

**Foundation Investigation and
Design Report
New Overhead Signs**

Highway 401 Rehabilitation from
Middlesex Road 30 (Putnam Road) to
Highway 19 (Harris Street), Ontario

Design Build Contract 2021-3037
G.W.P. 3087-16-00

Geocres No. 40P02-086



Prepared for:
Dufferin Construction Company
585 Michigan Drive, Suite 1
Oakville, Ontario L6L 0G1

Prepared by:
Stantec Consulting Ltd.
400 – 1331 Clyde Avenue
Ottawa, ON K2C 3G4

Project No. 165001280

October 2022



Table of Contents

1.0	INTRODUCTION.....	1
2.0	SITE DESCRIPTION AND GEOLOGY.....	2
2.1	SITE LOCATION	2
2.2	SITE DESCRIPTION	2
3.0	REVIEW OF AVAILABLE SUBSURFACE INFORMATION.....	3
3.1	CPR OVERHEAD BRIDGE INVESTIGATION (NEAR SIGN NO. 6W).....	3
3.2	HIGH MAST LIGHTING AT HIGHWAY 401-CULLODEN ROAD INVESTIGATION (NEAR SIGN NOS. 7W AND 34E)	4
3.3	HIGHWAY 401-PUTNAM ROAD AND CPR OVERPASS INVESTIGATION (NEAR SIGN 10W)	5
4.0	SUBSURFACE INVESTIGATION	5
4.1	FIELD INVESTIGATION PROCEDURES.....	5
4.2	LOCATION AND ELEVATION SURVEY	6
4.3	LABORATORY TESTING.....	7
5.0	SUBSURFACE CONDITIONS	7
5.1	OVERVIEW	7
5.2	OVERBURDEN STRATIGRAPHY.....	8
5.2.1	Asphaltic Concrete	8
5.2.2	Topsoil	9
5.2.3	Sand and Gravel (FILL).....	9
5.2.4	Sandy Silt to Gravelly Silty Sand (FILL).....	9
5.2.5	Silty Clay (FILL).....	10
5.2.6	Silty Clay	10
5.2.7	Clayey Silt (TILL).....	10
5.2.8	Native Cohesionless Soils.....	11
5.2.9	Silty Sand to Sandy Silt (TILL).....	11
5.2.10	Sand and Gravel	12
5.2.11	Bedrock.....	12
5.3	GROUNDWATER.....	12
6.0	CHEMICAL TESTING	13
7.0	MISCELLANEOUS	14
8.0	CLOSURE.....	15
9.0	DISCUSSIONS AND ENGINEERING RECOMMENDATIONS	16
9.1	OVERVIEW.....	16
9.2	OVERHEAD SIGN FOUNDATION DESIGN.....	16
9.2.1	General	16
9.2.2	Frost Penetration.....	17
9.2.3	Caisson Foundations for Overhead Signs	17
9.2.4	Design Parameters and Passive Lateral Earth Pressure	18
9.2.5	Construction Considerations	19



**FOUNDATION INVESTIGATION AND DESIGN REPORT
NEW OVERHEAD SIGNS**

9.3	CEMENT TYPE AND CORROSION POTENTIAL	19
10.0	CLOSURE.....	21
11.0	REFERENCES.....	22

LIST OF TABLES

Table 2.1:	Proposed Overhead Sign Locations	2
Table 4.1:	Borehole Co-ordinate and Elevation Information	6
Table 4.2:	Geotechnical Laboratory Testing Program	7
Table 5.1:	Summary of Subsurface Soil Conditions at The Borehole Locations	8
Table 5.2:	Measured Groundwater Levels.....	13
Table 6.1:	Results of Chemical Analysis	13
Table 9.1:	Proposed Sign Details	17

LIST OF APPENDICES

APPENDIX A.....		A.1
A.1	Drawings Nos. A1 to A4 – Borehole Location Plans and Soil Strata Plots	A.1
APPENDIX B.....		B.1
B.1	Symbols and Terms Used on Borehole Records	B.1
B.2	Borehole Records (Current Investigation).....	B.1
B.3	Borehole Records from Previous Studies (GEOCRES Reports No. 40P2-47, 40P2-50, and 40I15-29).....	B.1
APPENDIX C.....		C.1
C.1	Laboratory Test Results (Current Investigation).....	C.1
C.2	Corrosivity Testing Results (Current Investigation)	C.1
C.3	Laboratory Test Results from Previous Studies	C.1
APPENDIX D.....		D.1
D.1	Foundation Design Parameters for Sign Structures	D.1



FOUNDATION INVESTIGATION REPORT
For

Design-Build Contract 2021-3037
G.W.P 3087-16-00

New Overhead Signs – Highway 401 from Middlesex Road 30 (Putnam Rd.) to Highway 19 (Harris St.)
Sign Nos. 6W, 7W, 9W, 10W, 32E, 33E, and 34E

1.0 INTRODUCTION

Dufferin Construction Company (Dufferin) will be completing rehabilitation works on Highway 401 from Middlesex Rd. 30 (Putnam Road) to Highway 19 (Harris Street) for the Ministry of Transportation of Ontario (MTO) under Design Build Contract 2021-3037 (West Region). Stantec Consulting Ltd. (Stantec) was retained by Dufferin to undertake the detailed design services related to the Highway 401 rehabilitation works. A component of the engineering services to be provided included the preparation of a foundation investigation and design report (FIDR) for the installation of seven overhead signs.

Stantec completed a foundation investigation and prepared a *preliminary* FIDR for the overhead signs as part of the preliminary design stage for this project (GWP 3087-16-00 / Stantec reference Project No. 165001128). The purpose of the foundation investigation was to assess the subsurface conditions for the proposed replacement of the overhead signs by drilling boreholes, carrying out in-situ testing, and completing a laboratory testing program on selected soil samples obtained from the boreholes. The subsurface information obtained was collected to support the provision of foundation engineering recommendations for use by the designers of the overhead signs.

This report represents the *final* FIDR for the overhead signs and has been prepared specifically and solely for the proposed installation of the overhead signs at Site Nos. 6W, 7W, 9W, 10W, 32E, 33E, and 34E located within the project study limits.



2.0 SITE DESCRIPTION AND GEOLOGY

2.1 SITE LOCATION

The project involves improvements to Highway 401 from Middlesex Rd. 30 (Putnam Rd.) east to Highway 19 (Harris St.) in Ingersoll. The chainage on Highway 401 increases from west to east.

The proposed new overhead signs will replace existing signs in the highway corridor. The stations of the existing and proposed signs are indicated in the following table.

Table 2.1: Proposed Overhead Sign Locations

Sign No.	County	Existing Sign Station	Proposed Overhead Sign Station
6W	Oxford	15+928	15+870
7W	Oxford	14+925	14+870
9W	Middlesex	24+010	24+000
10W	Middlesex	23+010	23+005
32E	Middlesex	22+538	22+550
33E	Oxford	12+913	12+970
34E	Oxford	13+913	13+970

The locations of the boreholes advanced are shown on Drawings Nos. A1 to A4 in Appendix A.

2.2 SITE DESCRIPTION

At the project site, Highway 401 is a six-lane, divided freeway with three lanes in each direction. This portion of Highway 401 is classified as a Rural Freeway Divided (RFD 120) with a concrete median barrier. The design speed is 120 km/h and the posted speed is 100 km/h.

In the vicinity of the project study area, the terrain is generally flat to undulating.

The new signs will typically be located beyond the paved shoulder within the existing highway boulevard areas which often contain ditches. Existing approach embankments to overpass structures are present at the proposed locations of Sign Nos. 6W and 10W; as such, foundations for these signs will be located within side-slope areas of the highway fill embankments.

Physiographic Description

The site is located within a physiographic region known as the Mount Elgin Ridges (Chapman and Putnam, 1984). The ridges typically consist of moraines of pale brown calcareous clay or silty clay, whereas the vales generally contain alluvium deposits of gravel, sand, or silt.

Drift thickness and bedrock topography maps and review of available water well records indicate a depth to bedrock of around 30 m to 60 m. The bedrock has been mapped as dolomites and limestones of the Detroit River Group of Middle Devonian Age.



3.0 REVIEW OF AVAILABLE SUBSURFACE INFORMATION

Prior to carrying out the subsurface investigation, Stantec reviewed subsurface information available within the MTO GEOCRES database. The following provides a summary of reports that provided information near to the proposed sign locations.

3.1 CPR OVERHEAD BRIDGE INVESTIGATION (NEAR SIGN NO. 6W)

The results of an investigation conducted at a rail bridge, approximately 1.2 km west of the Highway 19 Underpass and about 60 m west of the proposed replacement Sign No. 6W, were available from the following document:

- GEOCRES Report titled “Foundation Investigation Report for CPR Overhead, W.P. 479-89-05, Site 23-209, HWY. 401, District 2, London” prepared by Engineering Materials Office – Foundation Design Section and dated Jan 25, 1991 (GEOCRES Reference No. 40P2-47).

Six boreholes, designated as Boreholes 1 to 6, were advanced in the area of the Highway 401 crossing of the CP Rail line to a maximum depth of 18.8 m. Boreholes 2 and 6 from this investigation are the closest boreholes to proposed Sign No. 6W. The approximate location of these boreholes are displayed on the Borehole Location Plan (Drawing No. A4) included in Appendix A and are based on the locations shown on the ‘Bore hole Locations & Soil Strata’ drawing for the overpass report (Drawing No. 4798905, dated Dec 20, 1990).

Subsurface information related to these boreholes, including the borehole records and the original borehole location plans from the GEOCRES report are included in Appendix B for reference. The results of laboratory testing from the above noted investigation are included in Appendix C for reference.

Boreholes 2 and 6 encountered subsurface conditions consisting of:

- Highway embankment fill (BH6) comprised of loose to dense sandy silt to sand from Elevation 290.8 m (ground surface) to 281.4 m.
- A glacial till deposit described as a heterogeneous mixture of clayey silt, sand, and gravel with a very stiff to hard consistency that extended to an Elevation of 277.9 m in Borehole 2. Borehole 6 was terminated in this layer at an elevation of 278.2 m.
- Dense sand and gravel from Elevation of 277.9 m to 273.3 m.
- Very dense, non-cohesive glacial till from Elevation 273.3 to 267.7 m (termination of BH2).
- The groundwater level was encountered at an Elevation of about 278.0 m in Borehole 2 at the time of drilling.



3.2 HIGH MAST LIGHTING AT HIGHWAY 401-CULLODEN ROAD INVESTIGATION (NEAR SIGN NOS. 7W AND 34E)

The results of an investigation conducted at the Highway 401-Culloden Road interchange for high mast lighting installation were available from the following document:

- GEOCRES Report titled “Foundation Investigation Report for High Mast Lighting at Highway 401-Culloden Road, W.P. 479-89-01, HWY. 401, District 2, London” prepared by Engineering Materials Office – Foundation Design Section and dated Oct 10, 1991 (GEOCRES Reference No. 40P2-50).

Eight boreholes, designated as P1 to P8, were advanced in the area of the Highway 401-Culloden Road interchange to a maximum depth of 14.2 m. Dynamic cone penetration tests were carried out adjacent to these boreholes to a maximum depth of 17.8 m. Of relevance to the current project, Boreholes P1 and P8 from the investigation were drilled near to proposed overhead Sign Nos 34E and 7W, respectively.

The approximate locations of these boreholes are shown on the Borehole Location Plan (Drawing No. A3) included in Appendix A and are based on the locations shown on the ‘Bore hole Locations’ drawing for the Highway 401-Culloden Road interchange for high mast lighting report (Drawing No. 4798901-A, dated Dec 20, 1991).

Subsurface information related to Borehole P1 and P8, including the original borehole location plan and borehole records are included in Appendix B for reference. The results of laboratory testing from the above noted investigation are included in Appendix C for reference.

Borehole P1, which was advanced near the proposed location for Sign No. 34E, encountered subsurface conditions consisting of:

- Compact sandy silt fill from Elevation 285.9 m (ground surface) to 284.5 m;
- Loose to compact silty sand to sandy silt from Elevation 284.5 to 278.4 m; and
- Compact gravelly sand from Elevation 278.4 to 276.3 m (termination of auger drilling). It was inferred that this layer extended to elevation 273.1 m based on a dynamic cone test conducted at this borehole location.
- The groundwater level in this borehole was recorded at a depth of 2.6 m (Elevation 283.3m) 24 hours after completion of drilling.

Borehole P8, which was advanced near the proposed location for Sign No. 7W, encountered subsurface conditions consisting of:

- Loose sandy silt from Elevation 287.7 m (ground surface) to 286.3 m;
- Stiff to very stiff clayey silt from Elevation 286.3 to 284.3 m; and
- Loose to compact silty sand/sandy silt from Elevation of 284.3 to 276.6 m (termination of auger drilling). It was inferred that this layer extended to Elevation 276.1 m based on a dynamic cone test conducted at this borehole location.
- The groundwater level in this borehole was recorded at a depth of 4.9 m (Elevation 282.8 m) one hour after completion of drilling.



3.3 HIGHWAY 401-PUTNAM ROAD AND CPR OVERPASS INVESTIGATION (NEAR SIGN 10W)

The results of an investigation conducted at the Hwy. 401 interchange with Putnam Road and the CPR Overpass was available from the following document:

- GEOCRE Report titled “Foundation Investigation Report for Proposed Structure Extension: Hwy. 401 -Putnam Road and CPR Overpass, W.P. 478-89-02, Bridge Site 19-306, District 2, London” prepared by Strata Engineering Corp. and dated Jan 07, 1991 (GEOCRE Reference No. 40I15-29).

Four boreholes and two dynamic cone penetration tests were advanced in the area of the overpass to a maximum depth of 14.7 m. Borehole 2 from this investigation is the closest borehole to the location of Sign No. 10W.

The approximate location of this borehole, based on the location shown on the ‘Bore hole Locations & Soil Strata’ drawing in the overpass report (Drawing No. 4798902-A dated Nov 14, 1990), is shown on the Borehole Location Plan (Drawing No. A1) included in Appendix A.

Subsurface information related to this borehole, including the original borehole location plan and the borehole record are included in Appendix B for reference. The results of laboratory testing from the investigation are included in Appendix C for reference.

Borehole 2 encountered subsurface conditions consisting of:

- Sand and gravel fill from Elevation 266.2 m to 264.9 m.
- Compact to dense sandy silt to silty sand from Elevation 264.9 m to 259.4 m; and
- Dense to very dense sand from Elevation 259.4 m to 253.5 m (termination of the borehole).
- The groundwater level was encountered at an Elevation of approximately 263.5 m.

4.0 SUBSURFACE INVESTIGATION

4.1 FIELD INVESTIGATION PROCEDURES

The foundation investigation program consisted of advancing 7 boreholes, identified as BH19-6W, BH19-7W, BH19-9W, BH19-10W, BH19-32E, BH19-33E, BH19-34E, with one borehole advanced at each overhead sign location. The boreholes were drilled on the existing highway shoulder adjacent to the sign location where the sign locations were not accessible due to access constraints (e.g. guard rails, ditches, etc.). The locations of the boreholes are shown on the Borehole Location Plans, Drawing Nos. A1 to A4, in Appendix A.

Prior to carrying out the investigation, Stantec contacted the public utility authorities to clear the borehole locations of both private and public utilities.



The field drilling program was carried out on September 26, 2019 and November 4-6, 2019. The boreholes were advanced using continuous flight hollow stem augers. Drilling was carried out with truck-mounted and track-mounted drill rigs, both equipped for soil sampling.

The subsurface stratigraphy encountered in each borehole was recorded in the field by a member of Stantec's geotechnical staff. Standard Penetration Tests (SPTs) were carried out in the boreholes and split spoon samples were collected at regular intervals. All recovered SPT samples were returned to our Ottawa laboratory for detailed classification and testing.

Groundwater conditions were observed during drilling and on completion of drilling of each borehole. After completion of drilling, the boreholes were sealed with bentonite. Boreholes advanced on the roadways were provided with a surficial layer of cold patch asphalt.

4.2 LOCATION AND ELEVATION SURVEY

The borehole locations were established in the field relative to the existing site features including the existing overhead signs and the borehole locations and elevations were subsequently determined by Stantec's Transportation team. The borehole co-ordinates and ground surface elevation information is considered accurate to 0.5 m and 0.1 m, respectively. Table 4.1 below summarizes the borehole location information with the borehole ground surface elevations, depths and termination elevations.

Table 4.1: Borehole Co-ordinate and Elevation Information

Borehole	MTM Zone 11 Coordinates		Approximate Ground Surface Elevation (m)	Borehole Depth (m)	Borehole Termination Elevation (m)
	Northing	Easting			
BH19-6W	4765476.1	193616.6	290.9	11.3	279.6
BH19-7W	4764843.5	192842.2	288.5	8.2	280.3
BH19-9W	4760794.8	187503.7	285.1	8.2	276.9
BH19-10W	4760614.2	186525.2	275.0	11.3	263.8
BH19-32E	4760483.5	186086.8	270.5	8.2	262.3
BH19-33E	4763598.1	191407.2	285.7	8.2	277.4
BH19-34E	4764233.9	192178.5	286.5	8.2	278.3



4.3 LABORATORY TESTING

All samples were taken to Stantec's Ottawa laboratory where they were visually examined by a geotechnical engineer. The geotechnical laboratory testing program completed on the borehole samples is summarized in Table 4.2.

Table 4.2: Geotechnical Laboratory Testing Program

Test Description	Number of Tests	Remarks
Moisture Content	70	by Stantec
Atterberg Limits	10	by Stantec
Grain Size Distribution (sieve & hydrometer)	21	by Stantec

Seven soil samples, one from each borehole location, were also tested for pH, soluble sulphate content, chloride content, and resistivity by Paracel Laboratories Ltd. of Ottawa.

Samples remaining after testing will be placed in storage for a period of one year after issuance of the final report. After the storage period, the samples will be discarded unless we are directed otherwise by MTO.

5.0 SUBSURFACE CONDITIONS

5.1 OVERVIEW

Borehole location plans are provided on Drawing Nos. A1 through A4 in Appendix A. The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are displayed on the Record of Borehole sheets contained in Appendix B. An explanation of the symbols and terms used to describe the Borehole Records is also provided in Appendix B. The results of geotechnical laboratory testing are also presented in Appendix C.

The stratigraphic boundaries on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact boundaries between geological units.

A summary of subsurface conditions at borehole locations is presented in the following table. An overview of the subsurface conditions encountered in the boreholes is provided in the following sections.



FOUNDATION INVESTIGATION AND DESIGN REPORT
NEW OVERHEAD SIGNS – DESIGN-BUILD CONTRACT 2021-3037

October 2022

Table 5.1: Summary of Subsurface Soil Conditions at The Borehole Locations

Borehole	Soil boundary depths (m)	Soil boundary elevations (m)	Soil type	Range of SPT 'N'-values
BH19-6W	0.3 to 1.1	290.6 to 289.8	Compact to dense sand and gravel (Fill)	17 to 36
	1.1 to 10.2	289.8 to 280.7	Loose to dense, silty sand to sandy silt (Fill)	6 to 46
	10.2 to 11.2	280.7 to 279.7	Compact, gravelly silty sand (Fill)	15
	11.2 to 11.3	279.7 to 279.6	Compact sand	N/A
BH19-7W	0.1 to 0.6	288.4 to 287.9	Compact sand and gravel (Fill)	26
	0.6 to 1.5	287.9 to 287.0	Compact silty sand (Fill)	14
	1.5 to 1.9	287.0 to 286.6	Compact silt	10
	1.9 to 4.6	286.6 to 283.9	Stiff to hard silty clay	10 to 33
	4.6 to 8.2	283.9 to 280.3	Loose to very dense sand	7 to 52
BH19-9W	0.15 to 1.1	281.0 to 284.0	Compact sand and gravel (Fill)	13 to 14
	1.1 to 1.5	284.0 to 283.6	Compact sandy silt (Fill)	14
	1.5 to 2.3	283.6 to 282.8	Stiff clayey silt (Till)	13
	2.3 to 3.1	282.8 to 282.1	Compact silty sand	26
	3.1 to 8.2	282.1 to 276.9	Compact to dense sand to sandy silt	17 to 44
BH19-10W	0.3 to 1.1	274.7 to 274.0	Dense sand and gravel (Fill)	32
	1.1 to 8.2	274.0 to 266.9	Loose to compact sand/silty sand (Fill)	8 to 26
	8.2 to 8.7	266.9 to 266.4	Very stiff silty clay (Fill)	N/A
	8.7 to 10.7	266.4 to 264.4	Dense sand	34
	10.7 to 11.3	264.4 to 263.8	Compact sandy silt	27
BH19-32E	0.1 to 0.8	270.4 to 269.8	Loose sand and gravel (Fill)	4
	0.8 to 3.1	269.8 to 267.5	Compact sand (Fill)	13 to 27
	3.1 to 5.6	267.5 to 264.9	Stiff to very stiff clayey silt (Till)	13 to 16
	5.6 to 8.2	264.9 to 262.3	Loose to compact sand	5 to 17
BH19-33E	0 to 1.1	285.7 to 284.6	Very dense sand and gravel (Fill)	>50
	1.1 to 2.3	284.6 to 283.4	Compact silt and sand (Fill)	14 to 15
	2.3 to 3.1	283.4 to 282.6	Compact silty sand	15
	3.1 to 5.3	282.6 to 280.3	Compact to very dense silty sand to sandy silt (Till)	21 to >50
	5.3 to 8.2	280.3 to 277.4	Dense to very dense sand and gravel	31 to 56
BH19-34E	0.2 to 1.5	286.3 to 285.0	Compact sand and gravel (Fill)	12 to 20
	1.5 to 3.1	285.0 to 283.4	Very loose to loose silty sand	3 to 7
	3.1 to 7.2	283.4 to 279.3	Compact sandy silt to silty sand (Till)	15 to 22
	7.2 to 8.2	279.3 to 278.3	Very stiff sandy clayey silt (Till)	24

5.2 OVERBURDEN STRATIGRAPHY

5.2.1 Asphaltic Concrete

Boreholes BH19-6W, BH19-7W, BH19-10W and BH19-34E were drilled through the existing asphalt. The asphalt thickness at these boreholes was approximately 280 mm, 130 mm, 300 mm and 240 mm, respectively.



5.2.2 Topsoil

Topsoil was encountered at the ground surface at boreholes BH19-9W and BH19-32E. The topsoil thickness ranged from approximately 75 mm to 150 mm at these boreholes.

5.2.3 Sand and Gravel (FILL)

Near-surface sand and gravel fill materials were encountered beneath the asphalt in Boreholes BH19-6W, BH19-7W, BH19-10W and BH19-34E, below the topsoil in Boreholes BH19-9W and BH19-32E, and at the ground surface at the location of Borehole BH19-33E. The sand and gravel fill materials extended to depths of 0.6 m to 1.4 m below the ground surface.

Standard Penetration Test (SPT) 'N' values recorded in the sand and gravel fill typically ranged between 4 and 36 blows per 0.3 m of penetration indicating these materials are very loose to dense. One SPT, conducted from 0 to 0.7 m depth in BH19-33E, measured a higher penetration resistance of 150 mm for 50 blows, indicating the sand and gravel fill at that location is in a very dense state.

Laboratory testing of the sand and gravel fill materials yielded moisture contents that ranged from approximately 3% to 11% expressed as a percentage of the dry weight of the soil.

Gradation analyses were carried out on two representative samples of the near-surface sand and gravel fill materials. The results of the tests are illustrated on the gradation curves on Figure C1 in Appendix C.

5.2.4 Sandy Silt to Gravelly Silty Sand (FILL)

Predominantly cohesionless fill materials varying in composition from silty sand/gravelly sand to sandy silt were encountered below the sand and gravel fill in all Boreholes except BH19-34E. Cobbles and/or boulders were encountered within the fill materials at Boreholes BH19-W and BH19-10W and should be expected to be present within fill materials at other sites.

The thickness of the cohesionless fill materials were highly variable extending to depths of 1.5 m to 11.2 m below ground surface at the borehole locations. The thicker fill materials were encountered at boreholes advanced through approach embankments to overpass structures.

SPT 'N' values recorded in these cohesionless fill materials ranged between 6 and 46 blows per 0.3 m of penetration but were typically less than 30 blows indicating these fill materials are generally loose to compact.

Laboratory testing of the silty sand/gravelly sand to sandy silt fill materials yielded moisture contents that ranged from approximately 5% to 16%.

The results of grain size distribution testing carried out on seven samples of the fill material are shown on Figure C2 in Appendix C.

Atterberg Limit testing was carried out on two samples of the predominantly cohesionless fill that were considered to have the highest fines contents. These tests yielded Liquid Limits of 16 and 19 percent,



Plastic Limits of 12 and 15 percent and a corresponding Plasticity Index of about 4 percent (both samples). Based on this testing, these specific samples are considered to be slightly plastic sandy silt (ML). The Atterberg Test results are plotted on Figure C3 in Appendix C.

