMK/KMM
Custody Seal Present: ☒
Custody Seal Intact: ☒

Cooling Agent Present: ☒

Temperature Upon Receipt (°C)

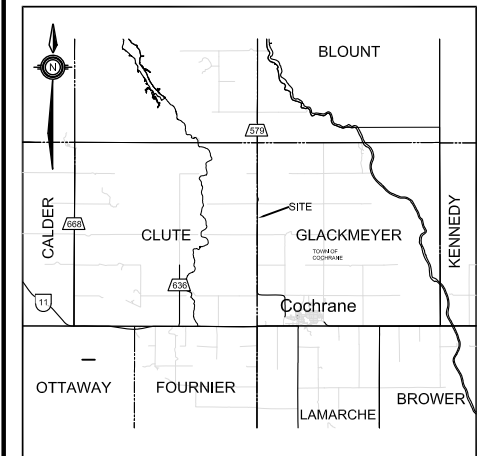
LAB LIMS #: Mani-40305

REPORT INFORMATION	INVOICE INFORMATION	PROJECT INFORMATION
Company: <u>Thurber Engineering Ltd.</u>	<input checked="" type="checkbox"/> (same as Report Information)	Quotation #: _____ P.O. #: <u>33730</u>
Contact: <u>Ali Rajaei</u>	Company: _____	Project #: <u>33730</u> Site Location/ID: <u>Highway 579 Culverts</u>
Address: <u>1815 Ironstone Manor Suite 11, Pickering, ON L1W 3W9</u>	Contact: _____	TURNAROUND TIME (TAT) REQUIRED
Phone: <u>4165759069</u>	Address: _____	<input checked="" type="checkbox"/> 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: <u>arajaei@thurber.ca</u>	Phone: _____	RUSH TAT (Additional Charges May Apply): <input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3 Days <input type="checkbox"/> 4 Days
Email: <u>akobylnski@thurber.ca</u>	Email: _____	PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION
		Specify Due Date: _____ Rush Confirmation ID: _____

[illegible]






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Sampled By (NAME):	Ali Rajaei	Signature:	AR	Date: 05/23/23 (mm/dd/yy)
Relinquished by (NAME):	Czarlene Pontejos	Signature:	C.P.	Date: 5/24/23 (mm/dd/yy)

