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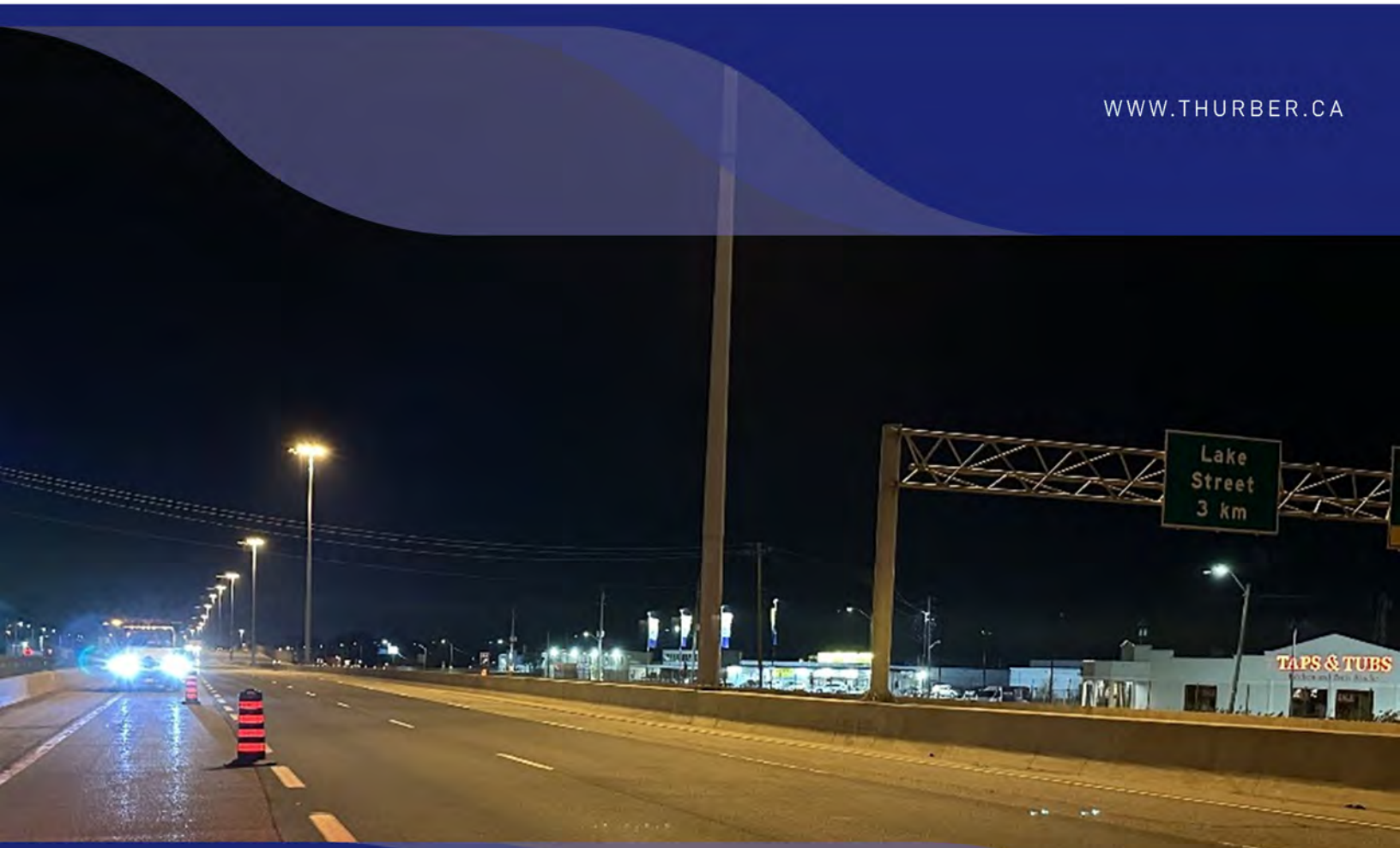

THURBER ENGINEERING LTD.

Foundation Investigation and Design Report

Sign Support for Proposed Pole-Mounted Variable Message Signs
Queen Elizabeth Way / Garden City Skyway
St. Catharines / Niagara-On-The-Lake, Ontario
Agreement No. 2019-E-0052

Latitude: 43.168789°, Longitude: -79.213881°

GEOCRES No. 30M3-330

Client Name: IBI Group
Date: June 2, 2023
File: 36995

Suite 11, 1815 Ironstone Manor, Pickering, Ontario L1W 3W9 | Phone: (905) 829-8666

THURBER ENGINEERING LTD.

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APPENDICES

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PART A – FACTUAL INFORMATION

1. INTRODUCTION

This report presents the data obtained from a foundation investigation carried out by Thurber Engineering Ltd (Thurber) near the proposed pole-mounted variable message signs on Queen Elizabeth Way (QEW), near the Garden City Skyway, in St. Catharines and Niagara-on-the-Lake, Ontario.

The purpose of this investigation was to explore the subsurface conditions near the proposed sign support locations and, based on the data obtained, to provide a borehole location plan, record of borehole, laboratory test results, and a written description of the subsurface conditions.

Thurber carried out the investigation as a subconsultant to IBI Group (IBI), under the Ministry of Transportation, Ontario (MTO) Assignment No. 2019-E-0052.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. SITE DESCRIPTION

In the area of the proposed pole-mounted Variable Message Signs (VMS), QEW is a six-lane divided freeway oriented in an east-to-west direction. Between the proposed VMSs is the Garden City Skyway, which spans over the Welland Canal. In general, the area to the west of the Garden City Skway is comprised of industrial parks with a cemetery to the south, while the area to the east of the Garden City Skyway is generally comprised of undeveloped public lands with farmlands to the north, and a retail development to the south.

QEW is on gradient from east to west with an approximately 16 m elevation relief, ranging from Elevation 118.5 m to 102.4 m.

The overall topography of the area is relatively flat, with a gentle slope downwards to the north towards Lake Ontario.

3. INVESTIGATION PROCEDURE

The foundation investigation was carried out between April 19 and 20, 2023, consisting of drilling and sampling of two boreholes to depths of 8.2 m and 8.8 m in Boreholes VMS-01 and VMS-02,

respectively. The boreholes were advanced through the outside shoulder of the highway near the proposed location of the VMSs.

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

The as-drilled borehole locations and elevations were measured relative to identifiable site features and superimposed on the base plan/contour plan. In accordance with the requirements for surveying of foundation boreholes, the survey readings have a vertical and horizontal accuracy of 0.1 m and 0.5 m, respectively. The locations of the boreholes as presented on the record of boreholes, and as shown on Drawings 1 and 2 are positioned relative to coordinate system MTM NAD 83, Zone 10. The borehole locations, geographic coordinates, ground surface elevations and depths of borehole prior to termination is summarized in summarized in Table 3.1.