5.2.5 Silty Clay (FILL)

An approximately 0.5 m thick layer of silty clay fill containing trace to some sand and trace gravel was encountered below the sand fill layer in borehole BH19-10W. The base of this layer was encountered at a depth of approximately 8.7 m corresponding to an elevation of 266.4 m.

Based on manual/tactile examination of the silty clay fill, it is considered to have a very stiff consistency.

5.2.6 Silty Clay

A deposit of native silty clay containing trace sand was encountered at a depth of 1.9 m below ground surface in BH19-7W. The silty clay deposit was approximately 2.7 m thick with the base of the deposit encountered at a depth of 4.6 m below ground surface corresponding to an elevation of approximately 283.9 m.

SPT 'N' values recorded in the silty clay ranged from 11 to 33 blows per 0.3 m. Based on the SPT penetration resistances and manual/tactile examination of the samples, the silty clay is considered to have a stiff to hard consistency.

Laboratory testing of samples of the silty clay materials yielded moisture contents that ranged from approximately 19% to 23%.

The results of a gradation analysis completed on a sample of the silty clay is illustrated on Figure No. C4 in Appendix C.

An Atterberg Limits test conducted on a portion of the sample referenced in the preceding paragraph yielded a Liquid Limit of 44 percent, a Plastic Limit of 21 percent and a Plasticity Index of 23 percent. The results of this test are illustrated on Figure No. C5 in Appendix C.

5.2.7 Clayey Silt (TILL)

Deposits of clayey silt till containing varying amounts of sand and trace gravel were encountered beneath the fill materials in Boreholes BH19-9W and BH19-32E. These deposits were approximately 0.8 m to 2.5 m thick with the base of the deposits encountered at depths of 2.3 m to 5.6 m below ground surface. The clayey silt till deposit encountered in Borehole BH19-32 contained layers of silty sand/sandy silt up to approximately 0.3 m thick.

Although not encountered within the till during the current investigation, the till deposits of Southern Ontario are known to contain cobbles and boulders and these materials should be expected throughout the till deposits encountered during the current investigation.



A deposit of sandy clayey silt till containing trace gravel was also encountered in Borehole BH19-34E beneath the cohesionless, native soil deposits (described below). The till was encountered at a depth of 7.2 m (~Elevation 279.3 m) and BH19-34E was terminated in this deposit at a depth of 8.2 m (~Elevation 278.3 m).

SPT 'N' values recorded in the clayey silt till ranged from 13 to 24 blows per 0.3 m, indicating a stiff to very stiff consistency.

Laboratory testing of samples of the clayey silt till materials yielded moisture contents that ranged from approximately 11% to 19%.

The results of grain size distribution carried out on four samples of the clayey silt till are presented on Figure C6 Appendix C.

Atterberg limit tests carried out on four representative samples of the clayey silt till yielded Liquid Limits of 17 to 29 percent, Plastic Limits of 12 to 16 percent and corresponding plasticity indices of 5 to 14 percent. The results of the Atterberg limit testing are presented on Figure C7 in Appendix C.

5.2.8 Native Cohesionless Soils

Native deposits of cohesionless soils varying in composition from silt/sandy silt to sand/silty sand containing trace clay and gravel were encountered beneath the fill, clayey silt till or silty clay deposits in all boreholes. Pieces of wood were observed within the upper portion of these materials in Borehole BH19-10W.

BH19-6W, BH19-7W, BH19-9W, BH19-10W, and BH19-32E were terminated in these deposits at depths of 8.2 m to 11.3 m below ground surface. The silty sand deposits were fully penetrated in Boreholes BH19-33E and BH19-34E and were found to be 0.8 m to 1.7 m thick.

SPT 'N' values measured in these cohesionless deposits ranged from 3 to 52 blows per 0.3 m of penetration but were more typically in the range of 7 to 34 blows indicating these materials are generally in a loose to dense state.

Laboratory testing of samples of the native, silt to sand materials yielded moisture contents that ranged from approximately 3% to 21%.

The results of grain size distribution testing carried out on four samples of this deposit are shown on Figure C8 in Appendix C.

The result of an Atterberg Limit testing carried out on one sample of the sandy silt indicated the sample was non-plastic. The USCS group symbol for the cohesionless soil deposits varies from sand (SP), to silty sand (SM), to silt (ML).

5.2.9 Silty Sand to Sandy Silt (TILL)

Deposits of silty sand to sandy silt till containing varying amounts of gravel as well as sand seams were encountered below the silty sand deposits in Boreholes BH19-33E and BH19-34E. The silty sand/sandy



silt till deposits were 2.2 m to 4.1 m thick and were encountered to depths of approximately 5.3 m to 7.2 m below ground surface.

Although not encountered within the till during the current investigation, the till deposits of Southern Ontario are known to contain cobbles and boulders and these materials should be expected throughout the till deposits encountered during the current investigation.

SPT 'N' values measured in the silty sand/sandy silt till ranged from 15 blows per 0.3 m of penetration to 50 blows per 0.13 m of penetration indicating the till is in a compact to very dense state.

Laboratory testing of samples of the silty sand/sandy silt till materials yielded moisture contents that ranged from approximately 8 to 14%.

The results of grain size distribution testing carried out on two samples of these materials are shown on Figure C8 in Appendix C.

The results of Atterberg Limit testing carried out on these samples indicated they were non-plastic. The USCS group symbol for the till varies from silty sand (SM) to silt (ML).

5.2.10 Sand and Gravel

A sand and gravel deposit was encountered beneath the silty sand/sandy silt till at a depth of 5.3 m in Borehole BH19-33E. This borehole was terminated within the sand and gravel at a depth of 8.2 m below ground surface.

SPT 'N' values measured in the sand and gravel deposit ranged between 31 and 56 blows per 0.3 m of penetration indicating these soils are dense to very dense.

The natural moisture content of samples of the sand and gravel were between 5% and 12%.

The results of grain size distribution testing carried out on one sample of this deposit is shown on Figure C10 in Appendix C. The USCS group symbol for the sand and gravel deposit is sand or gravel (SP/GP).

5.2.11 Bedrock

Borehole advancement was terminated above the bedrock level.

5.3 GROUNDWATER

The groundwater levels observed during drilling or on completion of drilling in each of the boreholes are summarized in Table 5.2 below.



FOUNDATION INVESTIGATION AND DESIGN REPORT
NEW OVERHEAD SIGNS – DESIGN-BUILD CONTRACT 2021-3037

October 2022

Table 5.2: Measured Groundwater Levels

Borehole No	Ground Surface Elevation (m)	Date	Measured Groundwater Level	
			Depth (m)	Elevation (m)
BH19-6W	290.9	Nov 4, 2019	Borehole Dry	N/A*
BH19-7W	288.5	Nov 6, 2019	6.1	282.4
BH19-9W	285.1	Nov 4, 2019	Borehole Dry	N/A
BH19-10W	275.0	Nov 6, 2019	10.0	265.0
BH19-32E	270.5	Nov 4, 2019	4.6	265.9
BH19-33E	285.7	Nov 5, 2019	4.6	281.1
BH19-34E	286.5	Nov 5, 2019	2.3	284.2

*As previously indicated in Section 3.1, Borehole 2 (from GEOCRETS Reference No. 40P2-47) is in vicinity of proposed Sign No. 6W and the groundwater level in that borehole was encountered at an Elevation of 278.0 m.

The groundwater level for Sign 9W is expected to be below the termination depth/elevation of Borehole BH19-9W (i.e. below Elevation 276.9 m).

Groundwater levels will be subject to seasonal fluctuations and precipitation events and should be expected to be higher during the spring season or during and following periods of heavy precipitation or snow melt.

6.0 CHEMICAL TESTING

One representative sample of the subsurface soils collected from each of the boreholes advanced at the locations of the new overhead signs was tested for pH, sulphate and chloride concentrations, and resistivity. The analysis results are provided in Table 6.1.

Table 6.1: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Resistivity (Ohm-m)	Chloride (µg/g)	Sulphate (µg/g)
BH19-6W	SS02	0.8-1.4	8.1	8.2	712	117
BH19-7W	SS02	0.8-1.4	7.6	2.3	2830	98
BH19-9W	SS02	0.8-1.4	7.7	10.1	425	89
BH19-10W	SS03	2.3-2.9	8.0	14.9	328	56
BH19-32E	SS03	1.5-2.1	8.1	24.5	167	14
BH19-33E	SS03	1.5-2.1	8.0	14.7	361	16
BH19-34E	SS03	1.5-2.1	7.6	6.6	883	166



7.0 MISCELLANEOUS

The field work was carried out under the supervision of David Lee and Braydon Sharer under the direction of Kevin Nelson, P.Eng.

The utility locates for the boreholes were arranged by Stantec personnel.

The drilling equipment was supplied and operated by London Soil Testing of London, Ontario.

Location and elevation information for the boreholes was provided by Stantec's Transportation Group.

Traffic control services were provided by On Track Safety Ltd. of Thornhill, Ontario.

Geotechnical laboratory testing was carried out at Stantec's Ottawa laboratory. The chemical testing for pH, soluble sulphate and chloride contents, and soil resistivity was carried out by Paracel Laboratories Ltd. of Ottawa.

This report was prepared by Ramin Ghassemi, M.Sc., Ph.D. and reviewed by Kevin Nelson, P.Eng. and John J. Brisbois, MScE., P.Eng, Designated Principal MTO Foundation Contact.



8.0 CLOSURE

A subsurface investigation is a limited sampling of a site. The subsurface conditions given herein are based on information gathered at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to assess the additional information.

Respectfully Submitted;

STANTEC CONSULTING LTD.



Ramin Ghassemi, P.Eng. M.Sc., Ph.D.



Kevin Nelson, P.Eng.
Principal, Senior Geotechnical Engineer



John J. Brisbois, MScE., P. Eng.
MTO Designated Principal Foundation Contact



FOUNDATION INVESTIGATION AND DESIGN REPORT
For

Design-Build Contract 2021-3037
G.W.P 3087-16-00

New Overhead Signs – Highway 401 from Middlesex Road 30 (Putnam Rd.) to Highway 19 (Harris St.)
Sign Nos. 6W, 7W, 9W, 10W, 32E, 33E, and 34E

9.0 DISCUSSIONS AND ENGINEERING RECOMMENDATIONS

9.1 OVERVIEW

This section of the report provides preliminary foundation design input for the proposed construction of seven overhead sign supports associated with the Putnam Road and Culloden Road interchanges with Highway 401.

The recommendations are based on interpretation of the factual data obtained from the subsurface investigation and the results of the laboratory testing program completed on samples obtained from the subsurface investigation. The discussion and preliminary input presented herein is intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the preliminary design of the foundations for the overhead signs.

Comments provided with respect to construction are intended to highlight those aspects that could affect the design of the project and for which special provisions may be required in the Contract Documents. Contractors bidding the work should make their own interpretation of the factual information provided as such interpretation may affect their design, equipment selection, proposed construction methods, scheduling and other aspects of execution of construction.

9.2 OVERHEAD SIGN FOUNDATION DESIGN

9.2.1 General

The rehabilitation of a section of Highway 401 from Middlesex Road 30 (Putnam Road) to Highway 19 (Harris St.) includes the installation of seven new cantilever sign supports. Table 9.1 below summarizes the location and support type of each of the proposed signs with reference to the borehole advanced at the respective sign location.



Table 9.1: Proposed Sign Details

Sign No.	Proposed Location	Highway 401 Direction	Sign Type	Borehole ID
6W	15+870	Westbound	Single Cantilever	BH19-6W
7W	14+870	Westbound	Single Cantilever	BH19-7W
9W	24+000	Westbound	Single Cantilever	BH19-9W
10W	23+005	Westbound	Single Cantilever	BH19-10W
32E	22+550	Eastbound	Single Cantilever	BH19-32E
33E	12+970	Eastbound	Single Cantilever	BH19-33E
34E	13+970	Eastbound	Single Cantilever	BH19-34E

9.2.2 Frost Penetration

In accordance with OPSD 3090.101, the design frost penetration depth for foundations, f , within the study area is 1.3 m. This depth of frost penetration should be considered in the design of the overhead sign foundation supports.

9.2.3 Caisson Foundations for Overhead Signs

Overhead sign supports founded on caissons should be designed in accordance with the requirements in MTO's Sign Support Manual (MTO, 2019). The Sign Support Manual (SSM) includes standard foundation designs for ground-mounted (single or tri-chord) cantilever overhead signs (Section 3 of the SSM and Standard Drawing SS118-3). The standard foundations for cantilever or tri-chord signs consist of caisson foundations with lengths of 5 m to 6.5 m (below the frost depth) and diameters of 1.2 m to 1.35 m depending on the size/Class of the sign.

The standard foundation designs provided in the SSM do not apply to sites where bedrock is at or near the surface, the footings will be located in rock fill, or where exceptionally soft/loose soils are present within the foundation zone. These conditions were not encountered within the boreholes advanced at the sign locations.

The standard sign foundations presented in the SSM for the ground-mounted, cantilever overhead sign supports have been developed for sites where the following minimum soil conditions are present within the foundation zone.

- Case 1 (Cohesionless Soils): Competent soils of uniform composition with a minimum internal friction angle of 28 degrees within the upper 2/3 of the caisson below the frost zone and 30 degrees within the lower third of the caisson below the frost zone.
- Case 2 (Cohesive Soils): Clay soil with a minimum undrained shear strength of 25 kPa within the upper 2/3 of the caisson below the frost zone and a minimum undrained shear strength of 50 kPa within the lower third of the caisson below the frost zone

A site-specific footing design is required for sites where the soil conditions do not meet the minimum requirements outlined above.



Based on the results of the current investigation, the soils within the anticipated founding elevations of the overhead sign supports (OHSS) consist predominantly of cohesionless soils with a minimum internal friction angle of at least 28 degrees with the majority of these soils having internal friction angles of at least 30 degrees. Deposits of cohesive silt clay or clayey silt till were encountered within the foundation zone at some borehole locations. These materials were identified as having stiff to hard consistencies with undrained shear strengths exceeding 50 kPa.

Based on the subsurface conditions encountered at the borehole locations, the standard OHSS foundation designs are considered applicable for the signs on this project where flat ground conditions exist.

As discussed further below, Sign Nos. 6W and 10W will be located within the side-slopes of the highway embankments. As such, the design of the foundations for those signs will need to account for reductions in the passive resistance due to sloping ground conditions.

9.2.4 Design Parameters and Passive Lateral Earth Pressure

Table D-1, Foundation Design Parameters for Sign Structures, provided in Appendix D of this report provides recommended design parameters for signs where site-specific foundation designs are undertaken.

The unfactored passive lateral earth pressure, P_p (kPa), may be calculated using the following equations:

$$P_p = K_p \gamma z \quad \text{Above the groundwater table}$$

$$P_p = K_p (\gamma z_w + \gamma' (z - z_w)) \quad \text{Below the groundwater table}$$

Where: K_p is the passive earth pressure coefficient;

γ is the total unit weight (kN/m³);

γ' is the effective unit weight below the groundwater level (kN/m³);

z is the depth below the ground surface (m); and

z_w is the depth to the groundwater level (m).

The passive resistance should be neglected within the frost penetration depth, which is 1.3 m below ground surface.

A resistance factor of 0.5 should be applied to the calculated lateral resistance to obtain the factored lateral geotechnical resistance at Ultimate Limit States (ULS).

9.2.4.1 Adjustments for Sloping Ground Conditions

Sign Nos. 6W and 10W are located within areas of high approach embankments and, as such, the foundation supports for these replacement signs will be constructed within the side-slopes of the



embankments. Therefore, the design of the foundations for these signs will need to account for reduced lateral resistance due to the sloping ground conditions.

For sloping ground conditions, the lateral earth pressure coefficients may be calculated using standard design methods/equations such as those presented in Section 24.3 of the Canadian Foundation Engineering Manual (2006). The following presents an equation for calculating the passive earth pressure coefficient for sloping ground conditions.

$$K_p = \cos \theta \left(\frac{\cos \theta + (\cos^2 \theta - \cos^2 \Phi)^{0.5}}{\cos \theta - (\cos^2 \theta - \cos^2 \Phi)^{0.5}} \right)$$

Where: K_p is the passive earth pressure coefficient;

Φ is the angle of internal friction (degrees); and

θ is the critical cross slope within a radius of 4.5 ft around the shaft (degrees).

9.2.5 Construction Considerations

Construction of the sign support foundations should be in accordance with OPSS.PROV 915 (Construction Specification for Sign Support Structures) and OPSS.PROV 903 (Construction Specification for Deep Foundations).

The soils at the sign support locations consist predominantly of cohesionless soil deposits, ranging in composition from silt to sand and gravel. The observed groundwater levels were within the anticipated installation depths of the sign foundations at several borehole locations. Where wet, cohesionless soil deposits are encountered, these materials should be expected to run or flow into the holes drilled for the sign support foundations. Therefore, provision should be included for the use of temporary liners and/or drilling fluids to reduce the potential for sidewall instability and ground loss during drilling/concrete placement and for the use of tremie methods for placement of concrete where the foundations extend below the water level.

Cobbles or boulders were encountered in the highway embankment fill materials at BH19-6W and BH19-10W. Cobbles or boulders should also be expected within the native till deposits encountered within Boreholes 19-9W, 19-32E, 19-33E and 19-34E during the investigation. In this regard, cobbles and boulders should be anticipated within all embankment fill materials as well as the native till deposits identified in Section 5 of this report. Therefore, the construction equipment and procedures used must be suitable for penetrating and/or removing cobbles and boulders (if encountered) during the drilling of the holes for the foundations of the overhead sign supports.

9.3 CEMENT TYPE AND CORROSION POTENTIAL

One soil sample from each sign location were submitted to Paracel Laboratories for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The testing was completed to determine the potential for degradation of the concrete in the presence of soluble sulphates and the potential for



**FOUNDATION INVESTIGATION AND DESIGN REPORT
NEW OVERHEAD SIGNS – DESIGN-BUILD CONTRACT 2021-3037**

October 2022

corrosion of exposed steel used in foundations and buried infrastructure. The analysis results are summarized in Table 6.1.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. The maximum soluble sulphate concentration for all the samples tested was 166 µg/g. Soluble sulphate concentrations less than 1000 µg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. Type GU (General Use) Portland Cement should therefore be suitable for use in concrete at this site.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The soil pH of the samples tested ranged from 7.6 to 8.1 which is within what is considered the normal range for soil pH of 5.5 to 9.0. However reported resistivity values of 2.3 to 24.5 (ohm-m) suggest a high to extreme degree of corrosiveness for steel.

The test results provided in Table 6.1 should be used by the designers in assessing the potential for corrosion of steel elements and may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.



10.0 CLOSURE

A soil investigation is a limited sampling of a site. The conclusions given herein are based on information gathered by others at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately to assess the additional information and its effects on the above recommendations.

This report was prepared by Ramin Ghassemi, M.Sc., Ph.D. and reviewed by Kevin Nelson, P.Eng. and John Brisbois, P.Eng, Designated Principal MTO Foundation Contact.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Respectfully submitted,

STANTEC CONSULTING LTD.



Ramin Ghassemi, P.Eng., M.Sc., Ph.D.



Kevin Nelson, P.Eng.
Principal, Senior Geotechnical Engineer



John J. Brisbois, MScE., P. Eng.
MTO Designated Principal Foundation Contact



11.0 REFERENCES

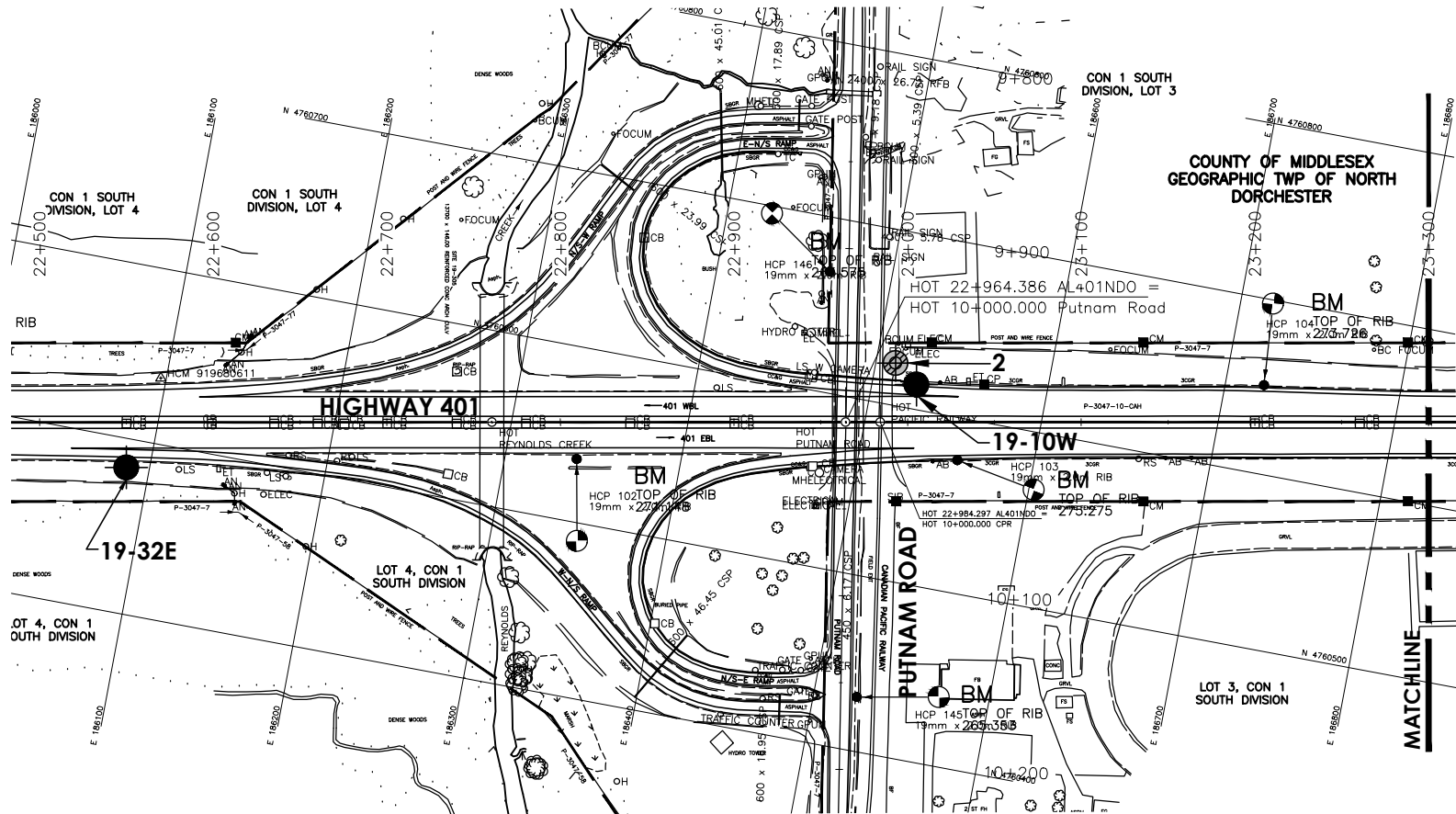
- Chapman, L.J., and Putnam, D.F. 1984. The physiography of Southern Ontario, Ontario Geological Survey Special Volume 2. Ontario Research Foundation, Toronto, Ontario.
- Geocres No. 40P2-47. Foundation Investigation Report for CPR Overhead, W.P. 479-89-05, Site 23-209, HWY. 401, District 2, London. Jan 25, 1991.
- Geocres No. 40P2-50. Foundation Investigation Report for High Mast Lighting at Highway 401-Culloden Road, W.P. 479-89-01, HWY. 401, District 2, London. Oct 10, 1991.
- Geocres No. 40I15-29. Foundation Investigation Report for Proposed Structure Extension: Hwy. 401 - Putnam Road and CPR Overpass, W.P. 478-89-02, Bridge Site 19-306, District 2, London. Jan 07, 1991.
- Ontario Geological Survey 2011. 1:250 000 scale bedrock geology of Ontario; Ontario Geological Survey, Miscellaneous Release - Data 126 - Revision 1.
- Ontario Ministry of Transportation (MTO). 2019. Sign Support Manual. Bridge Office, St. Catharines, Ontario. Feb 2019
- OPSD 3090.101. Foundation Frost Depths for Southern Ontario. Rev. 1. Nov 2010.
- OPSS.PROV 915. Construction Specification for Sign Support Structures. Nov 2014.



