THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT
PROPOSED CULVERT C-75 REPLACEMENT
HIGHWAY 400
CITY OF BARRIE, ONTARIO
G.W.P. 2504-17-00

GEOCRES NO. 31D-738

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Report

to

McIntosh Perry

Date: October 2, 2020
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THURBER

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PART 1: FACTUAL INFORMATION

1.0 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed culvert replacement (Culvert 75), located south of Anne Street, at Highway 400 in the City of Barrie, Ontario.

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

Thurber was retained by McIntosh Perry (MP) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Assignment Number 2017-E-0032. The assignment includes replacement of three underpass structures on Highway 400: at Dunlop Street, at Anne Street and at Sunnidale Road. It also includes reconstruction of the Highway 400 and Dunlop Street interchange, noise barrier and retaining walls, pavement rehabilitation, culvert replacements, drainage improvements (sewers) and illumination (high mast lighting). This report addresses the proposed replacement of Culvert 75.

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2.0 SITE DESCRIPTION

The existing culvert is located approximately 190 m south of Anne Street, crossing under Highway 400 near Station 11+609, in Barrie, Ontario.

The overall surface topography in the vicinity of the site is relatively flat and consists of residential and commercial properties to the east and west of Highway 400.

The existing culvert is a 1220 mm x 1220 mm concrete box culvert. The length of the existing culvert is 54.8 m. The Highway 400 grade at the existing culvert is at approximate Elevation 233.6 m. The maximum height of the embankment fill at the culvert is approximately 3.5 m. The water flows through the culvert easterly at the site.

It is understood that the new culvert will be located approximately 4 m south of the existing culvert.

Selected photographs of the site, taken during the course of the investigation, are presented in Appendix D.

Based on published geological mapping, the study area is located within the Simcoe Lowlands physiographic region. This region borders Georgian Bay and Lake Simcoe and can generally be separated into two major divisions: the Nottawasaga basin to the west, consisting of plains draining into Nottawasaga Bay, and the Lake Simcoe basin to the east, consisting of the lowlands which surround Lake Simcoe. These two basins are connected at Barrie by a flat-floored valley which extends from the shores of Kempenfelt Bay. The Simcoe Lowlands region is generally comprised of sand, silt and clay deposits of deltaic and lacustrine origin.

3.0 SITE INVESTIGATION AND FIELD TESTING

The borehole investigation and field testing program for this site were carried out between October 8 and November 4, 2019, and consisted of drilling and sampling five (5) boreholes, designated as Boreholes C75-01 to C75-05. All the boreholes were drilled near the proposed culvert alignment, and were terminated at depths of 15.4 m to 15.8 m (Elevations 218.2 to 216.1). Boreholes C75-01 and C75-03 were drilled near the culvert inlet and outlet areas, respectively. Boreholes C75-02, C75-04 and C75-05 were drilled through the highway embankment. The approximate locations of all the boreholes are shown on the Borehole Location Plan and

Stratigraphic Drawing in Appendix D. The records of borehole sheets are provided in Appendix A.

McIntosh Perry surveyed the boreholes in the field using a combination of GPS and total station equipment, and provided Thurber with the borehole coordinates and ground surface elevations. It is understood that the horizontal and vertical accuracy of the survey results meet the MTO terms of reference requirements of 0.5 m and 0.1 m, respectively.

Lane closures and traffic control were implemented during drilling of the boreholes for the investigation. Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

The boreholes were advanced using truck-mounted and track-mounted drill rigs with solid stem augers, hollow stem augers, as well as wash boring with tri-cone. Soil samples were obtained at selected intervals using a 50 mm outside diameter split-spoon sampler driven in conjunction with the Standard Penetration Test (SPT). The SPT was performed in accordance with ASTM D1586.

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

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers (25 mm diameter) were installed and enclosed in filter sand columns in selected boreholes to permit groundwater level monitoring. The details of the piezometer installations are shown in Table 3.1.

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Table 3.1 – Piezometer Details

Borehole	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
C75-01	15.8/216.1	15.2 / 216.7	Piezometer with 3.0 m slotted screen installed with sand filter from 15.8 m to 10.9 m, bentonite holeplug from 10.9 m to ground surface.
C75-03	15.8/216.4	14.9 / 217.4	Piezometer with 3.0 m slotted screen installed with sand filter from 15.8 m to 11.3 m, bentonite holeplug from 11.3 m to 10.4 m, grout from 10.4 m to 2.1, bentonite holeplug from 2.1 m to 0.46m, then sand to ground surface.

All remaining boreholes without piezometer installations were backfilled upon completion of drilling in general conformance with O.Reg. 903 as amended by O.Reg.128/03. Both piezometers have been decommissioned in April 2020 following completion of groundwater monitoring in general conformance with O.Reg. 903. Asphalt was reinstated on Boreholes C75-02, C75-04 and C75-05 drilled on the highway platform.

4.0 LABORATORY TESTING

The recovered soil samples were subjected to visual identification (VI) and to natural moisture content determination. Selected samples were subjected to grain size distribution analyses (sieve and/or hydrometer), and Atterberg Limits testing. Geotechnical laboratory testing results are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

In order to assess the potential for sulphate attack on a concrete culvert, as well as the potential for metal corrosion associated with the structure, a sample of the existing native soil was collected and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing for corrosivity parameters including sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix B.

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5.0 DESCRIPTION OF SUBSURFACE CONDITIONS

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

In general, the subsurface stratigraphy encountered under the highway grade consists of pavement structure overlying compact to very dense silty sand embankment fill. Below and beyond the embankment, the native deposits consist of topsoil overlying layers of native compact to dense sands and silts. Interlayers of clayey silt were encountered within the cohesionless soils. A layer of silty sand mixed with organics was contacted immediately below the topsoil in the borehole (C75-01) drilled at the culvert inlet. A sandy silt till deposit was encountered below the silt layer in one borehole. The groundwater table was measured at approximately 1 m to 2 m depths below the existing ground.

More detailed descriptions of the individual stratum are presented below.

5.1 Topsoil

Topsoil with occasional roots was encountered surficially in Boreholes C75-01 and C75-03, drilled near the culvert inlet and outlet, respectively. The thickness of the topsoil ranged from 600 mm to 900 mm.

SPT 'N' values recorded in the topsoil were 2 and 4 blows per 0.3 m of penetration, indicating a loose condition. The natural moisture contents measured on samples of the topsoil were 20 percent and 31 percent.

The topsoil thickness may vary between and beyond the borehole locations, and the data is not intended for the purpose of estimating quantities.

5.2 Pavement Structure

Pavement structure consisting of approximately 75 mm to 150 mm of asphalt overlying granular (sand, some gravel) road base was encountered in Boreholes C75-02, C75-04 and C75-05 advanced through the Highway 400 platform. The granular fill ranged in thickness from 600 mm to 900 mm.

SPT 'N' values recorded in the sand fill and the underlying silty sand embankment fill were 47 and 60 blows per 0.3 m of penetration indicating dense to very dense condition. The natural moisture contents measured on samples of the road base fill ranged from 3 percent to 9 percent.

5.3 Embankment Fill

Embankment fill was encountered underlying the pavement structure in Boreholes C75-02, C75-04 and C75-05. The embankment fill consisted of brown to grey silty sand containing trace to some gravel and some clay. The thickness of the cohesionless embankment fill ranged from 1.9 m to 2.7 m in Boreholes C75-02, C75-04 and C75-05. The depth to the base of the embankment fill ranged from 3.0 m to 3.6 m (Elevations 230.6 to 229.9) in Boreholes C75-02, C75-04 and C75-05.

The SPT 'N' values recorded in the embankment fill ranged from 11 to 52 blows per 0.3 m of penetration, indicating a compact to very dense condition. The natural moisture contents measured on samples of the cohesionless fill generally ranged from 6 percent to 14 percent.

The results of grain size analyses conducted on samples of the silty sand fill are provided on the Record of Borehole sheets in Appendix A, and illustrated on Figure B1 of Appendix B. The results are summarized as follows:

Soil Particle	Embankment Fill (Percent)
Gravel	4 to 11
Sand	60 to 66
Silt	19 to 20
Clay	10

5.4 Silty Sand mixed with Organics

A layer of dark brown silty sand mixed with organics, containing occasional roots and wood fibres was contacted below the topsoil in Borehole C75-01 drilled at the culvert inlet area. The thickness of the silty sand mixed with organics was 1.7 m. The depth to the base of the silty sand mixed with organics was at 2.3 m (Elevation 229.6).

The SPT 'N' values recorded in the silty sand mixed with organics were 1 blow per 0.3 m of penetration, indicating a very loose state. The natural moisture contents measured on samples of this soil were 32 percent and 63 percent.

5.5 Sand and Silt

A deposit of native dark brown/brown to grey sand and silt containing trace gravel and trace clay was contacted below the embankment fill and silty sand mixed with organics, at depths ranging from 1.5 m to 3.6 m, and below the topsoil in Borehole C75-03. The thickness of the sand and silt ranged from 6.2 m to 7.7 m. The depth to the base of the sand and silt varied from 9.6 m to 10.0 m (Elevations 223.7 to 221.9).

The SPT 'N' values recorded in the sand and silt varied from 11 to 55 blows per 0.3 m of penetration, indicating compact to very dense condition. An SPT 'N' value of 8 blows per 0.3 m of penetration, indicating a loose state, was measured immediately below the topsoil in Borehole C75-03 drilled at the culvert outlet area. The natural moisture contents measured on the sand and silt samples ranged from 11 percent to 28 percent.

The results of grain size analyses conducted on sand and silt samples are provided on the Record of Borehole sheets in Appendix A, and illustrated on Figure B2 of Appendix B. The results are summarized as follows:

Soil Particle	Sand and Silt (Percent)
Gravel	0 to 2
Sand	33 to 56
Silt	42 to 60
Clay	1 to 8

5.6 Clayey Silt

Interlayers of brown to grey clayey silt containing trace to some sand and trace gravel were contacted below the silt at 12.0 m depth in Borehole C75-01, and within the sand and silt at 2.2 m and 9.6 m depth in Borehole C75-03. The thickness of the clayey silt varied from 0.7 m to 1.9 m.

SPT 'N' values in the upper clayey silt contacted at 2.2 m depth were 11 and 15 blows per 0.3 m of penetration, indicating a stiff to very stiff consistency. In the lower layers of clayey silt, the SPT

'N' values were 42 and 44 blows per 0.3 m of penetration, indicating a hard consistency. Moisture contents measured in the clayey silt ranged from 12 percent to 30 percent.

The results of grain size distribution analyses carried out on a sample of the clayey silt are presented on the Record of Borehole sheets included in Appendix A. Grain size distribution curve of the sample tested is presented on Figure B3 Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Clayey Silt (Percent)
Gravel	0
Sand	7
Silt	71
Clay	22

The results of Atterberg Limits tests conducted on a sample of clayey silt are presented on the Record of Borehole sheets in Appendix A, and illustrated in Figure B7 of Appendix B. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	19
Plasticity Index	7

The results of the Atterberg Limits testing indicate that the clayey silt has a slight plasticity with a group symbol of CL-ML.

5.7 Silt

A layer of grey silt containing trace to some sand and some clay, was contacted below the sand and silt at depths ranging from 10.0 m to 11.0 m. The thickness of the silt varied from 2.0 m to 2.6 m in all five boreholes.

The depth to the base of the silt varied from 12.0 m to 13.3 m (Elevations 221.4 to 219.0).

SPT ‘N’ values recorded in the silt varied from 31 to 66 blows per 0.3 m of penetration, indicating dense to very dense state. The natural moisture contents measured in the silt samples ranged from 12 percent to 20 percent.

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

Soil Particle	Silt (Percent)
Gravel	0
Sand	3 to 11
Silt	76 to 90
Clay	7 to 15

5.8 Sand

A deposit of grey sand containing some silt, trace gravel and trace clay was contacted at depths ranging from 12.2 m and 13.3 m in Boreholes C75-01 to C75-03 and C75-05, which were terminated within the sand at 15.8 m depth (Elevations 217.9 to 216.1).

The SPT ‘N’ values recorded in the sand ranged from 17 to 90 blows per 0.3 m of penetration, indicating a compact to very dense condition. The natural moisture content measured on samples of the sand ranged from 10 percent to 22 percent.

The results of grain size distribution analyses carried out on selected samples of the sand are presented on the Record of Borehole sheets included in Appendix A. Grain size distribution curves of samples tested are presented on Figure B5 Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Sand (Percent)
Gravel	0
Sand	79 to 85
Silt	13 to 19
Clay	2

5.9 Sandy Silt Till

A deposit of grey sandy silt till containing trace gravel and some clay was contacted below the silt at 12.2 m depth in Borehole C75-04. Borehole C75-04 was terminated within the sandy silt till at 15.4 m depth (Elevation 218.2).

