THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT
16th AVENUE STORM SEWERS
HIGHWAY 404 HOV LANE EXPANSION AND REHABILITATION
CONTRACT 2
FROM HIGHWAY 407 TO MAJOR MACKENZIE DRIVE
MARKHAM, ONTARIO
G.W.P. 2930-17-00

GEOCRES NO. 30M14-503

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Report

to

WSP Canada Inc.

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TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

THURBER

APPENDICES

THURBER

FOUNDATION INVESTIGATION AND DESIGN REPORT
16th AVENUE STORM SEWERS
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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the proposed 16TH Avenue storm sewers (Contract 2) under Highway 404 from the Highway 404 Ramp N/E-W, (approximately STA 14+675) to approximately 100 m west of Catchet Woods Court (approximately STA 15+227) in the City of Markham, Ontario.

The purpose of this investigation was to explore the subsurface conditions at selected locations along the alignment and based on the data obtained, to provide borehole location plans, stratigraphic profiles, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by WSP Canada Inc. (WSP) to carry out this foundation investigation under the MTO Assignment Number 2016-E-0014.

Reference has been made to information on subsurface conditions contained in a previous foundation report prepared for this site. The title of this report is as below:

- Foundation Investigation Report for Highway 404 16th Avenue Overpass, Replacement and Widening, Highway 404 HOV Lane Expansion and Rehabilitation, Contract 2, Markham, Ontario, Site 37-666, G.W.P. 2930-17-00, GEOCRES No. 30M14-487 prepared by Thurber Engineering, dated January 30, 2019 (Reference 1).

Specifically, Boreholes 16TH-06 and 16TH-07 were referenced from this report.

2. PROJECT AND SITE DESCRIPTION

There are two storm sewer alignments covered in this report, both of which extend along 16th Avenue from the Highway 404 Ramp N/E-W (approximately STA 14+675) to approximately 100m west of Catchet Woods Court (approximately STA 15+227). The southern alignment runs approximately along the existing right eastbound lane of 16th Avenue, and the northern alignment runs approximately 10 m north of the north edge of 16th Avenue. Each sewer will be in the order of 500 m in length with pipe diameters ranging between 300 mm and 450 mm, except for the portion just north of the north abutment where the diameter will be 1,200 mm. The general locations of the proposed works are shown on the key plan and on the Borehole Locations and Soil Strata Drawings in Appendix D.

The land use adjacent to the north side of 16th Avenue consists of commercial office buildings and the grassy lands making up the Hwy 404 and 16th Avenue interchange. Along the south side of 16th Avenue to the west of Highway 404, the land use is also commercial with office buildings and parking lots. Buttonville Airport occupies the southeast quadrant of the site.

The project alignment is located within the physiographic region known as the Peel Plain. The topography is flat and gently undulating. The soil cover in the region typically comprises silty clay glacial tills with sand and silt layers. Shale bedrock of the Georgian Bay Formation is anticipated at an approximate depth of 50 m.

3. SITE INVESTIGATION AND FIELD TESTING

Site investigation and field testing for the proposed sewers consisted of drilling and sampling a total of 10 boreholes to depths ranging from 6.1 m to 6.7 m (Elevations 191.5 m to 184.3 m). Deeper boreholes drilled for previous investigations in the area (Boreholes 16TH-06 and 16TH-07 from Reference 1), varied in depth from 34.6 m to 39.2 m (Elevations 155.4 m to 150.8 m). All boreholes for the current investigation were drilled within the period of March 12 to March 18, 2019.

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

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawings in Appendix D. The coordinates and elevations of the boreholes are given on these

drawings and on the individual Record of Borehole Sheets in Appendices A and C. Northing and easting co-ordinates at the current borehole locations were obtained by Thurber using a GPS unit, and the corresponding ground surface elevations were provided by WSP based on the project DTM survey. The precision of the horizontal survey of the boreholes is rated at within 1 m, whereas the precision of the elevations is the same as that of the DTM survey.

The current boreholes were advanced using track-mounted D-25 and truck mounted D-90 drill rigs. The drill rigs were operated using half-mast for most of the boreholes due to height restrictions imposed by the airport. Solid stem augers were used to advance the boreholes, and soil samples were obtained at selected intervals using a 50-mm diameter split spoon sampler in conjunction with the Standard Penetration Test (SPT).

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full-time basis. The supervisor logged the boreholes, visually examined the recovered soil samples, and transported them to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Two standpipe piezometers were installed during the current investigation in Boreholes SS-02 and SS-06 to permit monitoring of groundwater levels. The standpipe piezometers consisted of a 19 mm diameter Schedule 40 PVC pipe with a 1.5 m long slotted screen and were installed within a column of filter sand. Upon completion, the boreholes were abandoned in general accordance with Ontario Regulation 903 amended by Ontario Reg. 372 (O.Reg. 903). The piezometers have been decommissioned in general accordance with O.Reg. 903 after the final readings were taken. The details of the current borehole completion are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth/ Elevation (m)	Completion Details
SS-01	6.4/186.0	None installed	Borehole backfilled with bentonite holeplug and auger cuttings, then asphalt patch to surface.

Borehole	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth/ Elevation (m)	Completion Details
SS-02	6.5/187.0	6.5/187.0	Piezometer with 1.5 m slotted screen installed with sand filter from 6.5 m to 4.3 m, bentonite holeplug from 4.3 m to 0.5 m, then auger cuttings from 0.5 m to ground surface.
SS-03	6.7/184.3	None installed	Borehole backfilled with bentonite holeplug and auger cuttings, then asphalt patch to surface.
SS-04	6.7/186.0	None installed	Borehole backfilled with bentonite holeplug to 1.5 m, then auger cuttings to surface.
SS-05	6.1/184.5	None installed	Borehole backfilled with bentonite holeplug and auger cuttings, then asphalt patch to surface.
SS-06	6.7/185.3	6.1/185.9	Piezometer with 1.5 m slotted screen installed with sand filter from 6.7 m to 3.3 m, bentonite holeplug from 3.3 m to 1.2 m, bentonite mixed with auger cuttings from 1.2 m to ground surface.
SS-07	6.7/187.1	None installed	Borehole backfilled with bentonite holeplug and auger cuttings, then asphalt patch to surface.
SS-08	6.7/189.8	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 0.5 m, then dry cement to 0.2 m, then asphalt patch to surface.
SS-09	6.7/190.7	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 0.5 m, then dry cement to 0.2 m, then asphalt patch to surface.
SS-10	6.7/191.5	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 0.5 m, then dry cement to 0.2 m, then asphalt patch to surface.

4. LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size analysis and Atterberg Limits testing. All the laboratory tests were carried out in accordance with MTO and/or ASTM Standards, as appropriate. The results of the laboratory testing are summarized on the Record of Borehole sheets and on the accompanying figures in Appendices A to C.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

This section presents a generalized summary of the subsurface conditions encountered at the boreholes drilled along the proposed sewer alignments. Borehole location plans and stratigraphic profiles along the sewer alignments are presented on the Borehole Locations and Soil Strata Drawings in Appendix D. Records of Borehole sheets and laboratory testing data are also included in Appendices A to C.

Boreholes 16TH-06 and 16TH-07 from Reference 1 are used in this discussion of subsurface conditions. The soil conditions in these boreholes below depths of 6.7 m are not discussed in this report but can be further reviewed in the report from Reference 1.

In general, the soil stratigraphy encountered along the proposed sewer alignment typically consists of pavement structure (asphalt on granular) and fill overlying native soils which typically comprised compact to dense sandy silt to silty sand overlying stiff to hard clayey silt to silty clay till.

More detailed descriptions of the individual stratum are presented below.

5.1 Organic Sand and Silt

Organic sand and silt, with some gravel and clay was encountered at the surface in Boreholes SS-02, SS-04, and SS-06. The thickness of the layer ranged from 0.3 m to 0.7 m. The thickness of the organic soils may vary between and beyond the borehole locations, and the data is not intended for the purpose of estimating quantities.

SPT ‘N’ values recorded in the organic sand and silt ranged from 9 to 16 blows for 0.3 m penetration with one value exceeding 100 blows for 0.15 m penetration, indicating a typically loose to compact condition. The higher ‘N’ value may be attributed to the presence of cobbles. Moisture contents between 11 percent and 35 percent were measured in the organic sand and silt.

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

Soil Particle	Percentage (%)
Gravel	12
Sand	38
Silt	37
Clay	13

5.2 Asphalt

Boreholes SS-01, SS-03, SS-05, SS-07 to SS-10, 16TH-06 and 16TH-07 were drilled through paved sections 16th Avenue. The asphalt ranged in thickness from 100 mm to 200 mm.

5.3 Sand and Gravel to Sand Fill

Fill consisting of sand and gravel to sand, some gravel and trace to some silt and clay was encountered beneath the asphalt in Boreholes SS-01, SS-03, SS-05, SS-07 to SS-10, 16TH-06 and 16TH-07 drilled within the paved portion of 16th Avenue. The sand and gravel to sand fill had a thickness of between 0.6 m and 1.9 m and extended to depths of approximately 0.8 m to 2.0 m (Elevation 189.2 to 196.8).

SPT ‘N’ values within the gravelly sand to sand fill ranged from 9 blows for 0.3 m of penetration to 100 blows for 0.15 m of penetration, indicating a loose to very dense condition. Moisture contents between 1 percent and 18 percent were measured in the fill.

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

Soil Particle	Percentage (%)
Gravel	11 to 29
Sand	54 to 74
Silt and Clay	15 to 18

5.4 Silt

A layer of silt, containing trace clay and trace sand, was encountered in Borehole SS-08 beneath the gravelly sand fill at a depth of approximately 1.4 m (Elevation 195.1 m). The silt layer was approximately 0.8 m thick and extended to a depth of approximately 2.2 m (Elevation 194.3 m).

An SPT 'N' value measured in the silt was 27 blows for 0.3 m penetration, indicating a compact condition. A moisture content of 20 percent was measured in the silt.

The result of a grain size distribution analysis carried out on a selected sample of the silt is presented on the Record of Borehole sheets included in Appendix A and on Figure B3 of Appendix B. The results of the grain size analysis are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	4
Silt	86
Clay	10

5.5 Sand

Sand, containing trace gravel and trace silt, was encountered in Boreholes 16TH-06 and 16TH-07 beneath the sand and gravel fill at a depth of approximately 0.8 m (Elevation 189.2 m). The sand was approximately 0.7 m to 1.5 m thick and extended to depths of 1.5 m and 2.3 m (Elevations 188.5 m and 187.7 m).

SPT 'N' values within the sand ranged from 23 to 41 blows for 0.3 m of penetration, indicating a compact to dense condition. Moisture contents between 4 percent and 19 percent were measured in the sand.

5.6 Silty Sand to Sandy Silt

Silty sand to sandy silt was encountered in Boreholes SS-05 to SS-10 at depths of between 0.7 m and 2.2 m (Elevations 189.2 m and 196.0 m). Where fully penetrated in Boreholes SS-05, SS-06, SS-07, and SS-09, the silty sand to sandy silt layer was approximately 0.8 m to 5.1 m thick and extended to depths of approximately between 1.5 m and 6.5 m (Elevations 188.4 m and 190.9 m). Boreholes SS-08 and SS-10 were terminated within the silty sand to sandy silt layer at a depth of 6.7 m (Elevations 189.8 m and 191.5 m, respectively).

SPT 'N' values within the silty sand to sandy silt ranged from 5 to 71 blows for 0.3 m of penetration, with typical values between 18 and 46 blows, indicating a compact to dense condition. Moisture contents between 4 percent and 20 percent were measured in the silty sand to sandy silt.

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

Soil Particle	Percentage (%)
Gravel	0 to 1
Sand	20 to 76
Silt	21 to 78
Clay	2 to 5

5.7 Upper Clayey Silt Till

An upper layer of clayey silt till, with sand, and trace gravel, was encountered in Borehole SS-10 at a depth of 1.4 m (Elevation 196.8 m). This till was approximately 0.8 m thick and extended to a depth of approximately 2.2 m (Elevation 196.0 m).

An SPT 'N' value measured in the upper clayey silt till was 13 blows for 0.3 m penetration, indicating a stiff consistency. A moisture content of 22 percent was measured in the clayey silt till.

