



THURBER ENGINEERING LTD.

**PRELIMINARY FOUNDATION INVESTIGATION REPORT
HIGHWAY 401 WIDENING, HIGHWAY 16 TO MAITLAND ROAD
HWY 416 SB CONNECTOR N-E REHABILITATION, SITE NO. 16X-0308
GWP 4024-20-00 / ASSIGNMENT NO. 4019-E-0010.2**

Geocres No.: 31B-105

Report to:

MTO c/o AECOM Canada Ltd.

Latitude: 44.760707°
Longitude: -75.495791°

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

Thurber Engineering Ltd. (Thurber) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation Ontario (MTO) under Assignment No. 4019-E-0010, Work Item No. 2, to carry out Foundation Investigations to support the Preliminary Design and Environmental Assessment for the widening of Highway 401 from Highway 16 to Maitland Road. The overall scope of work comprises replacement or rehabilitation of 14 existing structures, including ten bridges and four structural culverts.

This report addresses the proposed rehabilitation of the Highway 416 underpass ramp bridge connecting traffic coming from the north on Highway 416 to traffic traveling east on Highway 401 (416N-401E) and southbound Highway 16. The bridge, Site No. 16-308, is located approximately 1.5 km north of the Highway 401 and Highway 416 intersection, near the town of Prescott, Ontario.

This section of the report presents the factual findings obtained from a foundation investigation completed at the site, as well as data from existing subsurface information pertinent to the site, obtained from the MTO's Foundation Library and included:

- Report prepared by Jacques, Whitford Limited titled, "*Report on Foundation Investigation, W.P. 177-89-02, Site 16-308, Ramp 416 SB Connection Over Ramps W-N & N-W, Hwy. 401-416 Interchange, District 9, Ottawa*", dated April, 1992 (Geocres No. 31B-73).

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and rehabilitation of the structure was developed during the current investigation.

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

Highway 416 is generally oriented north to south and the bridge is oriented roughly northwest to southeast. For project purposes, Highway 416 and the bridge are herein described as oriented north-south and west-east, respectively.

The land adjacent to the site generally consists of forested lands and agricultural fields. The terrain is relatively flat, apart from the existing highway embankment and associated drainage ditches. Near the bridge, Highway 416 is in a nominal cut section. In this area, Highway 416 consists of a four-lane divided freeway, and the 416N-401E ramp consists of a single travelled lane with paved inside and outside shoulders. The existing bridge is a three span structure with an overall length of approximately 161.5 m. The two piers are located in the median which is approximately 68 m wide from centreline to centreline.

Within the vicinity of the bridge, the embankment side slopes are sloped at approximately 2H:1V and are generally covered with bushes and small trees growing around the abutments. At the time of the field work, the embankments did not show any visible signs of distress or other performance issues. The available structural drawings (Cont. No. 97-68, Sheets 186 to 192) identify the abutment wingwalls as RSS walls that tie into the earth approach embankments as much as 19 m behind the abutments.

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies near the southeastern extent of the physiographic region known as the Glengarry Till Plain. The area is characterized by an undulating surface consisting of morainic ridges and intervening clay flats and swamps, overlying till and similar glaciofluvial deposits containing many cobbles and boulders. The Glengarry Till Plain is known to be underlain by limestone and sandstone bedrock.

Photographs showing the existing conditions at the site at the time of the field investigation are included in Appendix D for reference.

3 SITE INVESTIGATIONS AND FIELD TESTING

The original foundation investigation for design of the 416N-401E ramp bridge was carried out in April 1991 and March 1992, prior to its construction. The current investigation was carried out in April/May 2021 to collect additional subsurface information near the existing bridge abutments. Summaries of the investigations are provided in the following sections.

3.1 Original (1991/1992) Investigations

A total of 11 boreholes were put down at the site as part of the original investigation. Boreholes 91-1 to 91-8 were put down at the proposed approach embankment and foundation element locations between April 17 and 29, 1991. Boreholes 92-1 to 92-3 were put down near the then-revised foundation locations on March 30, 1992. The locations of the 1991/1992 boreholes are within the as-constructed alignment near the west approach and abutment but are up to about 15 m south of the as-constructed alignment near the east abutment.