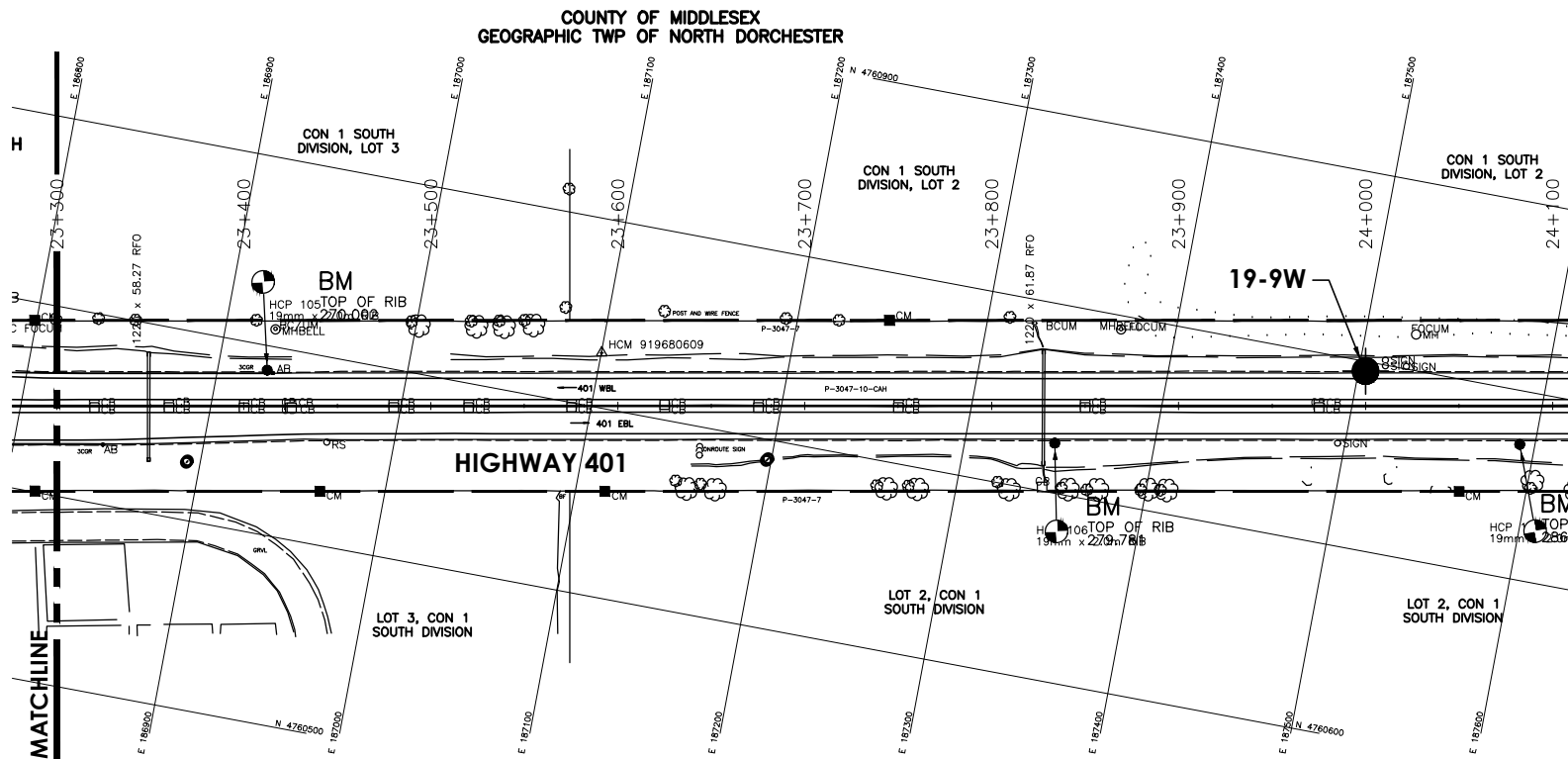
APPENDIX A

A.1 DRAWINGS NOS. A1 TO A4 – BOREHOLE LOCATION PLANS AND SOIL STRATA PLOTS





STA 22+500 TO STA 23+300



STA 23+300 TO STA 24+100

PLANS

SCALE



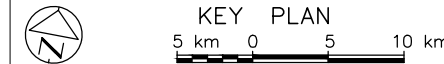
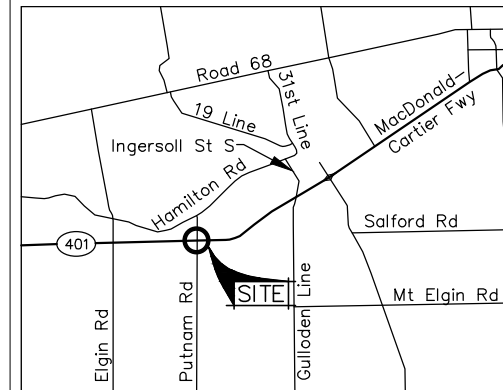
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

PLATE No
CONT
WP 3087-16-00

HWY 401 OVERHEAD SIGNS
STA 22+500 to STA 24+100
BOREHOLE LOCATIONS



SHEET



LEGEND

- Borehole (Stantec, 2019)
- Borehole (Strata, 1990)
(Approximate Location)

No	ELEVATION	MTM. ZONE 10 NORTH	COORDINATES EAST
19-9W	285.1	4 760 794.8	187 503.7
19-10W	275.0	4 760 614.2	186 525.2
19-32E	270.5	4 760 483.5	186 086.8
2	266.2	4 760 624.2	186 511.2

NOTES

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REVISIONS	DATE	BY	DESCRIPTION

GEORES No 40P02-086

HWY No 401	CHECKED	DATE 2020-09-03	DIST WEST
SUBM'D RG	CHECKED	APPROVED	SITE
DRAWN GBB	CHECKED		DWG A1



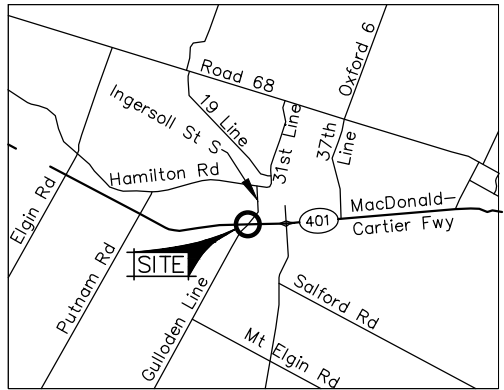
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

PLATE No
CONT
WP 3087-16-00



HWY 401 OVERHEAD SIGNS
STA 12+600 to STA 13+800
BOREHOLE LOCATIONS

SHEET



KEY PLAN
5 km 0 5 10 km

LEGEND

Borehole (Stantec, 2019)

No	ELEVATION	MTM, ZONE 10 NORTH	COORDINATES EAST
19-33E	285.7	4 763 598.1	191 407.2

NOTES

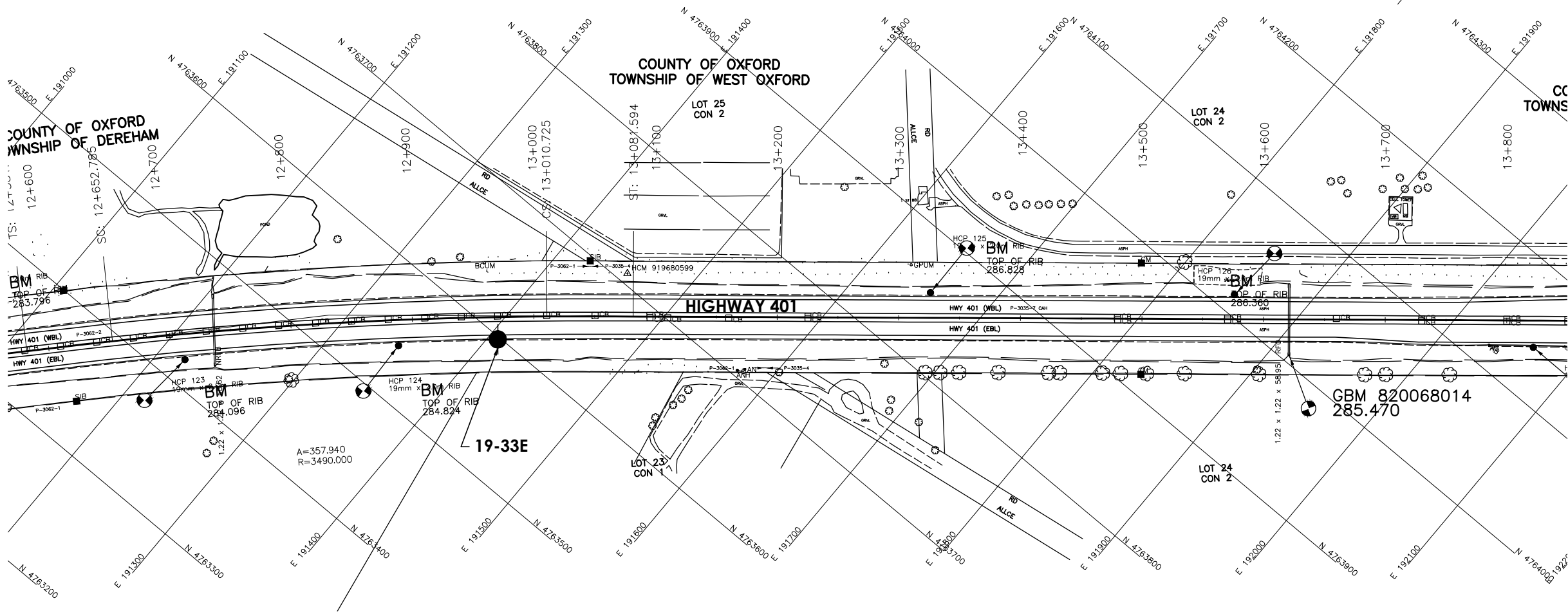
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REVISIONS	DATE	BY	DESCRIPTION

GEOCREs No 40P02-086			
HWY No 401		DIST WEST	
SUBM'D RG	CHECKED	DATE 2020-09-03	SITE
DRAWN GBB	CHECKED	APPROVED	DWG A2



PLAN
SCALE
40 m 0 40 80 m

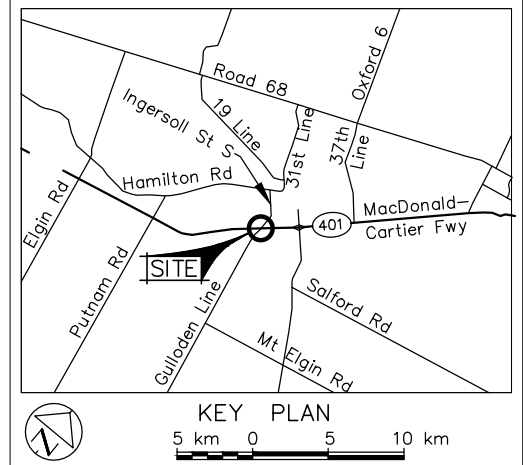


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

PLATE No
CONT
WP 3087-16-00

HWY 401 OVERHEAD SIGNS
STA 13+800 to STA 15+100
BOREHOLE LOCATIONS

SHEET



LEGEND

- Borehole (Stantec, 2019)
- Borehole (MTO, 1991)

No	ELEVATION	MTM. ZONE 10 NORTH	COORDINATES EAST
19-7W	288.5	4 764 843.5	192 842.2
19-34E	286.5	4 764 233.9	192 178.5
P1	285.9	4 764 248.8	192 228.9
P8	287.7	4 764 823.6	192 785.7

NOTES

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

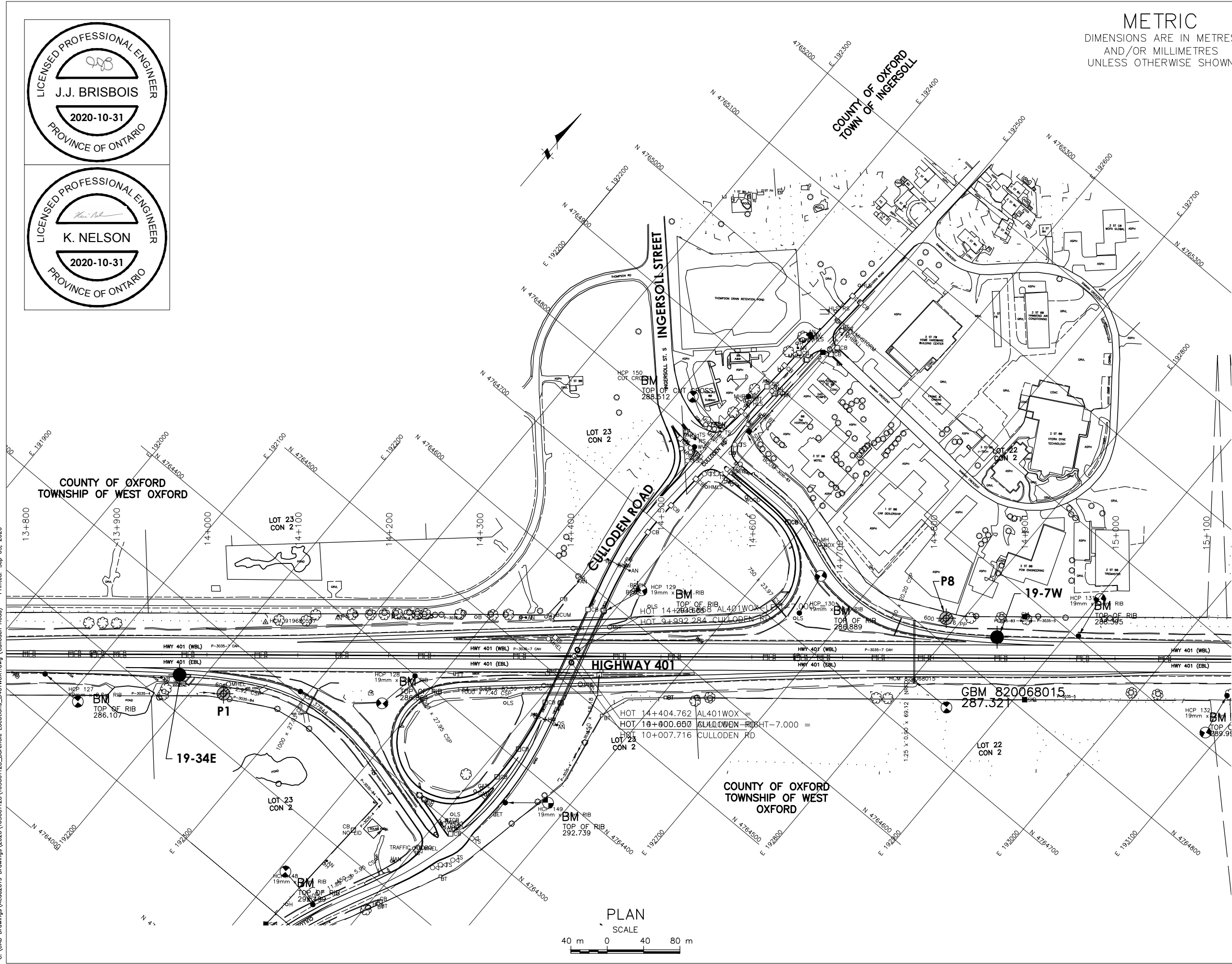
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REVISIONS	DATE	BY	DESCRIPTION

GEORES No 40P02-086

HWY No 401		DIST WEST
SUBM'D RG	CHECKED	DATE 2020-09-03 SITE
DRAWN GBB	CHECKED	APPROVED DWG A3





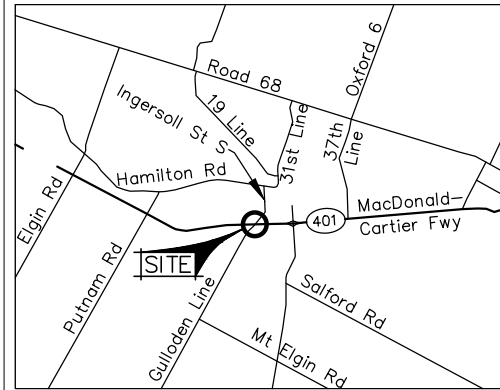
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

PLATE No
CONT
WP 3087-16-00



HWY 401 OVERHEAD SIGNS
STA 15+100 to STA 16+300
BOREHOLE LOCATIONS

SHEET



KEY PLAN
5 km 0 5 10 km

LEGEND

- Borehole (Stantec, 2019)
- Borehole (MTO, 1990)

No	ELEVATION	MTM_ZONE 10 NORTH	COORDINATES EAST
19-6W	290.9	4 765 476.1	193 616.6
2	281.6	4 765 460.5	193 560.7
6	290.8	4 765 444.5	193 581.1

NOTES

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

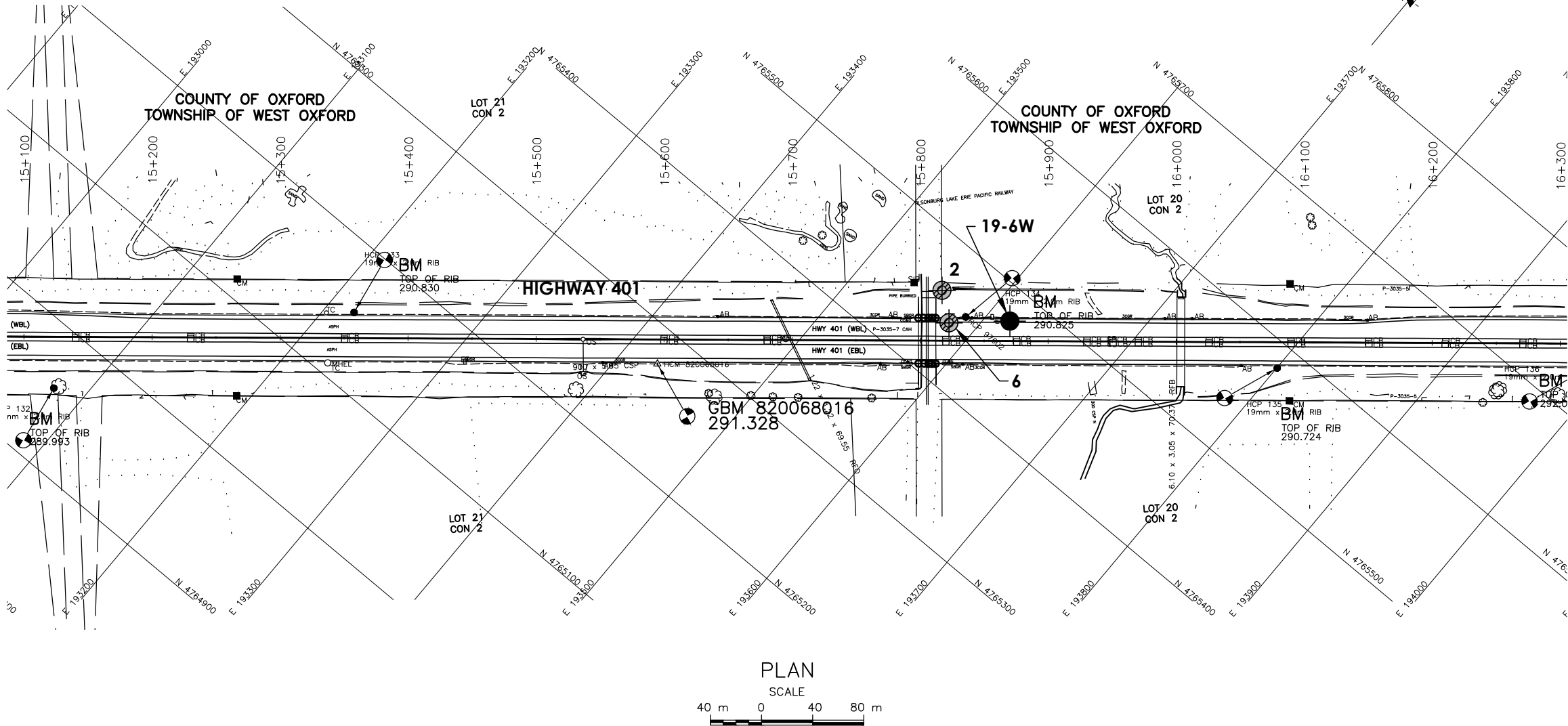
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REVISIONS	DATE	BY	DESCRIPTION

GEORES No 40P02-086

HWY No 401		DIST WEST
SUBM'D RG	CHECKED	DATE 2020-09-21 SITE
DRAWN GBB	CHECKED	APPROVED DWG A4



APPENDIX B

- B.1 SYMBOLS AND TERMS USED ON BOREHOLE RECORDS**
- B.2 BOREHOLE RECORDS (CURRENT INVESTIGATION)**
- B.3 BOREHOLE RECORDS FROM PREVIOUS STUDIES
(GEOCRETS REPORTS NO. 40P2-47, 40P2-50, AND 40I15-29)**



SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

<i>Rootmat</i>	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
<i>Topsoil</i>	- mixture of soil and humus capable of supporting vegetative growth
<i>Peat</i>	- mixture of visible and invisible fragments of decayed organic matter
<i>Till</i>	- unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

<i>Desiccated</i>	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
<i>Fissured</i>	- having cracks, and hence a blocky structure
<i>Varved</i>	- composed of regular alternating layers of silt and clay
<i>Stratified</i>	- composed of alternating successions of different soil types, e.g. silt and sand
<i>Layer</i>	- > 75 mm in thickness
<i>Seam</i>	- 2 mm to 75 mm in thickness
<i>Parting</i>	- < 2 mm in thickness

Terminology describing soil types:

The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):

Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%
<i>Frequent</i>	> 20%

Terminology describing compactness of cohesionless soils:

The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
<i>Very Loose</i>	<4
<i>Loose</i>	4-10
<i>Compact</i>	10-30
<i>Dense</i>	30-50
<i>Very Dense</i>	>50

Terminology describing consistency of cohesive soils:

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
<i>Very Soft</i>	<0.25	<12.5	<2
<i>Soft</i>	0.25 - 0.5	12.5 - 25	2-4
<i>Firm</i>	0.5 - 1.0	25 - 50	4-8
<i>Stiff</i>	1.0 - 2.0	50 - 100	8-15
<i>Very Stiff</i>	2.0 - 4.0	100 - 200	15-30
<i>Hard</i>	>4.0	>200	>30

ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	Very Poor Quality
25-50	Poor Quality
50-75	Fair Quality
75-90	Good Quality
90-100	Excellent Quality

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	Crushed
Severely Fractured	Shattered or Very Blocky
Fractured	Blocky
Moderately Jointed	Sound
Intact	Very Sound

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

Spacing (mm)	Discontinuities	Bedding
>6000	Extremely Wide	-
2000-6000	Very Wide	Very Thick
600-2000	Wide	Thick
200-600	Moderate	Medium
60-200	Close	Thin
20-60	Very Close	Very Thin
<20	Extremely Close	Laminated
<6	-	Thinly Laminated

Terminology describing rock strength:

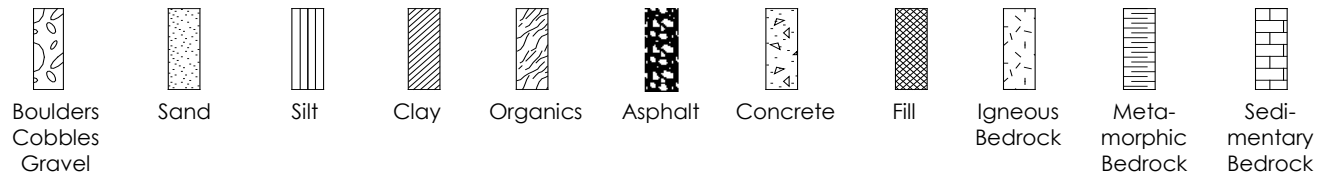
Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

STRATA PLOT

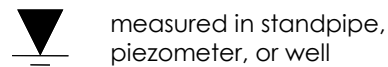
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT



RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

RECORD OF BOREHOLE No BH19-6W

1 OF 2

METRIC

W.P. 3087-16-00 LOCATION Highway 401 Ingersoll ORIGINATED BY DL
DIST West HWY 401 BOREHOLE TYPE 83 mm HOLLOW STEM AUGERS COMPILED BY RG
DATUM Geodetic DATE 2019.11.04 LATITUDE 43.02097029 LONGITUDE -80.86411897 CHECKED BY KN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				w _p	w	w _L						
								○ UNCONFINED + FIELD VANE												
								● QUICK TRIAXIAL × LAB VANE												
						WATER CONTENT (%)														
290.9	ASPHALTIC CONCRETE						20	40	60	80	100		20	40	60		GR	SA	SI	CL
0.0	280 mm ASPHALTIC CONCRETE																			
290.6																				
0.3	SAND and GRAVEL (FILL) Dense Brown Damp Compact and wet below 0.8 m		1	SS	36								○							
289.8			2	SS	17								○							
1.1	SILTY SAND (SM), some gravel to gravelly (FILL) Contains occasional cobbles Compact to dense Brown Moist												○							
			3	SS	10								○							
			4	SS	18								○							
			5	SS	46								○							
													○							
			6	SS	22								○	H						
			7	SS	34								○							
			8	SS	16								○							

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO 165001128 HWY 401 INGERSOLL.GPJ ONTARIO MTO.GDT 2/20/20

RECORD OF BOREHOLE No BH19-6W

2 OF 2

METRIC

W.P. 3087-16-00 LOCATION Highway 401 Ingersoll ORIGINATED BY DL
 DIST West HWY 401 BOREHOLE TYPE 83 mm HOLLOW STEM AUGERS COMPILED BY RG
 DATUM Geodetic DATE 2019.11.04 LATITUDE 43.02097029 LONGITUDE -80.86411897 CHECKED BY KN

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
						20	40	60	80	100	W _p	W	W _L			
	End of Borehole Borehole open to 9.8 m and dry on completion of drilling.															