The result of a grain size distribution analysis carried out on a sample of the upper clayey silt till is presented on the Record of Borehole sheets included in Appendix A and on Figure B5 of Appendix B. The results of the grain size analysis are summarized below:

Soil Particle	Percentage (%)
Gravel	3
Sand	38
Silt	40
Clay	19

Glacial tills inherently contain cobbles and boulders.

5.8 Lower Clayey Silt to Silty Clay Till

A lower layer of clayey silt to silty clay till, with sand and trace gravel, was encountered in Boreholes SS-01 to SS-07, SS-09, 16TH-06 and 16TH-07 at depths of between 0.3 m to 6.5 m (Elevations 187.7 m to 193.2 m). Boreholes SS-01 to SS-07, and SS-09 were terminated within the lower clayey silt to silty clay till layer at depths of between 6.1 m to 6.7 m (Elevations 184.3 m to 190.7 m).

SPT 'N' values within the lower clayey silt to silty clay till ranged from 4 blows for 0.3 m of penetration to 100 blows for 0.075 m penetration, with typical values between 12 and 30 blows, indicating a stiff to hard condition. In-situ vane shear tests conducted in Boreholes 16TH-06 and 16TH-07 indicated undrained shear strengths of 32 to 86 kPa, which corresponds to a firm to stiff consistency. Grinding of augers was observed below 4.5 m within the 100-blow till in Boreholes SS-01 and SS-02. Moisture contents between 8 percent and 25 percent were measured in the lower clayey silt to silty clay till.

The results of grain size distribution analyses and Atterberg Limits testing carried out on selected samples of the clayey silt to silty clay till are presented on the Record of Borehole sheets included in Appendix A and on Figures B6, B7 and B8 of Appendix B. The results of the grain size analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0 to 15
Sand	2 to 43
Silt	31 to 77
Clay	11 to 61

The results of Atterberg Limits testing are summarized below:

Index Property	Percentage (%)
Plastic Index	7 to 17
Liquid Limit	19 to 32

The results of the Atterberg Limits testing indicate this till to be of low plasticity with group symbol CL.

Glacial tills inherently contain cobbles and boulders.

5.9 Groundwater Conditions

Groundwater conditions were observed during drilling operations, and groundwater levels were measured in the open boreholes upon completion of drilling. Standpipe piezometers were installed in Boreholes SS-02 and SS-06 from the current investigation to monitor the groundwater level at the site. Piezometers were also installed in Boreholes 16TH-06 and 16TH-07 from the previous investigation. The groundwater levels measured in the open boreholes and in the standpipe piezometers are summarized below.

Table 5.4- Measured Groundwater Levels

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
SS-01	March 13, 2019	5.8	186.6	Open borehole.
SS-02	March 17, 2019	Dry	Dry	Standpipe piezometer
	March 26, 2019	2.0	191.5	
	August 8, 2019	2.5	191.0	
SS-03	March 13, 2019	4.6	186.4	Open borehole
SS-04	March 18, 2019	3.0	189.7	Borehole caved to 3.4m upon completion
SS-05	March 12, 2019	1.2	189.4	Borehole caved to 1.2 m upon completion
SS-06	March 17, 2019	1.5	190.5	Standpipe piezometer
	March 26, 2019	0.6	191.4	
	August 8, 2019	0.6	191.4	
SS-07	March 12, 2019	2.9	190.9	Borehole caved to 2.9 m upon completion
SS-08	March 17, 2019	4.2	192.3	Open borehole
SS-09	March 17, 2019	4.8	192.6	Open borehole
SS-10	March 17, 2019	5.8	192.4	Open borehole
16TH-06	October 9, 2018	3.1	186.9	Standpipe piezometer
	November 22, 2018	0.0	190.0	
	August 8, 2019	Found destroyed		
16TH-07	August 20, 2018	0.0	190.0	Standpipe piezometer
	October 9, 2018	0.8	189.2	
	August 8, 2019	0.2	189.8	

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

6. MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. WSP provided the ground surface elevations based on northing and eastings coordinates obtained with a GPS unit.

DBW Drilling of Toronto, Ontario, and Walker Drilling of Utopia, Ontario, supplied and operated a truck-mounted D-90 and a track mounted D-25 drill rigs, respectively, to carry out the drilling, sampling and in-situ testing operations in the boreholes.

The drilling and sampling operations in the field were supervised on a full-time basis by Mr. Kevin Kweon and Mr. Bryan Lui of Thurber. Geotechnical laboratory testing was carried out by Thurber in its MTO-approved laboratory. Overall supervision of the field program was carried out by Mr. Stephane Loranger, CET.

Overall project management was provided by Dr. Sydney Pang, P.Eng. Interpretation of the field data and preparation of this report was completed by Mr Cory Zanatta, 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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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This section of the report presents foundation recommendations and comments for the design and installation of two storm sewer alignments along 16TH Avenue (Contract 2). The alignments generally run under Highway 404 from the Highway 404 Ramp N/E-W on the west side, (approximately STA 14+675) to approximately 100 m west of Catchet Woods Court on the east side (approximately STA 15+227) in the City of Markham, Ontario.

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

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

8. STORM SEWER

Based on information from WSP, the two sewer alignments consist of a southern alignment which runs approximately along the existing right (eastbound) lane of 16th Avenue, and a northern alignment which runs approximately 10 m north of the existing north edge of 16th Avenue. Each sewer alignment will be in the order of 500 m in length with a pipe diameter ranging between 300mm to 450 mm, except for the portion just north of the north abutment of the proposed Highway 404 overpass where the pipe diameter will be 1,200 mm. The vertical profile of the sewers will typically follow the 16th Avenue road grade and the invert depths below existing ground surface will vary from about 3 m between the west limit and under the bridge, to about 2 m to the east of the bridge. A WSP storm sewer profile drawing shows that the invert elevations dipping from Elevations 190 to 191 m at the west limit to about Elevation 187 m below the bridge, and then rising to about Elevation 196 m at the east limit.

It is anticipated that installation of the proposed sewers is to be carried out by trenching. Where temporary protection (shoring) is not required, a trench box system should be adequate for enhancing worker safety for relatively shallow excavations. For deeper excavations, or where water seepage is a concern, or where adjacent ground movement is to be minimized, temporary protection such as interlocking sheetpiles or soldier piles and lagging may be considered. Sloped open cuts may be possible in some cases if there is sufficient available space adjacent to the trench. Water control in the form of sump pumping will generally be required in conjunction with various forms of earth support and excavation outlined above. In areas where water-bearing sands and silts are present at or above the trench invert, dewatering in the form of localized groundwater lowering using well points, or interlocking steel sheet piles to provide partial groundwater cutoff, may be required.

Prior to placement of the pipe bedding, the base of the trench excavation must be properly dewatered and dry, and free of disturbed or loose soil. In order to confirm uniformity along the alignment, the exposed subgrade should be inspected and approved prior to placing and compacting the bedding. Any identified disturbed/wet soils should be sub-excavated and replaced with compacted granular materials or clear crushed stone as per OPSS.PROV 1004. It is critical that the pipe be supported on well prepared bedding overlying a competent and uniform subgrade in order to minimize the potential for differential settlement.

It is recommended that sewer pipe installation, trenching, backfilling and compacting be carried out in accordance with OPSS.PROV 401, OPSS.PROV 410, OPSS 492 and OPSD 802.030, OPSD 802.031, OPSD 802.032 as appropriate. Care must be exercised when compacting the

fill immediately above the crown of the pipe in order not to damage the pipe. Reference should also be made to OPSS.PROV 501 and OPSS.PROV 1010.

8.1 Excavation and Groundwater Control

The following outlines the subsurface conditions that are likely to be encountered at the trench sidewalls and subgrade for the storm sewers.

The subsurface along both the north and south sewer alignments consists of a pavement structure, or organic sand and silt, overlying layers of gravelly sand to sand and gravel fill, which are typically underlain by compact to dense sand and silt to silty sand to the east of the bridge. Very stiff to hard clayey silt to silty clay till underlies the above soil deposits along the entire sewer alignments. The groundwater levels measured in the piezometers ranged from about 0 m (ground surface) to 3 m below ground surface, which are generally above the proposed pipe invert level. It is anticipated that the pipe subgrade would typically consist of very stiff to hard clayey silt to silty clay till from the westerly limit of the alignments to just east of the proposed Highway 404 overpass, where the subgrade will begin to transition into the water-bearing compact to dense silty sand to sand and silt at shallow depths above the till.

In general from the west limit to under the bridge, it is anticipated that excavations will be carried out through surficial fill and organic sand and silt into the clayey silt to silty clay till. Along this section, trench boxes with conventional sump pumping may be considered for sewer installation. It is noted that a trench box is primarily used to enhance the safety of workers inside trenches and is not effective in minimizing water seepage or limiting adjacent ground movements.

Some movement of the adjacent ground should be expected where trench boxes or timber sheathings are used. If this becomes a concern, consideration may be given to limiting the length of an excavation such that the pipe within the excavated section can be laid and the trench properly backfilled during the course of the same day.

Regardless of whether open cutting, trench box or other types of ground support is used, ground movement adjacent to trenches must be subjected to the criterion associated with Performance Level 2 as per Clause 539.04.01.01 in OPSS.PROV 539 (also see Section 8.2 Temporary Protection System). It is recommended that a new NSSP or additional statements to an existing NSSP be included in the contract documents. Suggested wording of such statements is included in Appendix E.

In general, from under the bridge to the east limit, it is anticipated that excavations are primarily through surficial fill into the cohesionless water-bearing sands and silts. Along this section, sloughing of the trench sidewalls should be expected especially in cases where the groundwater level is above the trench base. At these locations, temporary protection (shoring) in conjunction with localized effective dewatering, e.g. well points or sheetpile cutoff, may need to be used.

The contractor should be alerted that it is their responsibility to carry out groundwater control during excavation. Water seepage should be expected from the sands and silts that are likely to be exposed at and above the base of the trenches to the east of the bridges, water-bearing seams/layers within the clayey silt to silty clay till, and perched water within the existing surficial fill. Along sections where the trench subgrade is below the groundwater table, partial water cutoff such as steel interlocking sheetpiles may be required to reduce the risk of base boiling. Sump pumping will be required in all cases to maintain reasonably dry excavations. Surface runoff and precipitation should be diverted away from all trench excavations where practicable.

Dewatering and unwatering should be carried out in accordance with OPSS.PROV 517, SP 517F01 Amendment to OPSS 517, November 2016 (issued July 2017). There is no pre-construction condition survey and dewatering design engineer requirements.

It is noted that cobbles or boulders should be expected in the tills and the fills. Excavation of these obstructions and hard/very dense zones within the till is anticipated to be laboured and difficult. The contractor's excavating equipment must be capable of dislodging, handling and removing the obstructions, and penetrating the hard/very dense zones to reach the desired depths.

All excavations should conform to the requirements of the latest edition of the Ontario Occupational Health & Safety Act (OHSA), its regulations and other applicable local regulations. For the purpose of OHSA, the fill and native soils above the groundwater level may be classified as Type 3 soils. The clayey silt to silty clay till below the groundwater level may also be classified as a Type 3 soil. The fills and cohesionless soils below the groundwater level should be classified as Type 4 soils.

Where space permits and at the ends of the trenches, slopes of temporarily unsupported cuts conforming with the requirements of the OHSA may be formed, but should not be steeper than 1H : 1V above the groundwater level. Flatter slopes may be required at locations where water seepage or sloughing occurs during excavation.

Where excavation for pipe installation is located in close proximity to existing buried utilities and where temporary protection is otherwise required, consideration may be given to using interlocking sheetpile walls, or soldier pile and timber lagging walls. Design of a temporary protection system is the responsibility of the contractor (see Section 8.2 below).

Furthermore, should sloughing or caving occur at depths below the water table or at any other location, the contractor must immediately modify the excavating and shoring methods, and construction sequence in order to prevent further sloughing from occurring, and full support must be provided to the trench walls. It is always a good practice to excavate from areas of low trench invert elevations to areas of higher elevation (i.e. uphill) so that the previously placed sewer backfill may act as a drain to the subsequent sections of the trench.

Decisions regarding shoring methods and sequencing should be made by the contractor. Any required shoring system must be designed by a licensed Professional Engineer experienced in such designs. Any dewatering system must be designed by specialists experienced in such designs.

The sewer design should take into account any protective measures that may be required for crossing below any existing gas lines, hydro lines, watermains, structures and any other buried facilities that may exist in the vicinity of the work areas. This may require discussions with relevant owners of these facilities and design of temporary protection, support or relocation of the particular utility. During construction, some authorities may require that their representative(s) be on site on a full-time basis.