The 1991/1992 boreholes were advanced to depths ranging from 2.3 m to 18.4 m below the existing ground surface at the time of the investigation (prior to construction of the ramp bridge). A standpipe piezometer or monitoring well was installed in each of the boreholes (91-1 to 91-8 and 92-1 to 92-3).

The locations of the 1991/1992 boreholes were surveyed by others prior to the initiation of the field work, unless they were subsequently relocated due to site constraints, in which case the as-drilled borehole location was re-surveyed.

The northing, easting and elevation of the boreholes used in this investigation are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A and in Table 3-1, below. The site is located within MTM Zone 9. Note that the borehole locations were originally surveyed relative to NAD27 horizontal datum and have been converted relative to NAD83 in the drawing, on the Record of Borehole Sheets (where appropriate), and in Table 3-1, below.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing¹ (Latitude)	Easting¹ (Longitude)	Ground Surface² Elevation (m)	Termination Depth (m)
91-1	West Approach Embankment	4 958 406.3 (44.761249)	384 191.4 (-75.497145)	93.4	4.8
91-2	West Abutment	4 958 374.3 (44.760957)	384 230.6 (-75.496655)	96.7	7.9
91-3	West of West Pier	4 958 354.1 (44.760773)	384 251.1 (-75.496399)	97.5	8.9
91-4	South of West Pier	4 958 330.8 (44.760559)	384 283.9 (-75.495989)	98.4	18.4
91-5	South of Ramp, between East and West Piers	4 958 313.2 (44.760397)	384 315.9 (-75.495587)	98.0	8.6
91-6	South of East Pier	4 958 297.7 (44.760254)	384 348.1 (-75.495183)	98.3	12.0
91-7	Southeast of East Abutment	4 958 284.8 (44.760134)	384 385.8 (-75.494709)	97.7	5.2
91-8	South of East Approach Embankment	4 958 277.5 (44.760065)	384 414.4 (-75.494349)	97.5	3.3
92-1	South of East Approach Embankment	4 958 282.1 (44.760108)	384 396.5 (-75.494574)	98.0	10.3
92-2	South of West Abutment	4 958 376.0 (44.760973)	384 223.6 (-75.496743)	96.7	2.3
92-3	West of West Abutment	4 958 387.2 (44.761075)	384 213.9 (-75.496864)	96.2	3.5

Notes: 1) Boreholes were surveyed relative to NAD27; coordinates listed above were converted relative to NAD83.

2) Boreholes were put down prior to construction of the existing ramp and bridge.

The Borehole Locations and Soil Strata drawing included in the 1997 structural design drawing package shows three additional boreholes numbered 97-4, 97-5, and 97-6 that were put down



within the as-constructed alignment near the east abutment, centre pier, and west abutment, respectively. The drawing indicates that the boreholes were added in December 1997; however, Record of Borehole sheets for these 1997 boreholes were not included in the available Geocres information and are, therefore, not discussed in the current report.

3.2 Current (2021) Investigation

The current site investigation was carried out in the Spring of 2021. Two boreholes were put down at the 416N-401E ramp bridge site: one near the west abutment on April 28 and 29, 2021 (Borehole 308-21-1) and one near the east abutment on May 3 and 4, 2021 (Borehole 308-21-2). The boreholes were put down from truck-mounted CME 55 drill rig.

The locations of 2021 boreholes were surveyed by Thurber for both location and elevation with a Trimble Catalyst DA1 antenna with centimeter accuracy. The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A, the individual Record of Borehole sheets in Appendix B, and in Table 3-2 below. The site is located within MTM Zone 9.