The SPT 'N' values recorded in the sandy silt till ranged from 57 blows per 0.3 m of penetration to greater than 100 blows for less than 0.3 m of penetration, indicating a very dense condition. 'N' values greater than 100 indicate the possible presence of cobbles and/or boulders. The natural moisture content measured on samples of the sandy silt till ranged from 10 percent to 20 percent.

The results of grain size distribution analyses carried out on selected samples of the sandy silt till are presented on the Record of Borehole sheets included in Appendix A. Grain size distribution curves of samples tested are presented on Figure B6 Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Sandy Silt Till (Percent)
Gravel	1
Sand	26
Silt	60
Clay	13

Glacial tills inherently contain cobbles and boulders.

5.10 Groundwater Conditions

Groundwater levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. Standpipe piezometers were installed in Boreholes C75-01 and C75-03 to permit monitoring of groundwater levels. Water levels measured in the two installed piezometers and open boreholes are presented in Table 5.1 below.

Table 5.1- Groundwater Level Measurements

Borehole	Date	Groundwater Level		Comments
		Depth (m)	Elev. (m)	
C75-01	October 17, 2019	1.1	230.8	Open borehole
	November 7, 2019	1.0	230.9	Piezometer
	November 22, 2019	2.1	229.8	
	April 8, 2020	1.9	230.0	
C75-02	October 10, 2019	1.9	231.8	Open borehole
C75-03	November 7, 2019	1.4	230.9	Piezometer
	November 22, 2019	1.2	231.1	
	April 8, 2020	3.5	228.8	
C75-04	October 8, 2019	2.2	231.4	Open borehole
C75-05	October 9, 2019	1.5	231.9	Open borehole

The values shown in Table 5.1 are short-term readings, and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant or prolonged precipitation.

6.0 CORROSIVITY AND SULPHATE TEST RESULTS

A selected soil sample was submitted for analytical testing of corrosivity parameters including sulphate content. The results of the analytical tests are shown in Table 5.2. The laboratory certificates of analysis are presented in Appendix B.

Table 5.2 – Analytical Corrosivity Test Results

Sample ID	Depth (m)	Soil Sample Description	Sulphide (percent)	Chloride (µg/g)	Sulphate (µg/g)	pH	Resistivity (ohm.cm)	Redox Potential (mV)	Electrical Conductivity (µS/cm)
C75-03 SS3	1.5 - 2.1	Sand and silt	<0.02	550	10	8.59	573	226	1740

7.0 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. McIntosh Perry surveyed the boreholes in the field and provided the borehole coordinates and ground surface elevations.

DBW Drilling Ltd. from North York, Ontario and Landshark Drilling from Brantford, Ontario supplied and operated the drilling and sampling equipment for the field program.

Full time supervision of the field activities was carried out by Ms. Eckie Siu of Thurber. Overall supervision of the field program was performed by Mr. Stephane Loranger, CET of Thurber.

Interpretation of the field data and preparation of the report were carried out by Ms. Rocio Palomeque Reyna, P.Eng. The report was reviewed by Dr. Sydney Pang, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer

Sydney Pang, P.Eng.
Associate, Senior Foundation Engineer

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

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8.0 GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides foundation recommendations for the design of the replacement of the existing Culvert 75 located on Highway 400, near Station 11+609, in the City of Barrie, Ontario. The proposed works will include widening of Highway 400 in both NBL and SBL directions.

The existing structure is a non-reinforced concrete box culvert, measuring 1.22 m in width by 1.22 m in height. The highway embankment at the inlet and oulet are approximately 3.1 m and 3.5 m high. The fill on top of the existing culvert is approximately 2.1 m thick.

Based on a draft General Arrangement (GA) drawing dated August 2020 provided by McIntosh Perry, the project requirements involve replacement of the existing culvert with a concrete box culvert to be located approximately 4 m south of the existing culvert centreline. The proposed culvert will be approximately 77° skewed to the centreline of Highway 400. The opening of the new culvert will have dimenions of 1.8 m high and 1.8 m wide. The length of the new culvert will be about 82.8 m to accommodate the highway widening. The inlet and outlet invert levels of the culvert opening are at approximate Elevations 230.1 and 229.3, respectively. It is understood that the new culvert would be constructed within a temporary protection system as part of the Anne Street Underpass staged construction where temporary culvert extensions would be used for the existing culvert. Dewatering and unwatering will be required during construction. The GA drawing shows that the temporary culvert extensions would be decommissioned and the existing culvert would be plugged/abandoned or removed after the new culvert becomes operational.

Based on information provided by MP, the Highway 400 grade will be lowered at the culvert location, generally near the median, by approximately 110 mm to 400 mm. The GA drawing indicates that the fill cover between the pavement subgrade and the top of culvert will be about 1.5 m.

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

The discussion and recommendations presented in this report are based on the information provided by McIntosh Perry and on the factual data obtained during the course of this investigation.

9.0 CULVERT FOUNDATIONS

9.1 Culvert Replacement Options

This section presents discussions on available types of culverts for the proposed culvert replacement, foundation alternatives, and provides recommendations for feasible and/or preferred foundation options.

Several common culvert types that may be considered for the culvert replacement at this site are listed below:

- Concrete box (closed) culvert
- Concrete open frame culvert on strip footings
- Circular pipe culvert

A comparison of the technical advantages, disadvantages and relative risks and costs of each culvert alternative is presented in Appendix E. Discussions on feasible culvert alternatives are presented in the following paragraphs. A preferred culvert type from a foundations perspective is also recommended.

Concrete open frame culvert on strip footings

Concrete, open frame, culvert is technically feasible at this site. The shallow soils will provide less geotechnical resistance. Therefore, deeper excavation and/or wider footings may be required to provide adequate foundation support. Additionally, due to the presence of permeable soils (sands and silts) and relatively high groundwater table, temporary protection and effective dewatering efforts will be required. This may therefore be a relatively expensive option. Recommendations for this option have not been developed.

Circular Pipes

From a foundation engineering standpoint, concrete, steel and HDPE pipes are technically feasible alternatives provided that other design issues including flow capacity, hydraulic properties and durability can be satisfied. Multiple pipes may be required to provide adequate hydraulic capacity. It is understood that this option is not considered at this site and therefore foundation recommendations for pipe culverts are not further developed.

Trenchless installation technique is an option that can be considered in conjunction with circular pipes. Due to the shallow invert level, however, there is likely insufficient crown cover above the pipe to satisfy the minimum cover criteria acceptable to MTO.

Concrete box (closed) culvert

A concrete box culvert is considered suitable for replacing the existing culvert. Precast sections, rather than cast-in-place construction, can be installed rapidly with less potential for disturbance of the founding soils during installation. A segmental box structure can accommodate some potential differential settlement along the culvert axis. Effective groundwater control will be required at this site to maintain dry excavations during the course of staged construction. Dewatering and temporary protection (shoring) must be implemented at this site prior to excavation. Open cutting construction may be co-ordinated with the highway widening operations.

Due to the existing soil and groundwater conditions at this site, and from a foundation technical, constructability and cost-effectiveness perspective, the recommended culvert type for replacement is precast concrete box culvert. This report focuses on providing foundation recommendations for the design and construction of a concrete box culvert.

9.2 Foundation Design

In general, the subsurface stratigraphy encountered from the highway grade consists of pavement structure overlying compact to very dense silty sand embankment fill. Below and beyond the embankment, the native deposits consist of topsoil overlying native compact to dense sands and silts. Interlayers of clayey silt were encountered within the cohesionless soils. A layer of silty sand mixed with organics was contacted immediately below the topsoil, in the borehole drilled near the culvert inlet. A sandy silt till deposit was encountered below the silt layer in one borehole. The groundwater table was measured at approximately 1 m to 2 m depths below existing highway grade, or some 1 m to 2 m above the culvert invert.

It is understood that the invert levels of the replacement culvert are approximately the same as those of the existing culvert. This implies that the depth of excavation would be up to 3 m to 4 m depth below existing highway grade. Foundation design aspects for the replacement culvert include subgrade conditions and preparation, geotechnical resistances, settlement of founding soils, lateral earth pressures, temporary protection system design, groundwater control, staged construction, and restoration of the roadway embankment.

9.3 Concrete Box Culvert

Replacement of the culvert with precast concrete box culvert is considered a viable alternative for this site. Since widening of Highway 400 is proposed, it is anticipated that the subgrade soils in the vicinity of the culvert within the highway widening footprint will be subjected to additional loading.

The new culvert will be installed at a skew angle at a distance of about 4 m south of the existing culvert alignment. It is anticipated that the proposed inlet and outlet founding levels (bottom of bedding) of the culvert are at approximate Elevations 229.8 and 228.9, respectively. Widening of the Highway 400 SBL will be approximately 15 m towards the west, and widening of the Highway 400 NBL will be about 4.5 m towards the east.

The subgrade conditions immediately below the proposed culvert footprint typically consist of compact sand and silt and stiff clayey silt. The presence of silty sand mixed with organics is expected to be encountered in the inlet area. Silty sand fill may be daylighted in the outlet area.

In order to provide a uniform foundation subgrade, a 300 mm thick layer of bedding material conforming to OPSS PROV 1010 Granular A or Granular B Type II requirements should be provided under the base of the box culvert, similar to that shown on OPSD 803.010. The bedding material should be placed on a layer of non-woven geotextile which rests on the prepared subgrade as soon as practicable following its inspection and approval. The subgrade preparation, placement and compaction of the bedding material must be carried out in the dry. The surface prepared to support the box units should have a 75 mm minimum thickness top levelling course consisting of uncompacted Granular A as per OPSS 422. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which must be protected from disturbance during construction.

The following geotechnical resistances may be used for design of the proposed box culvert founded at or below Elevations 229.8 (inlet) and 228.9 (outlet) on the typically compact sand and silt, and stiff clayey silt subgrade:

- Factored Geotechnical Resistance at ULS of 250 kPa
- Geotechnical Resistance at SLS (less than 25 mm settlement) of 185 kPa.

At the inlet area, a deposit of very loose silty sand mixed with organics is present. This material, where exposed, should be sub-excavated and replaced with compacted granular materials.

A consequence factor of 1 was utilized in this design adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing, and 0.8 for settlement, both adopted for typical degree of understanding, were used to obtain the above values, as per CHBDC (2019), Sec. 6.9.

The ULS resistance and settlement are dependent on the culvert size, configuration and applied loads; the geotechnical resistances should therefore be reviewed if the culvert width or founding/invert elevation differs significantly from that given above.

The geotechnical resistances are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design must be reduced in accordance with the CHBDC (2019), Clause 6.10.5.

Resistance to lateral forces / sliding resistance between precast concrete and the underlying Granular A or B Type II should be calculated assuming an ultimate coefficient of friction of 0.45.

It is recommended that the culvert be designed to resist external loadings including frost forces, lateral earth pressures, hydrostatic pressure, weight of the embankment fill, traffic loadings and surcharge due to construction equipment.

9.3.1 Subgrade Preparation

After the excavation reaches the design founding elevation, any remaining fill, topsoil, alluvium deposits, loose/soft or disturbed soils and any deleterious materials within the culvert footprint must be sub-excavated to undisturbed native compact sand and silt or stiff clayey silt at or below the desired founding elevations. The exposed surface must be inspected to confirm that the subgrade is suitable and uniformly competent. It must be noted that Borehole C75-01, located near the culvert inlet, encountered very loose silty sand mixed with organics at shallow depths. The presence of alluvial and organic deposits should also be expected in the vicinities of the watercourses. Any loose/soft areas should be sub-excavated and replaced with well compacted granular fill consisting of OPSS.PROV 1010 Granular A or B Type II material compacted as per OPSS.PROV 501. OPSS.PROV 1004 clear stones may be used as a substitute for the first lift of compacted granulars should the subgrade be considered too wet for granular placement and compaction.

This work must be carried out in accordance with OPSS 902 and construction must be carried out in the dry. Any area of excavation required for removal of the existing box culvert should be restored with approved compacted granular materials as per OPSS 902.

9.3.2 Settlements

New fill will be placed around the new culvert at both ends for the highway widening. The top of fill will be approximately 2 m in height above the existing ground. It is anticipated that immediate (elastic) settlement will be induced in the underlying sands and silts as the fill is placed and should be essentially completed by the end of construction.

The actual settlement of the new culvert is expected to be controlled primarily by the settlement of the subgrade under the weight of the new widening fill. If the fill is placed to its top of grade prior to culvert construction, post construction settlement may be considered negligible. If the fill is placed after the culvert is constructed, it is estimated that total settlement could be up to the order of 25 mm to 35 mm.

The culvert must be designed to accommodate the estimated settlement or consideration should be given to preloading within the highway widening area prior to constructing the culvert within those areas.