8.2 Temporary Protection System

Temporary protection (shoring) may be required at some locations as discussed above. An item titled “Protection System” as per OPSS.PROV 539 should be included in the contract documents. It is recommended that Performance Level 2 as per Clause 539.04.01.01 be used.

The design of temporary protection is the responsibility of the Contractor. However, soldier pile and wood lagging walls or interlocking steel sheetpile walls may be considered as temporary shoring at this site. It is anticipated that the protection system will extend predominantly through the existing pavement structure and sand and gravel to gravelly sand fill, into the compact to dense sand and silt to silty sand or the underlying stiff to hard clayey silt to silty clay till to develop the required toe resistance. Installation of temporary protection should consider that the existing embankment fill and glacial till may contain obstructions which may impede driving of sheetpiles.

A temporary shoring wall may be designed using the parameters given below:

Soil Bulk Unit Weight	γ	=	20 kN/m^3
Soil Submerged Unit Weight (below gwl)	γ'	=	10 kN/m^3
Coefficient of Active Pressure	K_a	=	0.33 (embankment fill)
		=	0.33 (sands and silts)
		=	0.31 (clayey silt to silty clay till)
Coefficient of Passive Pressure	K_p	=	3.0 (fill)
		=	3.0 (sands and silts)
		=	3.2 (clayey silt to silty clay till)

It is recommended that lateral earth pressures acting on the wall be computed in accordance with the CHBDC 2014. The surcharge should include soil loadings above the retained soil 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 groundwater pressure will have to be taken into account for a sheetpile wall design. 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 temporary protection system.

The designer of the temporary protection system should check whether the depth of embedment is sufficient to provide base fixity.

All temporary protection systems should be designed by a Professional Engineer experienced in such designs.

8.3 Sewer Bedding

Prior to placement of the pipe bedding, the base of the trench excavation must be dewatered and in a reasonably dry condition. Where loose and wet materials are exposed at subgrade level, sub-excavation of these disturbed materials will be required. Backfill to replace the over-excavation should consist of OPSS Granular A placed in 150 mm thick loose lifts and compacted to a minimum 95% of its Standard Proctor Maximum Dry Density (SPMDD). If a reasonably dry trench base cannot be maintained, the Granular A backfill may be substituted with 19 mm clear stones as specified in OPSS.PROV 1004.05.02. The clear stone should be continuously wrapped in non-woven, Class II (heavy duty) geotextile filter cloth with an apparent opening size of 0.212mm, such as a Terrafix 360R. It is critical that the pipe be supported on uniform, competent subgrade and well compacted bedding in order to minimize the potential of differential settlement. At locations where less competent subgrade is encountered, the bedding thickness may be locally increased.

It is recommended that pipe bedding and cover should be in accordance with current MTO practice. It is recommended that the bedding materials meet the gradation requirements for OPSS Granular A materials and should be placed in loose lifts not thicker than 150 mm and be compacted to 100% of its Standard Proctor Maximum Dry Density (SPMDD) within 2 percent of its optimum moisture content (OMC). The bedding thickness depends on the pipe diameter D, typically equal to 0.15D, but should be a minimum 150 mm and should extend to at least 300 mm above the crown of the pipe to provide a granular surround. Care must be exercised when compacting the fill immediately above the crown of the pipe in order not to damage the pipe. Reference should be made to OPSD 802.030, 802.031 and 802.032, where applicable.

8.4 Trench Backfill

It is anticipated that the excavated materials will generally consist of asphalt, sand and gravel to gravelly sand fill, native sand and silt soils and native clayey silt to silty clay till.

Under travelled portions of the roadway, granular materials satisfying OPSS.PROV 1010 requirements such as Granular B Type I should be used for trench backfilling.

Elsewhere beyond the roadway, excavated soils including sand and gravel to gravelly sand fill and native sands/silts above the groundwater level may be considered for use as trench backfill for the storm sewer, provided that the environmental requirements are met. However, the backfill soils must be unfrozen, free of organics, debris and other deleterious materials, and are at a moisture content suitable for compaction. Such fill should be placed in loose lifts of not more than 200 mm in thickness and compacted to a minimum 98 percent of the SPMDD within ±2 percent of its OMC.

Other excavated soils including sands and silts under the groundwater level and the silty clay to clayey silt till should not be used as backfill. The water-bearing sands and silts are likely to be too wet for adequate compaction, and it is difficult to achieve adequate compaction of the clay till within a narrow trench. Instead, granular materials meeting the gradation requirements of OPSS Granular B, Type I may be used as trench backfill. The backfill materials should be placed in loose lifts not exceeding 200 mm and be compacted to at least 98 percent of its SPMDD within ±2 percent of its OMC.

Excess excavated materials may be disposed of off site or reused as general fill for landscaping purposes elsewhere within the project.

9. CONSTRUCTION CONCERNS

Potential construction concerns that have been identified for this project include the following:

9.1 Loss of Ground

Trenching along the 16th Avenue for sewer installation will result in some adjacent ground movements depending on the soil and groundwater conditions. Although the risk of causing pavement distress is lower than trenchless methods, the Contractor must recognize that construction sequencing including the implementation of temporary protection (shoring) and groundwater control will be critical to limiting ground movements to within tolerable limits. The pavement surface should be monitored periodically for signs of distress.

9.2 Groundwater Control

Groundwater control will be required for installation of the storm sewer. Sump pumping will be required at all locations. Localized dewatering by means of vacuum well points may need to be implemented as required. Partial groundwater cutoff using interlocking sheetpile walls may be required at some locations. Surface runoff and precipitation should be diverted away from excavations at all times.

9.3 Obstructions

Glacial tills inherently contain cobbles and boulders, and the existing road fill may contain similar and other obstructions. The Contractor's equipment and methodology must be selected to handle such obstructions and successfully remove them without jeopardizing 16th Avenue, the bridge abutments and other infrastructure in the vicinity. The impact of such obstructions on the pipe alignments should be assessed.

It is recommended that the Contractor be alerted to the need to handle obstructions either by a Non-Standard Special Provision (NSSP) or otherwise by inclusion in the Contract Documents.

Suggested wording of a NSSP for the above is included in Appendix E.

9.4 Buried Utilities

The Contractor must accurately establish, in three dimensions, the locations of all buried utilities crossing or closely paralleling the storm sewer alignments. The sewer installation must not damage any adjacent existing utilities. Any discrepancy from the Contract Drawings must be reported to the Contract Administrator.

10. CLOSURE

Engineering analysis and report preparation was carried out by Mr. Cory Zanatta, P.Eng., and Mr. Sydney Pang, P.Eng. Mr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects, reviewed the report.

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THURBER ENGINEERING LTD.

Cory Zanatta, P.Eng.
Geotechnical Engineer

Sydney Pang, P.Eng
Associate, Senior Foundation Engineer

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

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Appendix A

Record of Borehole Sheets
(current investigation)

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

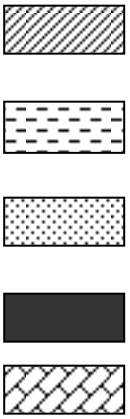
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, 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

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RECORD OF BOREHOLE No SS-01 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 858 315.0 E 314 701.0 ORIGINATED BY BC

HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2019.03.13 - 2019.03.13 LATITUDE 43.864740 LONGITUDE -79.376823 CHECKED BY CZ

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.4	GROUND SURFACE										
0.0	**ASPHALT:** (100mm)										
0.1	**SAND**, some gravel, some silt Loose to Dense Brown Moist (FILL)		1	GS			192				
			1	SS	37				○		11 74 15 (SI+CL)
190.4			2	SS	9		191		○		
2.0	Clayey **SILT**, with sand, trace gravel Stiff to Very Stiff Grey Moist (TILL)		3	SS	12		190		○		
			4	SS	19		189		○		2 30 46 22
	Hard		5	SS	100/ 0.275	▽	188		○		Augers grinding below 4.5m
186.0			6	SS	100/ 0.150		187		○		
6.4	END OF BOREHOLE AT 6.4m. BOREHOLE OPEN AND WATER LEVEL AT 5.8m COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS, THEN ASPHALT PATCH TO SURFACE.						186				

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
$\frac{}{10}$

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THURBER

RECORD OF BOREHOLE No SS-02 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 858 330.0 E 314 675.0 ORIGINATED BY BC

HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2019.03.17 - 2019.03.17 LATITUDE 43.864874 LONGITUDE -79.376325 CHECKED BY CZ

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.5	GROUND SURFACE										
0.0 / 193.2	Organic **SAND** and **SILT**, some clay, some gravel		1	SS	100/ 0.150		193				
0.3	Very Dense Brown Moist										
	Silty **CLAY**, with sand, trace gravel Hard to Very Stiff Brown Moist (TILL)		2	SS	33		192				3 23 39 35
			3	SS	24						
191.3											
2.2	Clayey **SILT**, with sand, trace gravel Very Stiff Brown Moist (TILL)		4	SS	17		191				
			5	SS	22	▼	190				2 26 54 18
	Hard						189				Augers grinding below 4.5m
			6	SS	100/ 0.075						
							188				
187.0			7	SS	100/ 0.225						
6.5	END OF BOREHOLE AT 6.5m. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2019.03.26 3.1 190.4										

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

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

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RECORD OF BOREHOLE No SS-03 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 858 330.0 E 314 741.0 ORIGINATED BY BC

HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2019.03.13 - 2019.03.13 LATITUDE 43.864875 LONGITUDE -79.377146 CHECKED BY CZ

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
191.0	GROUND SURFACE										
0.0	**ASPHALT:** (150mm)										
0.2	Gravelly **SAND**, some silt and clay Dense Brown Moist (FILL)		1	GS							
			1	SS	37		190				21 61 18 (SI+CL)
189.7											
1.3	Clayey **SILT**, with sand, trace gravel Very Stiff to Hard Grey Moist (TILL)		2	SS	20		189				
			3	SS	21						3 34 48 15
			4	SS	37		188				
						▽	187				
			5	SS	38		186				
			6	SS	40		185				
184.3											
6.7	END OF BOREHOLE AT 6.7m. WATER LEVEL AT 4.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS, THEN ASPHALT PATCH TO SURFACE.										

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

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

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RECORD OF BOREHOLE No SS-04 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 858 373.0 E 314 770.0 ORIGINATED BY BL

HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2019.03.18 - 2019.03.18 LATITUDE 43.865261 LONGITUDE -79.375963 CHECKED BY CZ

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.7	GROUND SURFACE										
0.0	Organic **SAND** and **SILT**, some clay, some gravel Compact Brown Moist		1	SS	16				○		12 38 37 13
192.0							192				
0.7	Silty **CLAY**, with sand, trace gravel Firm to Stiff Grey Moist (TILL)		2	SS	8				○		
			3	SS	7		191		○		0 16 55 29
			4	SS	9		190		○		
	Hard		5	SS	31	▽			○ ○		
							189				
	Firm to Stiff		6	SS	5		188		○		
							187				
			7	SS	8				○		
186.0							186				
6.7	END OF BOREHOLE AT 6.7m. BOREHOLE CAVED TO 3.4m AND WATER LEVEL AT 3.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.5m, THEN CUTTINGS TO SURFACE.										

+ ³, × ³: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No SS-05 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 858 381.0 E 314 878.0 ORIGINATED BY BC

HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2019.03.12 - 2019.03.12 LATITUDE 43.865332 LONGITUDE -79.374620 CHECKED BY CZ

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
190.6	GROUND SURFACE										
0.0	**ASPHALT:** (200mm)										
0.2	Gravelly **SAND**, some silt and clay Grey/Brown Moist (FILL)		1	GS					○		
189.2	Very Dense		1	SS	64	▽	190		○		29 54 17 (SI+CL)
1.4	Silty **SAND**, trace gravel, trace clay Compact Grey Wet		2	SS	22		189		○		
188.4											
2.2	Silty **CLAY**, with sand, trace gravel Very Stiff Grey Moist (TILL)		3	SS	17		188		○		2 30 42 26
			4	SS	22		187		○		
			5	SS	24		186		○		
			6	GS			185		○		
184.5											
6.1	END OF BOREHOLE AT 6.1m. BOREHOLE CAVED TO 1.2m AND WATER LEVEL AT 1.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS, THEN ASPHALT PATCH TO SURFACE.										