Table 3-2: Borehole Summary

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface ² Elevation (m)	Termination Depth (m)
308-21-1	West Abutment	4 958 382.2 (44.761036)	384 220.6 (-75.496783)	104.0	25.1
308-21-2	East Abutment	4 958 297.8 (44.760258)	384 386.8 (-75.494698)	105.1	25.2

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A standpipe piezometer was installed in Borehole 308-21-1 following completion of the drilling to allow for subsequent groundwater level measurements. Borehole 308-21-2 was abandoned by backfilling with bentonite and drill cuttings.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's geotechnical staff. The drilling supervisor logged the boreholes and processed the recovered soil and bedrock samples for transport to Thurber's Ottawa geotechnical laboratory for further examination and testing.

4 LABORATORY TESTING

Geotechnical laboratory testing carried out as part of the current investigation included natural moisture content determination and visual identification of all retained soil samples. Testing for grain size distribution was also carried out on selected samples to MTO and ASTM standards. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured.



The 1991/1992 investigation included natural moisture content determination, grain size distribution testing, and Atterberg Limit determinations.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and the laboratory test results are presented on the figures included in Appendix C.

5 GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. 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 Borehole Records takes precedence over the Soil Strata Drawing and the general description. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations. Soil classification on the 2021 Record of Borehole sheets is in accordance with ASTM D2487. Description of cohesive soils and secondary components of all deposits from the 2021 borehole are described as outlined in the MTO Guideline for Foundation Engineering Services Manual, Version 2 (October 2020). Terminology from the historic Geocres information may vary from current.

In general terms, the site was found to have granular fill over a layer of clayey silt (present at the time of the 1991/1992 investigations) overlying glacial till at relatively shallow depth. The till is, in turn, underlain by interlayered limestone and dolostone bedrock.

It is noted that the conditions reported on the 1991 and 1992 borehole records may not reflect current conditions due to construction or other activities in the area subsequent to those investigations.

5.1 Embankment Fill

Boreholes 308-21-1 and 308-21-2 were advanced behind the west and east abutments, respectively. The asphalt surface was 200 mm thick in both boreholes. Granular fill was encountered beneath the asphalt surface in both boreholes and extended to depths of 9.1 m (Elevation 94.9 m) and 7.8 m (Elevation 97.3 m) behind the west and east abutments, respectively.

The fill within approximately 1.4 m of top of pavement consisted of gravel with silt and sand to silty sand with gravel. Below this depth, the fill consisted predominantly of sand to sand some silt.

Standard Penetration Tests (SPTs) conducted in the embankment fill gave N-values from 8 to 50 blows per 0.3 m of penetration, but generally ranged between about 20 and 45 blows per 0.3 m of penetration, indicating a compact to dense relative density.

The moisture content of the fill samples tested ranged from about 2 to 16%. The results of grain size analysis testing conducted on four samples of the embankment fill are summarized below and are illustrated on Figures C1 and C2 in Appendix C.

Table 5-1: Summary of Grain Size Distribution Testing – Fill

Soil Particle	Percentage (%)	
	Upper Fill	Lower Fill
Gravel	27 – 49	0 – 2
Sand	42 – 58	89 – 92
Silt and Clay	9 – 15	6 – 11

5.2 Native Surficial Deposits

Surficial deposits consisting of layers of topsoil, sand, sand and gravel, and clayey silt were encountered at the ground surface of the boreholes put down as part of the 1991/1992 investigations that were carried out in the planning stages, prior to construction of the bridge in 1998. It is noted that some of these surficial materials may have been removed during construction of the piers, abutments, approach embankments or during grading/ditching for the new Highway 416 lanes. These deposits were not encountered in the 2021 investigation boreholes but have been described below for informational purposes.

5.2.1 Topsoil

A surficial layer of topsoil was observed in all historic boreholes. It ranged in thickness from 0.1 m to 0.3 m.

5.2.2 Sand, some Silt

A near surface deposit of sand with trace to some silt was observed in Boreholes 91-1, 91-4, 91-5, 91-6, 91-7, 91-8, 92-1, and 92-3 put down near the location of the then-proposed east pier and abutment during the 1991/1992 investigations. The sand deposit ranged from 0.1 to 1.6 m thick at these locations. N-values from 1 to 20 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

5.2.3 Sand and Gravel

A deposit of sand and gravel was encountered at the ground surface in Borehole 91-1 within the footprint of the then-proposed west approach embankment. The deposit extended to approximately 3.9 m below the existing ground surface (Elevation 89.5 m). SPTs conducted in the sand and gravel gave N-values ranging from 33 to 52 blows per 0.3 m of penetration, indicating a compact to dense relative density.