APPENDIX D
BOREHOLE LOCATION PLAN AND SOIL STRATA DRAWINGS



KEYPLAN

LEGEND

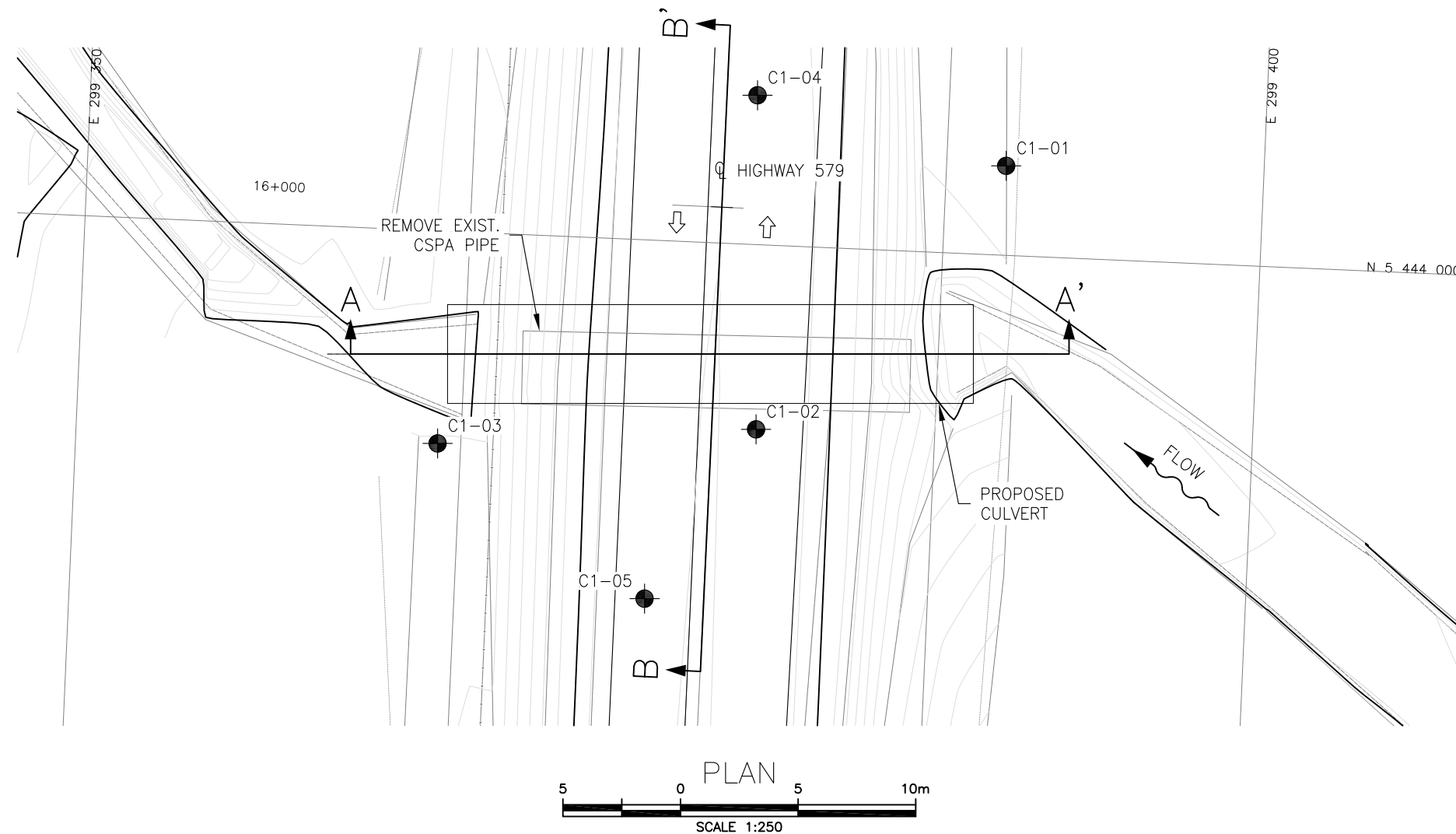
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
C1-01	254.8	5 444 003.8	299 389.0
C1-02	256.4	5 443 992.2	299 378.9
C1-03	254.6	5 443 991.0	299 365.4
C1-04	256.5	5 444 006.3	299 378.3
C1-05	256.5	5 443 984.8	299 374.5