RECORD OF BOREHOLE No BH19-7W

1 OF 1

METRIC

W.P. 3087-16-00 LOCATION Highway 401 Ingersoll ORIGINATED BY BS
 DIST West HWY 401 BOREHOLE TYPE 83 mm HOLLOW STEM AUGERS COMPILED BY RG
 DATUM Geodetic DATE 2019.11.06 LATITUDE 43.01516276 LONGITUDE -80.87349125 CHECKED BY KN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE															
	● QUICK TRIAXIAL	× LAB VANE																						
288.5	ASPHALTIC CONCRETE																							
288.0	130 mm ASPHALTIC CONCRETE																							
0.1	SAND and GRAVEL (SM), some silt (FILL) Compact Brown Dry to moist		1	SS	26		288						○					35	50	15				
287.9																								
0.6	SILTY SAND (SM), some gravel (FILL) Compact Grey Wet		2	SS	14								○											
287.0							287						○											
1.5	SILT (ML), some sand Compact Grey Wet		3	SS	10								○											
286.6													○											
1.9	SILTY CLAY (CI), trace sand Very stiff to hard Brown						286						○	—	—			0	2	49	49			
			4	SS	23																			
			5	SS	33		285						○											
	Stiff below 3.8 m		6	SS	11								○											
283.9							284						○											
4.6	SAND (SP), trace to some silt Loose to Compact Brwon Moist		7	SS	7								○											
			8	SS	15		283						○					0	87	12	1			
	Wet below 6.1 m		9	SS	24		282						○											
	Very dense below 7.6 m		10	SS	52		281						○											
280.3																								
8.2	End of Borehole																							
	Groundwater was observed below 6.1 m (~ Elev. 282.4) during drilling.																							

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO 165001128 HWY 401 INGERSOLL.GPJ ONTARIO MTO.GDT 2/20/20

RECORD OF BOREHOLE No BH19-9W

1 OF 1

METRIC

W.P. 3087-16-00 LOCATION Highway 401 Ingersoll ORIGINATED BY DL
 DIST West HWY 401 BOREHOLE TYPE 83 mm HOLLOW STEM AUGERS COMPILED BY RG
 DATUM Geodetic DATE 2019.11.04 LATITUDE 42.97792242 LONGITUDE -80.93811369 CHECKED BY KN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED	+ FIELD VANE									
								● QUICK TRIAXIAL	× LAB VANE									
							20	40	60	80	100	WATER CONTENT (%)						
285.1	TOPSOIL & GRASS																	
285.0	150 mm TOPSOIL																	
0.2	SAND and GRAVEL, trace silt (FILL) Compact Brown Moist		1	SS	13								○					
284.0																		
1.1	SANDY SILT (ML), some gravel, trace clay (FILL) Compact		2	SS	14								○					
283.6	Grey Moist																	
1.5	CLAYEY SILT (CL), trace to some sand (TILL) Stiff Brown		3	SS	13								○					
282.8																		
2.3	SILTY SAND (SM), trace to some gravel Compact Brown Moist		4	SS	26								○					
282.1																		
3.1	SAND (SM), some silt to SANDY SILT (ML) Compact Light brown Moist		5	SS	25								○					
			6	SS	17								○					
	Dense below 6.1 m		7	SS	41								○					
			8	SS	44								○					
276.9	End of Borehole																	
8.2	Borehole open to 7.3 m and dry on completion of drilling.																	

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH19-10W

1 OF 1

METRIC

W.P. 3087-16-00 LOCATION Highway 401 Ingersoll ORIGINATED BY DL
DIST West HWY 401 BOREHOLE TYPE 83 mm HOLLOW STEM AUGERS COMPILED BY RG
DATUM Geodetic DATE 2019.11.06 LATITUDE 42.97614584 LONGITUDE -80.95006785 CHECKED BY KN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p	w	w _L		GR	SA	SI	CL	
275.0	ASPHALTIC CONCRETE																				
0.0	300 mm ASPHALTIC CONCRETE																				
274.7																					
0.3	SAND and GRAVEL, trace silt (FILL) Dense Brown Moist		1	SS	32																
274.0							274														
1.1	SAND (SM), some to silty, some gravel, trace clay (FILL) Contains occasional cobbles and/or boulders Compact Brown Moist		2	SS	15												14	50	26	8	
							273														
			3	SS	26																
							272														
			4	SS	17																
							271														
	Loose below 3.8 m		5	SS	8																
							270														
			6	SS	8																
							269														
			7	SS	11																
							268														
			8	SS	13																
							267														
			9	SS	20																
266.9							266														
8.2	SILTY CLAY, trace to some sand and gravel (FILL) Very stiff Grey																				
266.4							265														
8.7	SAND (SP), trace silt Wood debris at top of SS10 Dense Brown Moist		10	SS	34																
							264														
264.4																					
10.7	SANDY SILT (ML) Compact Brown Wet		11	SS	27													0	30	66	4
263.8																					
11.3	End of Borehole																				
	Groundwater was observed below 10 m (~ Elev. 265.0) during drilling.																				

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO 165001128 HWY 401 INGERSOLL.GPJ ONTARIO MTO.GDT 2/20/20

RECORD OF BOREHOLE No BH19-32E

1 OF 1

METRIC

W.P. 3087-16-00 LOCATION Highway 401 Ingersoll ORIGINATED BY DL
DIST West HWY 401 BOREHOLE TYPE 83 mm HOLLOW STEM AUGERS COMPILED BY RG
DATUM Geodetic DATE 2019.11.04 LATITUDE 42.97490068 LONGITUDE -80.95541375 CHECKED BY KN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
270.5	TOPSOIL & GRASS						20	40	60	80	100							
270.4	75 mm TOPSOIL																	
269.8	SAND and GRAVEL, trace silt (FILL) Loose Brown Wet		1	SS	4								o					
0.8	SAND (SM), some silt, trace gravel, trace clay (FILL) Contains pockets of silty sand Compact Brown Moist		2	SS	24								o			5 72 19 4		
			3	SS	27								o					
			4	SS	13								o					
267.5	CLAYEY SILT (CL), some sand to sandy, trace gravel (TILL) Stiff to very stiff Brown		5	SS	14								o					
3.1			6	SS	16								o			0 18 54 28		
	SS7 contains layers of silty sand/sandy silt up to 0.3 m thick		7	SS	13								o			0 29 51 20		
264.9	SAND (SP), trace silt and gravel Loose to compact Brown Wet		8	SS	5								o					
5.6																		
			9	SS	17								o					
262.3	End of Borehole																	
8.2	Water level at 4.6 m depth (~ Elev. 265.9) in open borehole on completion of drilling.																	




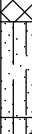
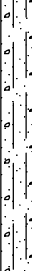
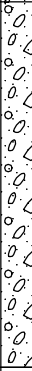
+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH19-33E

1 OF 1

METRIC

W.P. 3087-16-00 LOCATION Highway 401 Ingersoll ORIGINATED BY BS
 DIST West HWY 401 BOREHOLE TYPE 83 mm HOLLOW STEM AUGERS COMPILED BY RG
 DATUM Geodetic DATE 2019.11.05 LATITUDE 43.00374197 LONGITUDE -80.8908378 CHECKED BY KN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								20	40	60	80	100						○ UNCONFINED
285.7	0.0	SAND and GRAVEL (FILL) Very dense Brown Dry		1	SS	50/ 150 mm		285									5 43 45 7	
284.6	1.1	SILT and SAND (ML to SM), trace clay and gravel (FILL) Compact Brown Moist		2	SS	14		284										
283.4	2.3	SILTY SAND (SM), trace gravel Compact Brown Moist		3	SS	15		283										
282.6	3.1	SILTY SAND (SM) to SANDY SILT (ML), trace clay and gravel (TILL) Contains wet sand seams approximately 0.1 m in thickness at 3.4 m depth and 4.2 m depth Compact to very dense Brown Moist		4	SS	15		282										
				5	SS	21		281										
				6	SS	40												
				7	SS	50/ 130 mm												
280.3	5.3	SAND and Gravel (SP/GP), trace silt Dense to very dense Brown Wet		8	SS	31		280										
				9	SS	56		279										
				10	SS	37		278										
277.4	8.2	End of Borehole Water level of approximately 4.6 m depth (~ Elev. 281.1 m) in open borehole on completion of drilling.																

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH19-34E

1 OF 1

METRIC

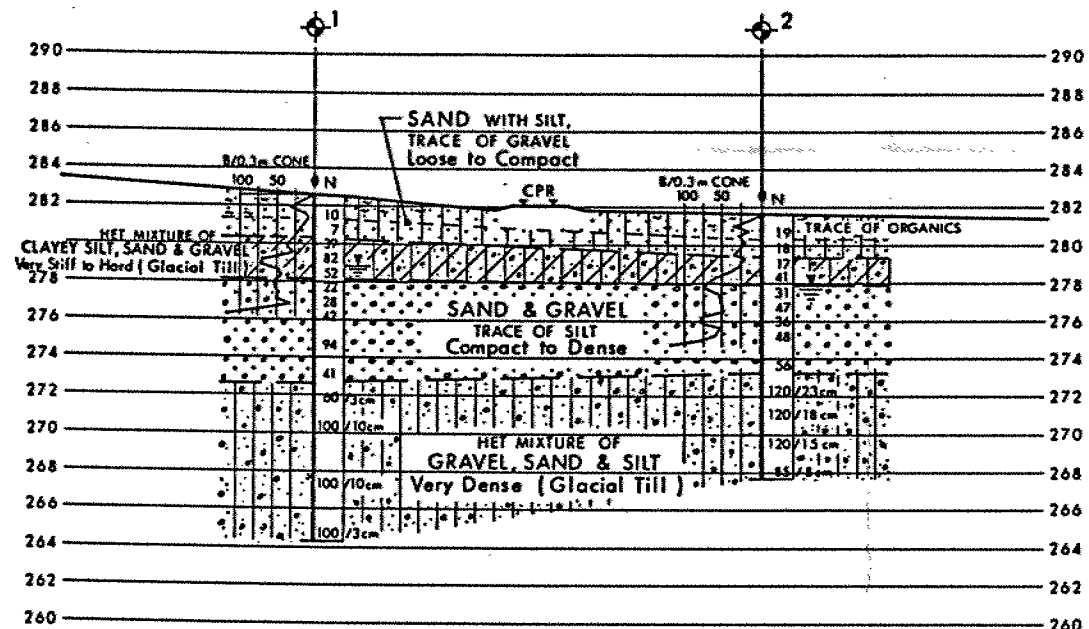
W.P. 3087-16-00 LOCATION Highway 401 Ingersoll ORIGINATED BY DL
 DIST West HWY 401 BOREHOLE TYPE 83 mm HOLLOW STEM AUGERS COMPILED BY RG
 DATUM Geodetic DATE 2019.09.26 - 2019.11.05 LATITUDE 43.00957892 LONGITUDE -80.88150827 CHECKED BY KN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								○ UNCONFINED	+ FIELD VANE										
								● QUICK TRIAXIAL	× LAB VANE										
							WATER CONTENT (%)												
							20	40	60	80	100	20	40	60					
286.5	ASPHALTIC CONCRETE																		
0.0 286.3	240 mm ASPHALTIC CONCRETE																		
0.2	SAND and GRAVEL (SP), trace to some silt (FILL) Compact Brown Moist			1	SS	20													
				2	SS	12													
285.0																			
1.5	SILTY SAND (SM), trace clay and gravel Loose Brown to light brown Moist Wet below 2.3 m SS4 inferred to be disturbed by drilling operation			3	SS	7													
				4	SS	3													
283.4																			
3.1	SANDY SILT (ML) to SILTY SAND (SM), trace clay and gravel (TILL) Compact Brown Wet			5	SS	19													
				6	SS	15													
				7	SS	20													
				8	SS	17													
				9	SS	22													
279.3																			
7.2	Sandy CLAYEY SILT (CL-ML), trace gravel (TILL) Very stiff Light brown Wet																		
				10	SS	24													
278.3																			
8.2	End of Borehole Groundwater observed at approximately 2.3 m depth (~ Elev. 284.2 m) during drilling.																		

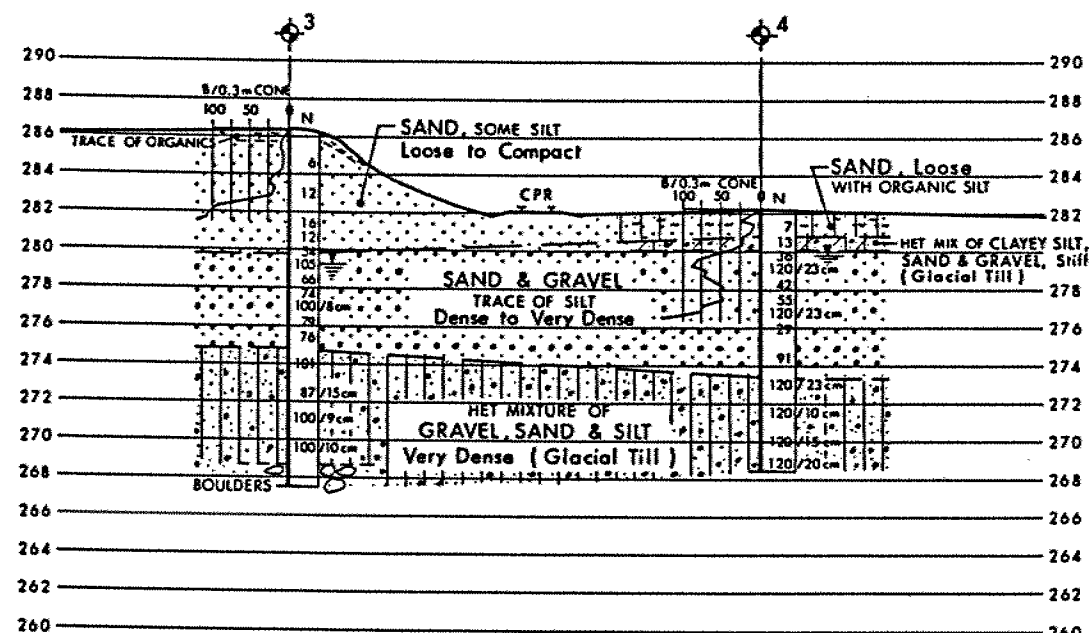
+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

**Borehole Records from Previous Studies
(GEOCRES Reports No. 40P2-47, 40P2-50, and 40I15-29)**



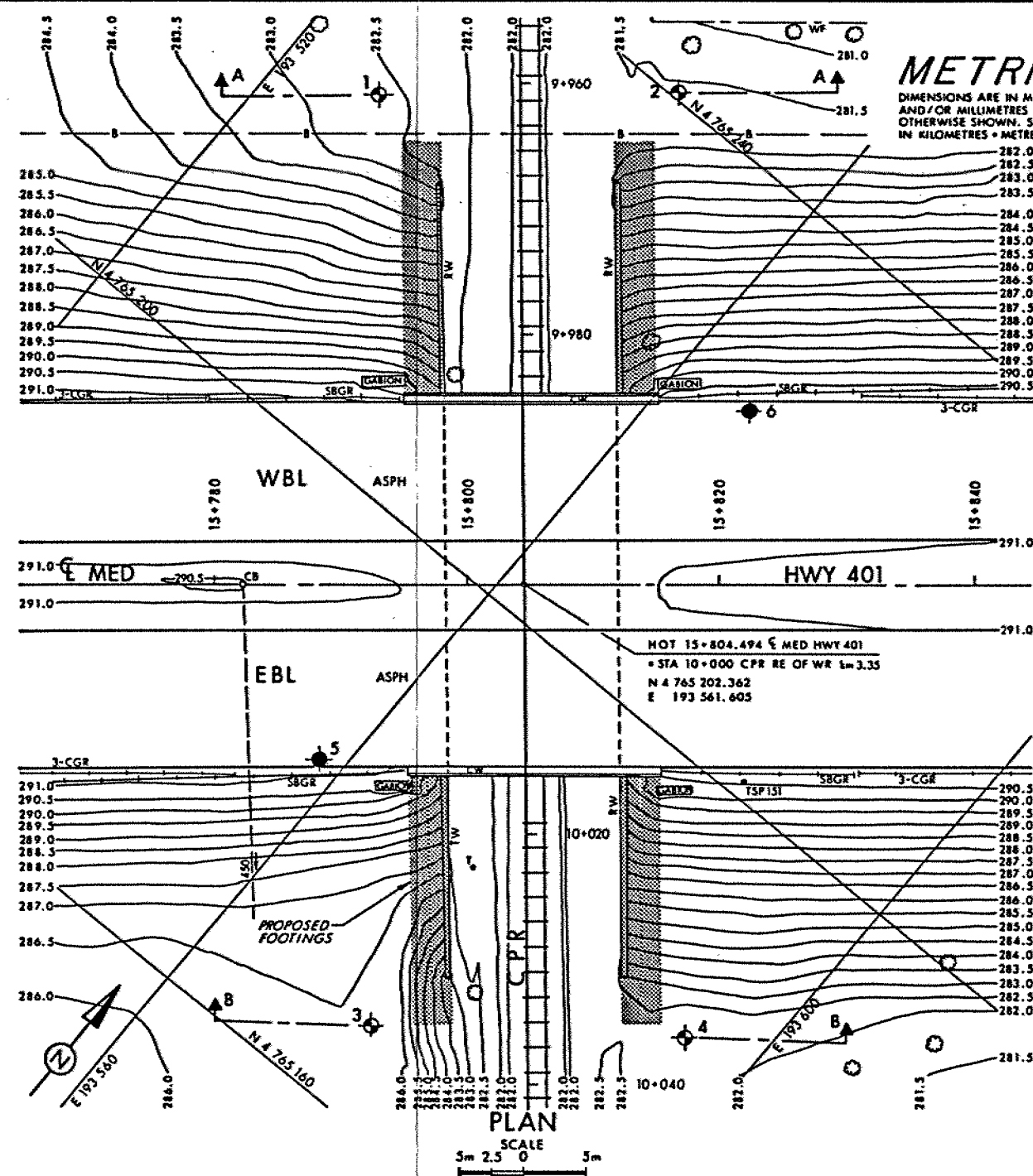


A-A



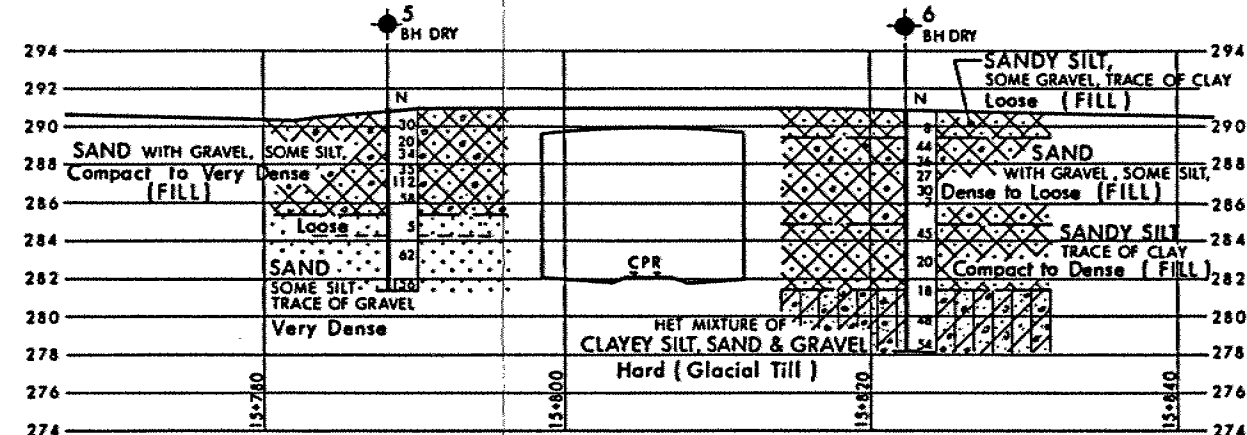
B-B

SECTIONS
SCALE
4m 2 0 4m



PLAN

SCALE
5m 2.5 0 5m



PROFILE - MEDIAN HIGHWAY 401

SCALE
5m 2.5 0 5m HOR
4m 2 0 4m VERT

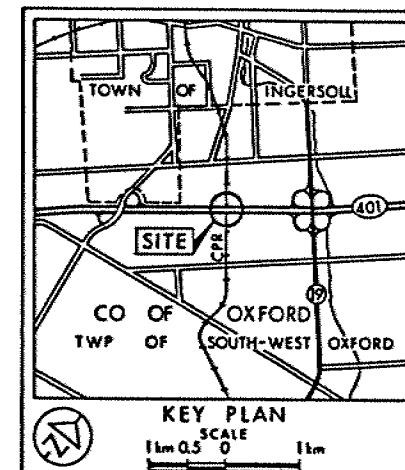
CONT No
WP No 479-89-05

CPR OVERHEAD

BORE HOLE LOCATIONS & SOIL STRATA



SHEET



LEGEND

- ◆ Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 1990 07

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	282.6	4 765 225.2	193 527.8
2	281.6	4 765 240.5	193 545.9
3	286.3	4 765 167.3	193 574.8
4	282.3	4 765 182.7	193 594.6
5	291.0	4 765 181.2	193 558.1
6	290.8	4 765 224.5	193 566.4

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

DATE	BY	DESCRIPTION
------	----	-------------

Geocres No 40P2-47

HWY No 401	SUBMIT BY	CHECKED BY	DATE 1990 12 20	DIST 2
DRAWN RS	CHECKED CH	APPROVED		SITE 23-209
				DWG 4798903-A

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 479 - 89 - 05 LOCATION CO - ORDS. N 4 765 240.5; E 193 545.9 ORIGINATED BY M V&J L
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M V
 DATUM GEODETIC DATE 90 07 16 & 90 07 17 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa									
								20	40	60						80	100

281.6	Ground Surface														
0.0	Trace of Organics		1	SS	19										
279.4	SAND With Silt, Trace of Gravel, Compact		2	SS	18										
2.2	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Hard (Glacial Till)		3	SS	17										
277.9			4	SS	41										
3.7			5	SS	31										
	SAND and GRAVEL, Trace of Silt, Dense		6	SS	47										43 46 (11)
			7	SS	36										
			8	SS	48										55 34 (11)
273.3			9	SS	56										
8.3			10	SS	120	/23cm									
	Heterogeneous Mixture of GRAVEL, SAND and SILT, Very Dense (Glacial Till)		11	SS	120	/18cm									
			12	SS	120	/15cm									
267.7			13	SS	85	/8cm									
13.9	End of Borehole														

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 479 - 89 - 05 LOCATION CO - ORDS. N 4 765 224.5; E 193 566.4 ORIGINATED BY M V&J L
 DIST 2 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGER COMPILED BY M V
 DATUM GEODETIC DATE 90 07 19 & 90 07 23 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
290.8	Hwy. 401 Shoulder																
0.0	SANDY SILT, Some Gravel, Trace of Clay, Loose (Fill)		1	SS	8	DRY	290										
289.4			2	SS	44												
1.4			3	SS	36												
	SAND With gravel, Some Silt, Dense to Loose (Fill)		4	SS	27		288										
			5	SS	30												
			6	SS	7		286										
284.9																	
5.9	SANDY SILT, Trace of Clay, Compact to Dense (Fill)		7	SS	45		284										
			8	SS	20												
281.4							282										
9.4	Trace of Organics Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		9	SS	18												
			10	SS	48		280										
278.2			11	SS	54												
12.6	End of Borehole																

METRIC

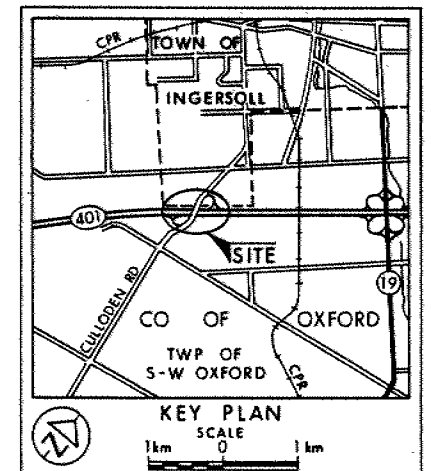
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 479-89-01

HWY 401 & CULLODEN ROAD
HIGH MAST LIGHTING
BORE HOLE LOCATIONS



SHEET



LEGEND

- ◆ Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ◆ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 1991 08

No	ELEVATION	CO-ORDINATES NORTH	EAST
P1	285.9	4 764 028	192 213
P2	286.4	4 764 134	192 337
P3	291.1	4 764 090	192 493
P4	287.3	4 764 220	192 458
P5	287.0	4 764 402	192 519
P6	287.7	4 764 562	192 475
P7	287.1	4 764 496	192 643
P8	287.7	4 764 602	192 771