The results of a grain size analysis test conducted on a sample of this material are summarized below and are illustrated on Figure C4 in Appendix C.

Table 5-2: Summary of Grain Size Distribution Testing – Sand and Gravel

Soil Particle	Percentage (%)
Gravel	49
Sand	40
Silt and Clay	11

5.2.4 Clayey Silt

A deposit of clayey silt was encountered near the then-proposed west abutment in Boreholes 91-1, 91-2, 91-3, and 92-2. The deposit was generally encountered near the original ground surface (Elevations 96.7 m to 97.5 m) however was noted to be deeper in Borehole 91-1 (Elevation 89.5 m). It ranged from 0.2 m to 1.6 m thick.

SPTs conducted within this layer gave N-values generally ranging from 2 to 3. In situ shear vane tests were not carried out in any of the boreholes put down at the time but, based on the in-situ testing, was described as having a soft to firm consistency.

The moisture content of the samples tested ranged from about 25 to 35%. The results of an Atterberg Limit test carried out on a sample of the clayey silt gave a Liquid Limit of 35% and a Plastic Limit of 22 %. The results are illustrated on Figure C5 Appendix C and indicate a soil of low to intermediate plasticity (CL).

The results of a grain size analysis test conducted on a sample of this material are summarized below and are illustrated on Figure C6 in Appendix C.

Table 5-3: Summary of Grain Size Distribution Testing – Clayey Silt

Soil Particle	Percentage (%)
Gravel	0
Sand	0
Silt	75
Clay	25

5.3 Glacial Till

A glacial till deposit consisting of a heterogeneous mixture of silty sand, sand, gravel, and clayey silt was encountered beneath the embankment fill or surficial clayey silt or sand at all boreholes. Cobbles and boulders were encountered in the glacial till in all boreholes. The glacial till was encountered at Elevations ranging from 89.3 m to 98.2 m. In the boreholes which fully penetrated this layer (91-4, 308-21-1 and 308-21-2), the thickness ranged from 12.3 m to 15.8 m.

SPTs conducted in this layer gave N-values ranging from 21 to greater than 100 blows for 100 mm of penetration, but were generally greater than 100 blows for 100 mm of penetration or effective refusal of the sampler below about Elevation 93 m, indicating a very dense relative density. Refusals within this deposit are likely due to the presence of cobbles and boulders. Penetration through this layer often required the use of coring techniques.



The moisture content of this unit ranged from 6 to 17%. The results of grain size distribution testing carried out on 13 samples of the till are summarized below and are illustrated on Figures C7 and C3 in Appendix C.

Table 5-4: Summary of Grain Size Distribution Testing – Glacial Till

Soil Particle	Percentage (%)
Gravel	7 – 31
Sand	15 – 68
Silt	14 – 55
Clay	7 – 14

The results of Atterberg Limits testing carried out on the fines of four samples of the glacial till from the 1991 boreholes are summarized below and are illustrated on Figure C7 in Appendix C. The laboratory results indicate that the fines are non-plastic to low plastic (ML to CL-ML to CL).

Table 5-5: Summary of Atterberg Limit Testing – Glacial Till Fines

Parameter	Value
Liquid Limit	15 – 23
Plastic Limit	11 – 14
Plasticity Index	3 – 9

5.4 Bedrock

Bedrock was proven by coring in Boreholes 308-21-1, 308-21-2, and 91-4. The bedrock encountered consisted of fresh, very strong, interbedded sandstone and dolostone. Photographs of the bedrock cores are provided in Appendix C. The following table summarizes the rock core quality:

Table 5-6: Summary of Rock Core Quality

Parameter	Range
Total Core Recovery (TCR), %	95 to 100
Solid Core Recovery (SCR), %	52 to 100
Rock Quality Designation (RQD), %	48 to 96
Fracture Index	0 to 3

The RQD values encountered in the upper 0.5 m of bedrock at Boreholes 308-21-1 and 308-21-2 were 48% and 52%, but below that in all boreholes the RQD ranged from about 85% to 96%, indicating a bedrock of good to excellent quality.