9.3.3 Construction Considerations

Staged open cutting will be employed to construct the replacement culvert at this site. The main foundation/geotechnical considerations are as follows:

- Traffic flow will be maintained at all times during construction.
- Creek water flow will be maintained inside the existing culvert until the new culvert is completed and operational.
- Effective groundwater control measures must be implemented during construction and prior to excavating below the groundwater level.
- Cofferdams may be required to be installed at the inlet and outlet areas as part of the surface water and groundwater control. This will likely involve the use of cofferdam enclosures as required.
- Temporary protection will be required during all stages of construction including between the existing and proposed culverts.
- Excavation and removal of the existing culvert (if planned), installation of the new culvert and backfilling will be carried out within temporary protection systems where required.
- Sump pumping will be required at all times. All works are to be carried out in the dry.

Temporary protection systems (shoring) such as the use of interlocking steel sheetpiles will likely be required. Foundation recommendations for design of such a system are provided in Section 13 of this report.

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10.0 CULVERT BACKFILL AND LATERAL EARTH PRESSURES

It is recommended that backfill to the culvert consists of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS.PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 803.01 as appropriate.

All fills must be placed in regular lifts and be compacted in accordance with OPSS.PROV 501. The backfill must be placed and compacted in simultaneous lifts on both sides of the culvert, and the difference of the top of backfill elevation on both sides of the culvert should be kept within 500 mm of each other at all times. Heavy compaction equipment must not be used adjacent to the culvert.

For a rigid structure such as concrete box culvert, it is recommended that at-rest horizontal earth pressures be used for design.

Earth pressures acting on the culvert walls may be assumed to impose a triangular distribution. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC 2019 but are generally given by the expression:

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

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

Earth pressure coefficients for backfill are dependent on the material used as backfill. Recommended unfactored values are shown in the following Table 10.1. Active pressures should be used for any unrestrained wall.

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Table 10.1 - Earth Pressure Coefficients (K)

Wall Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°$; $\gamma = 22.8\ kN/m^3$		OPSS Granular B Type I (modified) $\phi = 32°$; $\gamma = 21.2\ kN/m^3$		Embankment Fill $\phi = 30°$; $\gamma = 20.0\ kN/m^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48	0.33	0.54
At rest (Restrained Wall)	0.43	0.62	0.47	0.70	0.50	0.76
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-	3.0	-

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular A or Granular B Type II, or at a depth of 1.7 m for Granular B Type I. Compaction equipment to be used adjacent to the culvert walls should be restricted in accordance with OPSS.PROV 501.

11.0 EMBANKMENT DESIGN AND CONSTRUCTION

The existing highway embankment is up to the order of 3.5 m in height above the culvert invert. It is understood that widening of Highway 400 is planned for both the NBL and SBL lanes. Up to 2 m of new fill will be placed above the existing ground within the widening footprints.

Embankment widening construction should be carried out in accordance with OPSS.PROV 206. The new fill should consist of Granular A or B Type II material, or Select Subgrade Material (SSM). Cohesive earth fill, especially those with high plastic clay, should not be used as new fill.

These materials would be difficult to place and compact to specifications, and are prone to significant post construction settlement.

Provided that the granular material is placed as recommended, it is anticipated that slope inclination of 2H : 1V, should be stable. Where applicable, benching of the existing earth slope surface should be carried out as per OPSD 208.010 in order to enhance the keying in of the new fill.

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

12.0 EROSION CONTROL

Erosion protection should be provided at the culvert inlet and/or outlet areas. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

It is recommended that a clay seal or a concrete cut-off wall be used to minimize the potential for erosion near the inlet area. The clay seal should extend a minimum of 0.3 m above the high water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS.PROV 1205. A geosynthetic clay liner may be used as a clay seal.

13.0 EXCAVATION AND GROUNDWATER CONTROL

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the embankment fill, native sand and silt and clayey silt at this site are classified as Type 3 soils. Surficial alluvial deposits and very loose silty sand mixed with organics that are anticipated in the inlet and outlet areas are classified as Type 4 soils. Sands and silts below the groundwater level are classified as Type 4 soils.

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

Excavated granular fill should not be reused as backfill and should be disposed of off-site.

Excavations for culvert replacement will typically be carried out through the existing embankment fill and extended into the native sand and silt deposit. The work will be carried out in association with temporary protection (shoring) systems that are to be installed in association with the staging requirements for the reconstruction of the Anne Street Underpass. The temporary protection will be installed between the existing and proposed culverts, and elsewhere, as required. Temporary open cutting at inclinations of 3H : 1V or flatter may be required through the sands and silts below the groundwater table.

High groundwater levels, ranging from about 1 to 2 m depths (Elevations 231.1 to 229.8) were measured in the piezometers. Given the relatively high permeability of the embankment fill materials and native soils, water inflow/seepage into the excavation should be anticipated from the embankment fill and underlying native sands and silts. Surface runoff and precipitation will also tend to accumulate in these excavations. The groundwater level along the culvert alignment is expected to be largely governed by the water level in the creek. As discussed in previous Section 9.3.3, a combination of the use of enclosure sheetpile cofferdams at the inlet and outlet, surface water diversion, temporary protection systems such as sheetpiled enclosures, vacuum well-points, and pumping from filtered sumps may be required to maintain dry excavations during the course of staged construction. The dewatering scheme must be effective to lower the groundwater level to at least 0.5 m below the final subgrade level to avoid base boiling in the native soils.

It is understood that during construction of the new culvert, the existing culvert will remain operational to allow water flow along the creek.

Based on the grain size distribution curves, the coefficient of permeability (k) of the native sand and silt is as follows:

Soil	Permeability, k (cm/sec)
Sand and Silt	2×10^{-3} to 1×10^{-5}

Dewatering of all excavations should be carried out in accordance with OPSS.PROV 517, SP 517F01 Amendment to OPSS 517, November 2016 (issued July 2017), and OPSS. PROV 902 and NSSP FOUN0003. A design engineer with a minimum five years relevant experience will be required to design and implement a dewatering system. A preconstruction survey is required at this site, thus Designer Fill-In ** in SP FOUN0003 should be "Yes". The radius of influence for dewatering will vary from 50 m to 100 m. SP FOUN0003 and SP517F01 have been included in Appendix F.

The design of an effective dewatering system that may be required is the responsibility of the Contractor and the Contract Documents must alert him to this responsibility and the need to engage a dewatering specialist. Dewatering must remain operational and effective until the new culvert is installed and backfilled. Suggesting wording for an NSSP in this regard is included in Appendix F.

McIntosh Perry advised that a PTTW will be obtained for the entire project and will cover the requirements for Culvert 75.

14.0 SEISMIC CONSIDERATIONS

In accordance with the CHBDC, the selection of the seismic site class is based on the soil conditions encountered in the upper 30 m of the stratigraphic profile. In general, the subsurface stratigraphy encountered at the site consists of topsoil or pavement structure overlying embankment fill underlain by compact to very dense sand and silt, silt and sand, with interlayered clayey silt.

As per Table 4.1, Clause 4.4.3.2 of the CHBDC (2019), the site may be classified as Seismic Site Class D.

Based on the National Building Code of Canada (NBCC 2015), the peak horizontal ground acceleration (PGA), corresponding to a design earthquake having a 2 percent probability of being exceeded in 50 years (i.e. 2,475 year return period) is 0.082 g at the site.

The new structure is considered as seismic performance category 1 based on Table 4.10 of the CHBDC 2019.

Based on review of the SPT data, seismically-induced liquefaction of foundation soils is not anticipated under the design earthquake.

15.0 TEMPORARY PROTECTION SYSTEMS

Temporary protection (shoring) systems will be required during construction of the replacement culvert to maintain live traffic lanes and the integrity of the existing Culvert 75.

An item titled “Temporary Protection System” as per OPSS.PROV 539 and SP105S09 should be included in the contract documents. It is recommended that Performance Level 2 as per Clause 539.04.01.01 and the alignment of the temporary protection be specified on the contract drawings. For the temporary protection between the existing and new culverts, the structural designer should assess what performance level would be required to maintain the integrity of the existing culvert.

The selection and design of the temporary protection systems is the responsibility of the contractor. The design of such systems must incorporate traffic loading and surcharge loading due to the construction equipment and operations. It is anticipated that the temporary protection system will need to be extended through the existing embankment and driven into the underlying native compact to dense sand and silt to develop the required toe resistance. Installation of the system should consider that the existing embankment fill may contain obstructions.

For conceptual planning and costing purposes, an interlocking sheetpile wall is considered suitable for temporary protection and to provide partial groundwater cutoff. A soldier pile and lagging wall will provide shoring support to the excavation but will not have water control. These shoring walls may be designed using the geotechnical parameters given below:

γ	=	20 kN/m^3
γ_w	=	10 kN/m^3
K_a	=	0.33 (approach fills)
	=	0.33 (native sand and silt, silt, sand)
	=	0.35 (native clayey silt)
K_p	=	3.0 (approach fills)
	=	3.0 (native sand and silt, silt, sand)
	=	2.9 (native clayey silt)

It is recommended that lateral earth pressures acting on the wall be computed in accordance with the CHBDC 2019. The surcharge should include soil loadings above the top of the pile and other loadings adjacent to the wall. A properly designed and constructed soldier pile and lagging wall will be permeable and therefore water pressure acting on the retained height may be set to zero. Full hydrostatic pressure will need to be incorporated for design of sheetpile walls if this type of protection system is used.

The actual pressure distribution acting on the shoring system is a function of the construction sequence, and the relative flexibility of the wall, and these factors must be considered when designing the shoring system. All shoring systems should be designed by a Professional Engineer experienced in such designs.

16.0 ADJACENT STRUCTURES AND BURIED UTILITIES

The potential presence of underground utilities at the site should be confirmed prior to construction. It is recommended that the exact locations and elevations of any utilities be established by the designer, and compared with the extent of the potential work zones related to the proposed culvert replacement, new fills and associated works. Protection and/or relocation of utilities, if necessary, should be provided. Underground utilities should not be undermined or damaged during the culvert replacement and fill placement.

17.0 SOIL CORROSION POTENTIAL

The results of corrosivity and sulphate analytical tests conducted on a selected soil sample are included in Appendix B. Based on the test results, the following statements can be made:

- The potential for sulphate attack on concrete from the surrounding native soils is considered to be negligible due to the low concentration of sulphate and slightly alkaline pH values.
- The overall potential for corrosion on metal is considered high for the sand and silt taken at depths ranging from 1.5 m to 2.1 m (Elevations 230.8 to 230.2).
- The effects of road de-icing salts should also be considered when selecting the class of concrete and corrosion mitigation measures.

18.0 CONSTRUCTION CONCERNS

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

- The existing fills may contain obstructions. The Contractor must be equipped and prepared to remove, penetrate or otherwise handle these obstructions during construction.
- Based on water levels measured in piezometers, excavations through the existing fill into native sand and silt and clayey silt will be below the groundwater level. Also, seepage and perched groundwater will be encountered within the embankment fill. A combination of cofferdam and sump pumping will be required to maintain dry excavations during the course of staged construction.
- An effective dewatering / unwatering system must be employed to enable culvert construction in the dry and prevent base boiling, sloughing and instability of the excavation walls. A dewatering specialist should be retained to provide input on the required dewatering system.
- Daily visual inspection of the highway pavement surface must be carried out in the vicinity of the construction works. If cracks form in the pavement or settlement is observed to occur, these matters must immediately be brought to the attention of the CA for determining if further action is required.
- The forward and side embankment slopes should be inspected after construction for surficial disturbance. Where necessary, remedial measures such as re-vegetation and/or placement of gravel sheeting may be required.
- Removal of peat, organics, soft soils and alluvial deposits near creek channels particularly in the inlet and outlet areas

- Confirmation that the culvert backfills and approach fills are adequately placed and compacted to specifications.

19.0 CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Ms. R. Palomeque Reyna, P.Eng. The report was reviewed by Dr. Sydney Pang, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.

Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer

Sydney Pang, P.Eng.
Associate, Senior Foundation Engineer

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

2015 National Building Code Seismic Hazard Calculation

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

Site: 44.384N 79.709W **User File Reference:** Hwy 400- Culvert 75 2020-02-04 19:19 UT

Requested by: Thurber Engineering

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.080	0.050	0.032	0.011
Sa (0.1)	0.111	0.071	0.047	0.017
Sa (0.2)	0.108	0.071	0.049	0.018
Sa (0.3)	0.093	0.062	0.043	0.017
Sa (0.5)	0.077	0.052	0.036	0.013
Sa (1.0)	0.047	0.031	0.021	0.006
Sa (2.0)	0.024	0.016	0.010	0.003
Sa (5.0)	0.006	0.004	0.002	0.001
Sa (10.0)	0.003	0.002	0.001	0.000
PGA (g)	0.064	0.041	0.027	0.009
PGV (m/s)	0.063	0.040	0.026	0.008

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

References

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

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

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

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

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction
1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

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

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

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

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

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

UNIFIED SOILS CLASSIFICATION

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

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

SYMBOLS

CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

Bedding	**Bedding Plane Spacing**
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

TERMS

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

STRENGTH CLASSIFICATION

Rock Strength	**Approximate Uniaxial Compressive Strength (MPa)**	**(psi)**	**Field Estimation of Hardness***
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

Ministry of Transportation Ontario

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RECORD OF BOREHOLE No C75-01

METRIC

GWP# 2504-17-00	LOCATION N 4 916 050.4 E 288 129.6		ORIGINATED BY ES
DIST HWY 400	BOREHOLE TYPE Hollow Stem Augers/Tricone		COMPILED BY AN
DATUM Geodetic	DATE 2019.10.17 - 2019.10.17	LATITUDE 44.384268 LONGITUDE -79.709220	CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
231.9	GROUND SURFACE							
0.0	**TOPSOIL**, occasional roots, Very Loose, Dark Brown, Moist	1	SS	2			~26	
231.3 / 0.6	Silty **SAND**, mixed with organics, occasional roots and wood fibres, Very Loose, Dark Brown, Moist	2	SS	1	▽	231	~62	
	Dark Grey	3	SS	1	▼	230	~27	
229.6 / 2.3	**SAND** and **SILT**,trace clay, occasional oxidized stains, Compact, Brown, Wet	4	SS	13		229	~19	
		5	SS	12			~21	Switched to tricone at 3.0m; 0 56 42 2
	Dense	6	SS	30		228 / 227	~19	
		7	SS	40		226 / 225	~19	
		8	SS	36		224	~17	
	Grey	9	SS	32		223	~21	
221.9						222		

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 C75-01

METRIC

GWP# 2504-17-00 | LOCATION N 4 916 050.4 E 288 129.6 | ORIGINATED BY ES

DIST ___ HWY 400 | BOREHOLE TYPE Hollow Stem Augers/Tricone | COMPILED BY AN

DATUM Geodetic | DATE 2019.10.17 - 2019.10.17 | LATITUDE 44.384268 | LONGITUDE -79.709220 | CHECKED BY RPR

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
10.0	**SILT**, trace sand, trace clay Very Dense Grey Wet	10	SS	51	221		0	3	90	7
219.9 / 12.0	Clayey **SILT**, some sand, trace gravel Hard Grey Moist	11	SS	42	220					
219.2 / 12.7	**SAND**, some silt, trace gravel, trace clay Dense Grey Wet	12	SS	39	219, 218					
		13	SS	48	217		0	79	19	2
216.1 / 15.8	END OF BOREHOLE AT 15.8m. BOREHOLE OPEN AND WATER LEVEL AT 1.1m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.									

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2019.11.07	1.0	230.9
2019.11.22	2.1	229.8
2020.04.08	1.9	230.0

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

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RECORD OF BOREHOLE No C75-02

METRIC

GWP# 2504-17-00 | LOCATION N 4 916 025.7 E 288 148.0 | ORIGINATED BY ES

DIST ____ HWY 400 | BOREHOLE TYPE Solid Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2019.10.10 - 2019.10.10 | LATITUDE 44.384047 | LONGITUDE -79.708989 | CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
233.7	GROUND SURFACE							
0.0	**ASPHALT:** (150mm)							
0.2	**SAND**, some gravel Very Dense Brown Moist (FILL)		1	GS			233	
232.6			2	SS	60			11 60 19 10
1.1	Silty **SAND**, some gravel, some clay Very Dense to Dense Brown Moist (FILL)		3	SS	52	▽	232	
			4	SS	37		231	
230.6 / 3.0	**SAND** and **SILT**, trace clay Compact to Dense Brown Wet		5	SS	18		230	
	Occasional oxidized stains		6	SS	30		229 / 228	
	Grey		7	SS	28		227	0 39 53 8
			8	SS	21		226 / 225	
	Very Dense Moist		9	SS	55		224	
223.7								

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C75-02

METRIC

GWP# 2504-17-00 LOCATION N 4 916 025.7 E 288 148.0 ORIGINATED BY ES

DIST HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2019.10.10 - 2019.10.10 LATITUDE 44.384047 LONGITUDE -79.708989 CHECKED BY RPR

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
10.0	**SILT**, trace to some sand, some clay Dense to Very Dense Grey Wet					
					223	
	Thin sand seams	10	SS	33		
					222	
221.1		11	SS	66		0 11 76 13
12.6	**SAND**, some silt, trace gravel, trace clay Very Dense Grey Wet				221	
					220	
		12	SS	57		
					219	
		13	SS	75		
217.9					218	
15.8	END OF BOREHOLE AT 15.8m. BOREHOLE OPEN TO 11.3m AND WATER LEVEL AT 1.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.5m, CEMENT TO 0.2m, THEN ASPHALT TO SURFACE.					

Column headings: SOIL PROFILE (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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No C75-03

METRIC

GWP# 2504-17-00 | LOCATION N 4 916 017.4 E 288 183.1 | ORIGINATED BY ES

DIST ____ HWY 400 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY BH

DATUM Geodetic | DATE 2019.11.04 - 2019.11.04 | LATITUDE 44.383973 | LONGITUDE -79.708547 | CHECKED BY RPR

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
232.3	GROUND SURFACE				
0.0	**TOPSOIL**, occasional roots Loose Dark Brown Moist	1	SS	4	
231.4 / 0.9	**SAND** and **SILT**, trace clay, trace gravel Loose to Compact Dark Brown to Brown Moist to Wet	2	SS	8	
		3	SS	13	
230.1 / 2.2	Clayey **SILT**, trace sand Stiff to Very Stiff Brown to Grey Wet	4	SS	11	0 7 71 22
		5	SS	15	
228.2 / 4.1	**SAND** and **SILT**, trace clay Compact Grey Wet	6	SS	21	
		7	SS	11	
		8	SS	16	0 33 60 7
		9	SS	28	
222.7 / 9.6	Clayey **SILT**, some sand, trace gravel Very Stiff				

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (232 to 223); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

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 C75-03

METRIC

GWP# 2504-17-00 LOCATION N 4 916 017.4 E 288 183.1 ORIGINATED BY ES

DIST HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY BH

DATUM Geodetic DATE 2019.11.04 - 2019.11.04 LATITUDE 44.383973 LONGITUDE -79.708547 CHECKED BY RPR

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Clayey **SILT**, some sand, trace gravel Hard Grey Wet				222	
221.3 / 11.0	**SILT**, some sand, some clay Dense Grey Moist	10	SS	44	221	
		11	SS	39	220	
219.0 / 13.3	**SAND**, some silt, trace gravel, trace clay Compact to Dense Grey Wet	12	SS	17	219, 218	
		13	SS	41	217	
216.4 / 15.8	END OF BOREHOLE AT 15.8m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.					

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2019.11.07	1.4	230.9
2019.11.22	1.2	231.1
2020.04.08	3.5	228.7

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³; STRAT PLOT; GROUND WATER CONDITIONS.

+ ³, × ³ : Numbers refer to Sensitivity

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

ONTMT4S2 MTO-22424.GPJ 2017TEMPLATE(MTO).GDT 9/28/20

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No C75-04

METRIC

GWP# 2504-17-00 | LOCATION N 4 916 033.8 E 288 136.4 | ORIGINATED BY ES

DIST | HWY 400 | BOREHOLE TYPE Solid Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2019.10.08 - 2019.10.08 | LATITUDE 44.384119 | LONGITUDE -79.709134 | CHECKED BY RPR

SOIL PROFILE: 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; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT w_P; NATURAL MOISTURE CONTENT w; LIQUID LIMIT w_L
WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

ELEV / DEPTH	DESCRIPTION
233.6	GROUND SURFACE
0.0 / 0.1	**ASPHALT:** (75mm)
	SAND, some gravel Brown Moist (FILL)
232.9 / 0.7	Silty **SAND**, trace gravel, some clay Dense to Compact Brown to Dark Brown Moist (FILL)
230.2 / 3.4	**SAND** and **SILT**, trace clay Compact Grey Wet
223.6	

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	GS					
2	SS	30				
3	SS	44	4	66	20	10
4	SS	18				
5	SS	16				
6	SS	28				
7	SS	23				
8	SS	18				
9	SS	26	0	49	50	1

Groundwater level symbol ∇ shown at approx. elev. 231.4.

Elevation scale: 233, 232, 231, 230, 229, 228, 227, 226, 225, 224

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 C75-04

METRIC

GWP# 2504-17-00 | LOCATION N 4 916 033.8 E 288 136.4 | ORIGINATED BY ES

DIST ___ HWY 400 | BOREHOLE TYPE Solid Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2019.10.08 - 2019.10.08 | LATITUDE 44.384119 | LONGITUDE -79.709134 | CHECKED BY RPR

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
10.0	**SILT**, some sand, some clay, Dense, Grey, Wet				223	
		10	SS	31	222	
221.4 / 12.2	Sandy **SILT**, trace gravel, some clay, Very Dense, Grey, Moist (TILL)	11	SS	57	221	
		12	SS	100/0.200	220	1 26 60 13
	Clay pockets	13	SS	100/0.200	219	
218.2 / 15.4	END OF BOREHOLE AT 15.4m. BOREHOLE OPEN TO 12.5m AND WATER LEVEL AT 2.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.5m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.					

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No C75-05

METRIC

GWP# 2504-17-00 | LOCATION N 4 916 006.9 E 288 171.4 | ORIGINATED BY ES

DIST ____ HWY 400 | BOREHOLE TYPE Solid Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2019.10.09 - 2019.10.09 | LATITUDE 44.383878 | LONGITUDE -79.708694 | CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
233.4	GROUND SURFACE							
0.0	**ASPHALT:** (100mm)							
0.1	**SAND**, some gravel, Dense, Brown, Moist (FILL)	1	GS					
232.4 / 1.0	Silty **SAND**, trace gravel, some clay, Dense to Compact, Brown to Grey, Moist (FILL)	2	SS	47				
	(Groundwater level ∇ at approx. El. 232.0)	3	SS	48				
		4	SS	26				
		5	SS	11				
229.9 / 3.6	**SAND** and **SILT**, trace gravel, trace clay, Compact, Dark Brown to Brown, Moist							
	Silt lenses, Grey, Wet	6	SS	15	2	53	44	1
		7	SS	30				
		8	SS	30				
	Dense	9	SS	34				
223.4								

Elevation scale: 233, 232, 231, 230, 229, 228, 227, 226, 225, 224

Dynamic Cone Penetration Resistance Plot: 20 40 60 80 100. Shear Strength kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. Water Content (%): 20 40 60 (Plastic Limit w_P, Natural Moisture Content w, Liquid Limit w_L). Unit Weight γ kN/m³. Remarks & Grain Size Distribution (%).

Continued Next Page

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

RECORD OF BOREHOLE No C75-05

METRIC

GWP# 2504-17-00 LOCATION N 4 916 006.9 E 288 171.4 ORIGINATED BY ES

DIST HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2019.10.09 - 2019.10.09 LATITUDE 44.383878 LONGITUDE -79.708694 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT kN/m3	GR	SA	SI	CL
	Continued From Previous Page												
10.0	**SILT**, trace sand, some clay Dense Grey Moist						223						
			10	SS	40					0	7	78	15
221.2							222						
12.2	**SAND**, some silt, trace clay Very Dense Grey Moist		11	SS	90		221						
							220						
	Wet		12	SS	64		219						
217.6			13	SS	82		218			0	85	13	2
15.8	END OF BOREHOLE AT 15.8m. BOREHOLE OPEN TO 12.5m AND WATER LEVEL AT 1.5m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.4m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.												