TABLE 3.1 Borehole Information

Borehole / Location	Northing (Latitude, º)	Easting (Longitude, º)	Ground Surface Elevation (m)	Depth of Borehole (m)
VMW-01 QEW Niagara-Bound	4 781 039.7 (43.168849)	328 065.2 (-79.213868)	102.4	8.8
VMW-02 QEW Toronto-Bound	4 780 122.1 (43.160480)	331 379.5 (-79.173151)	118.5	8.2

Boreholes were advanced using a truck-mounted CME-45 drill rig using 150 mm outside diameter solid stem augers. Soil samples were obtained at selected intervals using a split-spoon sampler driven by automatic hammers in general accordance with ASTM D1586 Standard Penetration Testing (SPT) procedures. The maximum particle size that can be sampled from the standard split-spoon hammer used in the investigation is limited to 35 mm and therefore, particles that may exist within the soils larger than this dimension would not be recovered or represented in the grain size analyses. Field vane shear testing was carried out in general accordance with ASTM D2573 in cohesive soils for assessment of undrained shear strength using a MTO standard 'N' size vane.

Upon completion of drilling, all boreholes were abandoned in accordance with O.Reg. 903 (as amended) and was backfilled using bentonite/cement grout mix.

The investigation was supervised by a member of our technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling, and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples identified in the field were placed in appropriate containers, labelled, and transported to

our Pickering geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All laboratory tests were carried out to MTO and/or ASTM standards, as appropriate. Routine classification testing consisting of moisture content, grain size analysis, and Atterberg limits were carried out on selected soil samples.

4. SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The site lies within the physiographic region known as the Iroquis Plains, as delineated in the Physiography of Southern Ontario (Chapman and Putnam, 1984). The Iroquis Plain extends around the western shores of Lake Ontario and in the St. Catharines area, the Plain is located between the present Lake Ontario shore bluffs and the foot of the Niagara Escarpment. The Plain is comprised of a flat to undulating lakebed and beaches of the former glacial Lake Iroquis, which occupied this area during the last glacial recession.

The surficial soils in the Iroquis Plain are typically comprised of glaciolacustrine clays and silts; however, surficial deposit of beach sands and gravels are present in some areas. In general, the surficial clays and silts are underlain by an extensive till deposit containing interlayers of glaciolacustrine clay deposits (Halton Till). These deposits are underlain by shale bedrock of the Queenston Formation.

4.2 General Description of Subsurface Conditions

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following sections. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. Soil classification is in accordance with ASTM D2487. Description of cohesive soils and secondary components are described as outlined in the MTO Guideline for Foundation Services Manual (April 2022).

The results of in-situ testing (including standard penetration testing and field vane shear testing) as presented in the record of boreholes and in Section 4 are uncorrected. The boundaries between soil deposits on the record of boreholes have been inferred from non-continuous sampling, observation of the progress of drilling, and the results of Standard Penetration Testing. Therefore, the boundaries represent the transitions between soil deposits rather than exact planes

of geological change. Variation on the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In general, the subsurface conditions consist of asphalt, over embankment comprised of sand and gravel and reworked native clay, which in turn is underlain by a native deposit of silty clay to clay.

4.3 Asphalt

Asphalt was encountered at the ground surface in both boreholes within the highway with a recorded thickness of 300 mm and 125 mm in Boreholes VMS-01 and VMS-02, respectively.

4.4 Fill

4.4.1 Sand and Gravel Fill

Granular fill consisting of sand and gravel, some silt to silty, was encountered beneath the asphalt in both boreholes and extends to a depth of 1.4 m below ground surface (Elevations 101 m and 117.1 m in Boreholes VMS-01 and VMS-02, respectively). Measured SPT N-values in the granular fill were 11 and 50 blows per 0.3 m of penetration, indicating a compact to dense condition.

The moisture content of the sand and gravel fill ranged from 3% to 10%. The results of a grain size analysis carried out on a sample of the silty sand and gravel fill are presented in Figure C-1 of Appendix C. The results of the tests are summarized in Table 4.1 and on the Record of Borehole sheet in Appendix B.

TABLE 4.1 Gradation Results for Silty Sand and Gravel Fill

Soil Particle	Percentage (%)
Gravel	38
Sand	48
Silt	12
Clay	2

4.4.2 Clay Fill

A layer of clay fill containing trace sand was encountered beneath the sand and gravel fill in both boreholes and extends to depths of 2.2 m (Elevation 100.2 m) to 3.0 m (Elevation 115.5 m) in

Boreholes VMS-01 and VMS-02, respectively. SPT N-values measured in the cohesive fill were between 7 and 10 blows per 0.3 m of penetration, inferring a firm to stiff consistency.

The moisture content of clay fill ranges from 23% to 24%. The results of grain size analysis completed on a sample of the cohesive fill are presented on Figure C-2 of Appendix C. The results of the test are summarized in Table 4.2 and on the Record of Borehole sheets in Appendix B.

TABLE 4.2 Gradation Results for Clay Fill

Soil Particle	Percentage (%)
Gravel	0
Sand	7
Silt	37
Clay	56

The results of Atterberg limit tests completed on samples of the clay fill are presented on Figure C-3 of Appendix C. The results of the tests are summarized in Table 4.3 and on the Record of Borehole sheets in Appendix B. The results indicate that the material is a clay of high plasticity (CH).

TABLE 4.3 Atterberg Limit Results for Clay Fill

Parameter	Value
Liquid Limit	52
Plastic Limit	20 – 22
Plasticity index	30 – 32

4.5 Silty Clay to Clay

A native deposit of silty clay to clay containing trace sand was encountered underlying the cohesive fill in both boreholes and extends to a borehole termination depth of 8.8 m (Elevation 93.6 m) and 8.2 m (Elevation 110.3 m) in Boreholes VMS-01 and VMS-02, respectively. SPTs N-values measured in the silty clay to clay ranges from 7 to 31 blows per 0.3 m of penetration. An In-situ field vane test carried out in Boreholes VMS-01 measured undrained shear strengths greater than 100 kPa with a sensitivity value of 2.2. In consideration of the SPT N-values as well as the field vane shear strength, this deposit is considered to have a firm to hard consistency.

Recorded moisture contents ranged from 17 to 28%. The results of grain size analysis completed on one sample of the layer are illustrated on Figure C-4 of Appendix C. The results of the tests are summarized in Table 4.4 and on the Record of Borehole sheets in Appendix B.

TABLE 4.4 Gradation Results for Silty Clay to Clayey Silt

Soil Particle	Percentage (%)
Gravel	0
Sand	4
Silt	57
Clay	39

The results of Atterberg limit tests completed on four samples of the silty clay to clay are presented on Figure C-5 of Appendix C. The results of the tests are summarized in Table 4.5 and on the Record of Borehole sheets in Appendix B. The results indicate that the material is a silty clay of intermediate plasticity (CI) to a clay of high plasticity (CH).