Unconfined compressive strength (UCS) testing was carried out on a sample of the bedrock from Borehole 308-21-1. The results indicated a UCS value of 217 MPa, indicating a very strong rock. The results of the UCS testing are included in Appendix C.

A summary of the bedrock surface information is provided in Table 5-7 below:

Table 5-7: Summary of Bedrock Depth/Elevation

Borehole No.	Depth to Bedrock Surface (mbgs)	Bedrock Surface Elevation (m)
91-4	16.0	82.4
308-21-1	21.4	82.6
308-21-2	21.5	83.6

5.5 Groundwater

Standpipe piezometers or monitoring wells were installed in many of the boreholes put down as part of the 1991/1992/investigations, and in Borehole 308-21-1 put down as part of the current investigation. Groundwater levels recorded are presented in Table 5-8. The observations are considered short term and it should be noted that the groundwater level may vary with season and fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation.

Table 5-8: Summary of Groundwater Levels

Borehole No.	Bottom of Screen Elev. (m)	Screened Unit	Depth (mbgs)¹	Groundwater Elevation (m)	Date of Measurement
91-1	88.7	Overburden	0.4	93.0	May 10, 1991
			0.5	92.9	March 30, 1992
91-2	89.1	Glacial Till	0.2	96.5	May 10, 1991
			0.2	96.5	March 30, 1992
91-3	88.6	Glacial Till	0.4	97.1	May 10, 1991
			0.3	97.2	March 30, 1992
91-4	94.5	Glacial Till	0.2	98.2	May 10, 1991
			1.2	97.2	March 30, 1992
91-4	80.0	Bedrock	2.1	96.3	May 10, 1991
			2.1	96.3	March 30, 1992
91-5	89.6	Glacial Till	0.1	97.9	May 10, 1991
			-0.1	98.1	March 30, 1992
91-6	86.9	Glacial Till	0.3	98.0	May 10, 1991
			0.4	97.9	March 30, 1992
91-7	93.4	Glacial Till	0.0	97.7	May 10, 1991
			-0.2	97.9	March 30, 1992
91-8	94.2	Glacial Till	0.0	97.5	May 10, 1991
			0.0	97.5	March 30, 1992
92-1	87.7	Glacial Till	-	-	May 10, 1991
			5.6	92.4	March 30, 1992
92-2	94.4	Glacial Till	-	-	May 10, 1991
			2.0	94.7	March 30, 1992
308-21-1	85.7	Glacial Till	9.9	94.1	July 1, 2021
			9.4	94.6	December 23, 2022

Note: 1) Depths below ground surface at the time of reading; ground surface may have changed since.



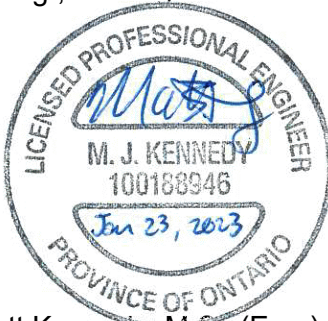
6 MISCELLANEOUS

It is noted that the conditions reported on the 1991 and 1992 borehole records may not reflect current conditions due to construction or other activities in the area subsequent to those investigations.

The 2021 borehole locations were selected by Thurber relative to existing site features. The as-drilled locations and ground surface elevations of the boreholes were surveyed by Thurber following completion of the field program. The elevation survey of the boreholes was carried out with reference to geodetic elevation benchmarks provided by the MTO. Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied and operated the drilling equipment and carried out the drilling, soil sampling, in-situ testing, and borehole decommissioning.

The field investigation was supervised on a full-time basis by Jamil Pirani of Thurber. Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Unconfined Compressive Strength Testing of the bedrock was carried out by Stantec's laboratory in Ottawa.