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

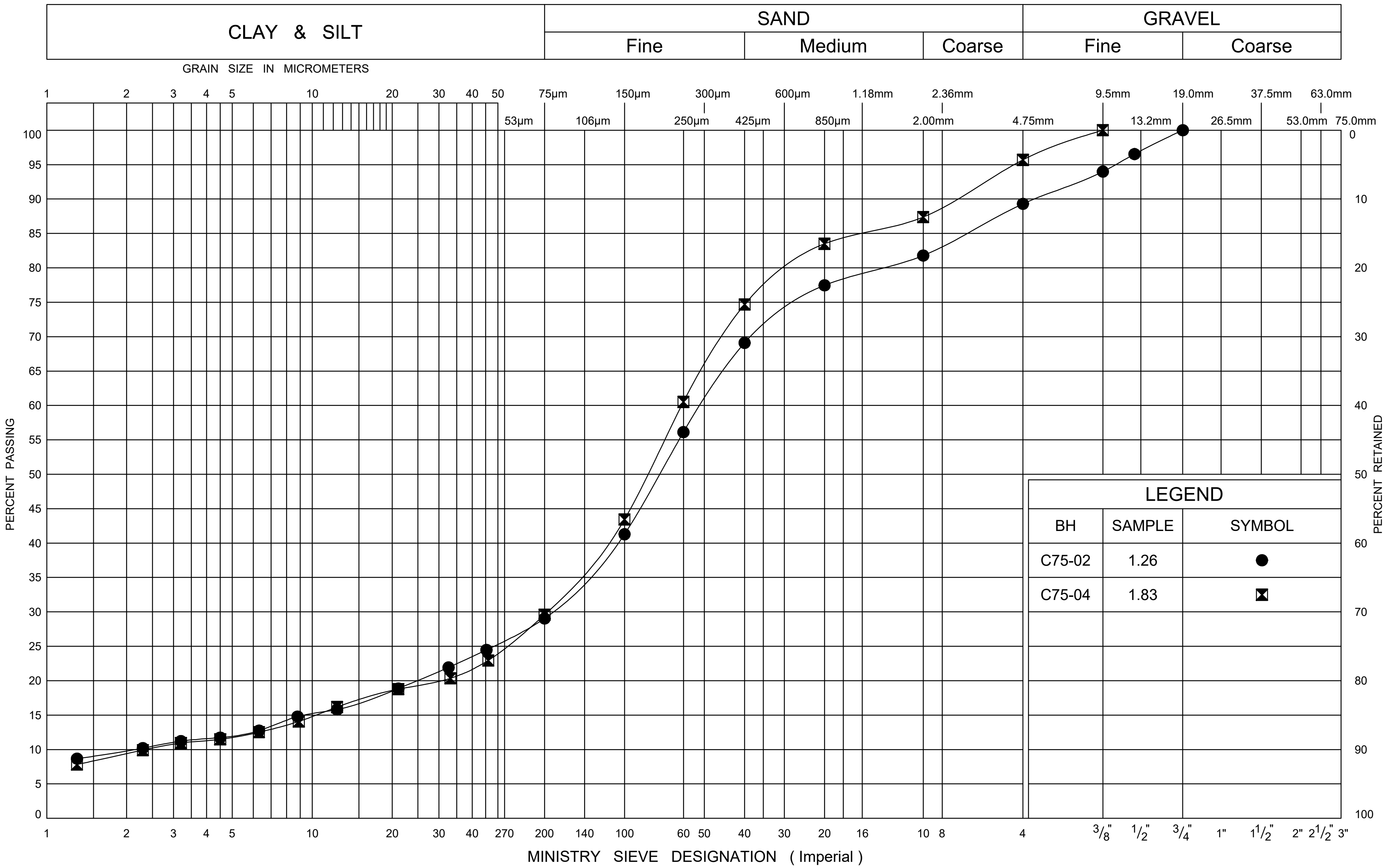
REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