TABLE 4.5 Atterberg Limit Results for Silty Clay to Clay

Parameter	Value
Liquid Limit	38 – 52
Plastic Limit	19 – 22
Plasticity index	19 – 30

4.6 Groundwater Conditions

Details of the water level observed in the boreholes upon completion of drilling are presented on the record of boreholes and summarized in Table 4.6.

TABLE 4.6 Measured Water Levels in the Open Boreholes

Borehole	Date of Reading	Depth and Elevation of Groundwater (m)	Remarks
VMS-01	2023-04-20	Dry 7.6 / 94.8	Boreholes were dry upon completion of drilling. Inferred groundwater level based on transition of brown to grey within the silty clay to clay deposit.
VMS-02	2023-04-19	Dry 6.1 / 112.4	

It should be noted that seasonal fluctuations of the groundwater level are to be expected, and that the groundwater may be at higher elevations after periods of significant or prolonged precipitation.

5. MISCELLANEOUS

Malone's Soil Samples Co. Ltd. (Malone) of Fenelon Falls, Ontario, supplied and operated the drilling equipment to carry out the drilling, sampling, and in-situ testing. The drilling and sampling operations were supervised on a full-time basis by Vihang Patel, EIT of Thurber. The Foundation Investigation Report was prepared by Messrs. Ali Rajaei, P. Eng. and Christopher Ng, P.Eng. The report was reviewed by Mr. Jason Lee, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Ali Rajaei, P.Eng.,
Geotechnical Engineer

Christopher Ng, P.Eng.,
Senior Geotechnical Engineer

Jason Lee, P.Eng.,
Review Principal,
Designated MTO Contact

Date: ***June 2, 2023***
File: ***36995***

THURBER

PART B: ENGINEERING DISCUSSION AND RECOMMENDATIONS

6. GENERAL

This report presents the interpretation of the factual data obtained from a foundation investigation carried out by Thurber for two proposed sign supports for Variable Message Sign (VMS) at locations along the Niagara-bound Queen Elizabeth Way (QEW) in the City of St. Catharines, Ontario and Toronto-bound Queen Elizabeth Way (QEW) in the Town of Niagara-on-the-Lake, Ontario. Foundation assessment and recommendations are provided to assist the project team in designing suitable foundations for the proposed sign foundations.

The section of the report provides foundation engineering parameters and recommendations for the design of the sign supports for the proposed VMSs. The recommendations are based on interpretation of the factual data obtained from the foundation investigation.

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

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

7. POLE-MOUNTED VARIABLE MESSAGE SIGN

It is understood that sign support foundation is required for the proposed pole-mounted variable message signs (VMSs) to be installed at the toe of embankment slope beyond the outside shoulders of QEW. The locations of the proposed VMSs, as provided by IBI Group, are summarized in Table 7.1.

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TABLE 7.1 Locations of Proposed VMSs

VMS Station and Site Number	Highway	Coordinates	Approximate Location
15+290.3 QEWVS0730VES	QEW Niagara-bound	Lat: 43.168789° / Long: -79.213881°	West of Garden City Skyway on the toe of outside shoulder
18+801.7 QEWVS0745VWS	QEW Toronto-bound	Lat: 43.160494° / Long: -79.173106°	East of Garden City Skyway, on the toe of outside shoulder

8. DESIGN OF SIGN SUPPORT FOUNDATIONS

Footing design for sign supports should be carried out in accordance with the following documents:

- Ministry of Transportation, Ontario (2019) “Sign Support Manual”, Provincial Highways Management Division, Highway Standards Branch, Bridge Office.
- Canadian Highway Bridge Design Code (2019) CAN/CSA-S6:19.

According to the structural drawing provided by IBI Group, dated April 27, 2023, the pole-mounted VMS will be supported on a 1.2 m diameter concrete footing with a depth of 6 m below the depth of frost penetration.

It is understood that the proposed sign support for each VMS consists of an augered footing (drilled shaft). Table D1 in Appendix D presents the recommended parameters for the foundation design of the footings.

According to OPSD 3090.101, the depth of frost penetration at this site is 1.1 m and as such, the upper 1.1 m below the final grade should be neglected in the foundation design to account for frost action.

It should be noted that full lateral resistance can only be mobilized where the width of the soil is equal to four times the width of the footing in the direction of the applied load. For sloping ground, the magnitude of the mobilized lateral resistance can be estimated by interpolating between zero passive resistance at the level where the slope face intersects the pile, and full passive resistance at the level where the slope face is at a horizontal distance equal to or greater than four times the width of the footing.

A resistance factor of 0.5 (consistent with a “typical” consequent level and degree of site understanding, per CHBDC (2019)) should be applied to the calculated unfactored lateral resistance to obtain the factored ultimate lateral geotechnical resistance.

Although groundwater was not encountered during the foundation investigation, the design groundwater level may be governed by the water level within the adjacent ditches. However, in the absence of groundwater and drainage data, it is recommended that the design groundwater level is assumed to be at ground surface at the toe of embankment.

9. CONSTRUCTION CONSIDERATIONS

Construction of the footing for the sign support should be carried out in accordance with OPSS.PROV 915.

Appropriate equipment and procedures should be required to minimize ground loss during drilling and concrete placement. This could include the use of temporary lines, and/or the use of bentonite and/or polymer slurry.

10. CLOSURE

The Foundation Design Report was prepared by Messrs. Ali Rajaei, P. Eng. and Christopher Ng, P.Eng. The report was reviewed by Mr. Jason Lee, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Ali Rajaei, P.Eng.,
Geotechnical Engineer