NOTE

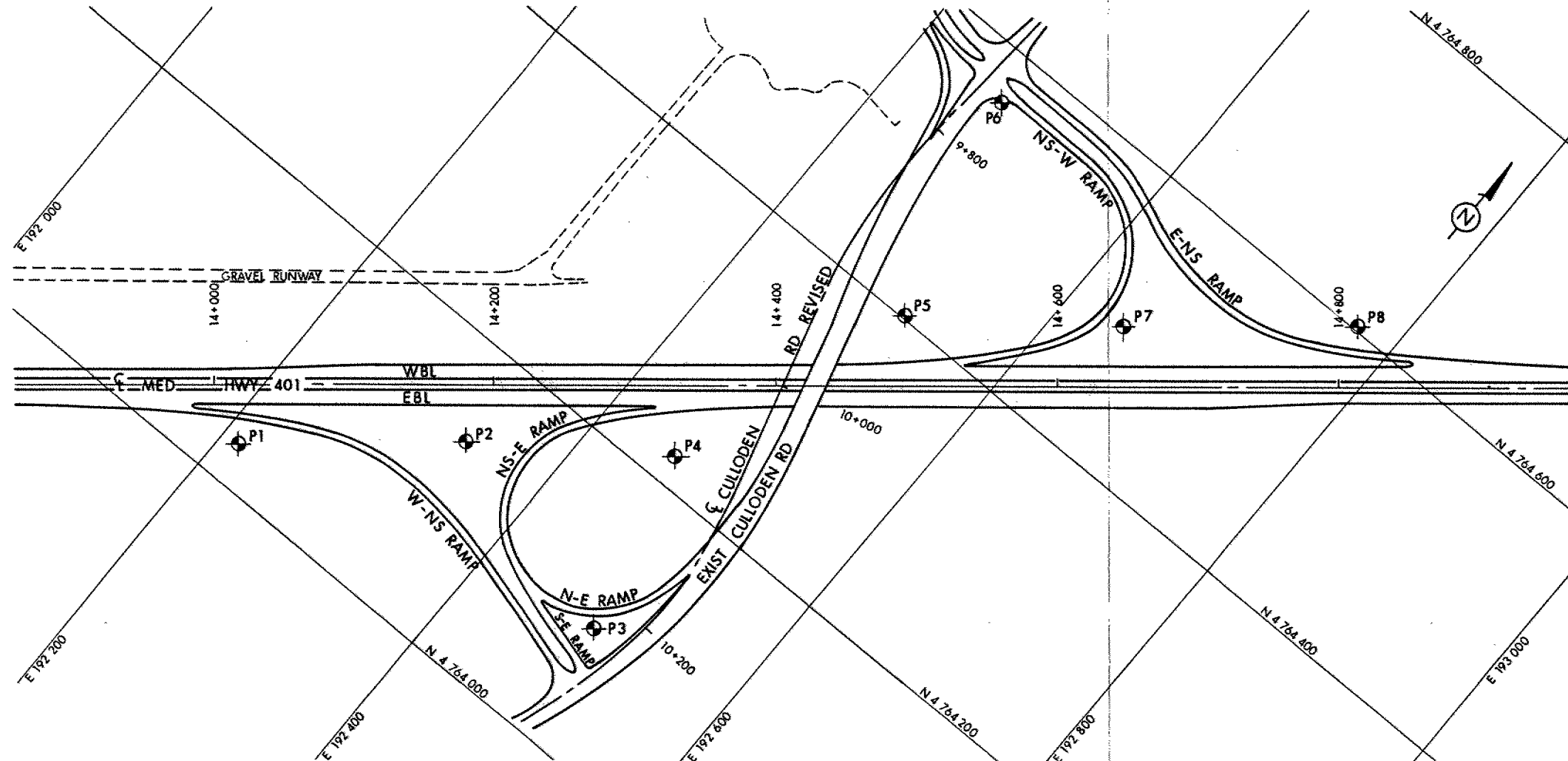
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION

Geocres No 40P2-50

HWY No 401	DIST 2
SUBMD MV [CHECKED 9] DATE 1991 09 19	SITE
DRAWN RS [CHECKED 0] APPROVED	DWG 4798901-A



PLAN



NOTE

For Soil details refer to
Record of Borehole Sheets.

RECORD OF BOREHOLE No P1

1 OF 1

METRIC

W.P. 479 - 89 - 01 LOCATION CO - ORDS. N 4 764 028; E 192 213 ORIGINATED BY M V

DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V

DATUM GEODETIC DATE 91 08 27 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
285.9	Ground Surface													
0.0	SANDY SILT, Some Gravel, Trace of Organics, Compact, (Fill)		1	SS	11		285							
284.5			2	SS	8		284							0 54 (46)
1.4			3	SS	11		283							
			4	SS	18		282							
	SILTY SAND to SANDY SILT, trace of Gravel, Loose to Compact		5	SS	22		281							
			6	SS	21		280							
			7	SS	24		279							5 26 (69)
			8	SS	22		278							
278.4			9	SS	12		277							
7.5	GRAVELLY SAND, Trace of Silt, Compact		10	SS	1									27 67 (6)
276.3														
9.6	End of Borehole													
	Probable GRAVELLY SAND, Trace of Silt													
273.1														
12.8	End of Cone Test													
	Note: Water Level 24 Hours After Completion of Drilling													

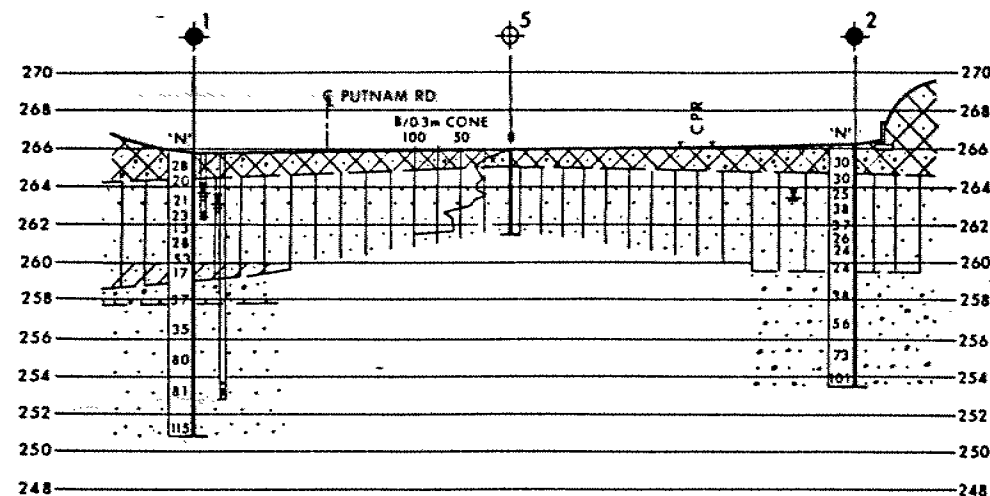
RECORD OF BOREHOLE No P8

1 OF 1

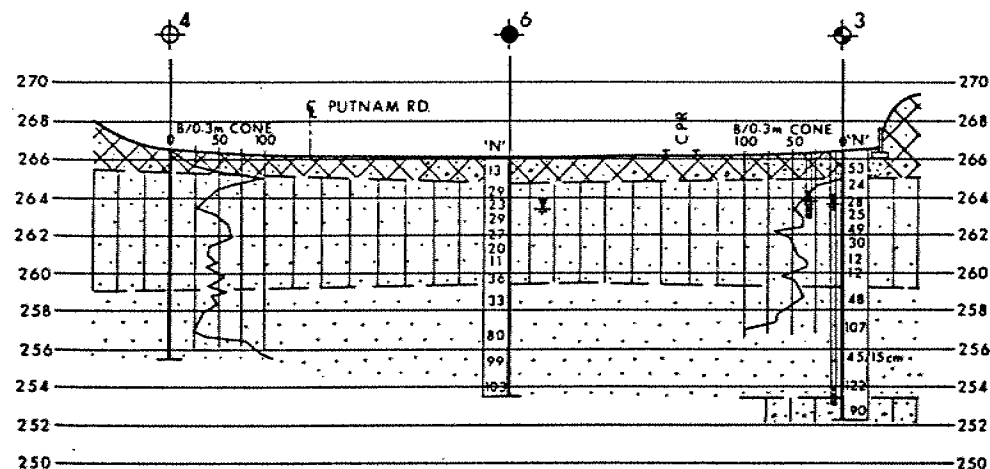
METRIC

W.P. 479 - 89 - 01 LOCATION CO - ORDS. N 4 764 602; E 192 771 ORIGINATED BY M.V.
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M.V.
DATUM GEODETIC DATE 91 08 28 CHECKED BY P.P.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
287.7	Ground Surface													
0.0	SANDY SILT, Trace of Gravel, Loose		1	SS	6									
286.3														
1.4	CLAYEY SILT, Occasional Silt & Sand Seams, Stiff to Very Stiff		2	SS	10									
			3	SS	16									
284.3			4	SS	15									
3.4			5	SS	22									
			6	SS	11									
			7	SS	9									
			8	SS	16									
	SILTY SAND to SANDY SILT, Trace of Gravel, Loose to Compact		9	SS	18									
			10	SS	32									
276.6			11	SS	25									
11.1	End of Borehole													
276.1														
11.6	End of Cone Test													
	Note: Water Level 1 Hour After Completion of Drilling													

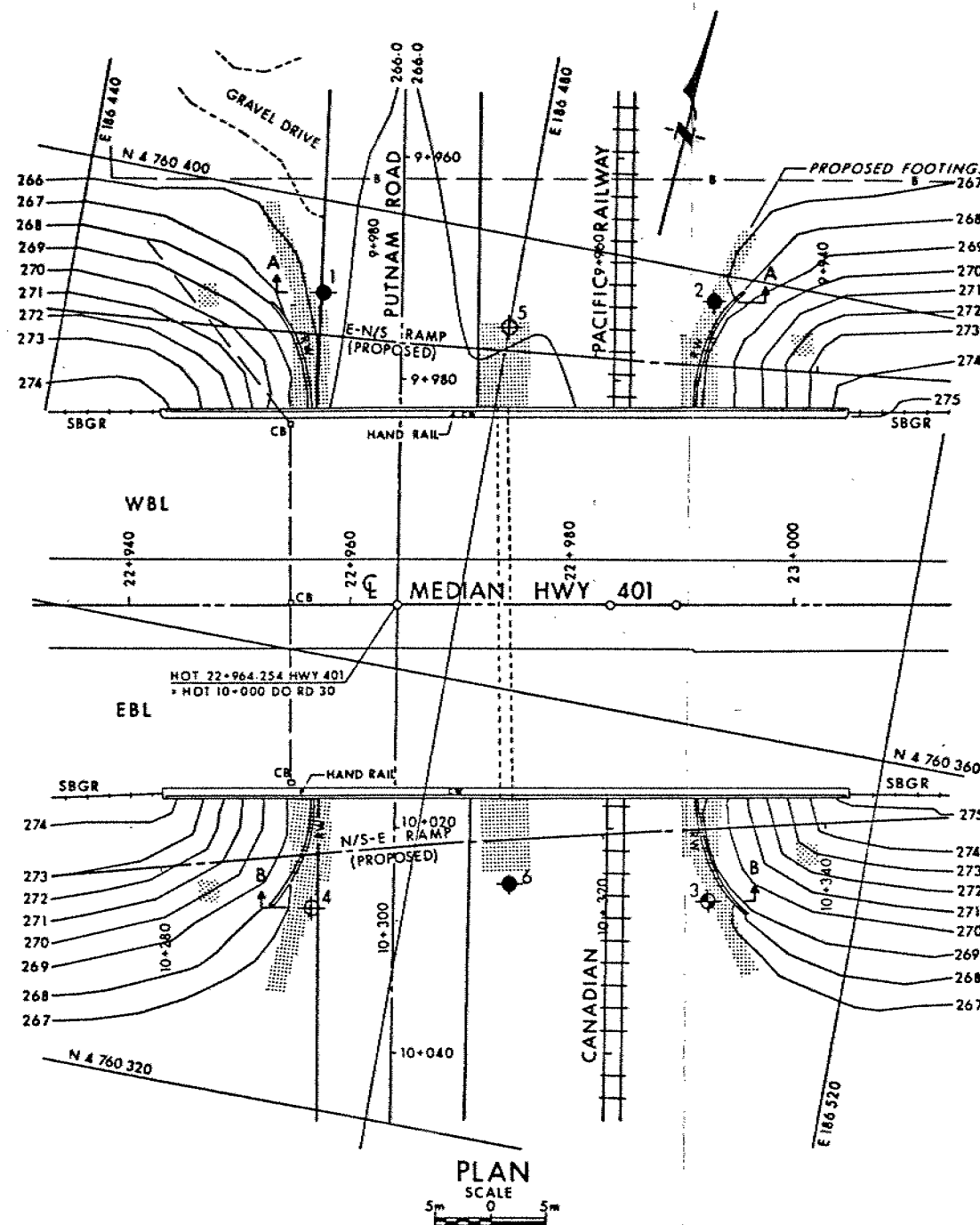


SECTION A-A
SCALE
0 5m

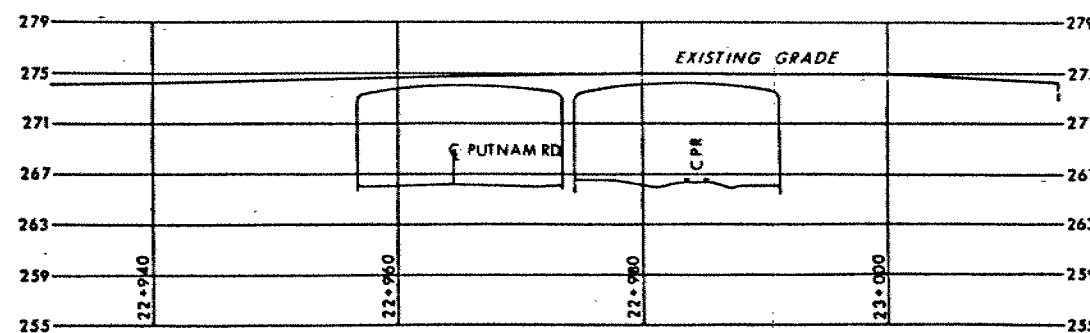


SECTION B-B
SCALE
0 5m

SOIL STRATA SYMBOLS			
	SAND & GRAVEL (ROAD FILL) Compact - V.Dense		SANDY SILT to SILTY SAND Compact - Dense
	COARSE SAND Dense - V.Dense		CLAYEY SILT SOME SAND V.Stiff
	SANDY SILT (GLACIAL TILL) V.Dense		GRAVELLY SAND Dense - V.Dense



PLAN
SCALE
0 5m



☐ MED PROFILE HIGHWAY 401

SCALE
0 5m

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 479-89-02

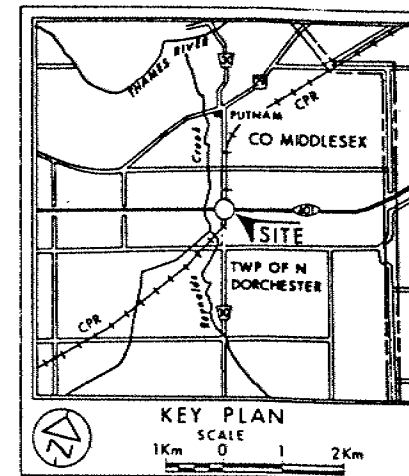
PUTNAM RD/CPR OVERPASS

BORE HOLE LOCATIONS & SOIL STRATA



SHEET

STRATA ENGINEERING CORP.



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N: Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation
July & August 1990
- Strand Pipe

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	265.8	4760 392	186 463
2	266.2	4760 398	186 498
3	266.4	4760 345	186 507
4	266.4	4760 338	186 472
5	266.0	4760 392	186 480
6	266.1	4760 343	186 489

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION
1			

Geocres No 40115-29

MWY No 401	DIST 2
SUBMD A.A. [CHECKED A] DATE Nov 14, 1990	SITE 19-306
DRAWN A.K. [CHECKED A] APPROVED	DWG 4798902-A

RECORD OF BOREHOLE No2

METRIC

W P 479-89-02 LOCATION Co-ords. 4 760 398 N; 186 498 E ORIGINATED BY JK
DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Wash Boring COMPILED BY AK
DATUM Geodetic DATE 1990 07 26 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
266.2	Ground surface																GR SA SI CL
0.0	Sand, Gravel Tr. asphaltic concrete (Road Fill)		1	SS	30		266										
264.9							265										
1.3	Sandy Silt to Silty Sand		2	SS	30												
							264										
	Compact to Dense		3	SS	25												
							263										
	Brown		4	SS	38												
							262										
			5	SS	37												
							261										
			6	SS	26												
							260										
			7	SS	24												
							259										
			8	SS	24												
259.4							258										
6.8	Coarse Sand Tr. gravel		9	SS	38												
	Dense to Very Dense						257										
							256										
	Grey		10	SS	56												
							255										
	Occ. clayey silt seams throughout		11	SS	73												
							254										
253.5			12	SS	101												
12.7	End of borehole																

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

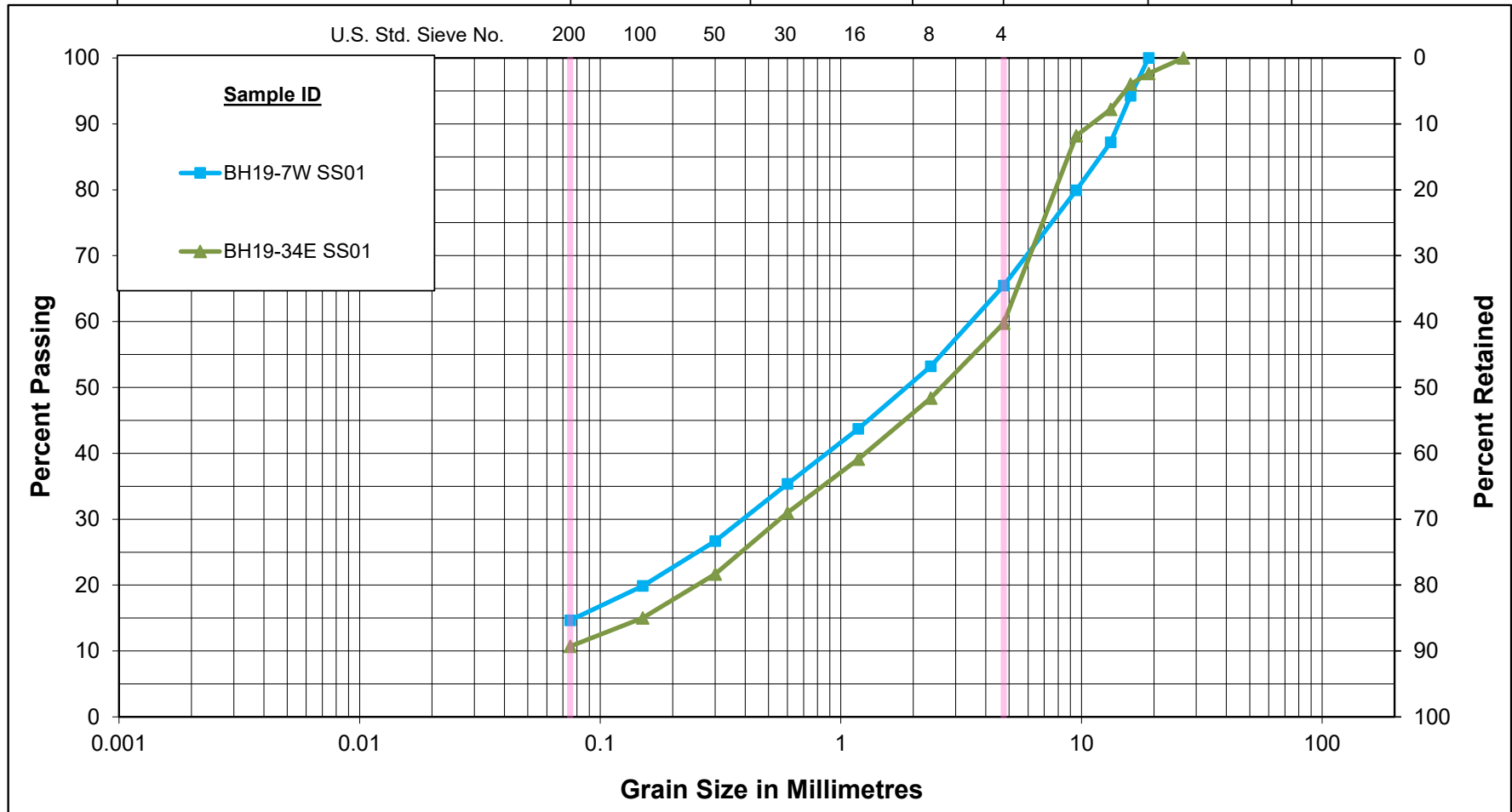
APPENDIX C

- C.1 LABORATORY TEST RESULTS (CURRENT INVESTIGATION)**
- C.2 CORROSIVITY TESTING RESULTS (CURRENT INVESTIGATION)**
- C.3 LABORATORY TEST RESULTS FROM PREVIOUS STUDIES**



Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

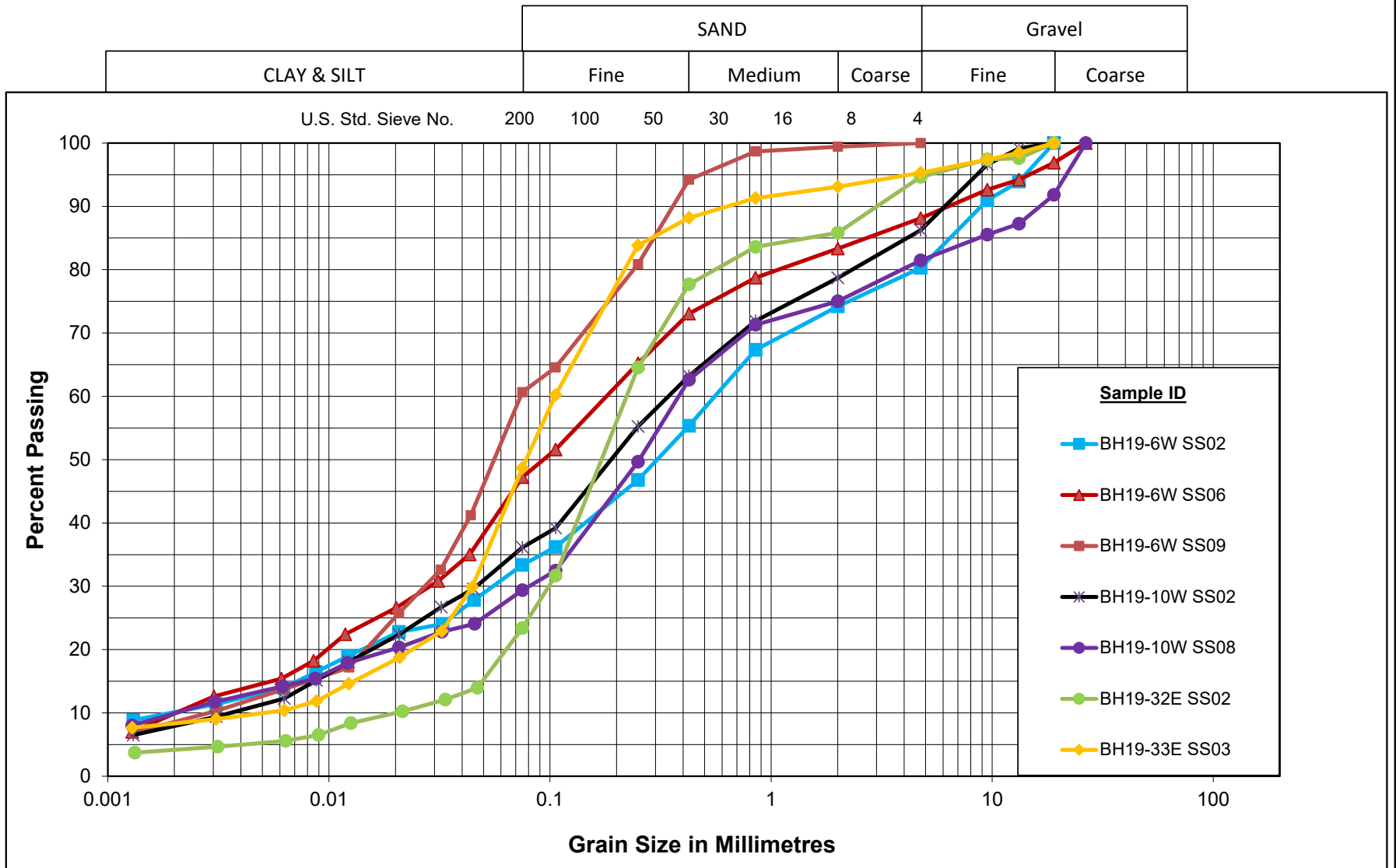


GRAIN SIZE DISTRIBUTION
 SAND and GRAVEL (FILL)
 Highway 401 Rehabilitation, Ingersoll