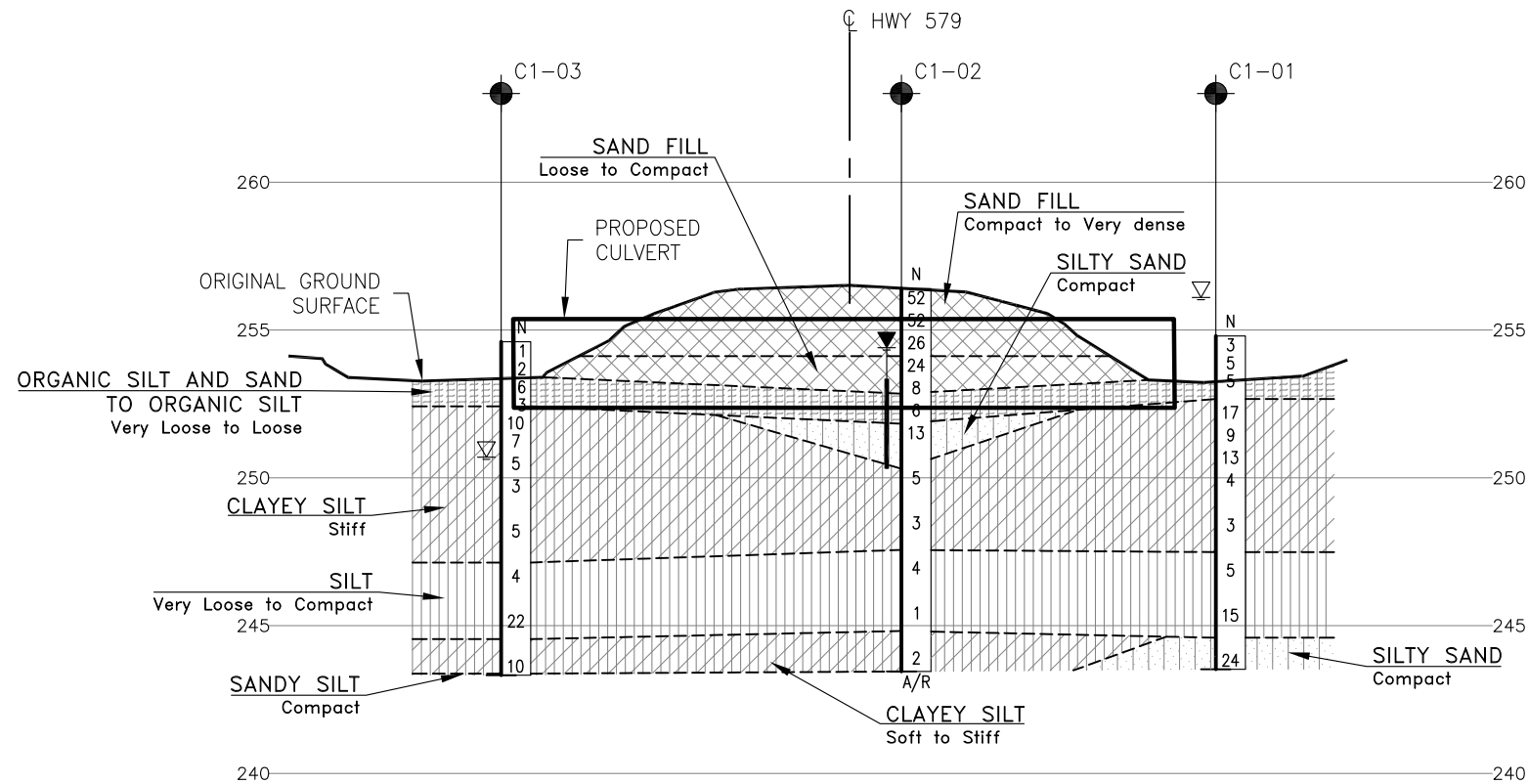
-NOTES-

- 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.