Christopher Ng, P.Eng.,
Senior Geotechnical Engineer

Jason Lee, P.Eng.
Review Principal,
Designated MTO Contact

Date: ***June 2, 2023***
File: ***36995***

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

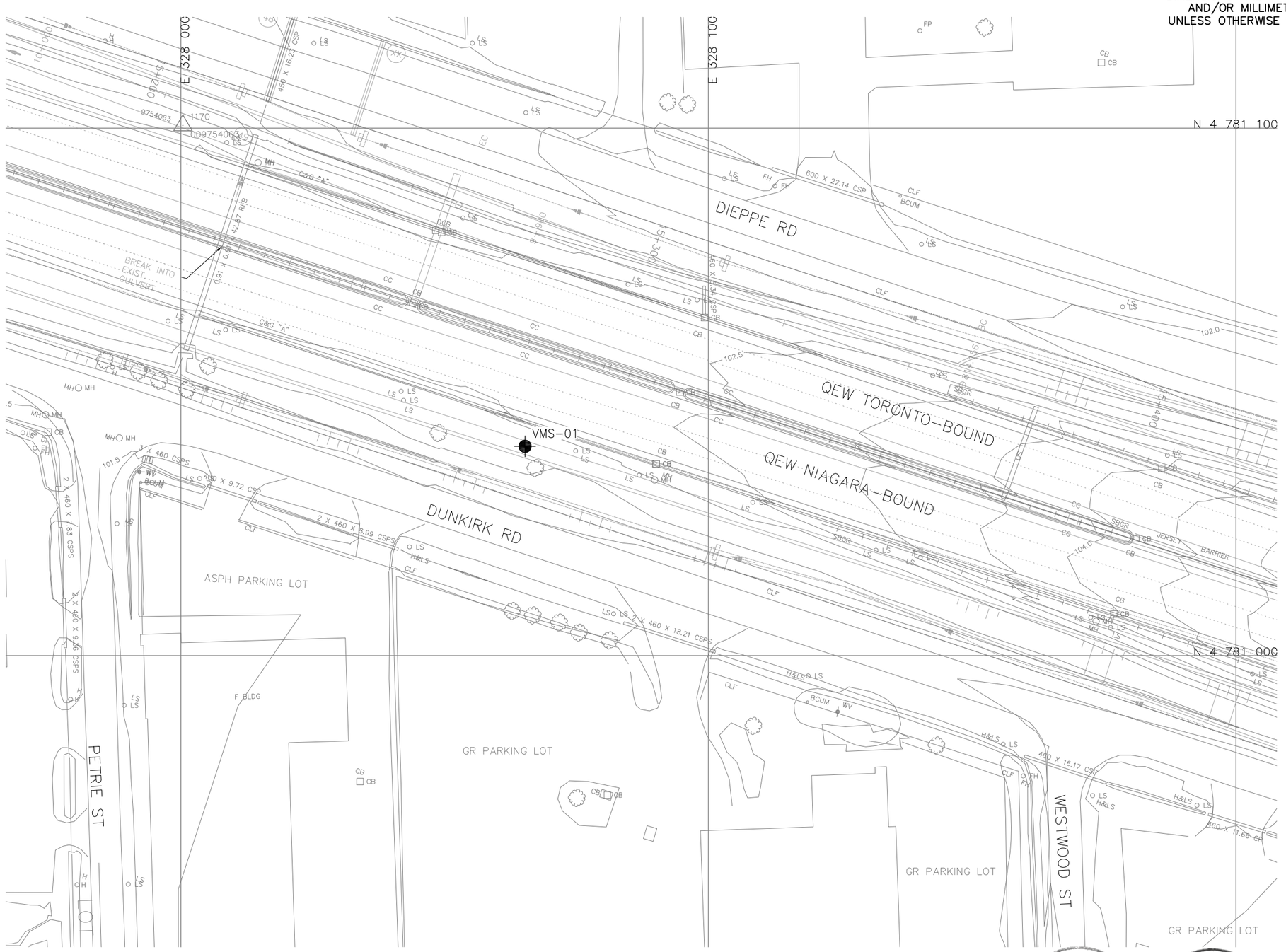
APPENDIX A

DRAWINGS

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PLAN

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QEW–GARDEN CITY SKYWAY
VARIABLE MESSAGE SIGN
NIAGARA–BOUND
BOREHOLE LOCATIONS PLAN

SHEET

THURBER ENGINEERING LTD.

KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
VMS-01	102.4	4 781 039.7	328 065.2

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 30M3-330

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REVISIONS		
DATE	BY	DESCRIPTION

DESIGN AR	CHK CN	CODE	LOAD	DATE	JUN 2023
DRAWN MC	CHK JL	SITE	STRUCT	DWG	1

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MINISTRY OF TRANSPORTATION, ONTARIO

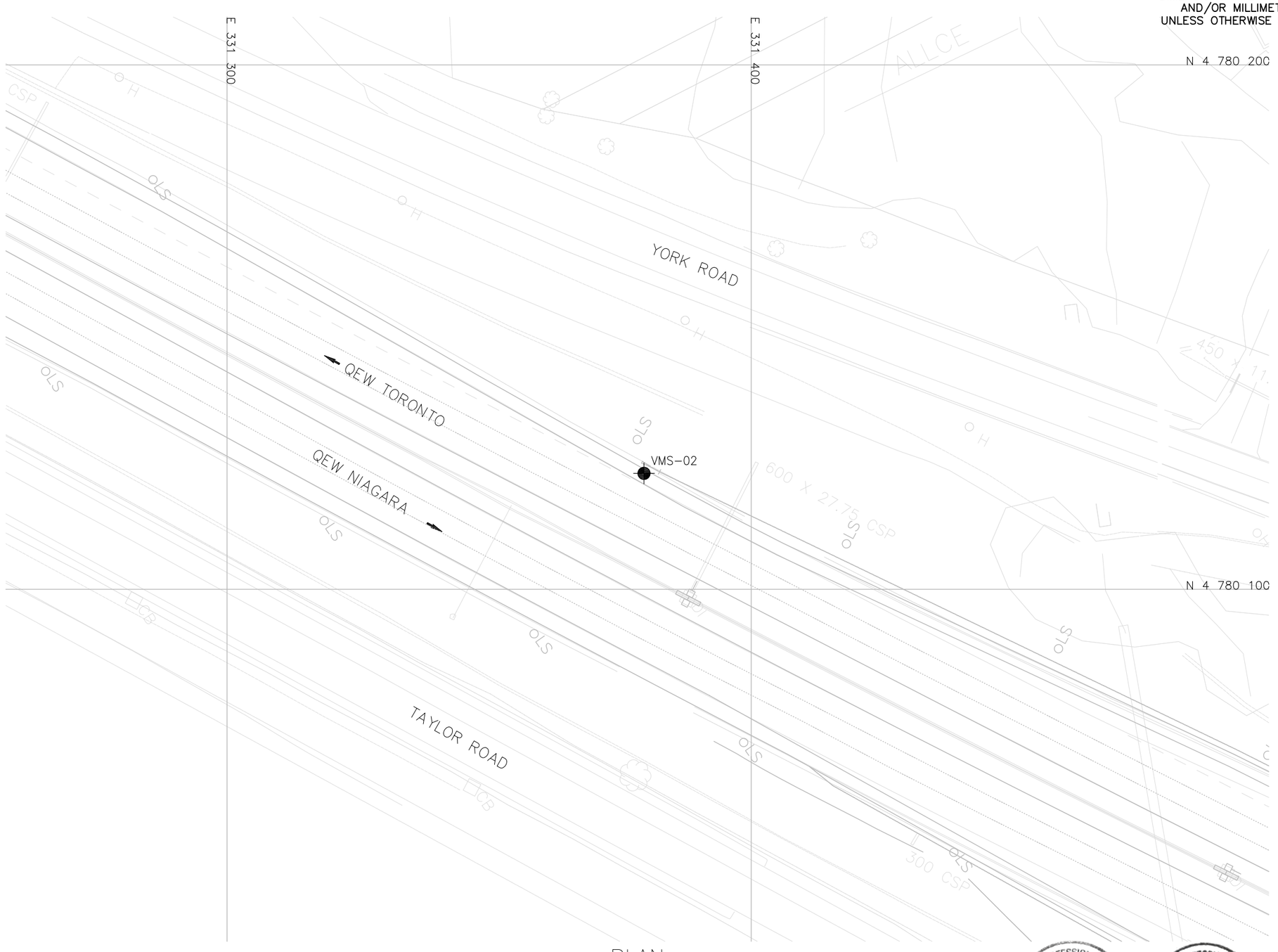
METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No

QEW–GARDEN CITY SKYWAY
VARIABLE MESSAGE SIGN
TORONTO–BOUND
BOREHOLE LOCATIONS PLAN

SHEET



PLAN

16 0 16 32m

SCALE 1:800

THURBER ENGINEERING LTD.