THURBER

Appendix B

Geotechnical and Analytical Laboratory Test Results



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GRAIN SIZE DISTRIBUTION

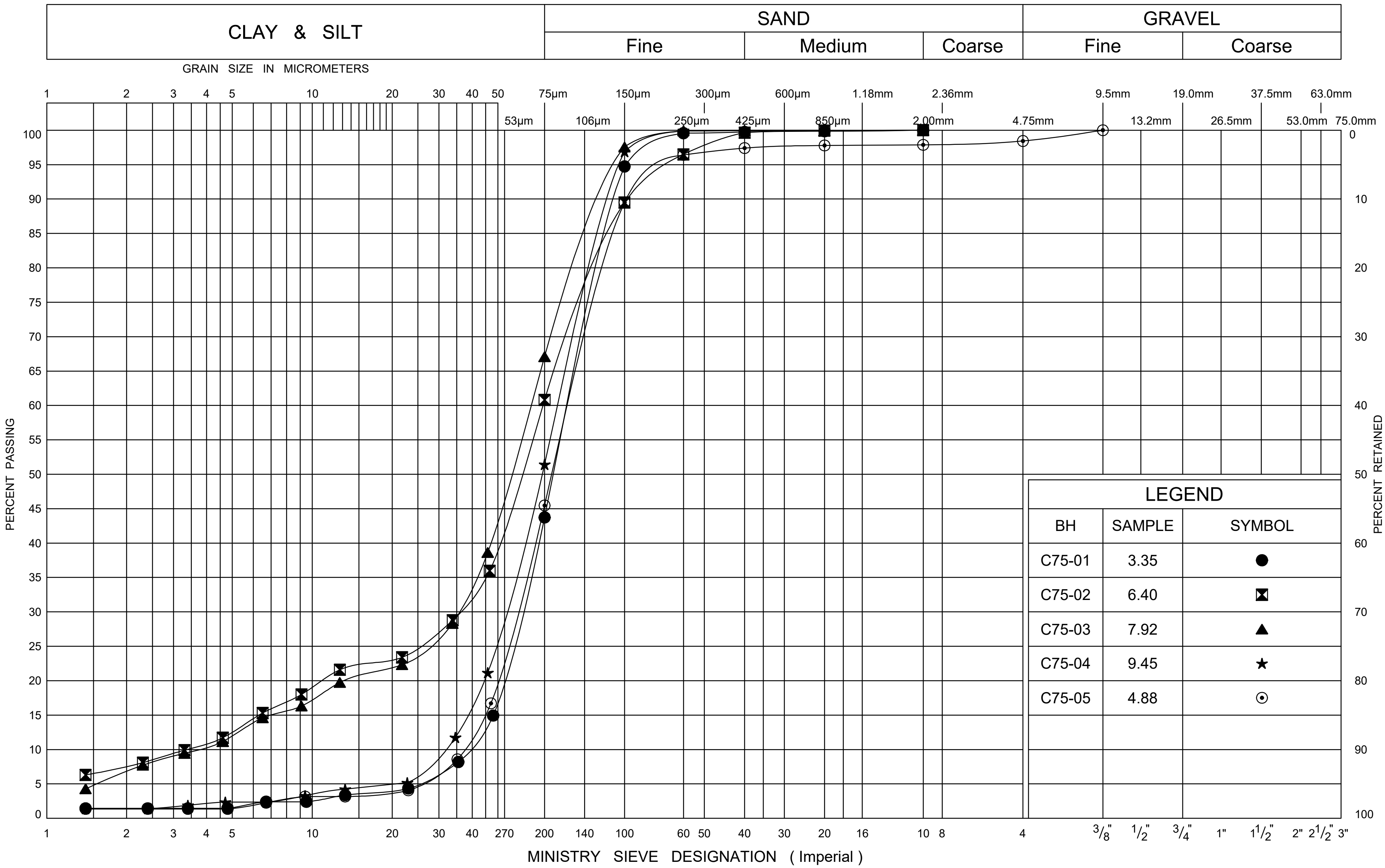
Silty SAND FILL / SAND FILL

FIG No B1

W P 2504-17-00

ONTARIO MOT GRAIN SIZE 2 MTO-22424.GPJ ONTARIO MOT.GDT 12/5/19

78 12 M



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Ontario

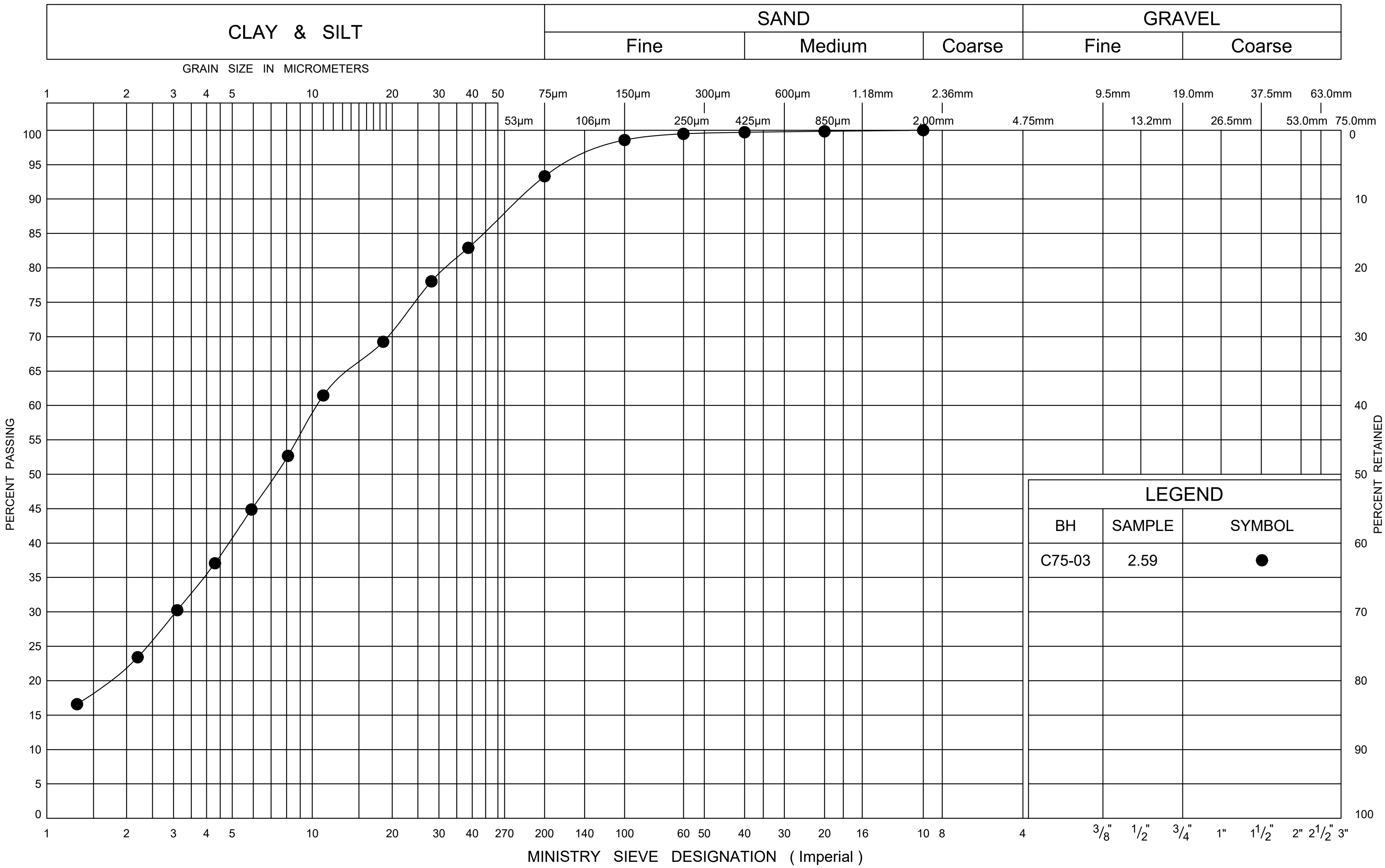
GRAIN SIZE DISTRIBUTION

SAND and SILT

FIG No B2

W P 2504-17-00

ONTARIO MOT GRAIN SIZE 2 MTO-22424.GPJ ONTARIO MOT.GDT 12/5/19



BH	SAMPLE	SYMBOL
C75-03	2.59	●

ONTARIO MOT GRAIN SIZE 2 MTO-22424.GPJ ONTARIO MOT.GDT 12/5/19

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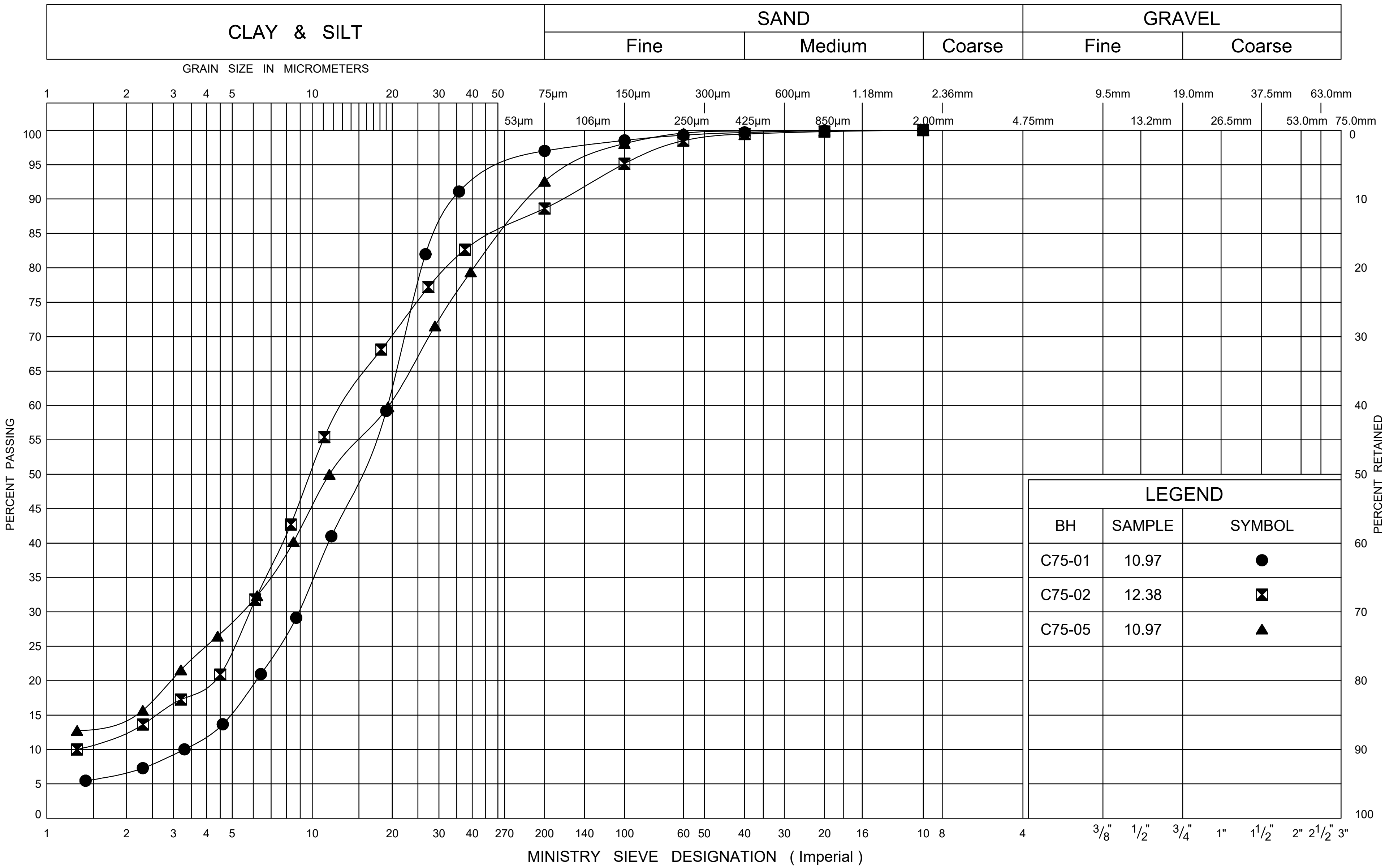
GRAIN SIZE DISTRIBUTION

Clayey SILT

FIG No B3

W P 2504-17-00

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
C75-01	10.97	●
C75-02	12.38	⊠
C75-05	10.97	▲

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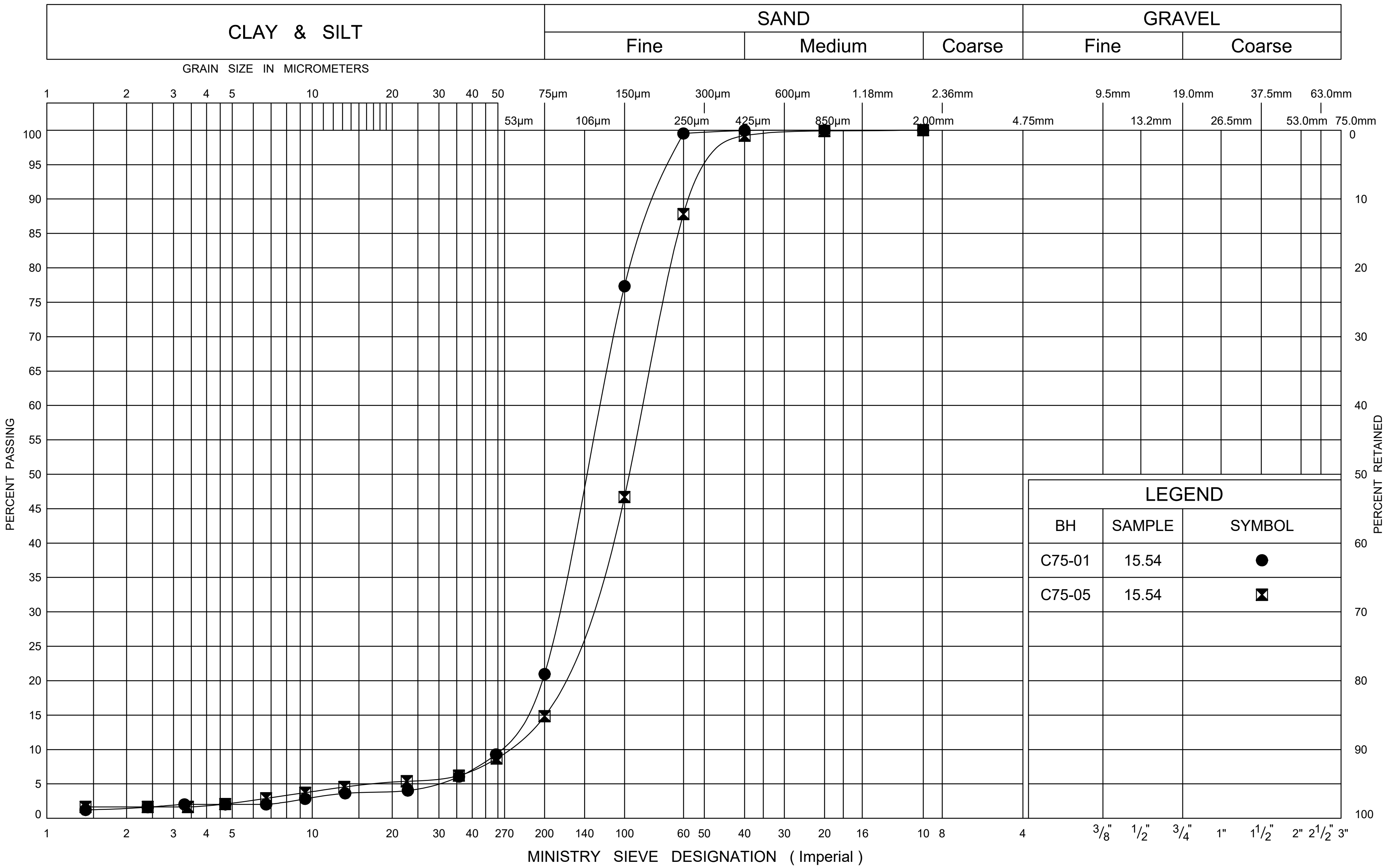
GRAIN SIZE DISTRIBUTION
SILT

FIG No B4

W P 2504-17-00

78 12 M



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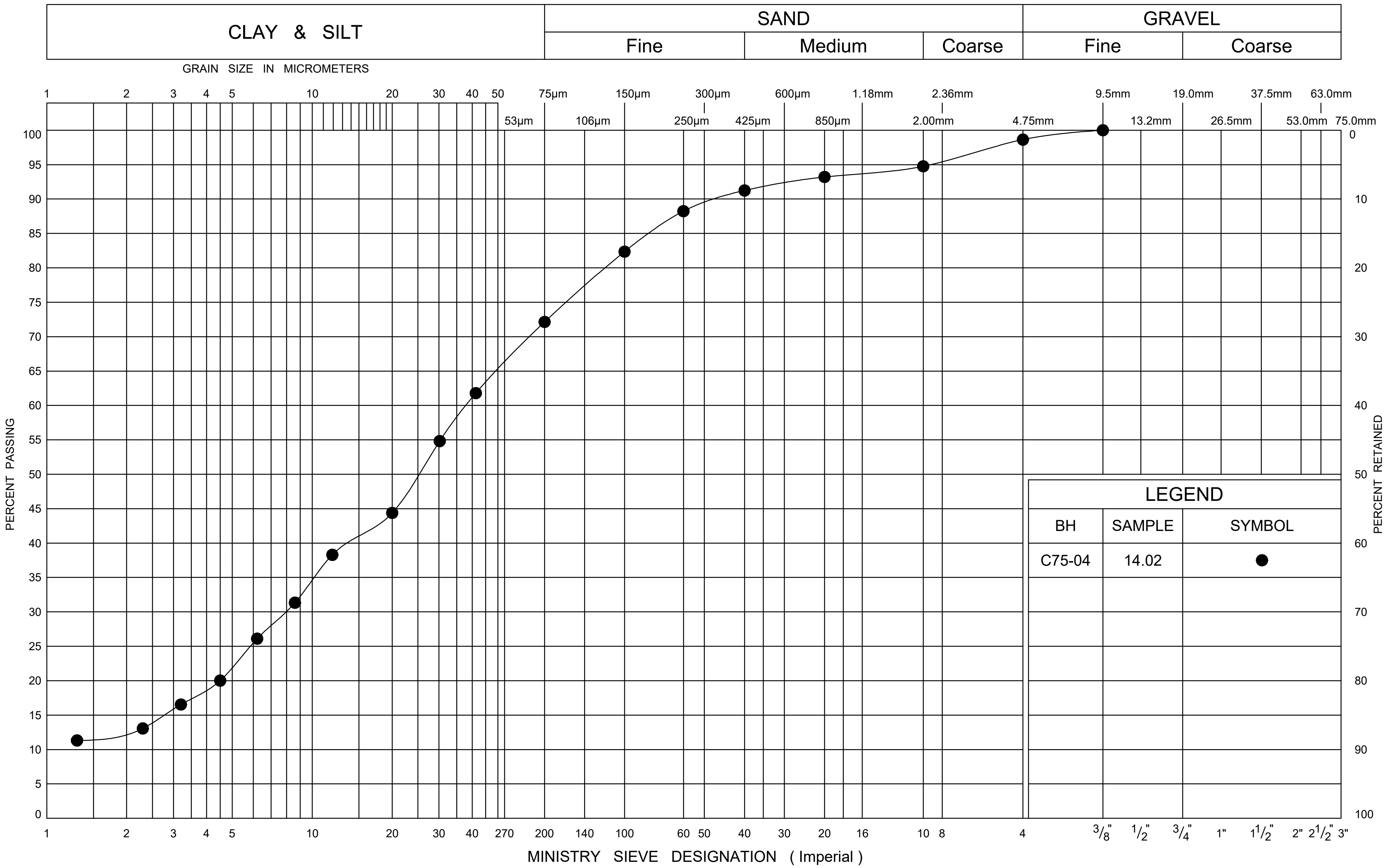
GRAIN SIZE DISTRIBUTION

SAND

FIG No B5

W P 2504-17-00



GRAIN SIZE DISTRIBUTION

Sandy SILT TILL

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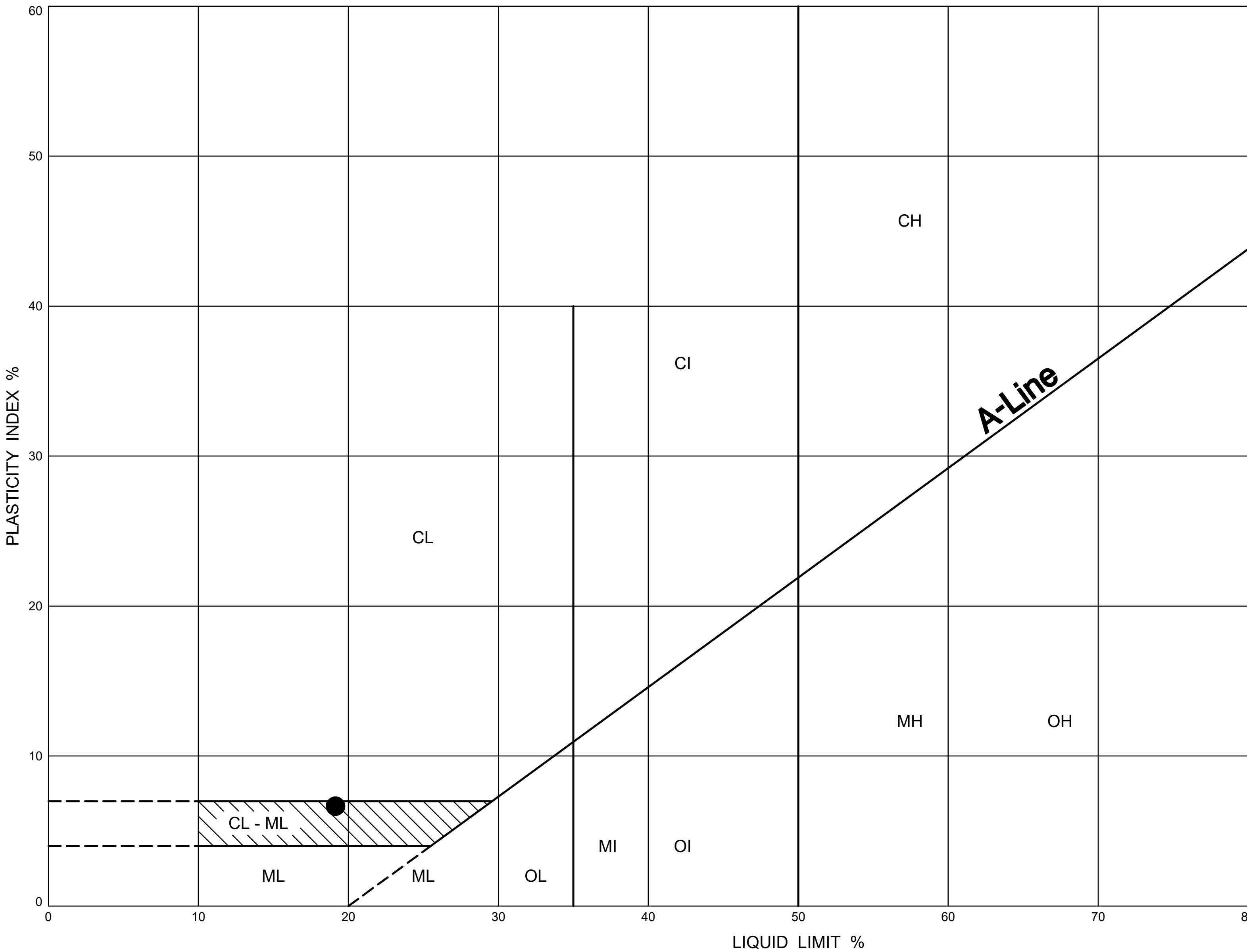
FIG No B6