Overall project management and direction of the field investigation was provided by Matt Kennedy, P.Eng. Interpretation of the factual data and preparation of this report was carried out by Matt Kennedy, P.Eng. The report was reviewed by Paul Carnaffan, P.Eng. and Fred Griffiths, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



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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.

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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.

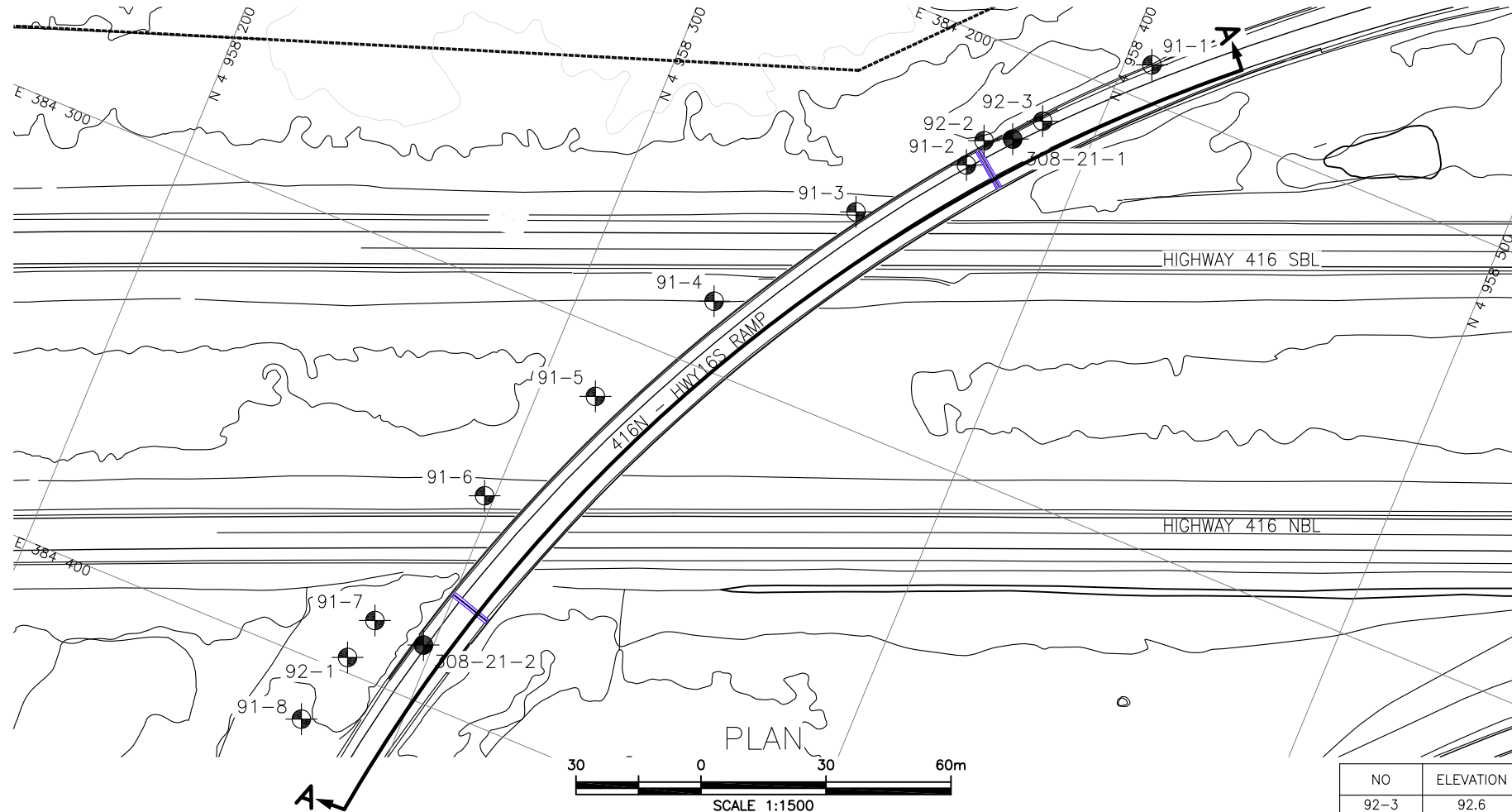
7. INDEPENDENT JUDGEMENTS OF CLIENT

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.