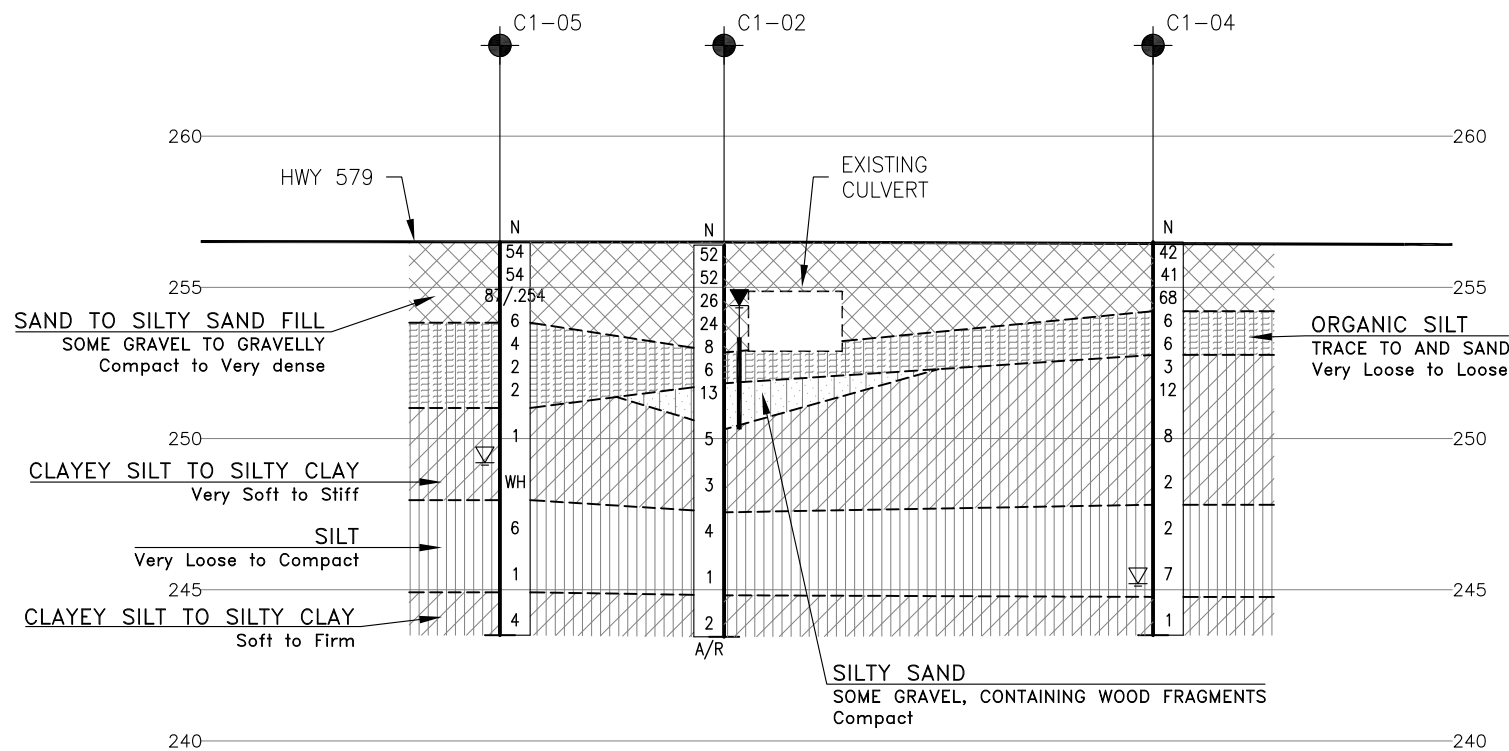
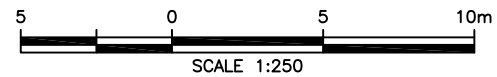
GEOCRES No. 42H00-091



REVISIONS									
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DESIGN	AK	CHK		CODE	LOAD	DATE	JAN 2024		
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PROFILE ALONG CULVERT AT STA. 15+994 (A-A')



PROFILE ALONG HIGHWAY 579 (B-B')

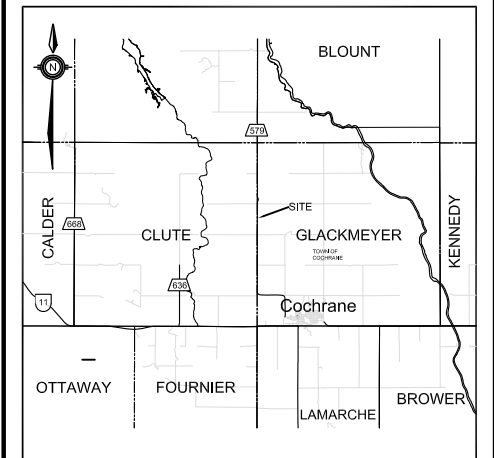


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No. 5232-18-02

HIGHWAY 579
CULVERT REPLACEMENT
STA 15+994 (CLUTE CREEK)
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



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
C1-01	254.8	5 444 003.8	299 389.0
C1-02	256.4	5 443 992.2	299 378.9
C1-03	254.6	5 443 991.0	299 365.4
C1-04	256.5	5 444 006.3	299 378.3
C1-05	256.5	5 443 984.8	299 374.5

-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 12.

GEOCRES No. 42H00-091



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	AK	CHK	CODE
DRAWN	AN	CHK AK	SITE
			LOAD
			STRUCT
			DWG 2
			DATE JAN 2024