W P 2504-17-00

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
C75-03	2.59	●

ONTARIO MOT PLASTICITY CHART MTO-22424.GPJ ONTARIO MOT.GDT 12/5/19

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Ontario

PLASTICITY CHART
Clayey SILT

FIG No B7

W P 2504-17-00

FINAL REPORT

CA14866-NOV19 R1

22424

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Brad Moore Hon. B.Sc
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7. Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Rocío Palomeque	Telephone	705-652-2143
Telephone	905-829-8666 x 263	Facsimile	705-652-6365
Facsimile		Email	brad.moore@sgs.com
Email	rreyna@thurber.ca	SGS Reference	CA14866-NOV19
Project	22424	Received	11/22/2019
Order Number		Approved	11/28/2019
Samples	Soil (1)	Report Number	CA14866-NOV19 R1
		Date Reported	11/28/2019

COMMENTS

Temperature of Sample upon Receipt: 9 degrees C
Cooling Agent Present:Yes
Custody Seal Present:Yes

Chain of Custody Number:002534

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

Brad Moore Hon. B.Sc

TABLE OF CONTENTS

Client: Thurber Engineering Ltd.

Project: 22424

Project Manager: Rocío Palomeque

Samplers: N/A

PACKAGE: **- Corrosivity Index** (SOIL)

Sample Number	5
Sample Name	C75-03 SS3
Sample Matrix	Soil
Sample Date	08/11/2019

Parameter	Units	RL		Result
Corrosivity Index				
Corrosivity Index	none	1		14
Soil Redox Potential	mV	-		226
Sulphide	%	0.02		< 0.02
pH	pH Units	0.05		8.59
Resistivity (calculated)	ohms.cm	-9999		573

PACKAGE: **- General Chemistry** (SOIL)

Sample Number	5
Sample Name	C75-03 SS3
Sample Matrix	Soil
Sample Date	08/11/2019

Parameter	Units	RL		Result
General Chemistry				
Conductivity	uS/cm	2		1740

PACKAGE: **- Metals and Inorganics** (SOIL)

Sample Number	5
Sample Name	C75-03 SS3
Sample Matrix	Soil
Sample Date	08/11/2019

Parameter	Units	RL		Result
Metals and Inorganics				
Moisture Content	%	0.1		18.3
Sulphate	µg/g	0.4		10

FINAL REPORT

CA14866-NOV19 R1

Client: Thurber Engineering Ltd.

Project: 22424

Project Manager: Rocío Palomeque

Samplers: N/A

PACKAGE: **- Other (ORP)** (SOIL)

Sample Number	5
Sample Name	C75-03 SS3
Sample Matrix	Soil
Sample Date	08/11/2019

Parameter	Units	RL		Result
Other (ORP)				
Chloride	μg/g	0.4		550

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 (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Chloride	DIO0444-NOV19	µg/g	0.4	<0.4	9	20	93	80	120	96	75	125
Sulphate	DIO0444-NOV19	µg/g	0.4	<0.4	5	20	98	80	120	98	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 (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Sulphide	ECS0044-NOV19	%	0.02	<0.02	ND	20	115	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 (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Conductivity	EWL0420-NOV19	uS/cm	2	0.002	0	10	99	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 l 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	EWL0420-NOV19	pH Units	0.05	NA	1		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

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

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” published by the Ministry and dated March 9, 2004 as amended.

-- End of Analytical Report --

SGS 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

Request for Laboratory Services and CHAIN OF CUSTODY

No: 002534

Page ____ of ____

Laboratory Information Section - Lab use only

Received By: Oleg Mozkiv
Received Date (mm/dd/yyyy): 11 \ 22 \ 19 (mm\dd\yy)
Received Time: 11 : 00
Received By (signature): [signature]
Custody Seal Present: ☑
Custody Seal Intact: ☑
Cooling Agent Present: ☑ ice
Temperature Upon Receipt (°C) 9,9,9
LAB LIMS #: CA14866 NOV19 JJ

REPORT INFORMATION	INVOICE INFORMATION
Company: Thurber Engineering Ltd.	☐ (same as Report Information)
Contact: Rocio Palomeque	Company:
Address: 103-2010 Winston Park Dr. Oakville, ON L6H 5R7	Contact:
Phone: 905-829-8666 x 260	Address:
Fax:	Phone:
Email: rreyna@thurber.ca	Email:

PROJECT INFORMATION

Quotation #: P.O. #:
Project #: 22424 Site Location/ID:

TURNAROUND TIME (TAT) REQUIRED

☐ 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

RUSH TAT (Additional Charges May Apply): ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date: Rush Confirmation ID:

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

REGULATIONS

Regulation 153/04: ☐ Table 1 ☐ Table 2 ☐ Table 3 ☐ Table ____ ☐ Res/Park ☐ Ind/Com ☐ Agri/Other
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

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Field Filtered (Y/N)	Metals & Inorganics	PHC F1-F4 ☐ VOC ☐ BTEX ☐ BTEX/F1 ☐ F2-F4 ☐	PAH ☐ ABN ☐ SVOC(all) ☐	PCB Total ☐ Aroclor ☐	Pesticides OC ☐ OP ☐	TCLP M&I ☐ VOC ☐ PCB ☐ B(a)P ☐ ABN ☐ Ignit. ☐	Water Pkg Gen. ☐ Ext. ☐	Sewer Use:	Corrosivity						COMMENTS:
1																					
2	C75-03 SS3	Nov/8/19	–	1	Soil										✓						
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					
11																					
12																					

Observations/Comments/Special Instructions

Sampled By (NAME):	Signature:	Date: __ / __ / __ (mm/dd/yy)	Pink Copy - Client
Relinquished by (NAME):	Signature: [signature]	Date: 21 / 11 / 19 (mm/dd/yy)	Yellow & White Copy - SGS

Revision #: 1.1
Date of Issue: 04 April, 2018

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Appendix C

Selected Site Photographs

Photo 1- Highway 400 at Culvert 75

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Photo 2- Borehole C75-01, at Culvert 75 inlet

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Photo 3- Borehole C75-01, at Culvert 75 inlet

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Photo 4- Borehole C75-03, at Culvert 75 outlet

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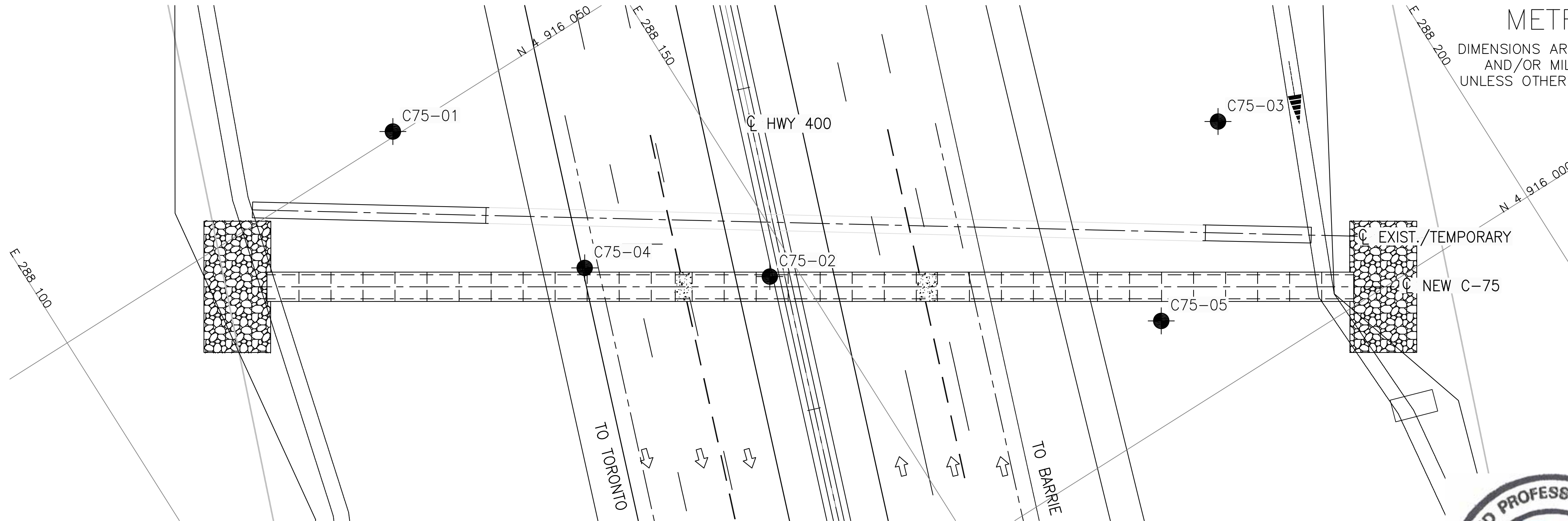
Appendix D

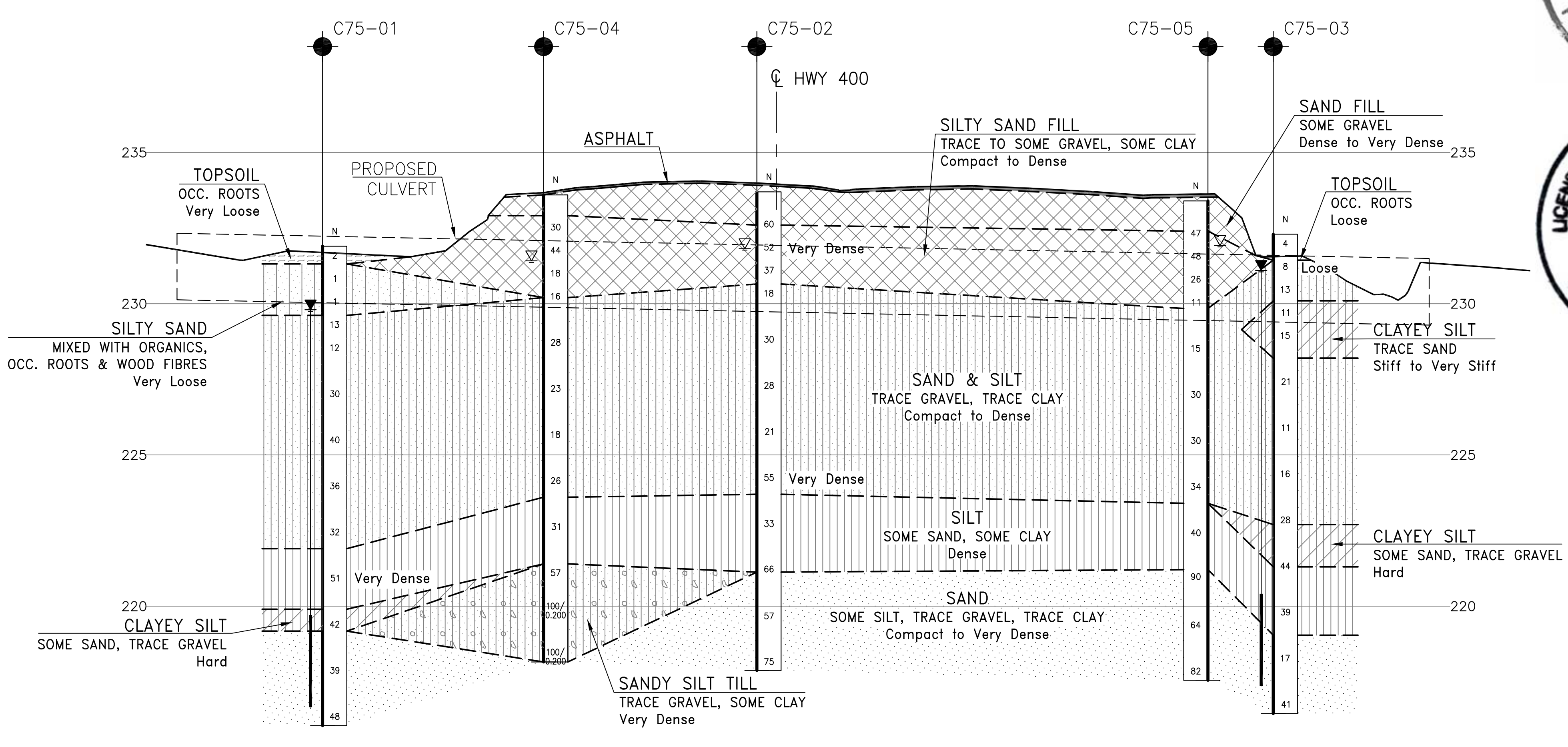
Borehole Locations and Soil Strata Drawing