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

20
15 5
10
(%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No SS-06 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 858 436.0 E 314 954.0 ORIGINATED BY BC

HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2019.03.17 - 2019.03.17 LATITUDE 43.865826 LONGITUDE -79.373673 CHECKED BY CZ

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
192.0	GROUND SURFACE										
0.0 / 191.3	Organic **SAND** and **SILT**, some clay Loose Grey Moist		1	SS	9						
0.7 / 190.5	Sandy **SILT**, trace gravel Dense Grey/Brown Moist		2	SS	30		191				
1.5	Clayey **SILT**, with sand, trace to some gravel Very Stiff to Hard Grey Moist (TILL)		3	SS	18		190				3 30 47 20
			4	SS	18		189				
			5	SS	15		188				
			6	SS	30		187				15 43 31 11
			7	SS	59		186				
185.3											
6.7	END OF BOREHOLE AT 6.7m. WATER LEVEL AT 1.5m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2016.03.26 1.6 190.4										

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

$\frac{20}{15 \quad 5}$ (%) STRAIN AT FAILURE
$\frac{10}{}$

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Ontario

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RECORD OF BOREHOLE No SS-07 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 858 425.0 E 315 005.0 ORIGINATED BY BC

HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2019.03.12 - 2019.03.12 LATITUDE 43.865726 LONGITUDE -79.373039 CHECKED BY CZ

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
193.8	GROUND SURFACE										
0.0	**ASPHALT:** (200mm)										
0.2	Gravelly **SAND**, trace silt Very Dense Brown Moist (FILL)		1	GS					○		
192.4			1	SS	100/ 0.150		193		○		
1.4	Sandy **SILT**, trace gravel, trace clay Very Dense to Compact Grey Moist		2	SS	71		192		○		0 20 78 2
190.8			3	SS	18	▽	191		○		
3.0	Silty **SAND**, trace gravel, trace clay Loose Brown/Grey Wet		4	SS	5		190		○		
188.2			5	SS	7		189		○		1 76 21 2
5.6	Clayey **SILT**, with sand, trace gravel Very Stiff Grey Moist (TILL)		6	SS	28		188		○		
187.1											
6.7	END OF BOREHOLE AT 6.7m. BOREHOLE CAVED TO 2.9m AND WATER LEVEL AT 2.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS, THEN ASPHALT PATCH TO SURFACE.										

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

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

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 3/26/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SS-08 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 858 452.0 E 315 082.0 ORIGINATED BY KK

HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2019.03.17 - 2019.03.17 LATITUDE 43.865968 LONGITUDE -79.372080 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
196.5	GROUND SURFACE										
0.0	**ASPHALT:** (200mm)										
0.2	Gravelly **SAND**, trace silt Dense to Very Dense Brown Moist (FILL)		1	SS	33		196		○		
			2	SS	51				○		
195.1											
1.4	**SILT**, trace sand, trace to some clay Compact Brown Moist		3	SS	27		195		○		0 4 86 10
194.3											
2.2	**SAND** and **SILT**, trace clay Compact to Dense Brown to Grey Moist		4	SS	27		194		○		0 42 53 5
			5	SS	30		193		○		
						▽					
			6	SS	25		192		○		
							191				
			7	SS	35		190		○		
189.8											
6.7	END OF BOREHOLE AT 6.7m. BOREHOLE OPEN UPON COMPLETION AND WATER LEVEL AT 4.2m BELOW GROUND SURFACE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.5m, DRY CEMENT TO 0.2m, THEN ASPHALT TO SURFACE.										

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

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

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 3/26/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SS-09 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 858 478.0 E 315 110.0 ORIGINATED BY KK

HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2019.03.17 - 2019.03.17 LATITUDE 43.866183 LONGITUDE -79.371072 CHECKED BY CZ

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.4	GROUND SURFACE										
0.0	**ASPHALT:** (175mm)										
0.2	Gravelly **SAND**, trace silt Dense to Compact Brown Moist (FILL)		1	SS	39		197		○		
			2	SS	19				○		
196.0							196				
1.4	**SAND** and **SILT**, trace clay Compact Brown Moist		3	SS	24				○		
			4	SS	25		195		○		0 52 44 4
			5	SS	20		194		○		
			6	SS	28	▽	193		○		
							192				
190.9			7	SS	49		191		○		
190.7	Clayey **SILT**, trace sand								○		0 6 77 17
6.7	Hard Grey Wet (TILL)										
	END OF BOREHOLE AT 6.7m. BOREHOLE OPEN UPON COMPLETION AND WATER LEVEL AT 4.8m BELOW GROUND SURFACE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.5m, DRY CEMENT TO 0.2m, THEN ASPHALT TO SURFACE.										

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

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

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 3/26/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SS-10 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 858 476.0 E 315 163.0 ORIGINATED BY KK

HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2019.03.17 - 2019.03.17 LATITUDE 43.866202 LONGITUDE -79.371731 CHECKED BY CZ

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
198.2	GROUND SURFACE										
0.0	**ASPHALT:** (175mm)						198				
0.2	Gravelly **SAND** Very Dense to Compact Brown Moist (FILL)		1	SS	57				○		
196.8			2	SS	17		197		○		
1.4	Clayey **SILT**, with sand, trace gravel Stiff Brown Moist		3	SS	13				○		3 38 40 19
196.0	(TILL)						196				
2.2	**SAND** and **SILT**, trace clay Dense Brown Moist		4	SS	46				○		
			5	SS	45		195		○		
			6	SS	31		194		○		0 62 35 3
						▽	193				
191.5			7	SS	31		192		○		
6.7	END OF BOREHOLE AT 6.7m. BOREHOLE OPEN UPON COMPLETION AND WATER LEVEL AT 5.8m BELOW GROUND SURFACE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.5m, DRY CEMENT TO 0.2m, THEN ASPHALT TO SURFACE.										

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

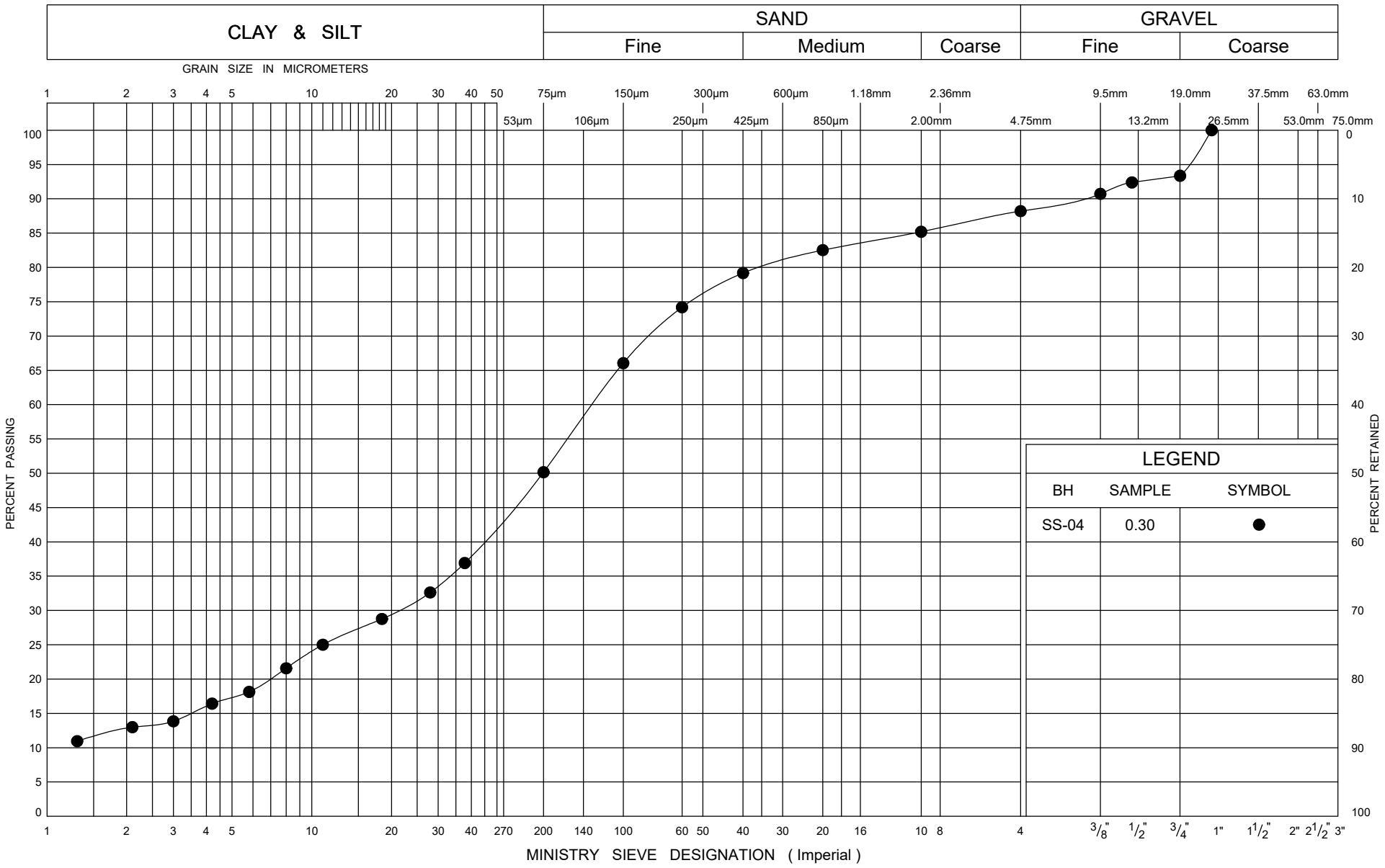
20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 3/26/19