Figure No. C1

Project No. 165001128

Unified Soil Classification System

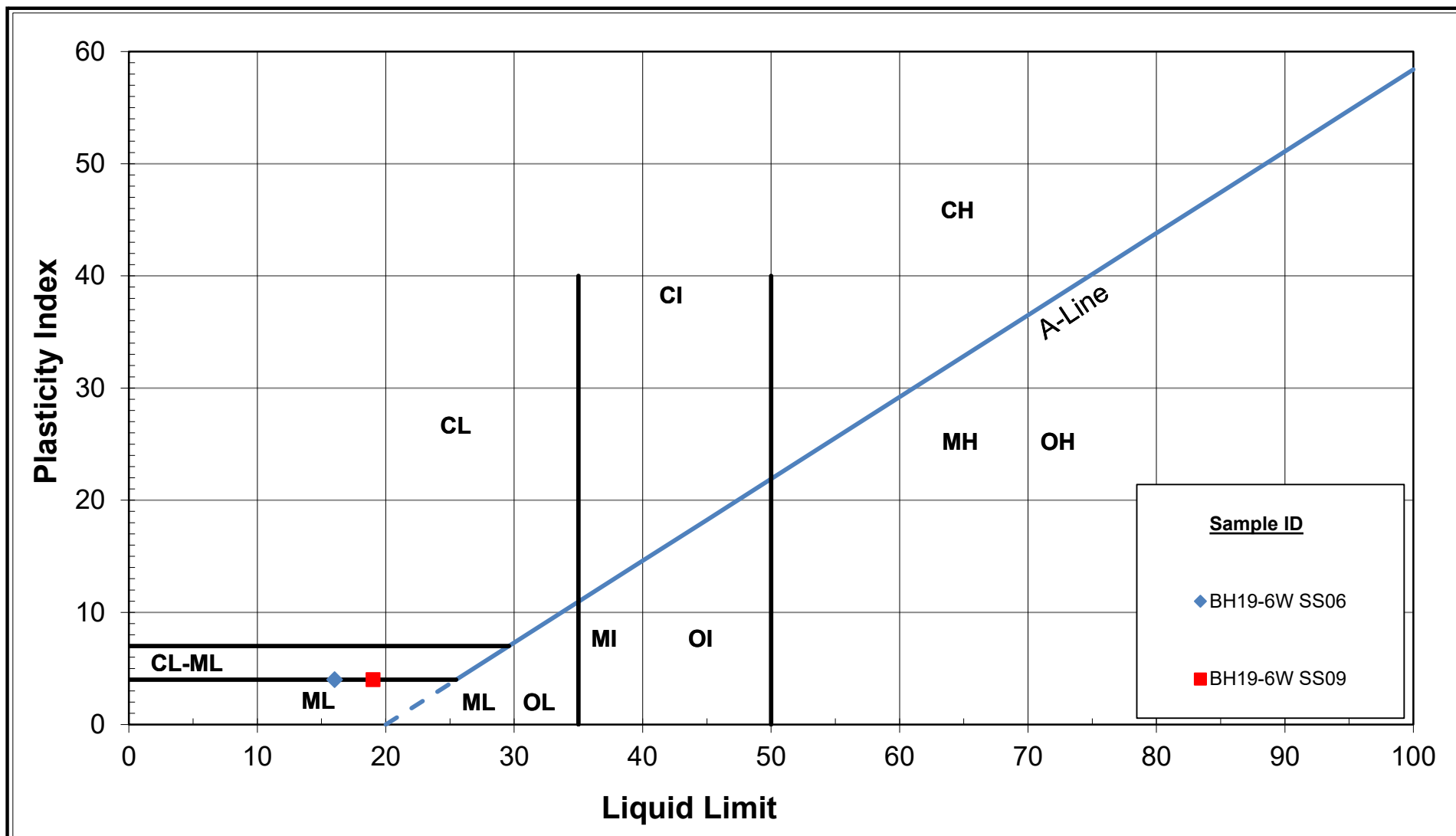


GRAIN SIZE DISTRIBUTION

Gravelly SILTY SAND to SANDY SILT (FILL)
Highway 401 Rehabilitation, Ingersoll

Figure No. C2

Project No. 165001128



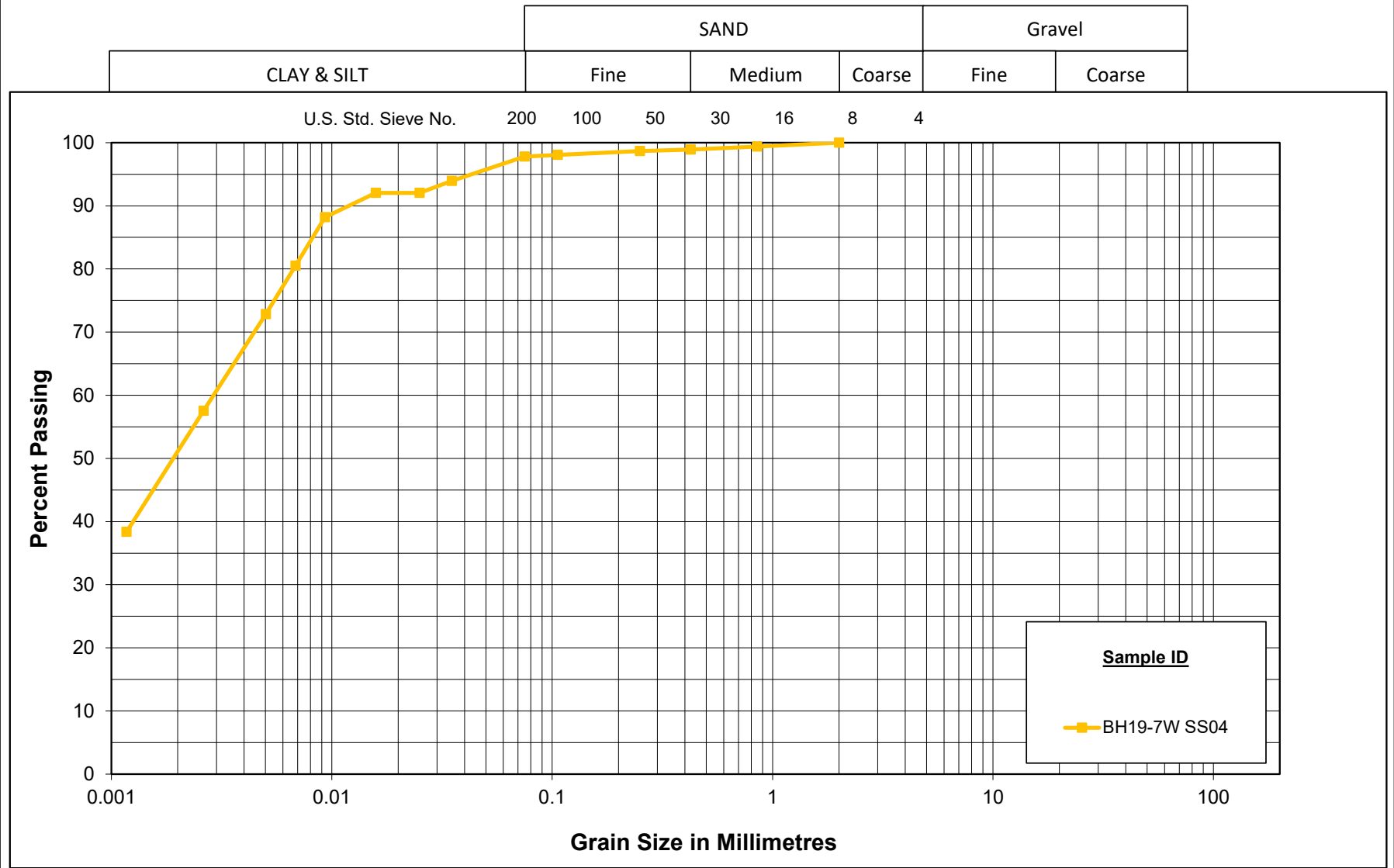
Highway 401 Rehabilitation, Ingersoll
SANDY SILT (FILL)

PLASTICITY CHART

Figure No. C3

Project No. 165001128

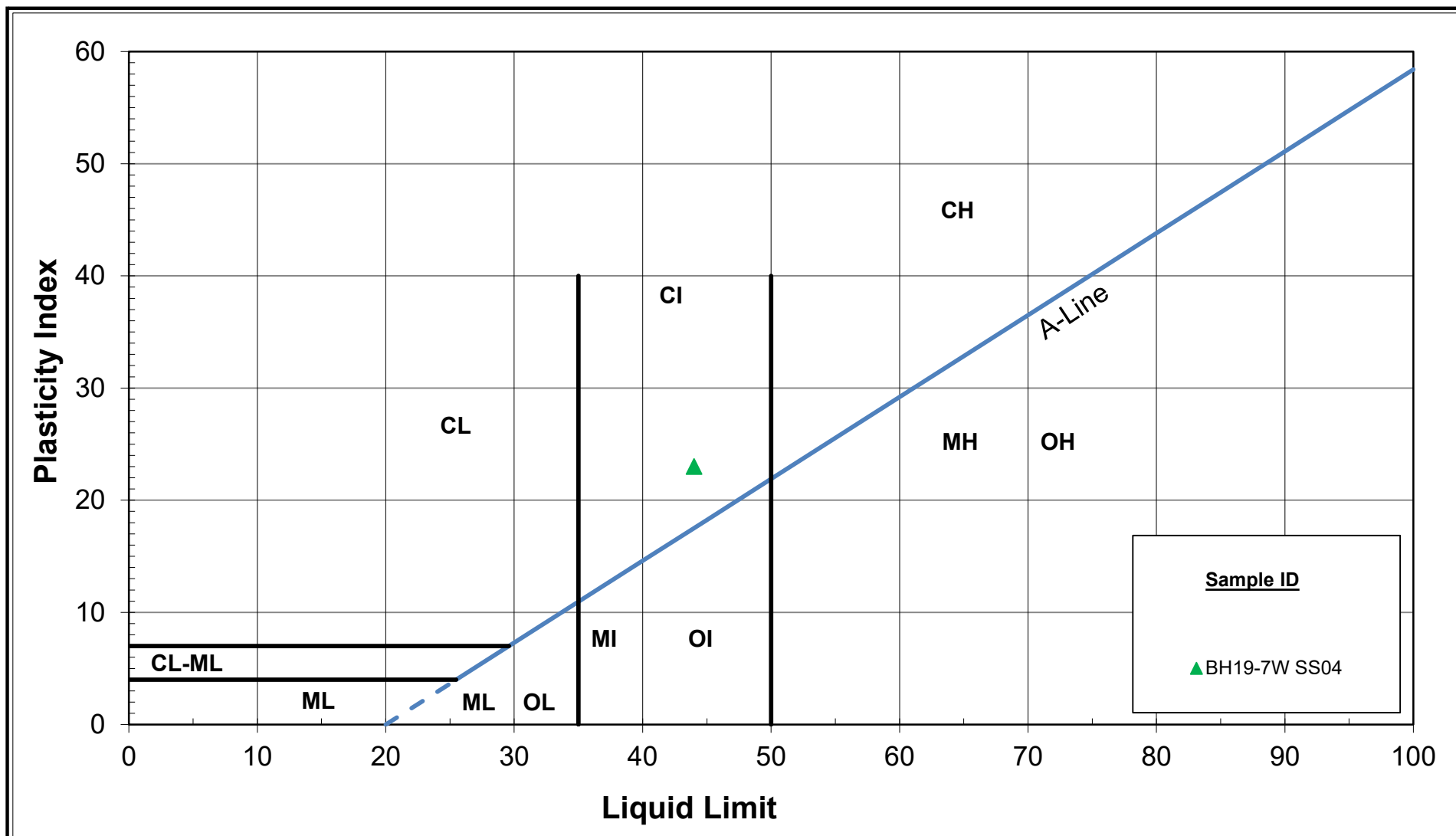
Unified Soil Classification System



GRAIN SIZE DISTRIBUTION
SILTY CLAY
Highway 401 Rehabilitation, Ingersoll

Figure No. C4

Project No. 165001128



Highway 401 Rehabilitation, Ingersoll
SILTY CLAY
PLASTICITY CHART

Figure No. C5

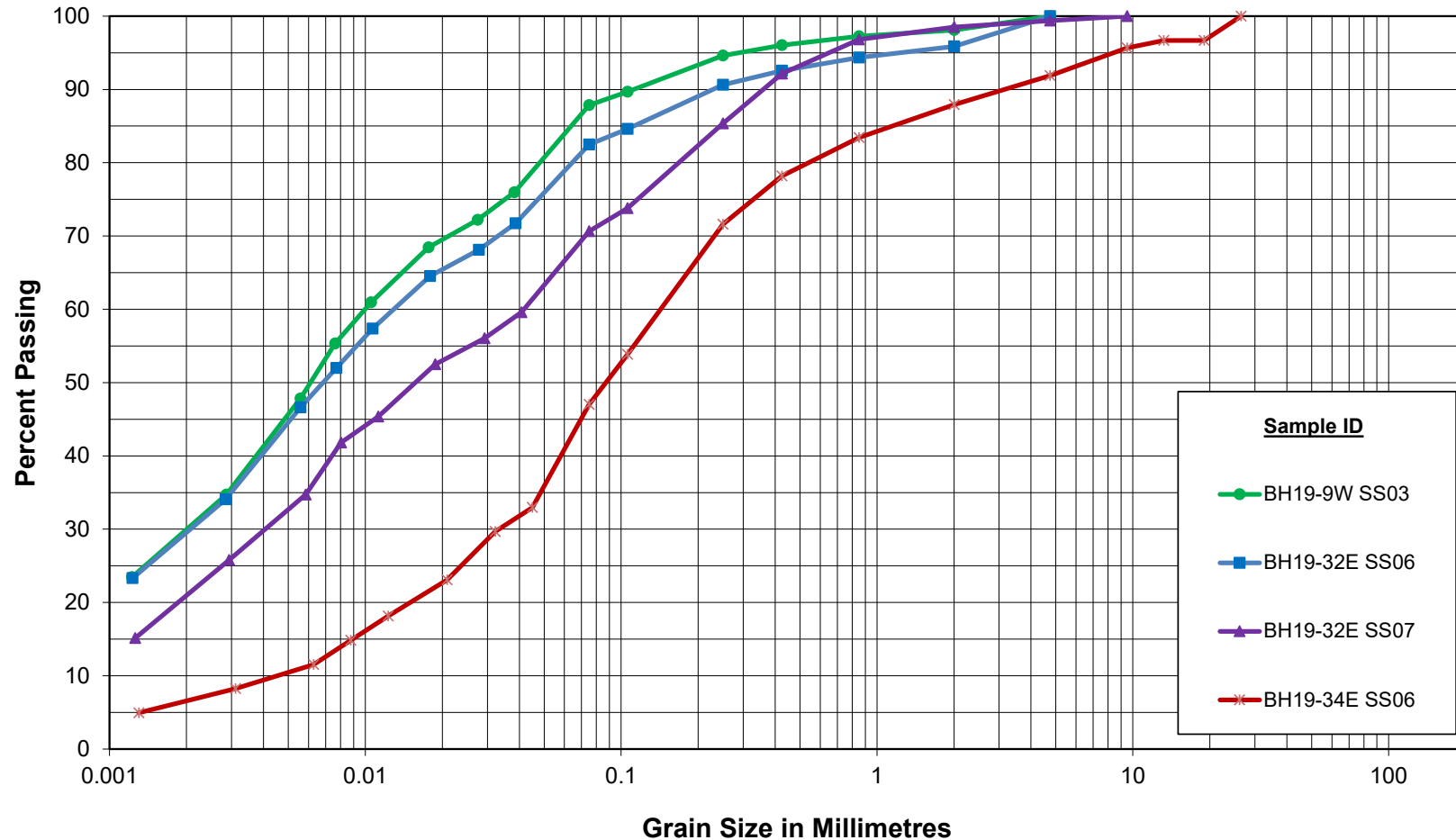
Project No. 165001128

Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse

U.S. Std. Sieve No.

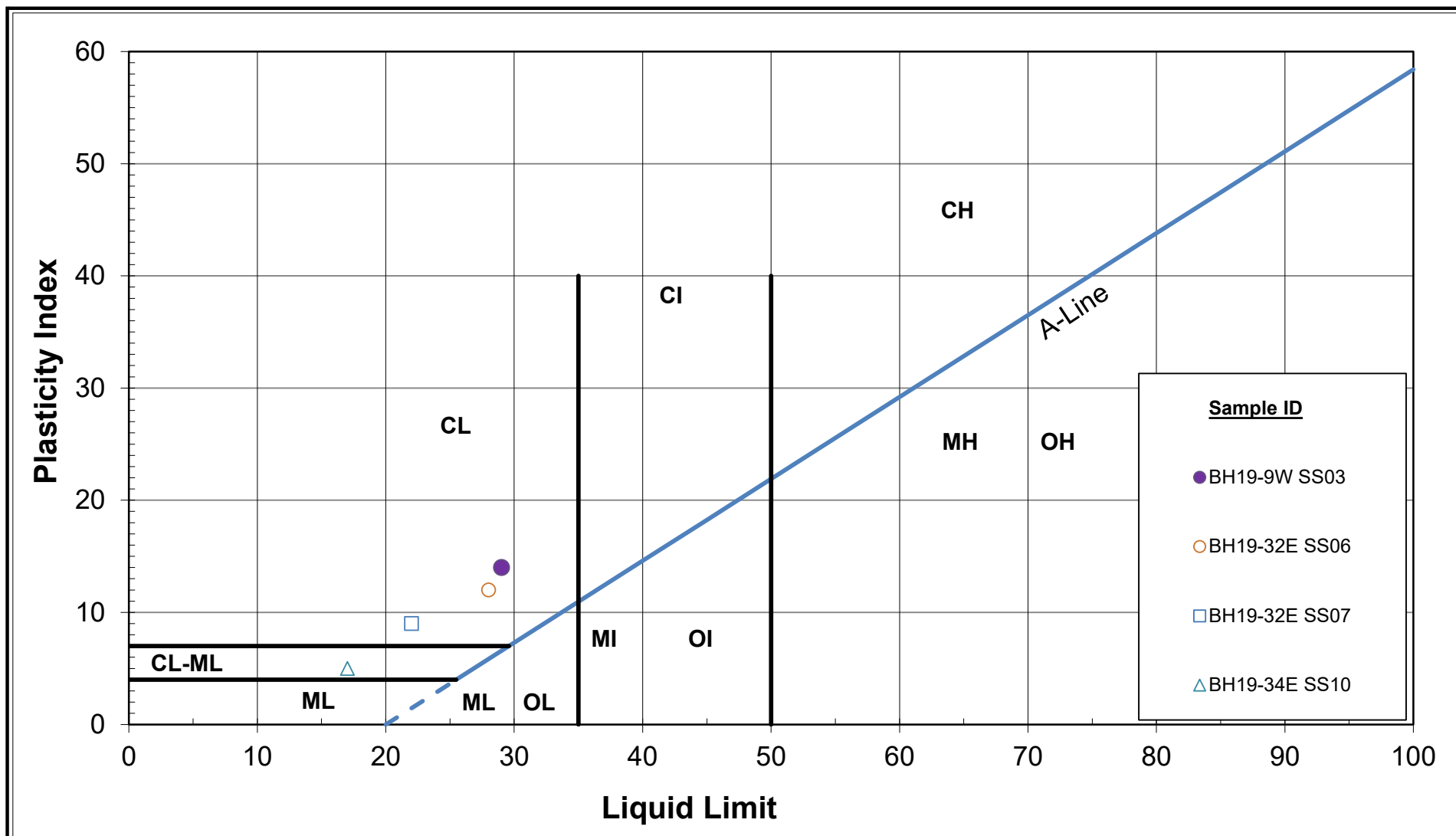
200 100 50 30 16 8 4



GRAIN SIZE DISTRIBUTION
CLAYEY SILT (TILL)
Highway 401 Rehabilitation, Ingersoll

Figure No. C6

Project No. 165001128



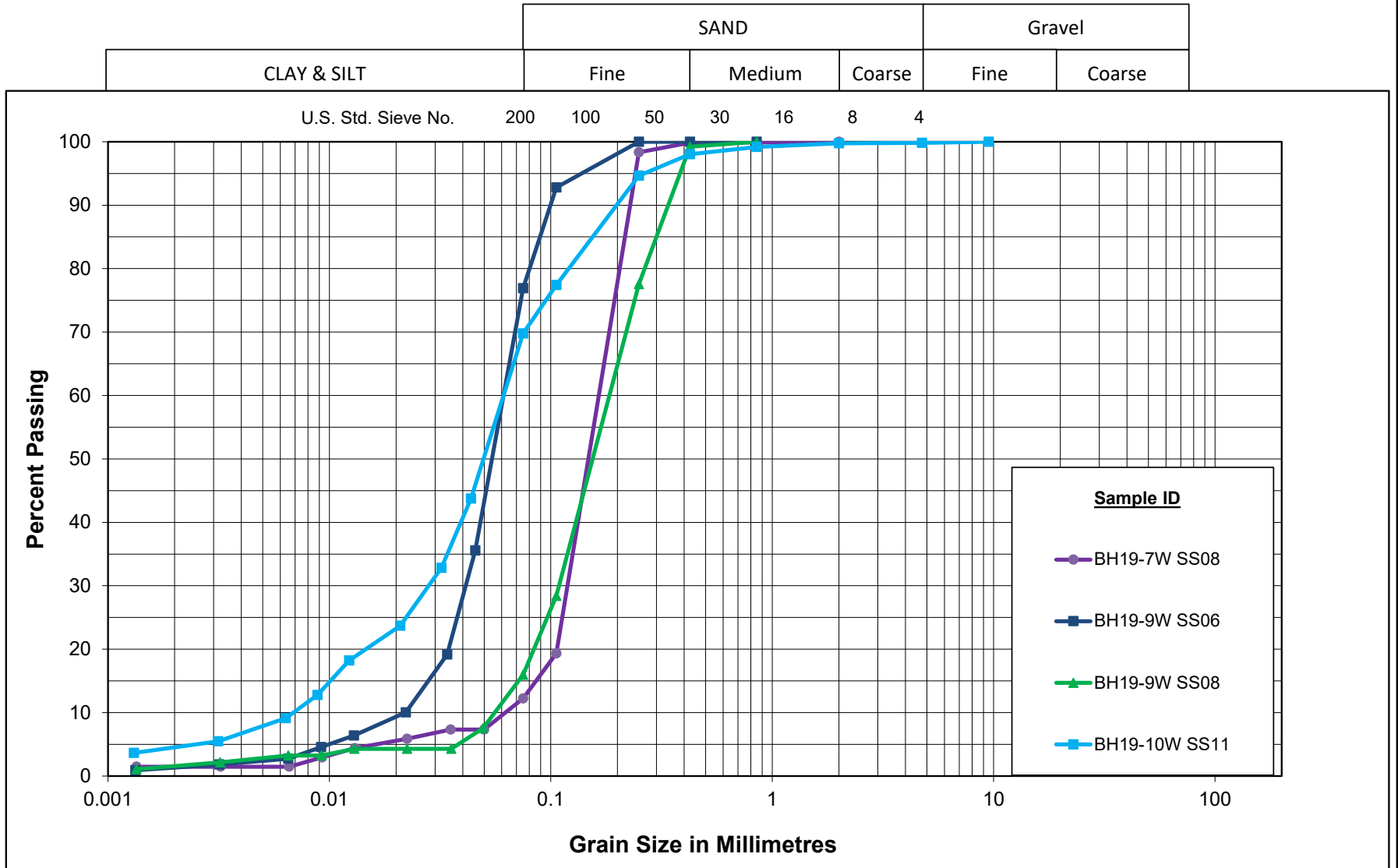
Highway 401 Rehabilitation, Ingersoll
CLAYEY SILT (TILL)

PLASTICITY CHART

Figure No. C7

Project No. 165001128

Unified Soil Classification System



GRAIN SIZE DISTRIBUTION
 SAND to SANDY SILT
 Highway 401 Rehabilitation, Ingersoll