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



PLAN

SCALE 1:400



PROFILE ALONG ℄ PROP. CULVERT 75

H 1:400
V 1:200

CONT No
GWP No 2504-17-00

HIGHWAY 400
CULVERT C75
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

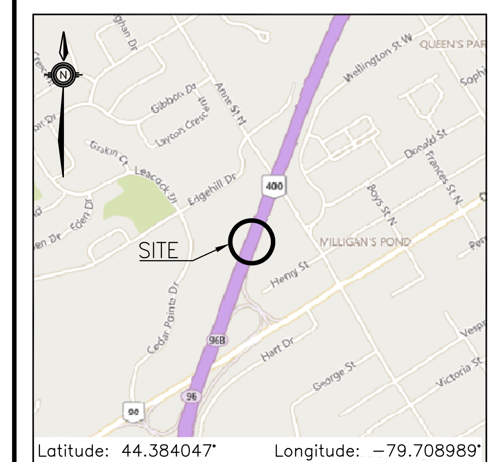
SHEET

McINTOSH PERRY

THURBER ENGINEERING LTD.

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
10/02/2020
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
S. PANG
35314509
10/02/2020
PROVINCE OF ONTARIO



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
C75-01	231.9	4 916 050.4	288 129.6
C75-02	233.7	4 916 025.7	288 148.0
C75-03	232.3	4 916 017.4	288 183.1
C75-04	233.6	4 916 033.8	288 136.4
C75-05	233.4	4 916 006.9	288 171.4

-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 10.

GEOCRES No. 31D-738

REVISIONS	DATE	BY	DESCRIPTION
DESIGN RPR	CHK SKP	CODE	LOAD	DATE OCT 2020
DRAWN AN	CHK RPR	SITE	STRUCT	DWG 1

MINISTRY OF TRANSPORTATION, ONTARIO

FILENAME: H:\Drafting\22000\22424\TES-22424-PLPP-C75.dwg
PLOTDATE: 10/5/2020 11:58 AM

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Appendix E

Foundation Comparison

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COMPARISON OF ALTERNATIVE CULVERT TYPES

Concrete Box (Closed) Culvert	Concrete Open Footing Culvert	Corrugated Steel Pipe (CSP) Culvert
Advantages: i. Relatively rapid installation and less disturbance to subgrade soils if pre-cast segments are used. ii. Segmental option can accommodate limited amount of potential differential settlement along culvert axis. iii. Less requirement for soil geotechnical resistances as loading is spread over a larger width. iv. Can accommodate differential settlement. ***Disadvantages:*** i. More expensive than a CSP culvert and sheet pile system. ii. Culvert subgrade preparation and bedding placement must be carried out in the dry. iii. Dewatering is required. iv. Requires subexcavation of soft or organic material from streambed if encountered. v. Requires complete excavation of creek bed. vi. Roadway protection will be required.	***Advantages:*** i. Relatively rapid installation if precast units are used. ii. Conventional construction. iii. Generally, less costly than deep foundation elements. iv. Eliminates bedding requirement. v. May have less environmental issues such as those involving spawning fish species. ***Disadvantages:*** i. Requires higher soil geotechnical resistances to support strip footings. ii. Requires deeper excavation below the groundwater level. iii. High groundwater levels Dewatering will be required. Potential longer dewatering requirements. iv. Cannot tolerate differential settlement. v. Shallow foundations close to water would be at risk due to scour, erosion and undermining problems. vi. Roadway protection will be required.	***Advantages:*** i. May be installed using trenchless methods. ii. Ease of construction. iii. CSP's can accommodate small differential settlement along culvert axis iv. Steel pipes are likely to be more cost effective than concrete box or open footing culverts. ***Disadvantages:*** i. Possible hydraulic and/or hydrologic issues. ii. Multiple pipes may be needed to meet hydraulic requirements. iii. CSP cannot be rehabilitated as concrete culverts. iv. Culvert subgrade preparation and bedding placement must be carried out in the dry. v. Dewatering is required. vi. Requires subexcavation of soft or organic material from streambed if encountered. vii. Roadway protection will be required.
RECOMMENDED	**NOT RECOMMENDED**	**FEASIBLE**

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Appendix F

List of OPSS Documents NSSP Wording

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1. List of OPSS and OPSD Referenced in this Report

-	OPSS PROV 206	Construction specification for grading
-	OPSS PROV 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
-	OPSS PROV 501	Construction specification for compacting
-	OPSS.PROV 517	Construction specification for dewatering
-	SP 517F01	Amendment to OPSS 517
-	OPSS PROV 539	Construction specification for temporary protection systems
-	OPSS PROV 804	Construction specification for seed and cover
-	OPSS PROV 902	Construction specification for excavating and backfilling – Structures
-	NSSP FOUN0003	Amendment to OPSS.PROV 902
-	OPSS PROV 1010	Material specification for aggregates - base, subbase, select subgrade, and backfill material
-	OPSS PROV 1205	Material Specification for Clay
-	OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans less than or equal to 3.0 m.
-	OPSD 208.010	Benching of Earth Slope

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2. Suggested Text for NSSP on Groundwater Control

High groundwater levels and permeable soils are present at this site. Therefore, water inflow/seepage should be anticipated from the embankment fill and underlying native sands and silts, and surface runoff and precipitation will accumulate within the excavation. Excavation into the wet cohesionless soils below the water level will encounter sloughing of unsupported excavation sidewalls, caving and subgrade loosening/softening. The Contractor must implement effective dewatering measures during construction and prior to excavating below the water level. Effective dewatering shall be designed and provided by the Contractor during structure excavation, bedding placement and backfilling to allow the work to proceed in the dry. A combination of interlocking sheetpiles along the culvert alignment where required, cofferdam enclosures at the inlet and outlet areas, surface water diversion, vacuum well-points where required, and pumping from filtered sumps may be warranted. The dewatering system must be effective to maintain the water level at a minimum depth of 0.5 m below the final subgrade level throughout construction. The dewatering system must remain operational and effective until the culvert is installed and backfilled.

The dewatering system is to be designed in accordance with SP FOUN0003 and OPSS.PROV.517. A preconstruction survey is required, thus Designer Fill-In ** in SP FOUN0003 should be "Yes".

It is recommended that a Professional Engineer with more than 5 years of experience in designing dewatering systems be retained to design and implement a dewatering system.

3. Suggested Wording for NSSP on Obstructions

Excavations and installation of cofferdams and roadway protection systems could encounter obstructions embedded in the fill and native soils. Such obstructions may impede excavation progress and/or sheet pile installation. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths.

DEWATERING STRUCTURE EXCAVATIONS - Item No.

Special Provision No. FOUN0003 March 8, 2018

Amendment to OPSS 902, November 2010

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

902.02 REFERENCES

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

Ontario Provincial Standard Specifications, Construction

OPSS 517 Dewatering
OPSS 805 Temporary Erosion and Sediment Control Measures

902.03 DEFINITIONS

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

Automatic Transfer Switch means as defined in OPSS 517.

Cofferdam means as defined in OPSS 539.

Cut-Off Wall means as defined in OPSS 517.

Design Storm Return Period means as defined in OPSS 517.

Dewatering System means as defined in OPSS 517.

Groundwater Control System means as defined in OPSS 517.

Plug means as defined in OPSS 517.

Sediment means as defined in OPSS 517.

Sediment Control Measure means as defined in OPSS 517.

Temporary Flow Passage System means as defined in OPSS 517.

Unwatering means as defined in OPSS 517.

Vegetated Discharge Area means as defined in OPSS 517.

Waterbody means as defined in OPSS 517.

Watercourse means as defined in OPSS 517.

902.04 DESIGN AND SUBMISSION REQUIREMENTS

902.04.01 Design Requirements

902.04.01.01 Dewatering

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

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

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

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

902.04.02 Submission Requirements

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

902.04.02.01 Working Drawings

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

902.04.02.02 Preconstruction Survey

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

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

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

902.04.02.03 Milestone Inspections

Clause 902.04.02.03 of OPSS 902 is deleted in its entirety.

902.07 CONSTRUCTION

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

902.07.04 Dewatering Structure Excavation

902.07.04.01 General

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

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

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

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

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

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

Unwatering shall be carried out as necessary.

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

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

902.07.04.02 Discharge of Water

The discharge of water shall be according to OPSS 517.

902.07.04.03 Monitoring

Monitoring shall be according to OPSS 517.

902.07.04.04 System Amendments

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

902.07.04.05 Removal

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

NOTES TO DESIGNER:

<u>Designer Fill-Ins</u>

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

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

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

CUSTODIAN: Tony Sangiuliano, MERO - Foundation Group.

DEWATERING SYSTEM - Item No.
TEMPORARY FLOW PASSAGE SYSTEM - Item No.

Special Provision No. 517F01 July 2017

Amendment to OPSS 517, November 2016

Design Storm Return Period and Preconstruction Survey Distance

517.01 SCOPE

Section 517.01 of OPSS 517 is deleted in its entirety and replaced with the following:

This specification covers the requirements for the design, operation, and removal of a dewatering or temporary flow passage system or both to control water during construction, and the control of the water prior to discharge to the natural environment and sewer systems.

517.04 DESIGN AND SUBMISSION REQUIREMENTS

517.04.01 Design Requirements

Subsection 517.04.01 of OPSS 517 is amended by deleting the first paragraph in its entirety and replacing it with the following:

A dewatering or temporary flow passage system or both shall be designed to control water at the locations specified in the Contract Documents and at any other location where a system is necessary to complete the work. The design of the system shall be sufficient to permit the work at each location to be carried out as specified in the Contract Documents.

Subsection 517.04.01 of OPSS 517 is further amended by deleting the second last paragraph in its entirety and replacing it with the following:

Temporary flow passage systems shall be designed, as a minimum, for a 2 year design storm return period and groundwater discharge, except for the work specified in Table A. For the work specified in Table A, the temporary flow passage system shall be designed, as a minimum, for the design storm return period specified in Table A and groundwater discharge. A longer return period shall be used when determined appropriate for the work.

Intensity-Duration Factor (IDF) curve location, site specific minimum return period, return period flow estimates, and other information is provided in Table A. The IDF information can be accessed through the MTO IDF Curve Look up Tool on the Drainage and Hydrology page of MTO's website. The return period flow estimates do not include flow volumes from groundwater discharge. The Owner specifically excludes these flow estimates from the warranty in the Reliance on Contract Documents subsection of OPSS 100, MTO General Conditions of Contract.

Table A

<table>
<tr><td colspan="3">IDF Curve Location</td><td colspan="3">Latitude: *</td><td colspan="2">Longitude: *</td></tr>
<tr><td colspan="8">Temporary Flow Passage Systems</td></tr>
<tr><td rowspan="2" colspan="2">Site Name /
Station Reference</td><td rowspan="2">Minimum
Return Period
(Years)</td><td colspan="4">Return Period Flow Estimates (m³/s)</td><td rowspan="2">Design Engineer
Requirements
(Note 1)</td></tr>
<tr><td>2
Year</td><td>5
Year</td><td>10
Year</td><td>25
Year</td></tr>
<tr><td colspan="2">**</td><td>***</td><td>****</td><td>****</td><td>****</td><td>****</td><td>*****</td></tr>
<tr><td colspan="8">Dewatering Systems</td></tr>
<tr><td colspan="2">Site Name /
Station Reference</td><td colspan="5">Preconstruction Survey Distance (Note 2)
(m)</td><td>Design Engineer
Requirements
(Note 1)</td></tr>
<tr><td colspan="2">**</td><td colspan="5">******</td><td>*****</td></tr>
<tr><td colspan="8">Note:
1. “Yes” means the design Engineer and design-checking Engineer shall have a minimum of 5 years of experience in designing systems of similar nature and scope to the required work. “No” means a minimum experience level is not required for the design Engineer and design-checking Engineer.
2. “N/A” indicates a preconstruction survey is not required.</td></tr>
</table>