THURBER

Appendix B

Laboratory Test Results



Ministry of Transportation
Ontario

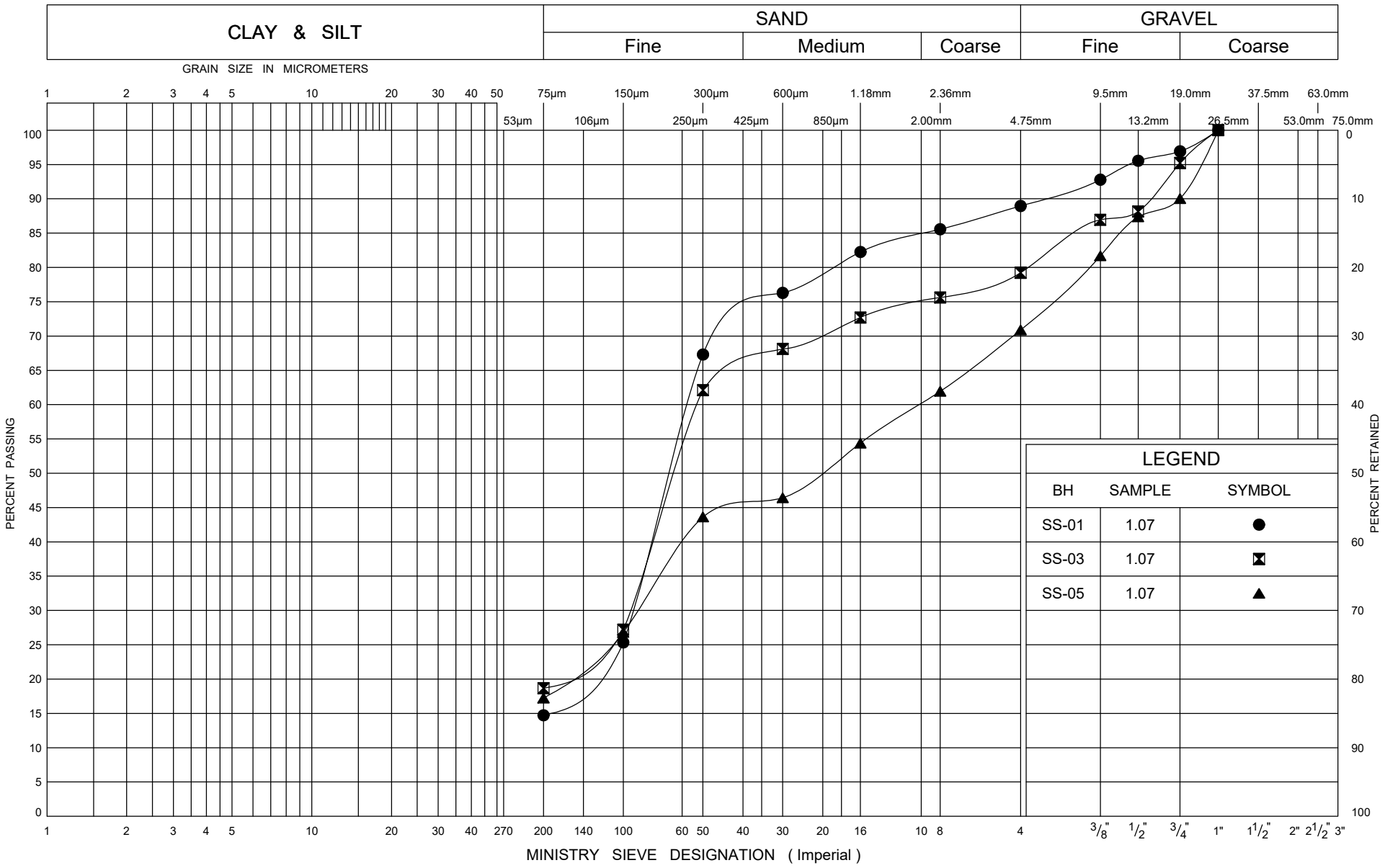
GRAIN SIZE DISTRIBUTION

Organic SAND and SILT

FIG No B1

W P 2930-17-00

ONTARIO MOT GRAIN SIZE 2X MTO-15786.GPJ ONTARIO MOT.GDT 3/26/19



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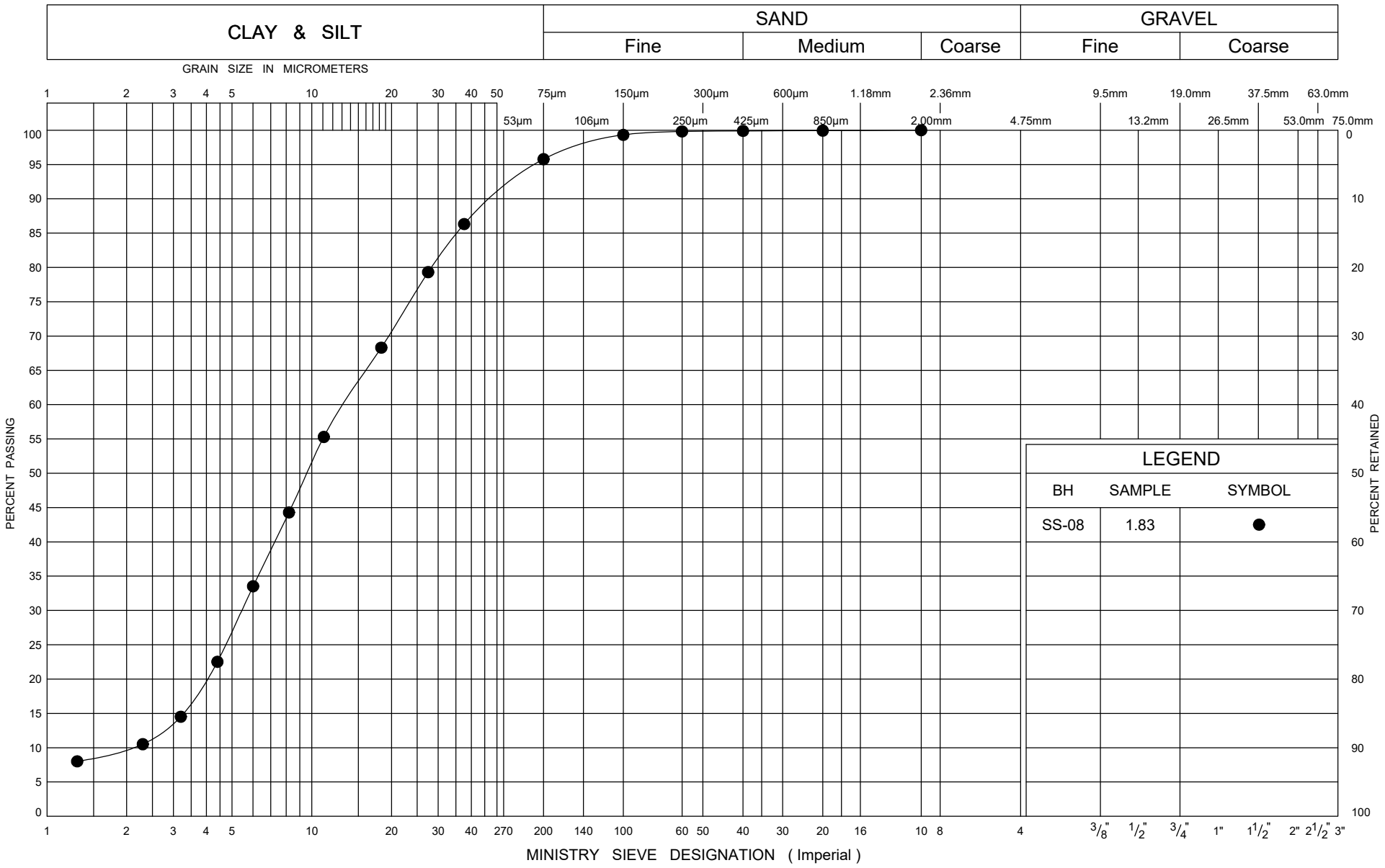
GRAIN SIZE DISTRIBUTION

SAND and GRAVEL to SAND FILL

FIG No B2

W P 2930-17-00

ONTARIO MOT GRAIN SIZE 2X MTO-15786.GPJ ONTARIO MOT.GDT 3/26/19



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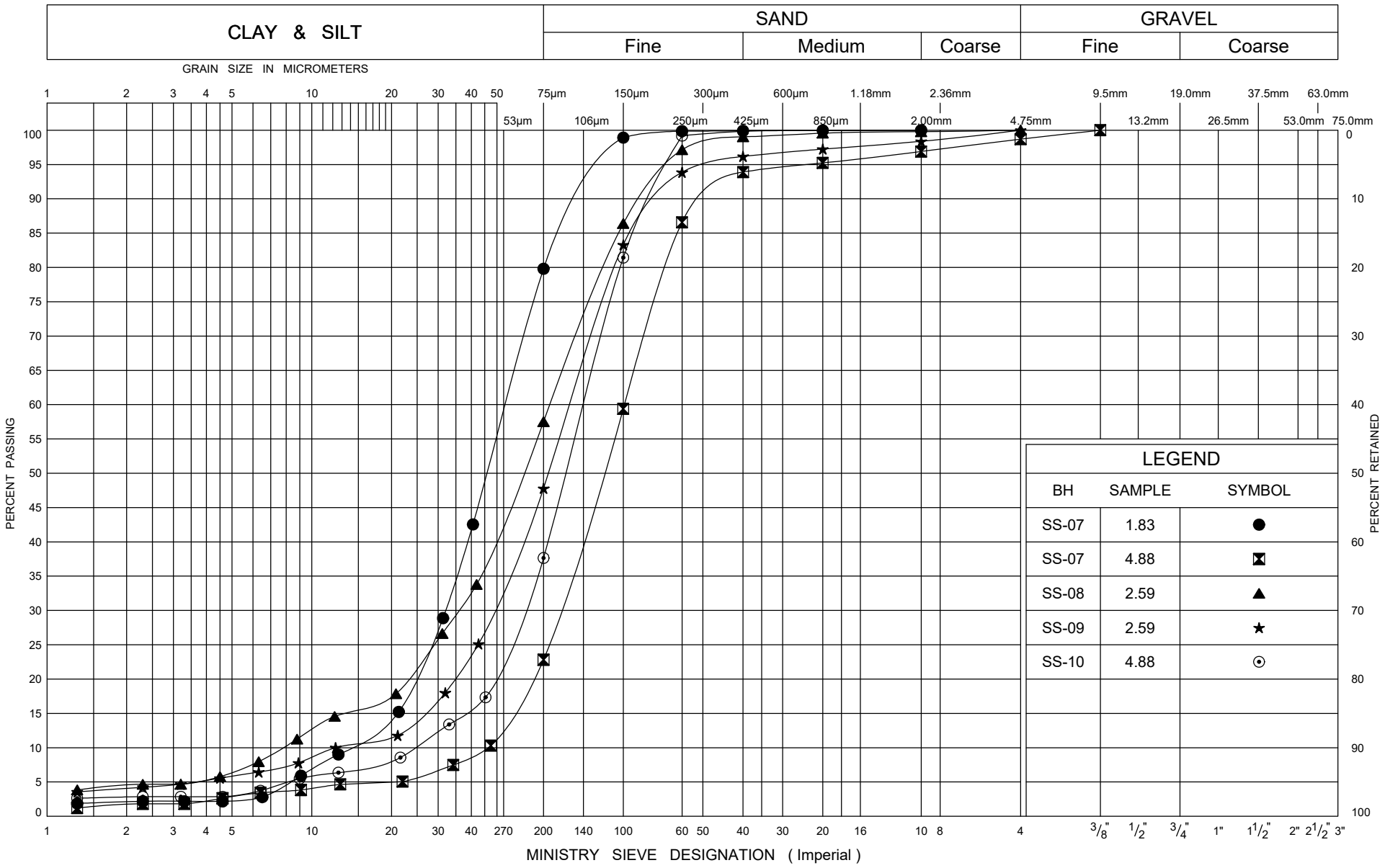
GRAIN SIZE DISTRIBUTION

SILT

FIG No B3

W P 2930-17-00

ONTARIO MOT GRAIN SIZE 2X MTO-15786.GPJ ONTARIO MOT.GDT 3/26/19



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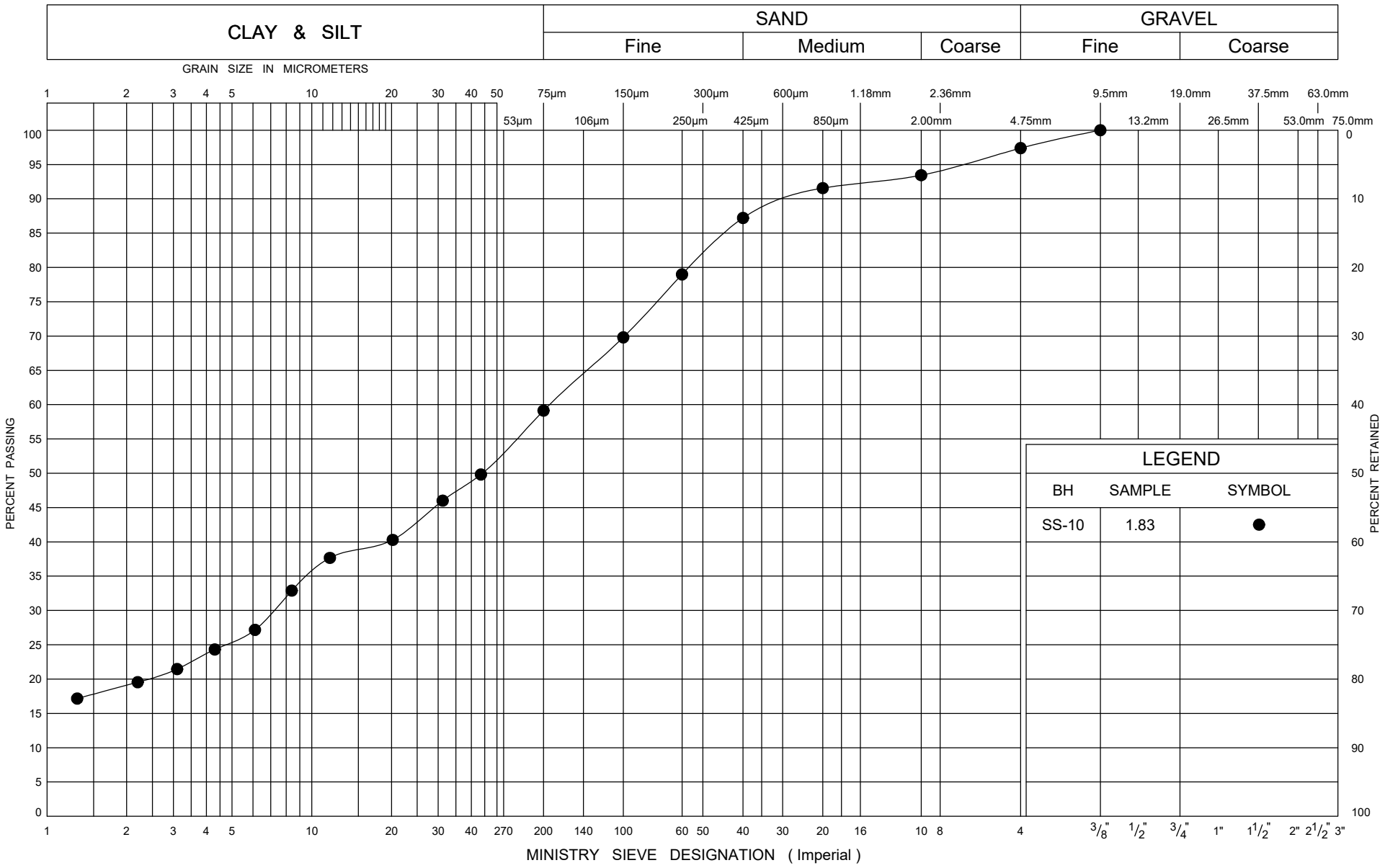
GRAIN SIZE DISTRIBUTION