KEYPLAN

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

NO	ELEVATION	NORTHING	EASTING
VMS–02	118.5	4 780 122.1	331 379.5

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 30M3-330

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REVISIONS		
DATE	BY	DESCRIPTION

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APPENDIX B

RECORD OF BOREHOLE SHEETS

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

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

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

UNIFIED SOILS CLASSIFICATION

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

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RECORD OF BOREHOLE No VMS-01 1 OF 1 METRIC

W.P. 2132-21-00 LOCATION MTM Zone 10: N 4 781 039.7 E 328 065.2 ORIGINATED BY VP

DIST Niagara HWY QEW BOREHOLE TYPE C.M.E. 45, Truck Mounted, Solid Stem Augers COMPILED BY AR

DATUM Geodetic DATE 2023.04.20 - 2023.04.20 LATITUDE 43.168849 LONGITUDE -79.213868 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
102.4	GROUND SURFACE										
0.0 102.1	**ASPHALT:** (300 mm)										
0.3	**SAND** and **GRAVEL**, some silt Dense Brown Moist (FILL)		1	GS	-		102				
			1	SS	50				○ ○		
101.0							101				
1.4	**CLAY**, trace sand Stiff Dark Brown Moist		2	SS	10				⊢●		0 7 37 56
100.2	(FILL)										
2.2	Silty **CLAY** to **CLAY**, trace sand Firm to Very stiff Brown Moist		3	SS	19		100		○		
			4	SS	18		99		○		
			5	SS	13		98		⊢●		
			6	SS	10		97		⊢●		
	Becoming grey at a depth of 7.6 m.		7	SS	7		96		○		
93.6							95				
8.8	END OF BOREHOLE AT 8.8 m. BOREHOLE CAVED TO 7.9 m AND WAS DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE/CEMENT GROUT MIX AND, CONCRETE PATCH AT SURFACE.						94	2.2 +			

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

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

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RECORD OF BOREHOLE No VMS-02 1 OF 1 METRIC

W.P. 2132-21-00 LOCATION MTM Zone 10: N 4 780 122.1 E 331 379.5 ORIGINATED BY VP

DIST Niagara HWY QEW BOREHOLE TYPE C.M.E. 45, Truck Mounted, Solid Stem Augers COMPILED BY AR

DATUM Geodetic DATE 2023.04.19 - 2023.04.19 LATITUDE 43.160480 LONGITUDE -79.173151 CHECKED BY CN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
118.5	GROUND SURFACE										
0.0	**ASPHALT:** (125 mm)										
0.1	Silty **SAND** and **GRAVEL**, trace clay Compact Brown Moist (FILL)		1	GS	-		118				
			1	SS	11						38 48 12 2
117.1							117				
1.4	**CLAY**, trace sand Firm to Stiff Dark Brown Moist (FILL)		2	SS	10						
			3	SS	7		116				
115.5											
3.0	Silty **CLAY**, trace sand Very Stiff to Hard Brown Moist		4	SS	27		115				
			5	SS	31		114				0 4 57 39
	Becoming grey at a depth of 6.1 m.		6	SS	15		113				
			7	SS	17		112				
110.3							111				
8.2	END OF BOREHOLE AT 8.2 m. BOREHOLE CAVED TO 7.9 m AND WAS DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE/CEMENT GROUT MIX AND, CONCRETE PATCH AT SURFACE.										

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

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

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APPENDIX C

GEOTECHNICAL LABORATORY SOIL TEST RESULTS

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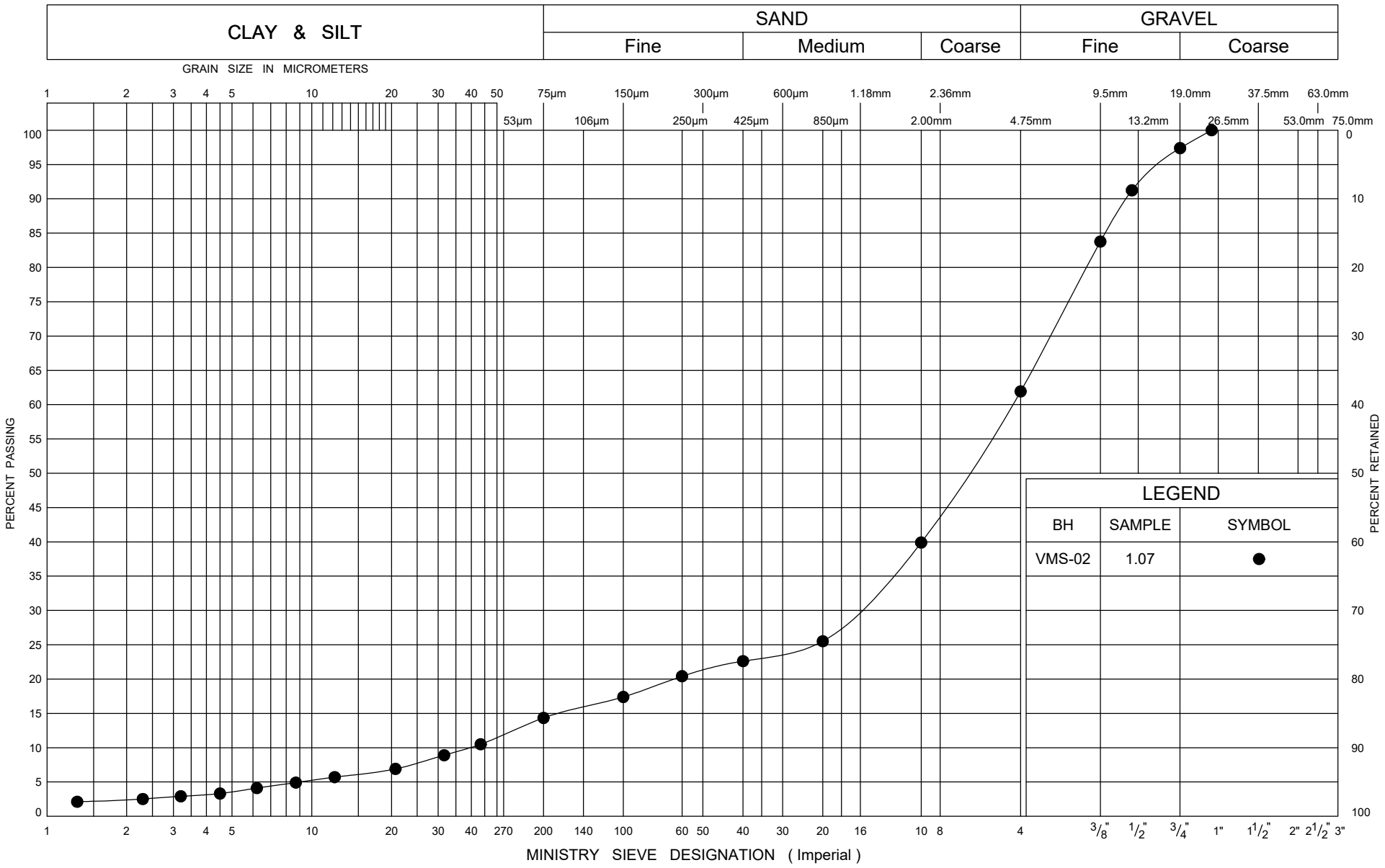
78 12 M