Borehole Location Plan and Stratigraphic Drawings



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

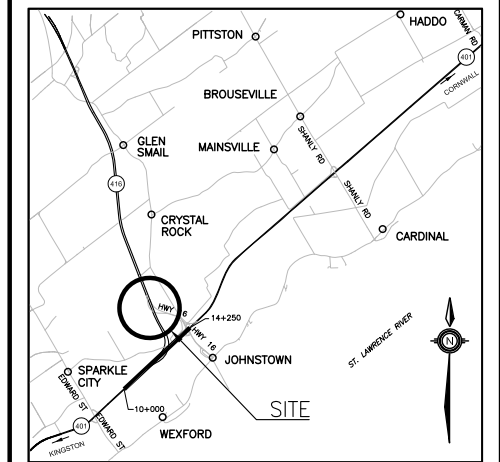


CONT No
GWP No 4024-20-00

HIGHWAY 416
416N - HIGHWAY 16S RAMP
REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

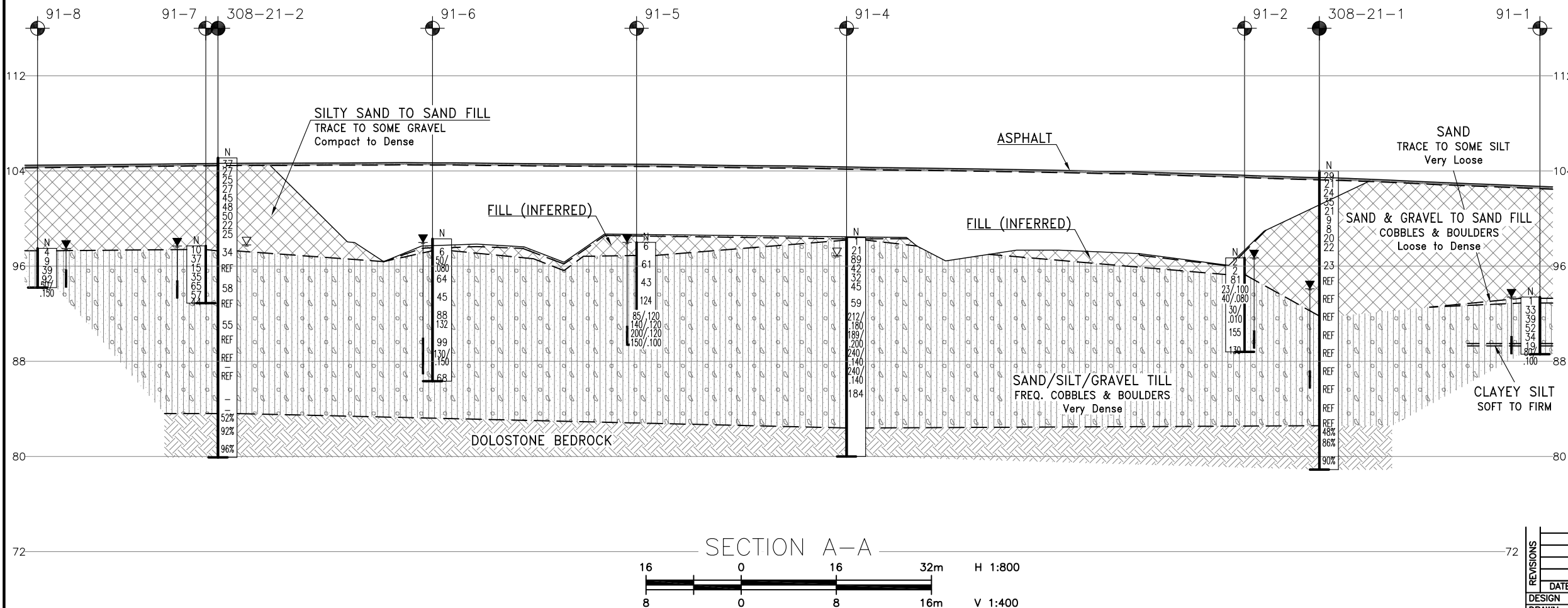
- Borehole (Current Investigation)
- Borehole (Previous Investigation)
- Blows /0.3m (Std Pen Test, 475J/blow)
- Blows /0.3m (60° Cone, 475J/blow)
- Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- Rock Quality Designation (RQD)
- Auger Refusal