Silty SAND to Sandy SILT

FIG No B4

W P 2930-17-00

ONTARIO MOT GRAIN SIZE 2X MTO-15786.GPJ ONTARIO MOT.GDT 3/26/19



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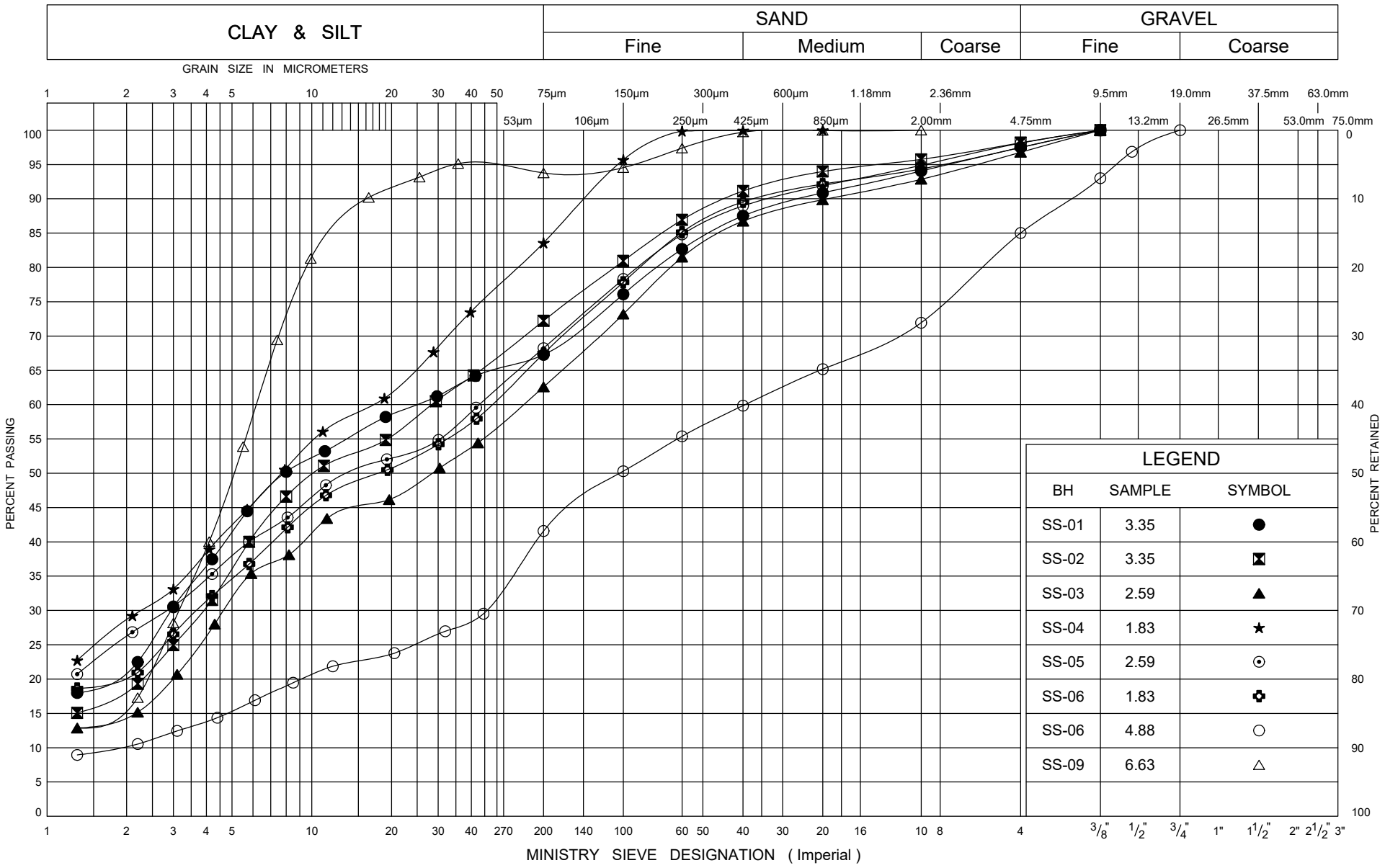
GRAIN SIZE DISTRIBUTION

Upper Clayey SILT TILL

FIG No B5

W P 2930-17-00

ONTARIO MOT GRAIN SIZE 2X MTO-15786.GPJ ONTARIO MOT.GDT 3/26/19



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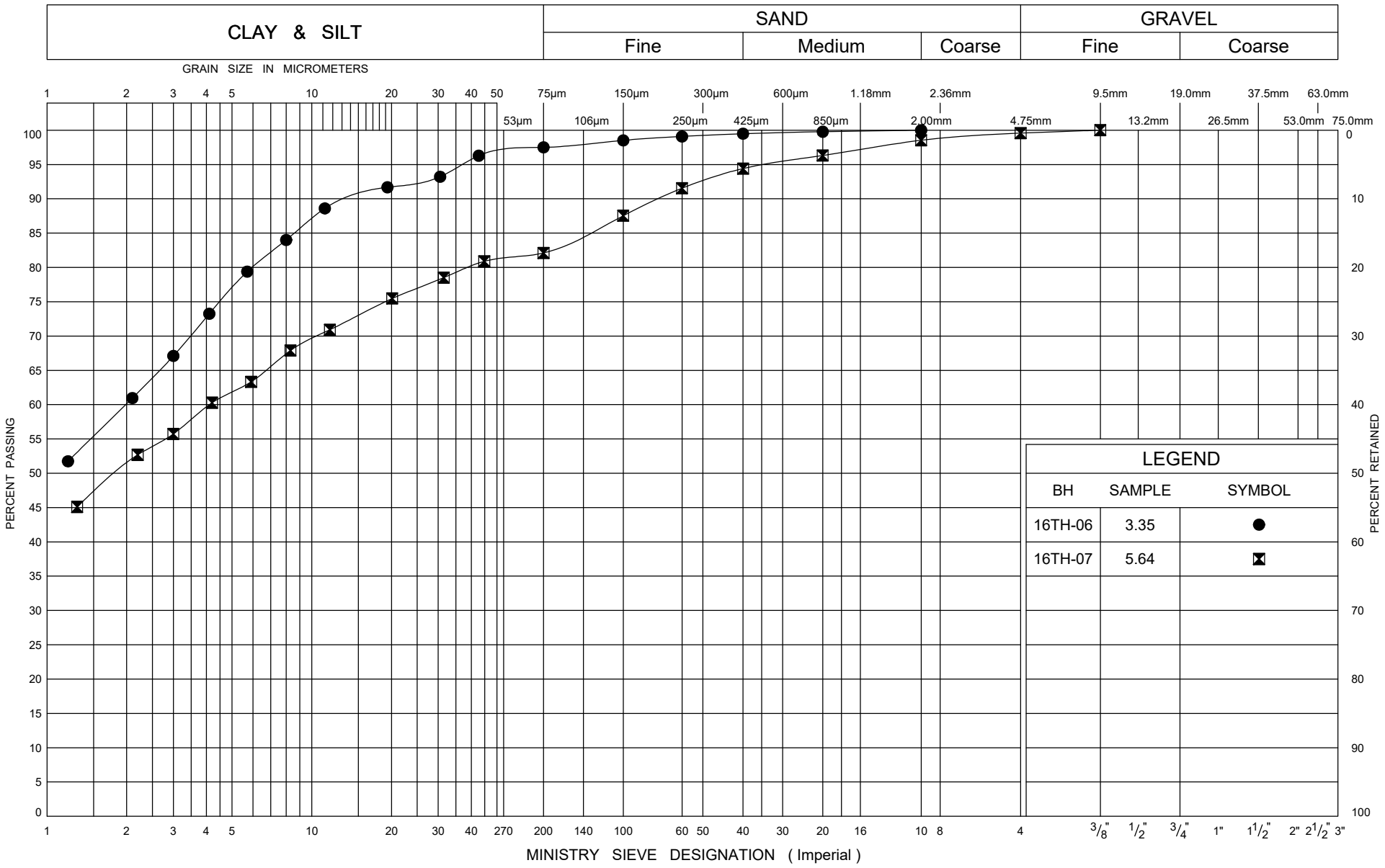
GRAIN SIZE DISTRIBUTION

Lower Clayey SILT to Silty CLAY TILL

FIG No B6

W P 2930-17-00

ONTARIO MOT GRAIN SIZE 2X MTO-15786.GPJ ONTARIO MOT.GDT 3/26/19



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Ontario

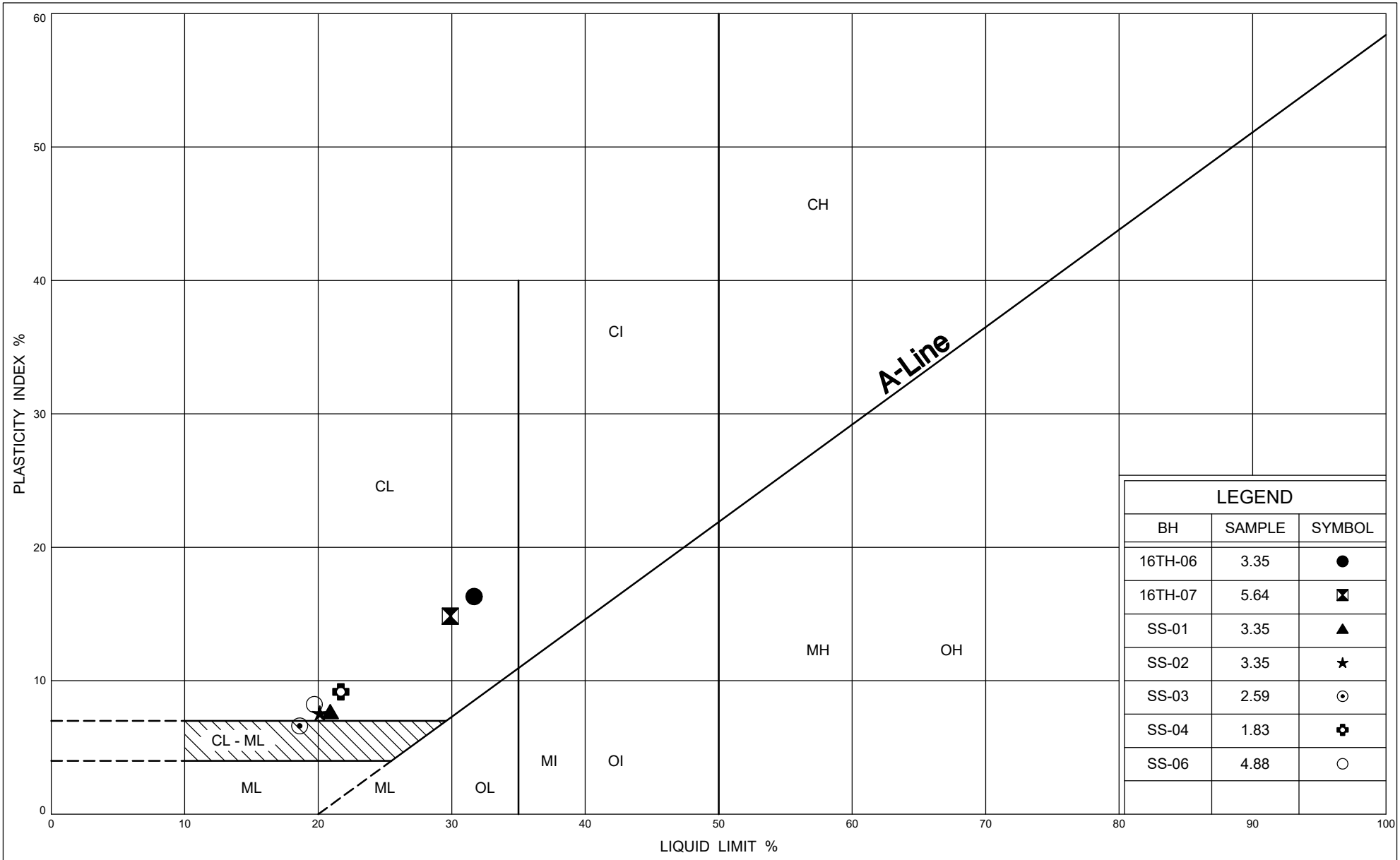
GRAIN SIZE DISTRIBUTION

Lower Silty CLAY TILL

FIG No B7

W P 2930-17-00

Oct 75, FF - S - 21



ONTARIO MOT PLASTICITY CHART MTO-15786.GPJ ONTARIO MOT.GDT 3/26/19

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Ontario

PLASTICITY CHART

Lower Silty CLAY TILL

FIG No B8

W P 2930-17-00

THURBER

Appendix C

Record of Borehole Sheets
(previous investigation)