ONTARIO MOT GRAIN SIZE 2 MTO-36995.GPJ ONTARIO MOT.GDT 5/12/23

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GRAIN SIZE DISTRIBUTION

SILTY SAND AND GRAVEL (FILL)

FIG No C-1

W.P. 2132-21-00

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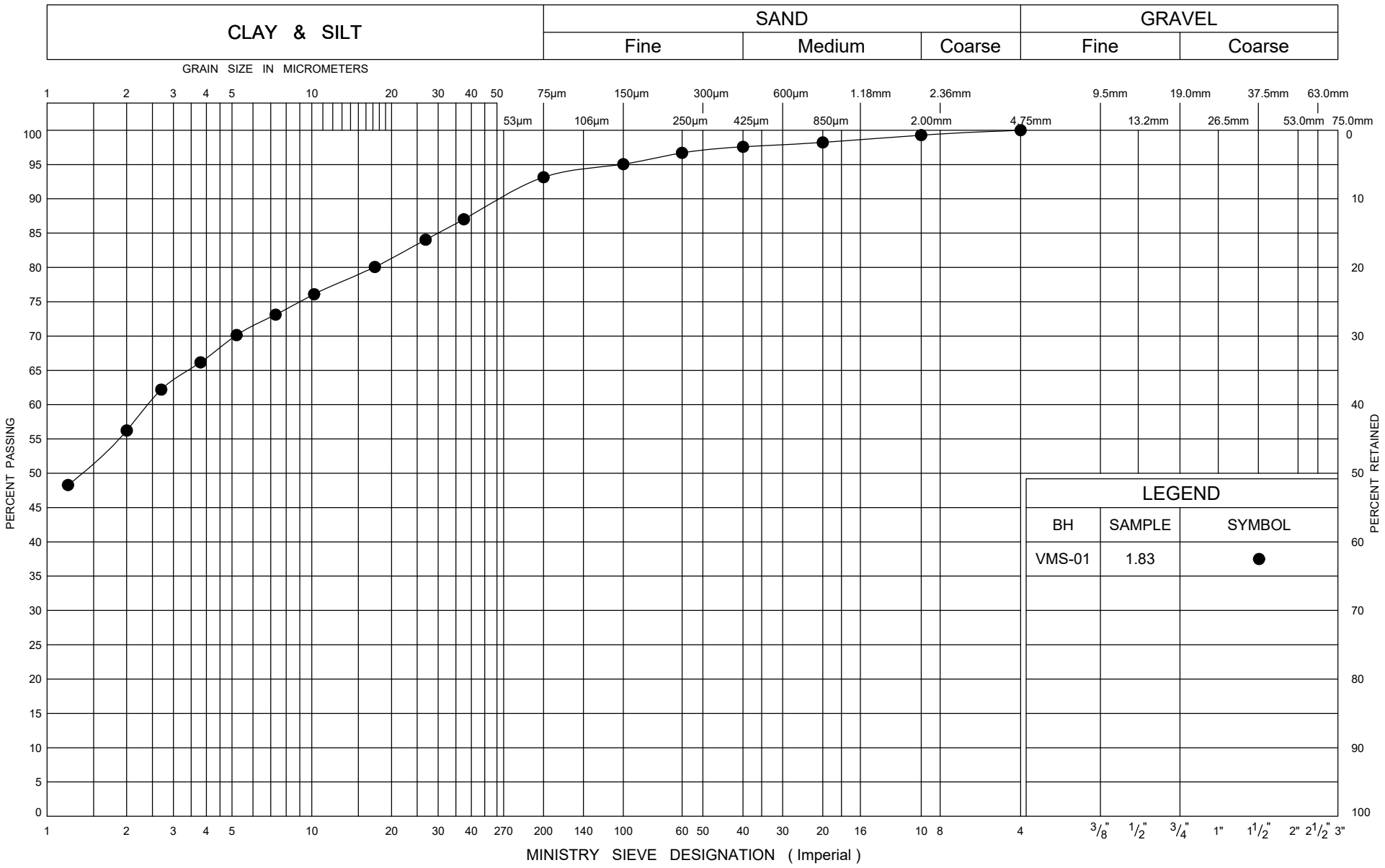
78 12 M



ONTARIO MOT GRAIN SIZE 2 MTO-36995.GPJ ONTARIO MOT.GDT 5/12/23

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GRAIN SIZE DISTRIBUTION

CLAY (FILL)