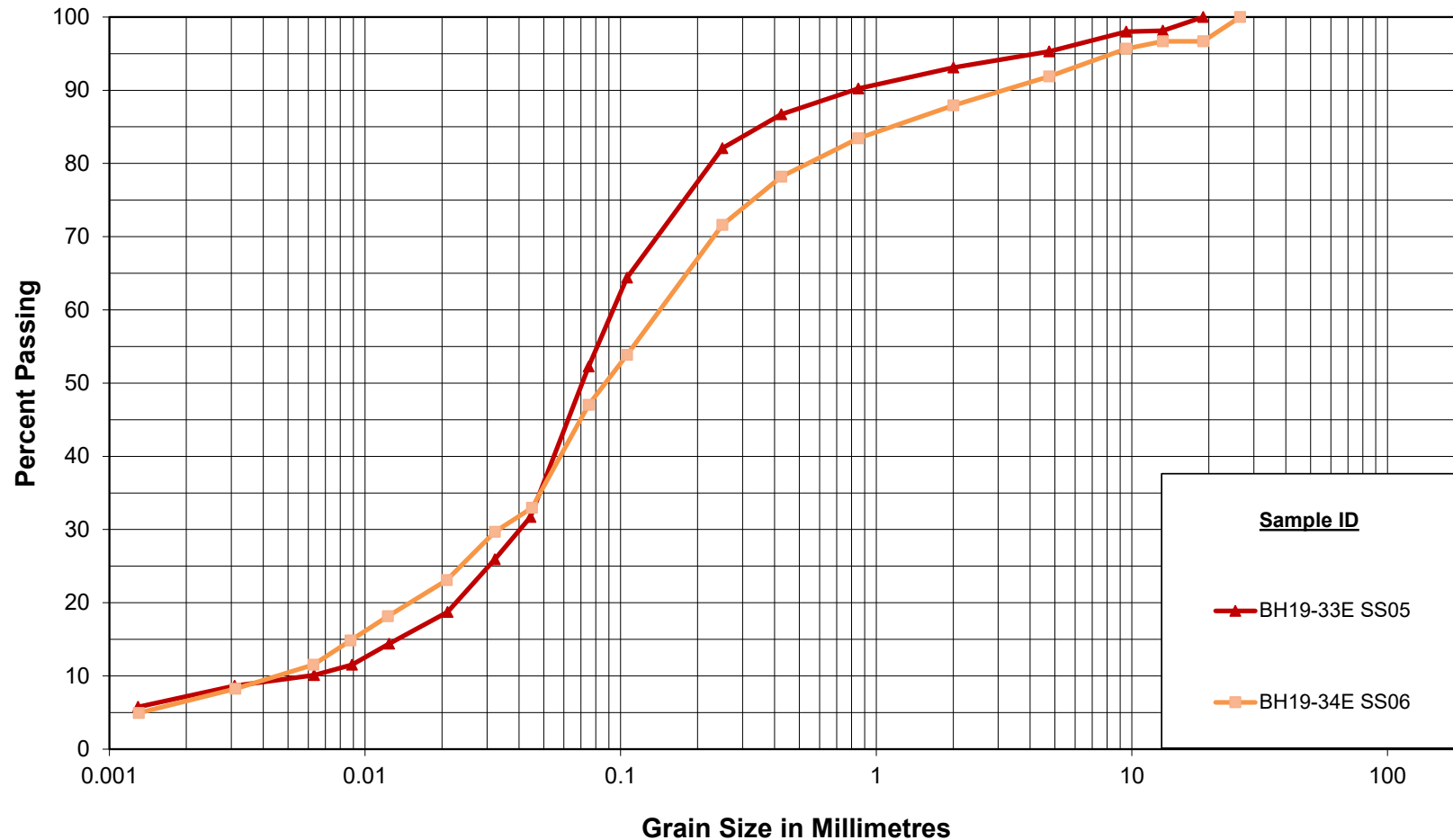
Figure No. C8

Project No. 165001128

Unified Soil Classification System

		SAND			Gravel	
CLAY & SILT		Fine	Medium	Coarse	Fine	Coarse

U.S. Std. Sieve No. 200 100 50 30 16 8 4



GRAIN SIZE DISTRIBUTION
SANDY SILT (TILL)
 Highway 401 Rehabilitation, Ingersoll

Figure No. C9

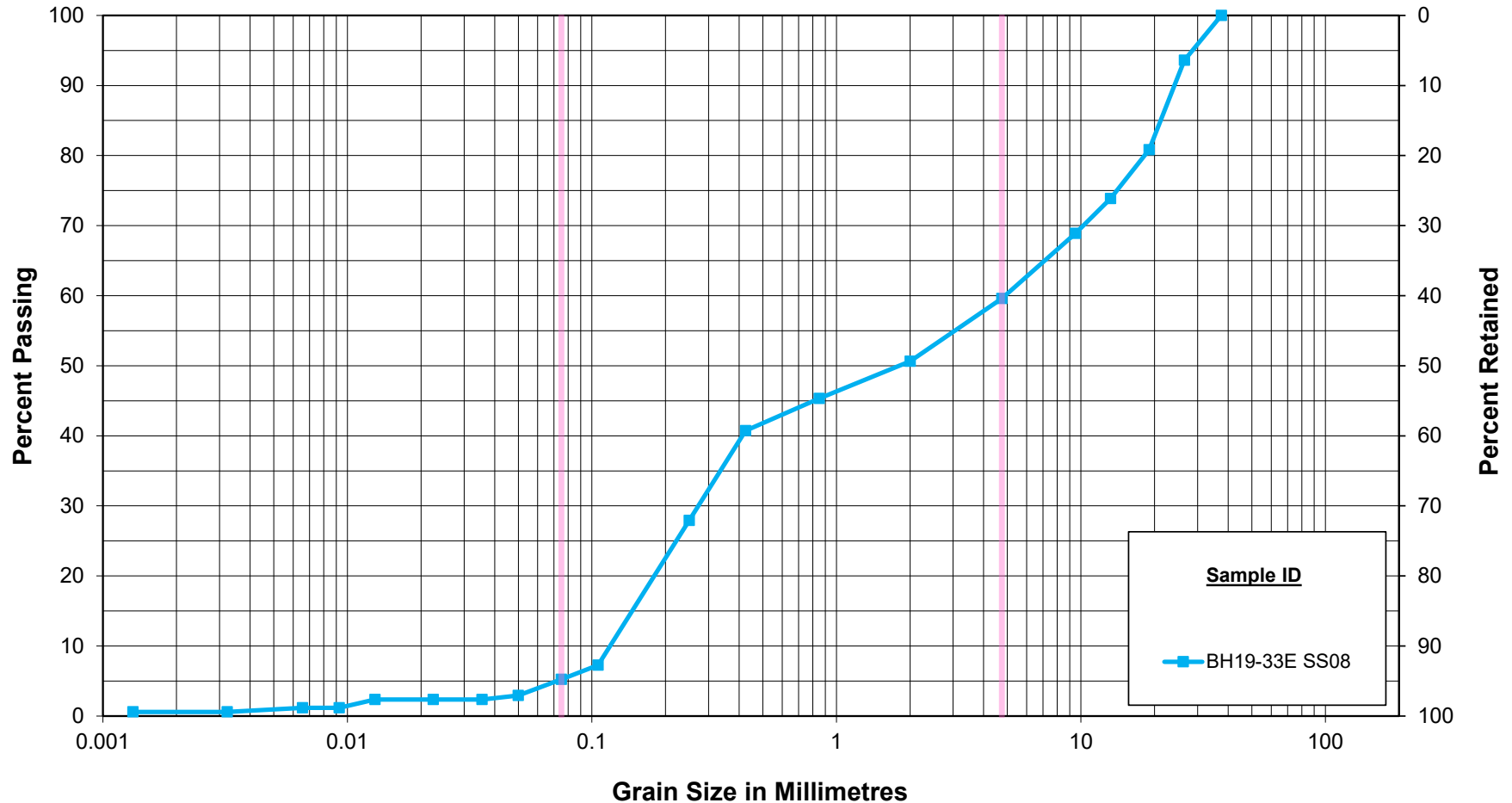
Project No. 165001128

Unified Soil Classification System

				Gravel	
CLAY & SILT				Fine	Coarse
				SAND	
				Fine	Coarse

U.S. Std. Sieve No.

200 100 50 30 16 8 4



GRAIN SIZE DISTRIBUTION

SAND and GRAVEL

Highway 401 Rehabilitation, Ingersoll

Figure No. C10

Project No. 165001128

Certificate of Analysis
Client: Stantec Consulting Ltd. (Ottawa)
Client PO: Highway 401 Rehab, Ingersoll

Report Date: 15-Jan-2020

Order Date: 10-Jan-2020

Project Description: 165001128

Client ID:	BH19-6W, SS02, 2.5'-4.5'	BH19-7W, SS02, 2.5'-4.5'	BH19-9W, SS02, 2.5'-4.5'	BH19-10W, SS03, 7.5'-9.5'
Sample Date:	04-Nov-19 09:00	06-Nov-19 09:00	04-Nov-19 09:00	06-Nov-19 09:00
Sample ID:	2002423-01	2002423-02	2002423-03	2002423-04
MDL/Units	Soil	Soil	Soil	Soil

Physical Characteristics

% Solids	0.1 % by Wt.	99.9	100	99.9	100
----------	--------------	------	-----	------	-----

General Inorganics

pH	0.05 pH Units	8.10 [1]	7.62 [1]	7.71 [1]	7.99 [1]
Resistivity	0.10 Ohm.m	8.15	2.27	10.1	14.9

Anions

Chloride	5 ug/g dry	712 [1]	2830 [1]	425 [1]	328 [1]
Sulphate	5 ug/g dry	117 [1]	98 [1]	89 [1]	56 [1]

Client ID:	BH19-32E, SS03, 5'-7'	BH19-33E, SS03, 5'-7'	BH19-34E, SS03, 5'-7'	-
Sample Date:	04-Nov-19 09:00	05-Nov-19 09:00	26-Sep-19 09:00	-
Sample ID:	2002423-05	2002423-06	2002423-07	-
MDL/Units	Soil	Soil	Soil	-

Physical Characteristics

% Solids	0.1 % by Wt.	100	99.9	99.4	-
----------	--------------	-----	------	------	---

General Inorganics

pH	0.05 pH Units	8.06 [1]	7.97 [1]	7.63 [1]	-
Resistivity	0.10 Ohm.m	24.5	14.7	6.57	-

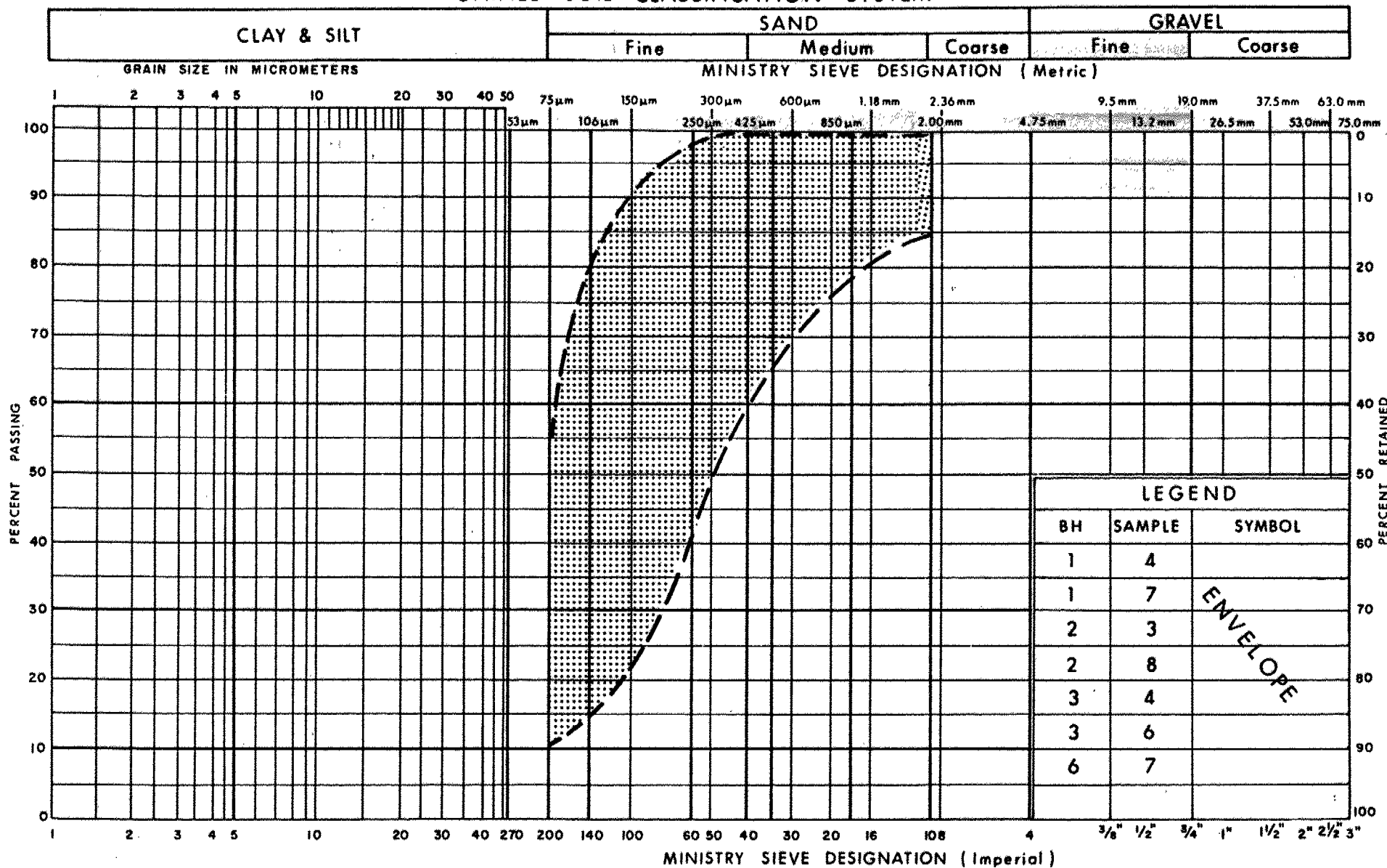
Anions

Chloride	5 ug/g dry	167 [1]	361 [1]	883 [1]	-
Sulphate	5 ug/g dry	14 [1]	16 [1]	166 [1]	-

Laboratory Test Results from Previous Studies



UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

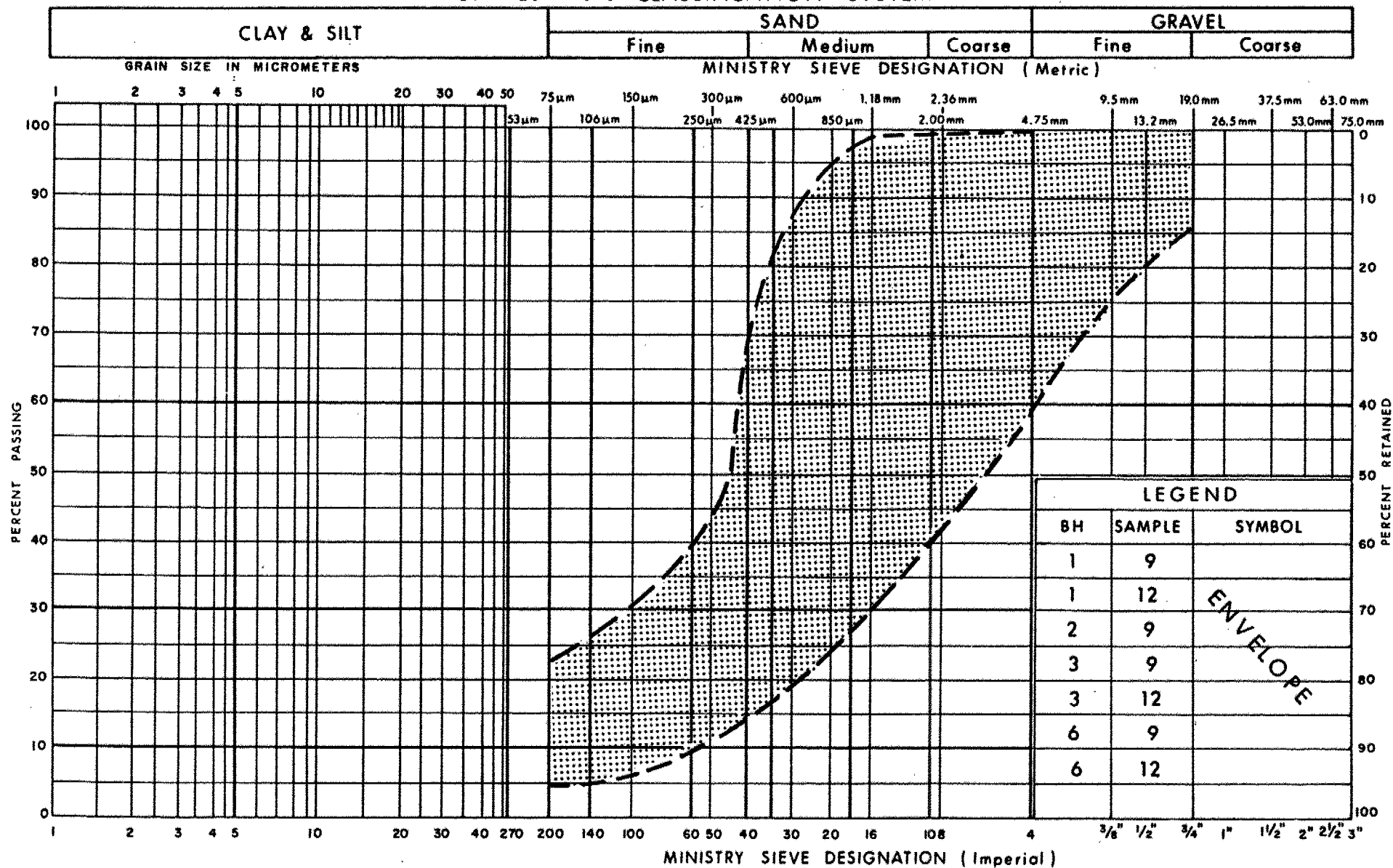
Sandy Silt to Silty Sand

FIG No 2

W P 479-89-02

Site No. 19-306

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

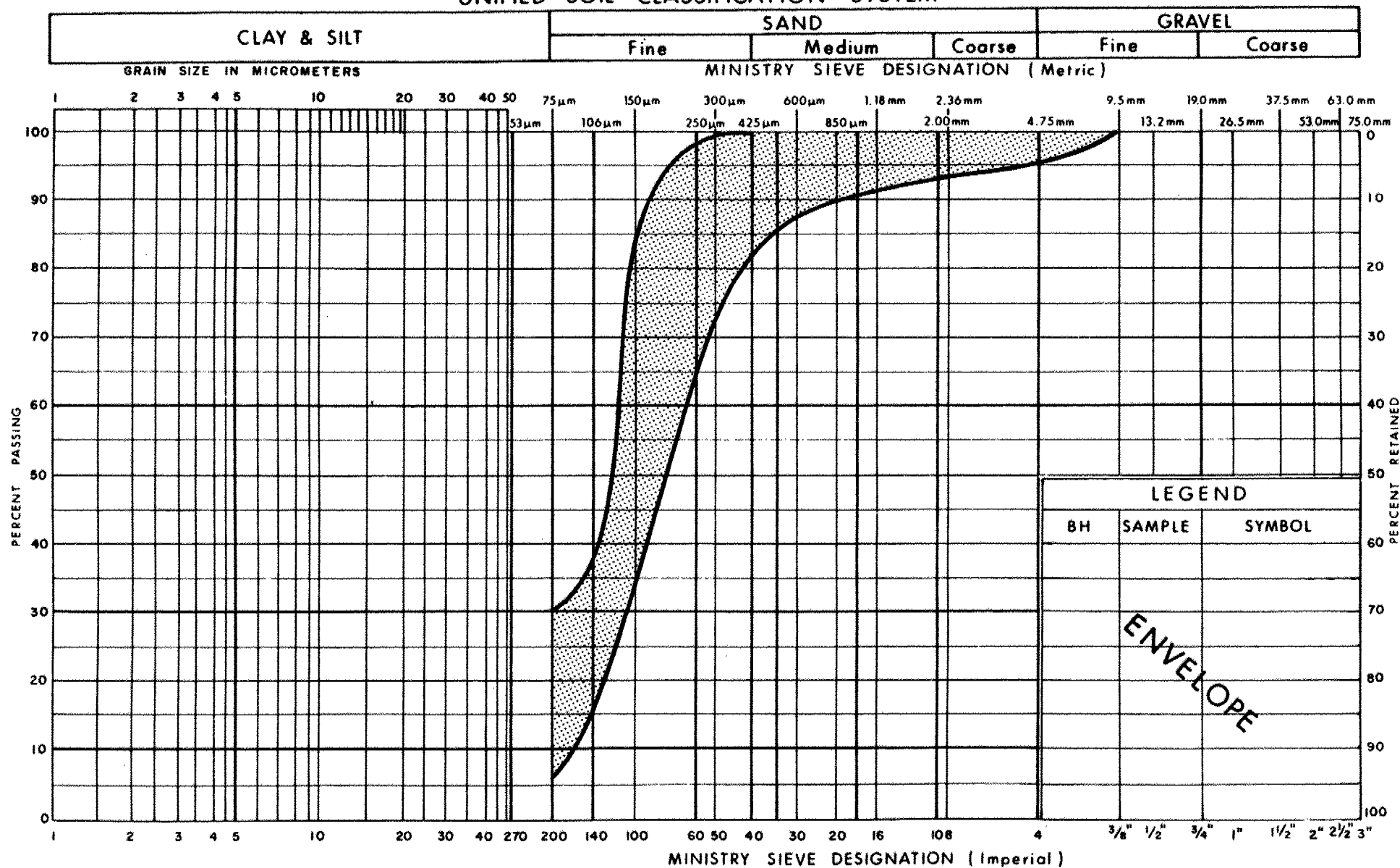
Coarse Sand with Gravel

FIG No 5

W P 479-89-02

Site No. 19-306

UNIFIED SOIL CLASSIFICATION SYSTEM



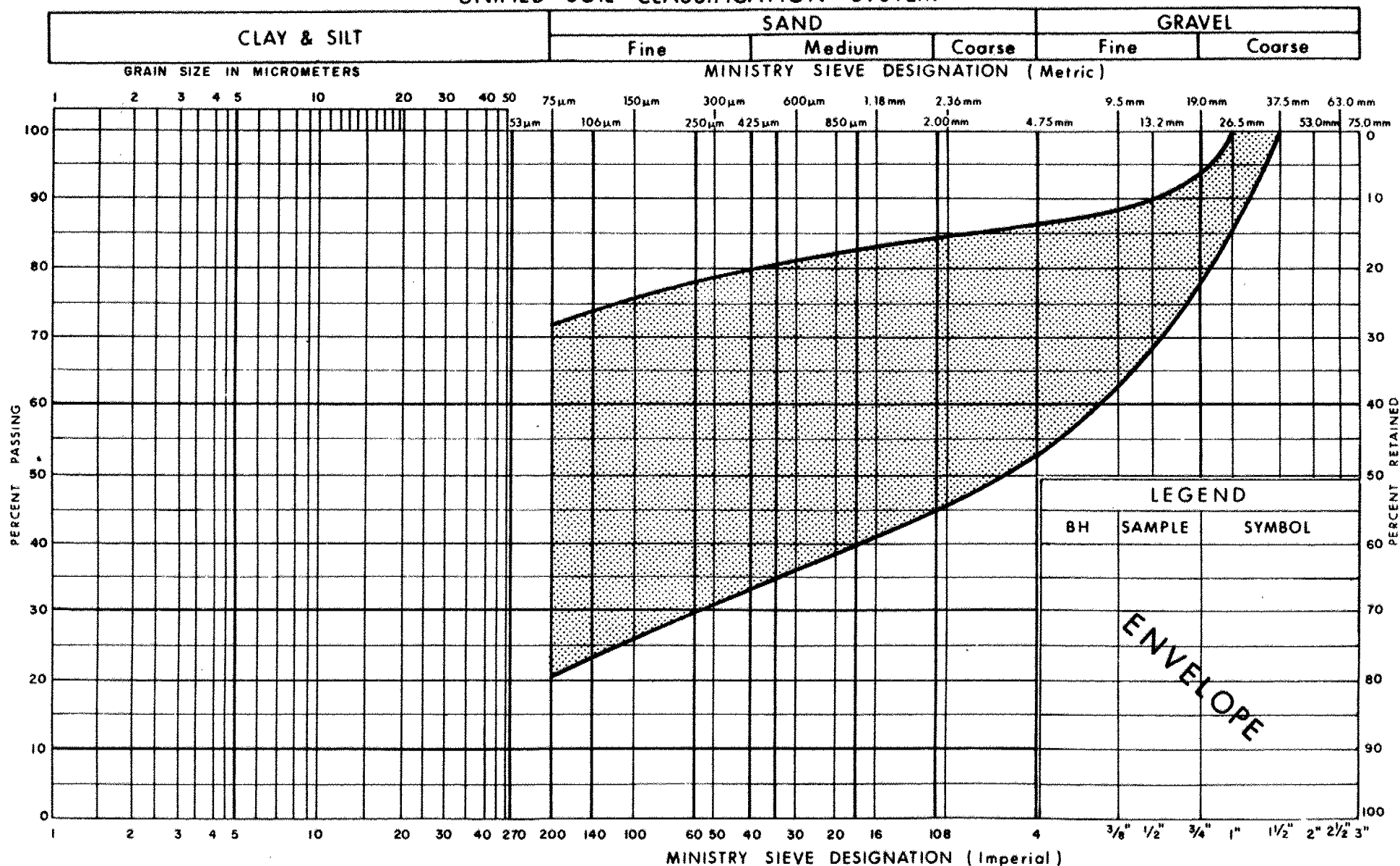
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SAND, SOME/WITH SILT, TRACE OF GRAVEL