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16TH-06 1 OF 5 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 374.0 E 314 817.1 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN

DATUM Geodetic DATE 2018.06.13 - 2018.06.15 LATITUDE 43.865269 LONGITUDE -79.375377 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES
190.0	GROUND SURFACE			
0.0	**ASPHALT:** (175mm)			
0.2	**SAND** and **GRAVEL** Brown Moist	1	GS	
189.2	(FILL)			
0.8	**SAND**, trace gravel, trace silt Dense to Compact Brown to Grey Moist	1	SS	33
		2	SS	23
187.7				
2.3	Silty **CLAY**, trace sand, trace gravel Very Stiff to Firm Grey Moist (TILL)	3	SS	21
		4	SS	6
		5	SS	5
	Stiff	6	SS	12
183.3				
6.7	Silty **SAND**, trace clay Compact Grey Wet	7	SS	20
181.3		8	SS	22
8.7	Silty **CLAY**, some sand, trace gravel Very Stiff Grey Wet (TILL)			

GROUND WATER CONDITIONS

ELEVATION SCALE: 189, 188, 187, 186, 185, 184, 183, 182, 181

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

2.2

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%)
20 40 60

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
0	2	37	61

Continued Next Page

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

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

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/31/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16TH-06 2 OF 5 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 374.0 E 314 817.1 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN

DATUM Geodetic DATE 2018.06.13 - 2018.06.15 LATITUDE 43.865269 LONGITUDE -79.375377 CHECKED BY RPR

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
	Continued From Previous Page										
	Silty **CLAY**, some sand, trace gravel Stiff Grey Moist (TILL)		9	SS	11				○		
			10	SS	12		179		○		
177.5							178				
12.5	Hard		11	SS	58		177		○		
			12	SS	75		176		○		
			13	SS	57		175		○		
			14	SS	30		174		○		
			15	SS	27		173		○		0 5 66 29
170.4							172				
19.6	Silty **SAND**, some gravel Compact						171				

Continued Next Page

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16TH-06 3 OF 5 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 374.0 E 314 817.1 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN

DATUM Geodetic DATE 2018.06.13 - 2018.06.15 LATITUDE 43.865269 LONGITUDE -79.375377 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **SAND**, some gravel Compact Grey Wet (TILL)						169 168				
			16	SS	27				○		
							167 166				
165.2 24.8	Silty **CLAY**, some sand, trace gravel Firm to Stiff Grey Wet (TILL)						165		○		
			17	SS	8						
163.9 26.1	Very Dense						164 163 162				
			18	SS	83				○		
							161				

Continued Next Page

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

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/31/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16TH-06 4 OF 5 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 374.0 E 314 817.1 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN

DATUM Geodetic DATE 2018.06.13 - 2018.06.15 LATITUDE 43.865269 LONGITUDE -79.375377 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							20 40 60 80 100	20 40 60		
	Silty **SAND**, trace gravel, trace clay Very Dense Grey Wet (TILL)						159				
			19	SS	100/ 0.125		158		○		4 70 18 8
157.4											
32.6	Silty **CLAY**, with sand, trace gravel Hard Grey Moist (TILL)		20	SS	68		157		○		
							156				
							155				
			21	SS	100/ 0.200		154		○		
							153				
			22	SS	100/ 0.250		152		⊢●		0 22 38 40
							151				
150.8			23	SS	100/ 0.175				○		
39.2	END OF BOREHOLE AT 39.2m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16TH-06 5 OF 5 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 374.0 E 314 817.1 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN

DATUM Geodetic DATE 2018.06.13 - 2018.06.15 LATITUDE 43.865269 LONGITUDE -79.375377 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.10.09 3.1 186.9 2018.11.22 0.0 190.0										

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

$\frac{20}{15 \quad 5}$ (%) STRAIN AT FAILURE
$\frac{}{10}$

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/31/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16TH-07 1 OF 4 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 357.8 E 314 812.8 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Tricone COMPILED BY AN

DATUM Geodetic DATE 2018.06.25 - 2018.06.27 LATITUDE 43.865124 LONGITUDE -79.375431 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
190.0	GROUND SURFACE									
0.0	**ASPHALT:** (175mm)									
0.2	**SAND** and **GRAVEL** Brown Moist (FILL)		1	GS						
189.2							189			
0.8	**SAND**, trace gravel, trace silt Dense Brown Wet		1	SS	41					
188.5							188			
1.5	Silty **CLAY**, trace to some sand, trace gravel Stiff to Firm Grey Moist (TILL)		2	SS	10					
			3	SS	13					
187.1							187			
2.9	sand seam (300mm)									
186.8			4	SS	6			2.5		
3.2	Wet						186			
							185			
			5	SS	4					0 17 31 52
							184	3.2		
			6	SS	5		183			
								3.4		
181.8							182			
8.2	Silty **SAND** Compact Grey Wet		7	SS	20					
							181			
180.0										

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 16TH-07 2 OF 4 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 357.8 E 314 812.8 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Tricone COMPILED BY AN

DATUM Geodetic DATE 2018.06.25 - 2018.06.27 LATITUDE 43.865124 LONGITUDE -79.375431 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
10.0	Silty **CLAY**, some sand, trace gravel Very Stiff to Hard Grey Wet (TILL)		8	SS	17						
			9	SS	17		179				
			10	SS	17		178				
			11	SS	62		177				3 25 72 (SI+CL)
			12	SS	35		176				
			13	SS	21		175				
171.1							174				
18.9	Silty **SAND**, some clay, trace gravel Compact Grey Wet (TILL)		14	SS	19		173				
170.0							172				
							171				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/31/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16TH-07 3 OF 4 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 357.8 E 314 812.8 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Tricone COMPILED BY AN

DATUM Geodetic DATE 2018.06.25 - 2018.06.27 LATITUDE 43.865124 LONGITUDE -79.375431 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
20.0	Silty **SAND**, some clay, trace gravel Compact Grey Wet						169				
168.0							168				
22.0	Silty **CLAY**, with sand, trace gravel Firm to Hard Grey Moist (TILL)		15	SS	7				○		4 37 37 22
							167				
							166				
			16	SS	52		165		○		
							164				
162.3							163				
27.7	**SAND** and **SILT**, trace to some clay, trace gravel Very Dense Grey Wet (TILL)		17	SS	100/ 0.225		162		○		
			18	SS	100/		161		○		1 42 47 10

Continued Next Page

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

$\frac{20}{15}$ 5 $\frac{}{10}$ (%) STRAIN AT FAILURE

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/31/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16TH-07 4 OF 4 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 357.8 E 314 812.8 ORIGINATED BY SB

HWY 404 BOREHOLE TYPE Tricone COMPILED BY AN

DATUM Geodetic DATE 2018.06.25 - 2018.06.27 LATITUDE 43.865124 LONGITUDE -79.375431 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT** Very Dense Grey Wet (TILL)				0.200						
			19	SS	100/ 0.100		159				
157.7							158				
32.3	Silty **CLAY**, some sand, trace gravel Hard Grey Moist (TILL)		20	SS	65		157				
							156				
155.4			21	SS	100/ 0.175						
34.6	END OF BOREHOLE AT 34.6m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 6.10m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.08.20 0.0 190.0 2018.10.09 0.8 189.2										

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

$15\frac{20}{10}5$ (%) STRAIN AT FAILURE

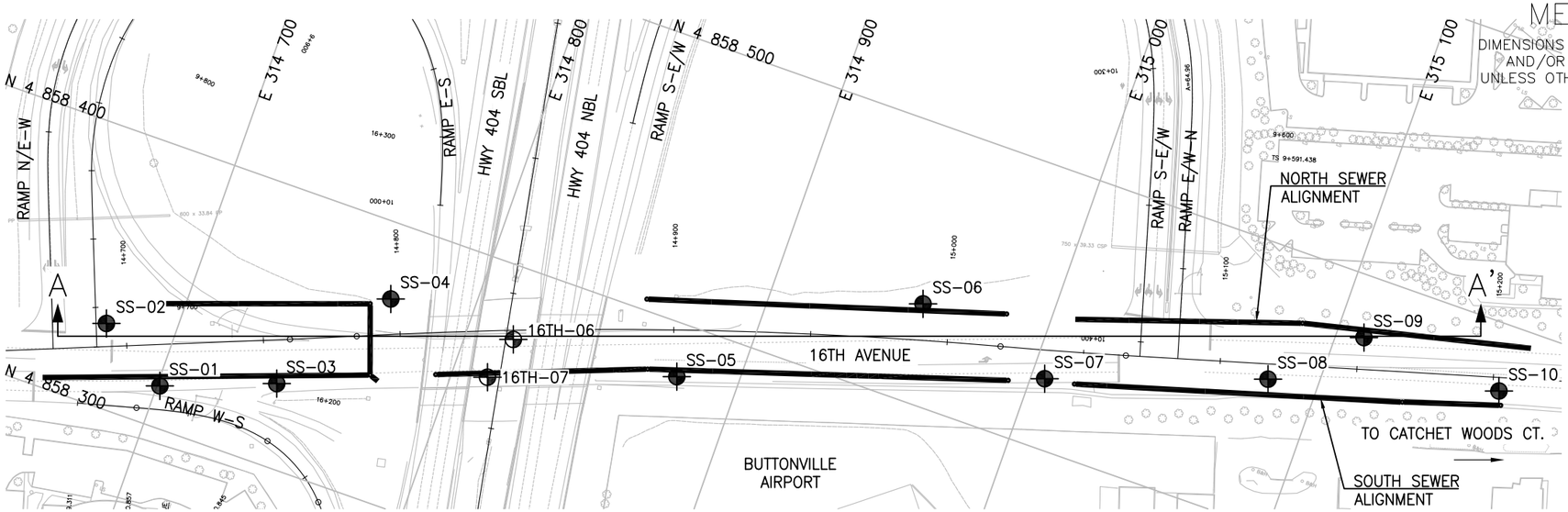
ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/31/19