FIG No C-2

W.P. 2132-21-00

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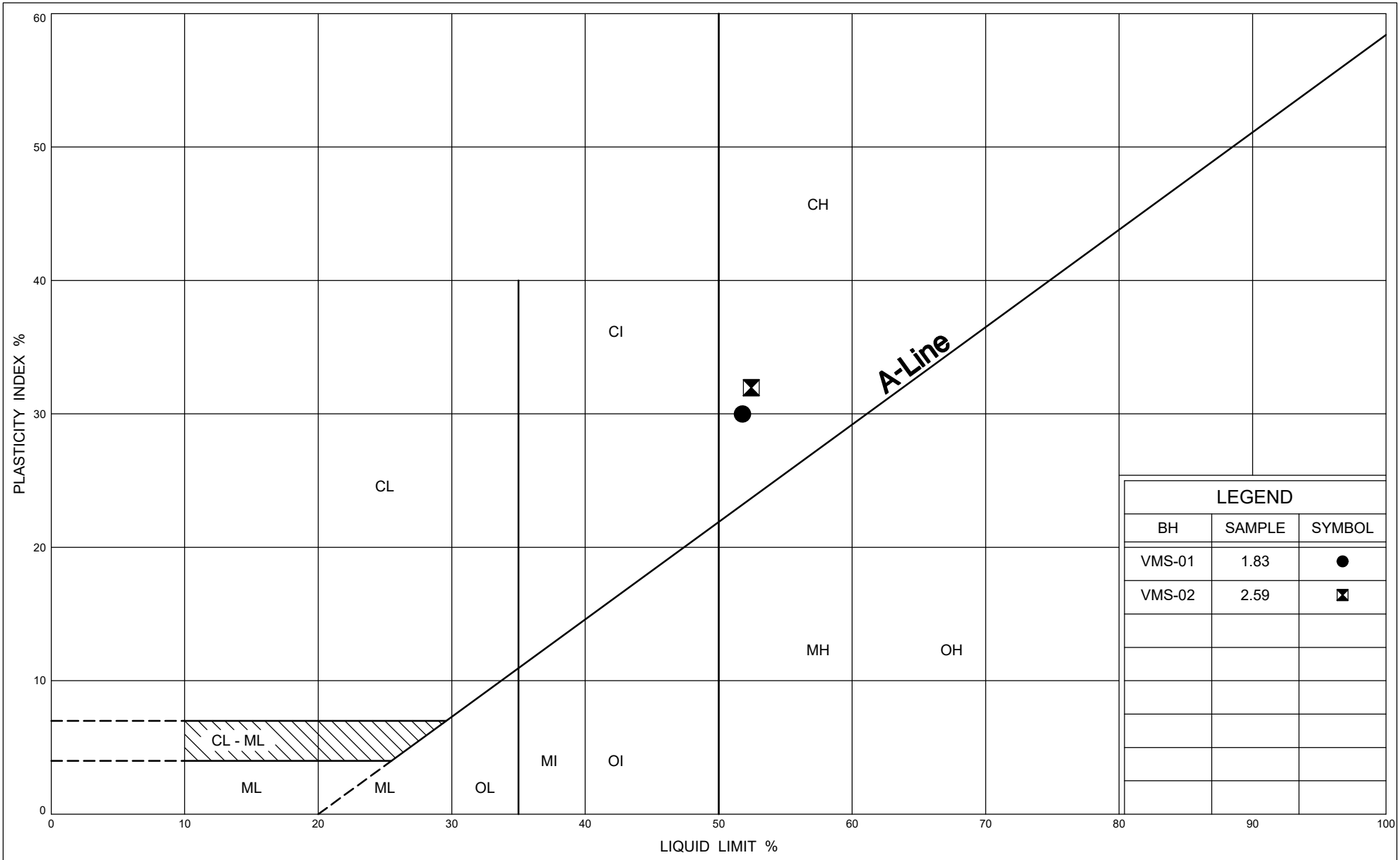
Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
VMS-01	1.83	●
VMS-02	2.59	⧓

ONTARIO MOT PLASTICITY CHART MTO-36995.GPJ ONTARIO MOT.GDT 5/12/23

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PLASTICITY CHART

CLAY (FILL)

FIG No C-3

W.P. 2132-21-00

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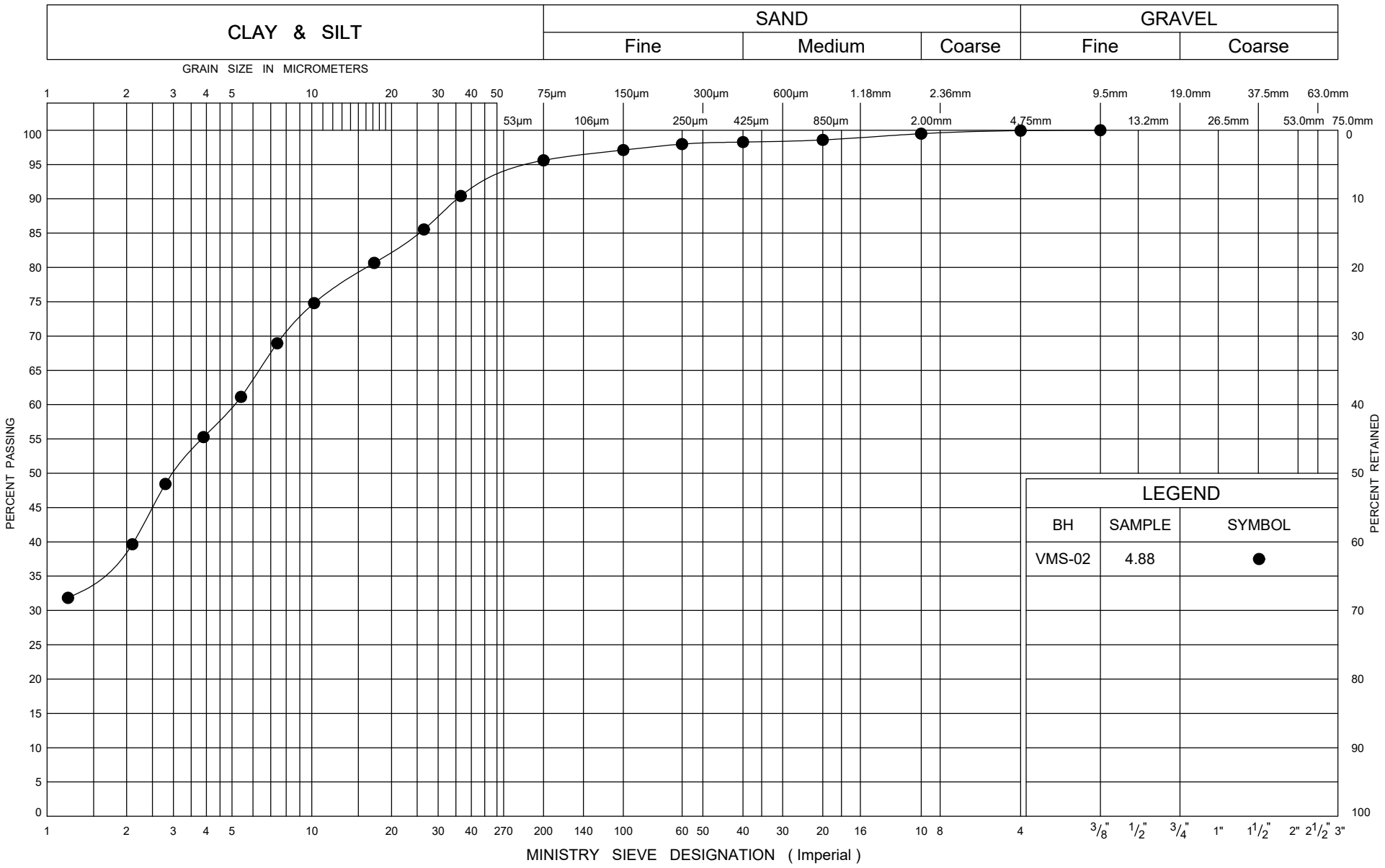
78 12 M