FIG No 1

W P 479-89-05

UNIFIED SOIL CLASSIFICATION SYSTEM



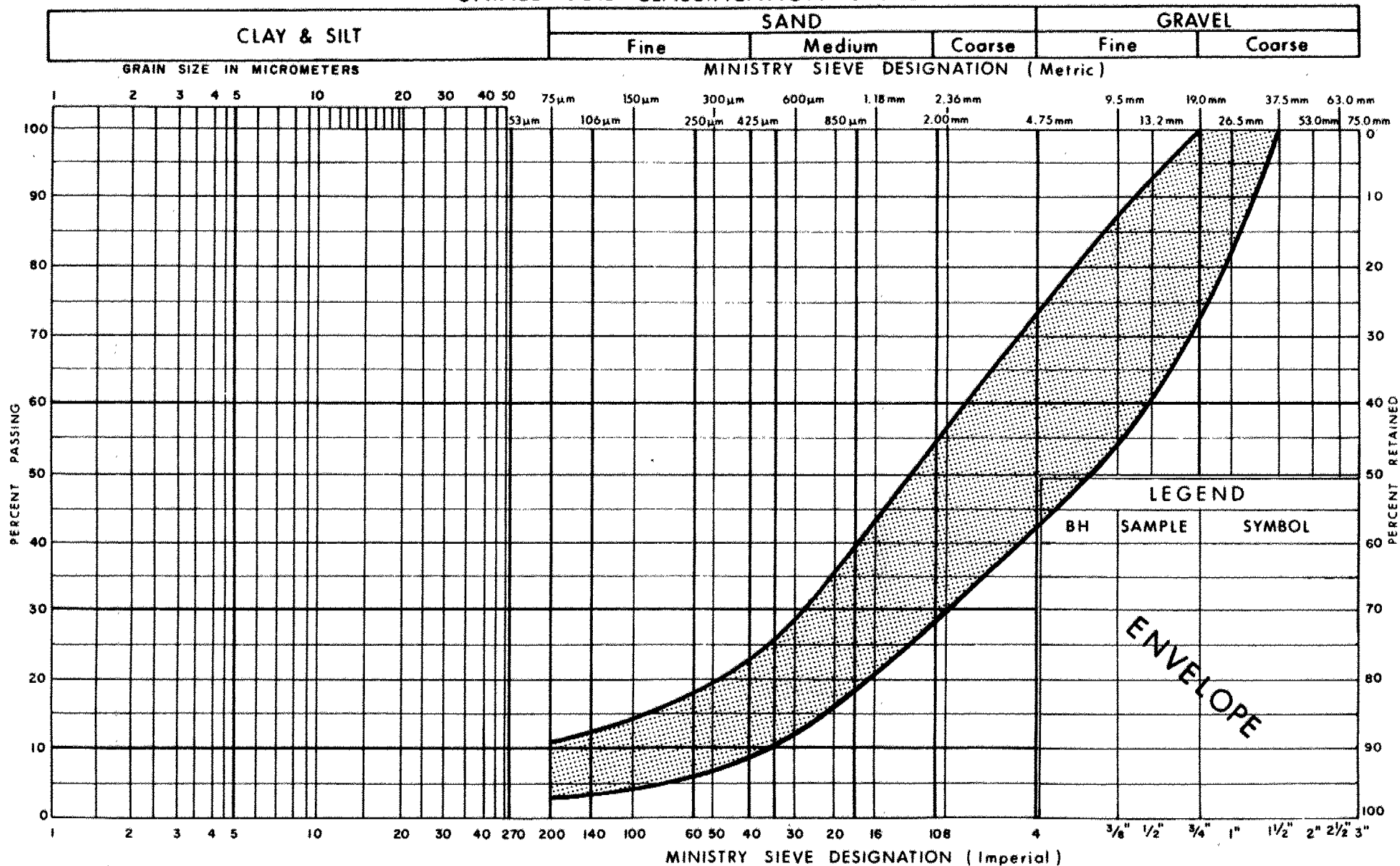
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 2

W P 479-89-05

UNIFIED SOIL CLASSIFICATION SYSTEM



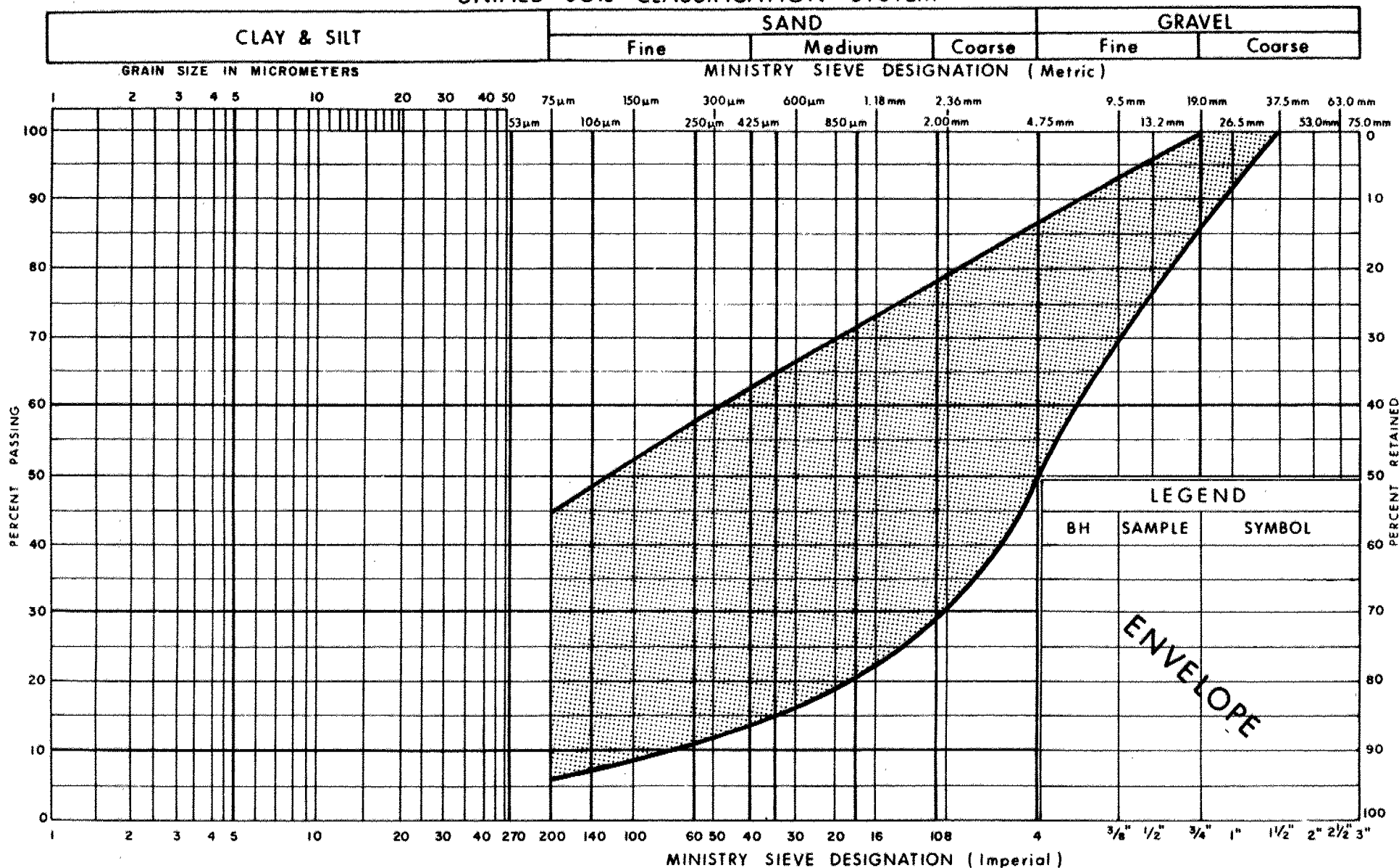
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION SAND & GRAVEL, TRACE OF SILT

FIG No 4

W P 479-89-05

UNIFIED SOIL CLASSIFICATION SYSTEM



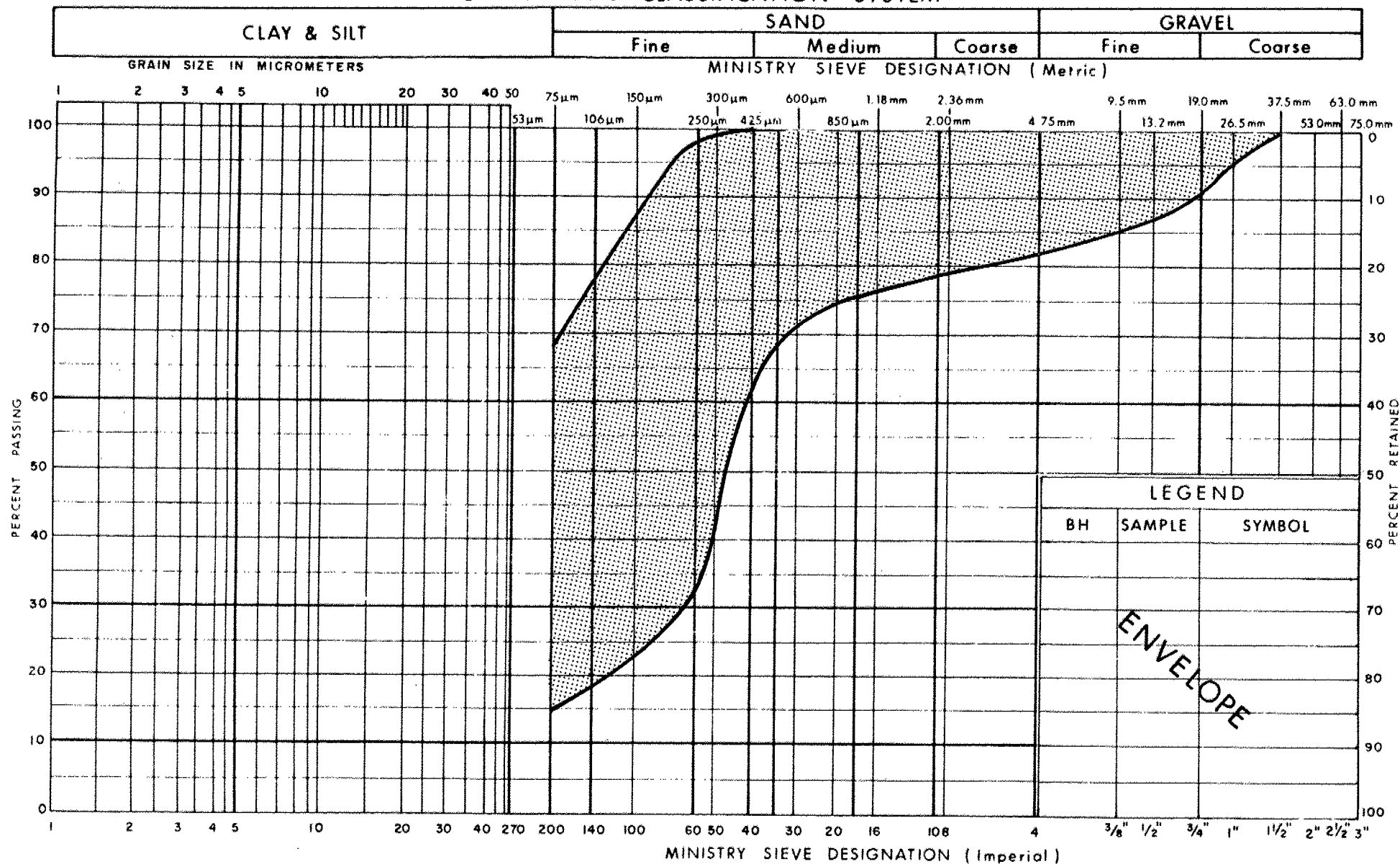
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
GRAVEL, SAND & SILT (Glacial Till)

FIG No 5

W P 479-89-05

UNIFIED SOIL CLASSIFICATION SYSTEM



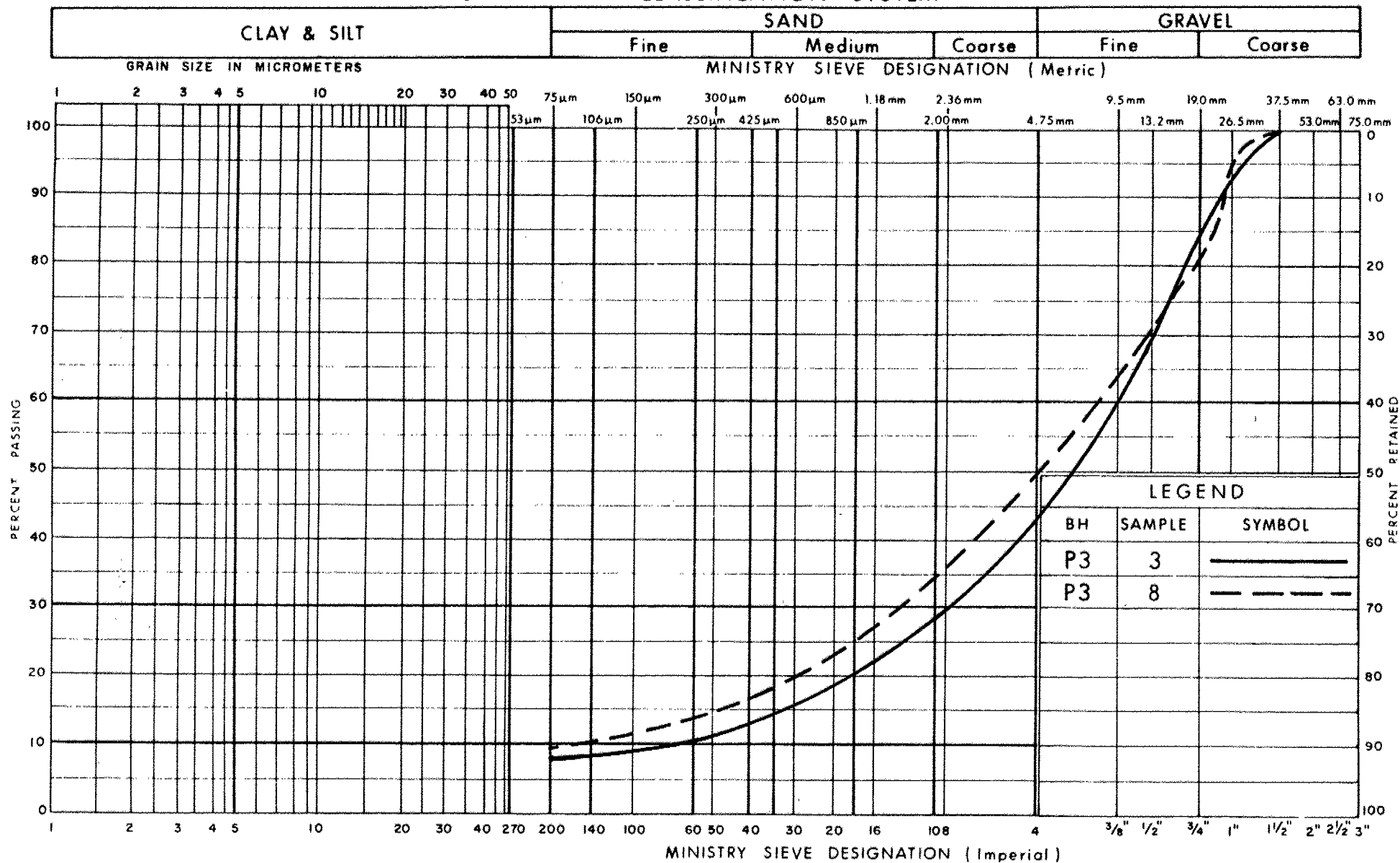
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SANDY SILT
TRACE / SOME GRAVEL

FIG No 1

W P 479 - 89 - 01

UNIFIED SOIL CLASSIFICATION SYSTEM

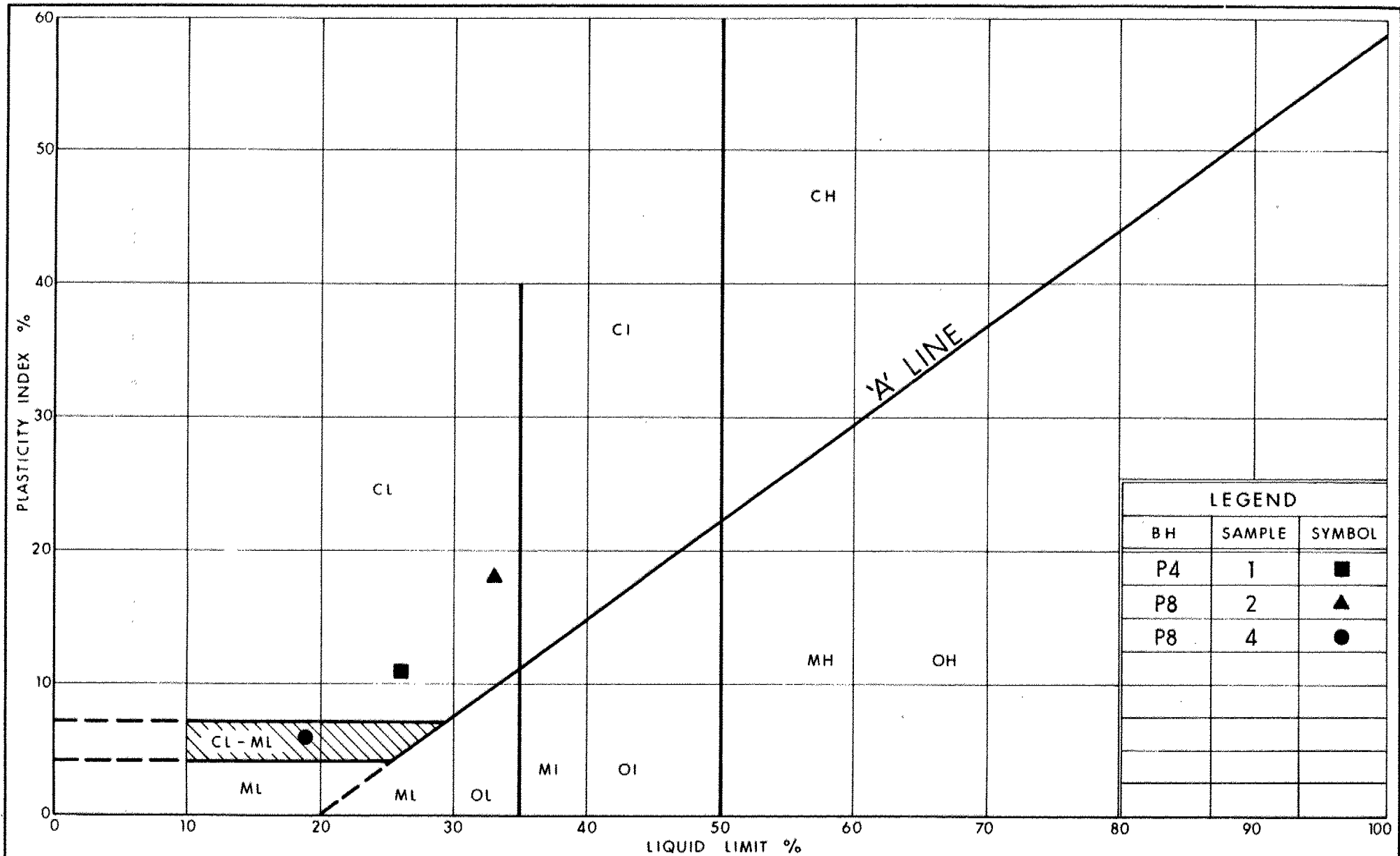


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SANDY GRAVEL, TRACE OF SILT, COBBLES

FIG No 3

W P 479 - 89 - 01



LEGEND		
BH	SAMPLE	SYMBOL
P4	1	■
P8	2	▲
P8	4	●



Ministry of
Transportation

Ontario

PLASTICITY CHART CLAYEY SILT

FIG No 5

W P 479-89-01

APPENDIX D

D.1 FOUNDATION DESIGN PARAMETERS FOR SIGN STRUCTURES



Table D.1: Foundation Design Parameters for Signs

Sign ID	Borehole Ground Surface Elevation (m)	Top of soil layer (m)	Bottom of soil layer (m)	Soil type	Groundwater Level (m)	γ Total unit weight (kN/m³)	γ' ¹Effective unit weight (kN/m³)	φ' Effective soil friction angle (°)	S_u Shear strength (kPa)	K_a Coefficient of active earth pressure	K_0 Coefficient of earth pressure at rest	3K_p Coefficient of passive earth pressure	Meets MTO Minimum Soil Parameters for Standard Sign Design
6W	290.9	0.3	1.1	Sand and gravel (Fill)	278.0	22.0	12.2	35	n/a	0.27	0.43	3.69	Yes
		1.1	8.7	Silty sand (Fill)		20.0	10.2	32	n/a	0.31	0.47	3.25	Yes
		8.7	10.2	Sandy silt to silt and sand (Fill)		18.0	8.2	28	n/a	0.36	0.53	2.77	⁴No
		10.2	11.2	Gravelly silty sand (Fill)		19.0	9.2	32	n/a	0.31	0.47	3.25	Yes
		11.2	11.3	Sand		19.0	9.2	32	n/a	0.31	0.47	3.25	Yes
7W	288.5	0.1	0.6	Sand and gravel (Fill)	282.4	22.0	12.2	33	n/a	0.29	0.46	3.39	Yes
		0.6	1.5	Silty sand (Fill)		19.0	9.2	32	n/a	0.31	0.47	3.25	Yes
		1.5	1.9	Silt, some sand		18.0	8.2	30	n/a	0.33	0.50	3.00	Yes
		1.9	4.6	Silty clay		19.0	9.2	²n/a	100	-	-	-	Yes
		4.6	7.6	Sand		18.5	8.7	30	n/a	0.33	0.50	3.00	Yes
		7.6	8.2	Sand		21.0	11.2	35	n/a	0.27	0.43	3.69	Yes
9W	285.1	0.2	1.1	Sand and gravel (Fill)	Below 276.9 (the termination elevation of borehole BH19-9W)	22.0	12.2	33	n/a	0.29	0.46	3.39	Yes
		1.1	1.5	Sandy silt (Fill)		18.0	8.2	30	n/a	0.33	0.50	3.00	Yes
		1.5	2.3	Clayey silt (Fill)		18.5	8.7	n/a	60	-	-	-	Yes
		2.3	3.1	Silty sand		19.0	9.2	32	n/a	0.31	0.47	3.25	Yes
		3.1	8.2	Sand to sandy silt		20.0	10.2	33	n/a	0.29	0.46	3.39	Yes
10W	275.0	0.3	1.1	Sand and gravel (Fill)	265.0	22.0	12.2	35	n/a	0.27	0.43	3.69	Yes
		1.1	8.2	Sand (Fill)		18.5	8.7	31	n/a	0.32	0.48	3.12	Yes
		8.2	8.7	Silty clay (Fill)		19.0	9.2	n/a	100	-	-	-	Yes
		8.7	10.7	Sand		20.0	10.2	34	n/a	0.28	0.44	3.54	Yes
		10.7	11.3	Sandy silt		18.0	8.2	30	n/a	0.33	0.50	3.00	Yes
32E	270.5	0.1	0.8	Sand and gravel (Fill)	265.9	20.0	10.2	30	n/a	0.33	0.50	3.00	Yes
		0.8	3.1	Sand (Fill)		19.0	9.2	32	n/a	0.31	0.47	3.25	Yes
		3.1	5.6	Clayey silt (Till)		19.0	9.2	n/a	80	-	-	-	Yes
		5.6	8.2	Sand		19.0	9.2	30	n/a	0.33	0.50	3.00	Yes
33E	285.7	0	1.1	Sand and gravel (Fill)	281.1	22.0	12.2	34	n/a	0.28	0.44	3.54	Yes
		1.1	2.3	Silt and sand (Fill)		18.0	8.2	30	n/a	0.33	0.50	3.00	Yes
		2.3	3.1	Silty sand		19.0	9.2	32	n/a	0.31	0.47	3.25	Yes
		3.1	5.3	Silty sand to sandy silt (Till)		20.0	10.2	34	n/a	0.28	0.44	3.54	Yes
		5.3	8.2	Sand and gravel		22.0	12.2	35	n/a	0.27	0.43	3.69	Yes
34E	286.5	0.2	1.5	Sand and gravel (Fill)	284.2	22.0	12.2	33	n/a	0.29	0.46	3.39	Yes
		1.5	3.1	Silty sand		18.0	8.2	29	n/a	0.35	0.52	2.88	Yes
		3.1	7.2	Sandy silt to silty sand (Till)		19.0	9.2	32	n/a	0.31	0.47	3.25	Yes
		7.2	8.2	Sandy clayey silt		19.5	9.7	n/a	100	-	-	-	Yes

Notes:

- 1) The effective unit weight (γ') should be used below the groundwater level.
- 2) n/a: Not applicable
- 3) K_p values provided are for flat ground conditions; values must be adjusted if sloping ground conditions exist at sign locations.
- 4) Borehole 19-6W was dry on completion of drilling. Water level elevation information for Sign 6W site based on Borehole 2 from Geocres Report No. 40P2-47,
- 5) Sandy silt to silt and sand fill in BH19-6W is anticipated to extend below base of standard sign support foundation.