THURBER

Appendix D

Borehole Locations and Soil Strata Drawings

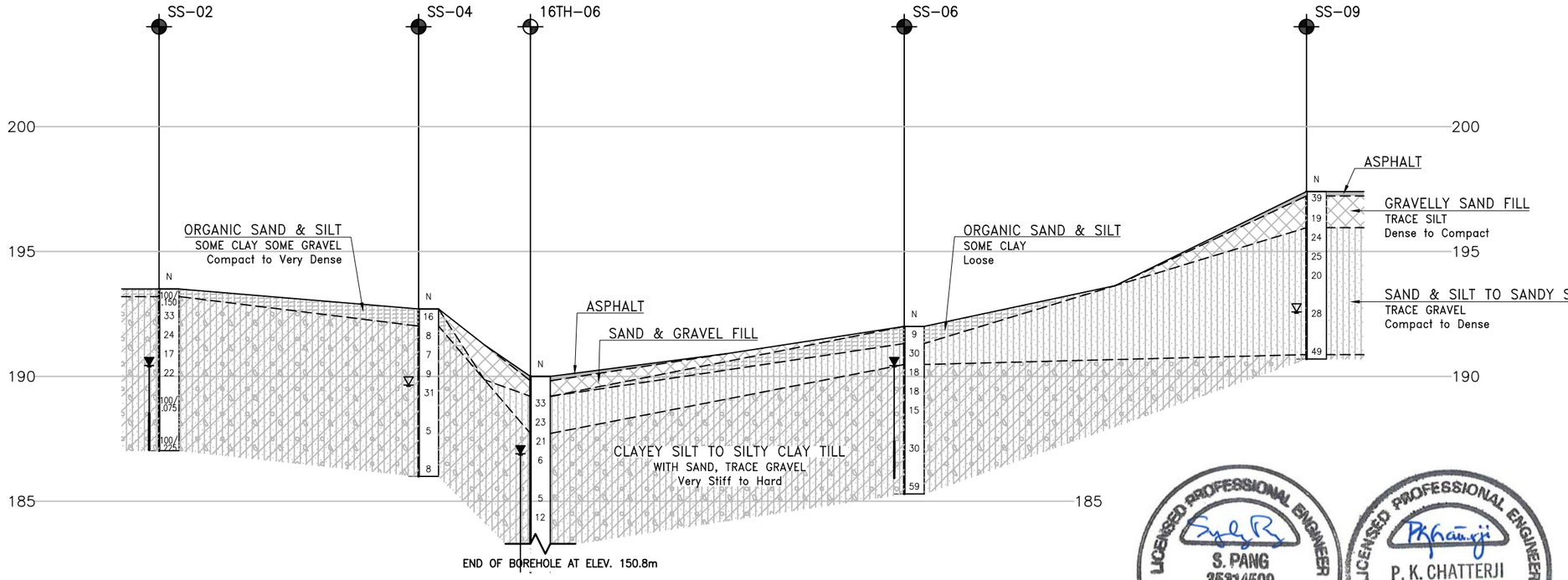
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

40 0 40 80m

SCALE 1:2000



SECTION ALONG A–A'

40 0 40 80m H 1:2000

4 0 4 8m V 1:200

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No

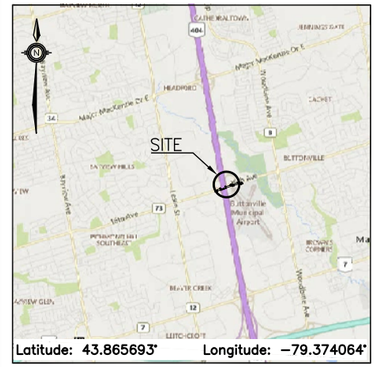
GWP No 2930-17-00

HIGHWAY 404
AT 16TH AVENUE
STORM SEWER
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

wsp

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

⊕	Borehole (Current Investigation)
⊕	Borehole (Previous Investigations)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level (Open Borehole)
▮	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
16TH-06	190.0	4 858 374.0	314 817.1
16TH-07	190.0	4 858 357.8	314 812.8
SS-01	192.4	4 858 315.0	314 701.0
SS-02	193.5	4 858 330.0	314 675.0
SS-03	191.0	4 858 330.0	314 741.0
SS-04	192.7	4 858 373.0	314 770.0
SS-05	190.6	4 858 381.0	314 878.0
SS-06	192.0	4 858 436.0	314 954.0
SS-07	193.8	4 858 425.0	315 005.0
SS-08	196.5	4 858 452.0	315 082.0
SS-09	197.4	4 858 478.0	315 110.0
SS-10	198.2	4 858 476.0	315 163.0

-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. 30M14-503

LICENSED PROFESSIONAL ENGINEER S. PANG 35314509 Aug 15/19 PROVINCE OF ONTARIO

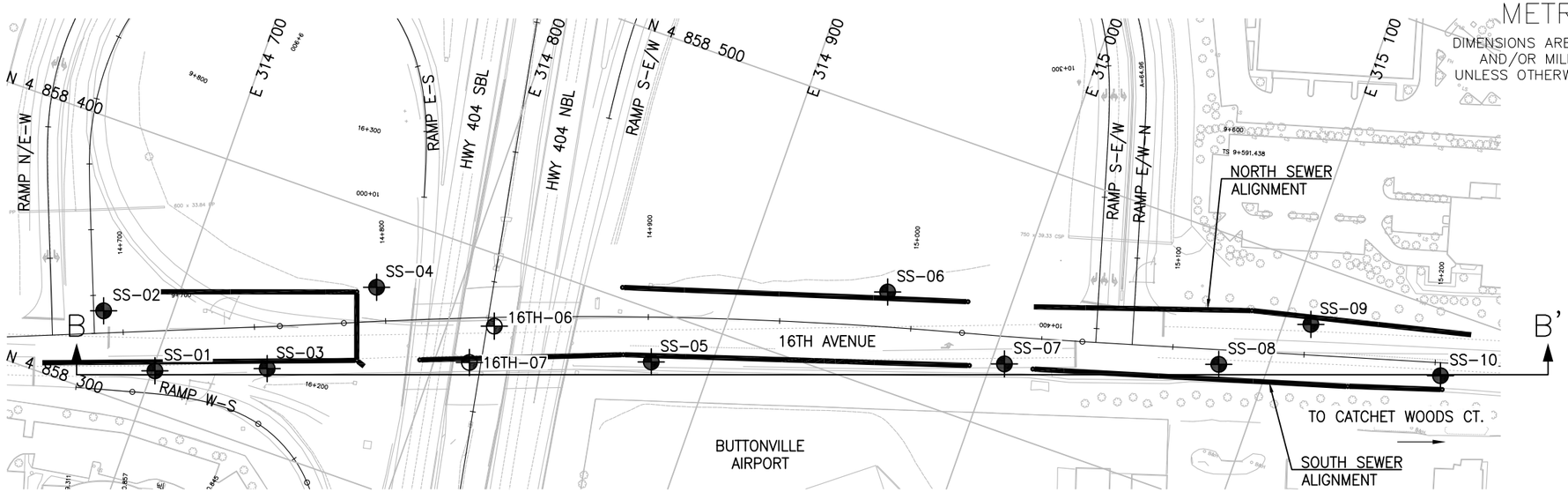
LICENSED PROFESSIONAL ENGINEER P. K. CHATTERJI Aug 15/19 PROVINCE OF ONTARIO

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN CZ	CHK SKP	CODE	LOAD DATE AUG 2019
DRAWN AN	CHK CZ	SITE	STRUCT DWG 1

FILENAME: H:\Drafting\15000\15786\TES-15786-PLPR-Sewer.dwg
PLOTDATE: 8/15/2019 12:04 PM

MINISTRY OF TRANSPORTATION, ONTARIO

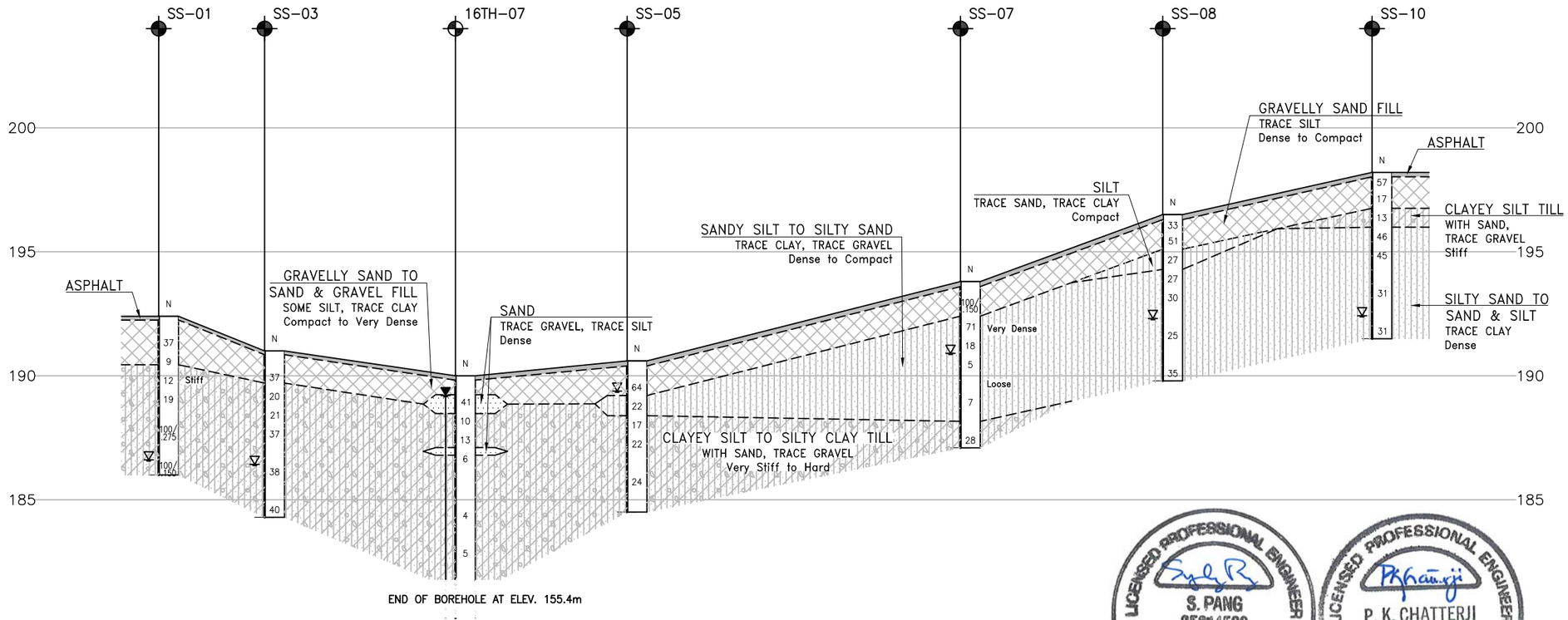
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PLAN

40 0 40 80m

SCALE 1:2000



SECTION ALONG B–B'

40 0 40 80m H 1:2000

4 0 4 8m V 1:200

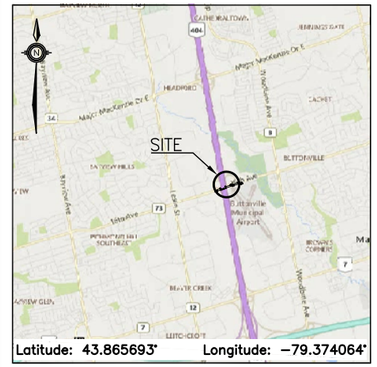
CONT No
GWP No 2930-17-00

SHEET

HIGHWAY 404
AT 16TH AVENUE
STORM SEWER
BOREHOLE LOCATIONS AND SOIL STRATA

wsp

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
16TH-06	190.0	4 858 374.0	314 817.1
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SS-01	192.4	4 858 315.0	314 701.0
SS-02	193.5	4 858 330.0	314 675.0
SS-03	191.0	4 858 330.0	314 741.0
SS-04	192.7	4 858 373.0	314 770.0
SS-05	190.6	4 858 381.0	314 878.0
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GEOCRES No. 30M14-503

LICENSED PROFESSIONAL ENGINEER
S. PANG
35314509
Aug 15/19
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Aug 15/19
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN CZ	CHK SKP	CODE	LOAD	DATE	AUG 2019
DRAWN AN	CHK CZ	SITE	STRUCT	DWG	2

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PLOTDATE: 8/15/2019 12:05 PM

THURBER

Appendix E

List of Ontario Provincial Standards and Suggested Wording for NSSP

1. List of Ontario Provincial Standards Referenced in this Report

- OPSS.PROV 401
- OPSS.PROV 410
- OPSS 492
- OPSS.PROV 501
- OPSS.PROV 539
- OPSS.PROV 1004
- OPSS.PROV 1010
- OPSD 802.030
- OPSD 802.031
- OPSD 802.032

2. Suggested Text for NSSP on Open Cut Excavation.

The Contractor's attention is drawn to the following:

- The fill materials and glacial till deposits may contain cobbles and boulders. Other obstructions may also be present in the fill. The Contractor must be equipped to dislodge, remove and otherwise handle such obstructions during excavation.

3. Suggested Text for NSSP on Ground Movement Adjacent to Trenches.

The Contractor's attention is drawn to the following:

- All trenching and other excavations shall not adversely affect the adjacent roadway operation. Regardless of whether open cutting, trench box or other types of ground support is used, ground movement adjacent to trenches and excavations must not exceed the limit provided in Performance Level 2 as per Clause 539.04.01.01 in OPSS.PROV 539.