ONTARIO MOT GRAIN SIZE 2 MTO-36995.GPJ ONTARIO MOT.GDT 5/12/23

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GRAIN SIZE DISTRIBUTION

CLAY

FIG No C-4

W.P. 2132-21-00

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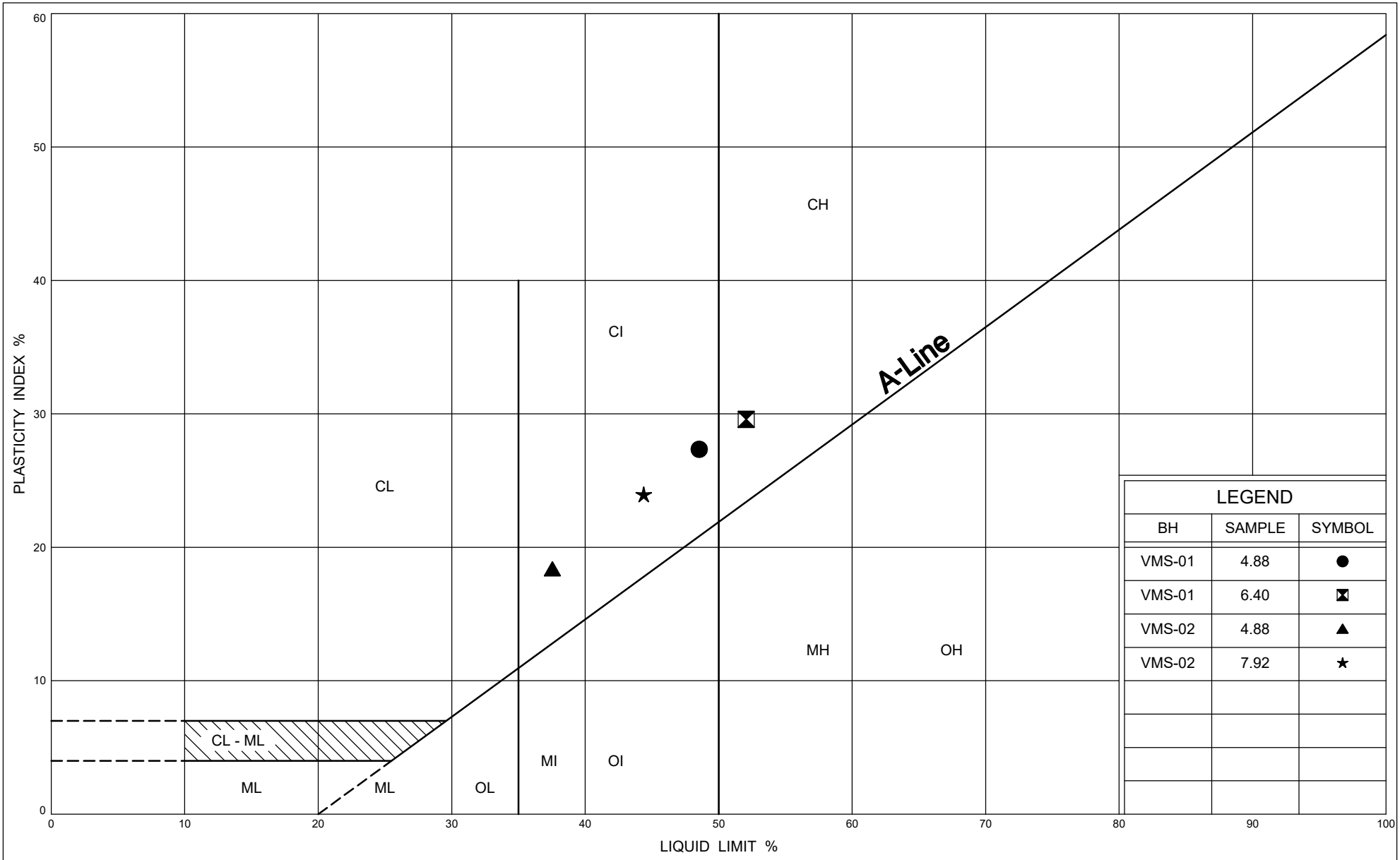
Oct 75, FF - S - 21



ONTARIO MOT PLASTICITY CHART MTO-36995.GPJ ONTARIO MOT.GDT 5/12/23

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PLASTICITY CHART

SILTY CLAY to CLAY

FIG No C-5

W.P. 2132-21-00

APPENDIX D

FOUNDATION ENGINEERING PARAMETERS

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TABLE D1: FOUNDATION ENGINEERING PARAMETERS FOR THE DESIGN OF SIGN SUPPORTS

VMS Location	Borehole No. / Ground Elevation (m)	Soil Deposit	Depth Below Existing Grade (m)	Design Parameters					Observed Groundwater Depth (m)
				S_u (kPa)	φ' (°)	γ (kN/m^3)	γ' (kN/m^3)	K_p See Note 2	
Niagara-bound	VMS-01 102.4	Dense Sand and Gravel Fill	0.3 – 1.4	--	32	20	10	3.2	See Note 1
		Stiff Clay Fill	1.4 – 2.2	60	28	18	8	2.7	
		Firm to Very Stiff Silty Clay to Clay	2.2 – 8.8	75	30	20	10	3.0	
Toronto-bound	VMS-02 118.5	Compact Silty Sand and Gravel	0.1 – 1.4	--	32	20	10	3.2	
		Firm to Stiff Silty Clay Fill	1.4 – 3.0	60	28	18	8	2.7	
		Very Stiff to Hard Silty Clay	3.0 – 8.2	100	30	20	10	3.0	

Design Parameters:

S_u = Undrained shear strength (kPa)

φ' = Effective friction angle (°)

γ= Bulk unit weight (kN/m^3)

γ' = Effective unit weight below groundwater level (kN/m^3)

K_p = Passive earth pressure coefficient

Notes: 1) Groundwater levels were not encountered during the foundation investigation. In the absence of additional information, the design groundwater level should be assumed to be at ground surface at the toe of embankment.

2) The total passive resistance may be calculated based on the K_p indicated above but reduced by an appropriate factor that considers the allowable movement of the footing in accordance with Figure C6.27 of the Canadian Highway Bridge Design Code (CHBDC, 2019) to account for large strain required to mobilize full passive resistance.

3) The information provided herein is presented for design purposes only.

APPENDIX E

LIST OF REFERENCED SPECIFICATIONS

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LIST OF REFERENCED SPECIFICATIONS

OPSS.PROV 915	Construction Specifications for Sign Support Structures
OPSD 3090.101	Foundation Frost Depths for Southern Ontario