NO	ELEVATION	NORTHING	EASTING
308-21-1	104.0	4 958 382.2	384 220.6
308-21-2	105.1	4 958 297.8	384 386.8
91-1	93.4	4 958 406.3	384 191.4
91-2	96.7	4 958 374.3	384 230.6
91-3	97.5	4 958 354.1	384 251.1
91-4	98.4	4 958 330.8	384 283.9
91-5	98.0	4 958 313.2	384 315.9
91-6	98.3	4 958 297.7	384 348.1
91-7	97.7	4 958 284.8	384 385.8
91-8	97.5	4 958 277.5	384 414.4
92-1	98.0	4 958 282.1	384 396.5
92-2	96.7	4 958 376.0	384 223.6

NOTES

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 9.

GEOCRES No. 31B-105



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MJK	CHK -	CODE
DRAWN	MFA	CHK MK	SITE 16-308
			LOAD
			DATE JAN 2023
			DWG 1



Appendix B.

Record of Borehole Sheets



Appendix B.1

Current (2021) Investigation



SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

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

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "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 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.



STRATA PLOT:

Strata plots symbolize the soil and 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.



Boulders
Cobbles
Gravel Sand Silt Clay Organics Asphalt Concrete Fill Bedrock

TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT "N" Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	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	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, 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.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L = Liquid Limit



EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

TERMS

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

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

RECORD OF BOREHOLE No 308-21-1

1 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.761036°, Long: -75.496784° N 4 958 382.2 E 384 220.6 ORIGINATED BY JP
 HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
 DATUM Geodetic DATE 2021.04.28 - 2021.04.29 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
104.0								<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>						GR SA SI CL
0.0	ASPHALT (200 mm)							<div><div>204060</div><div>W P W W L</div><div>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT</div></div>						
0.2	SAND and GRAVEL to Gravelly SAND, trace to some fines Grey-brown to brown Compact FILL		1	SS	29		103							49 42 9 (SI+CL)
			2	SS	21									27 58 15 (SI+CL)
102.6														
1.4	SAND Brown Loose to dense FILL		3	SS	24		102							
			4	SS	35									
							101							
			5	SS	21									
							100							
			6	SS	9									
							99							2 92 6 (SI+CL)
			7	SS	8									
							98							
			8	SS	20									
							97							
			9	SS	22									
							96							
			10	SS	23									
							95							
94.9														
9.1	GRAVELLY SILTY SAND to SILT, some gravel and sand Grey-brown to grey Very dense Frequent cobbles/boulders GLACIAL TILL		11	SS	REF									18 68 14 (SI+CL)

Continued Next Page

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

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22

RECORD OF BOREHOLE No 308-21-1

2 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.761036°, Long: -75.496784° N 4 958 382.2 E 384 220.6 ORIGINATED BY JP
 HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
 DATUM Geodetic DATE 2021.04.28 - 2021.04.29 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page							SHEAR STRENGTH kPa						
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL × LAB VANE						
								WATER CONTENT (%)						
								20	40	60				
			12	SS	REF		93							
							92							
			13	SS	REF		91							
							90							
			14	SS	REF		89							
							88							
			15	SS	REF		87							
							86							
			16	SS	REF		85							
			17	SS	REF									
			18	SS	REF									

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+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22

RECORD OF BOREHOLE No 308-21-1

3 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.761036°, Long: -75.496784°
N 4 958 382.2 E 384 220.6 ORIGINATED BY JP
HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2021.04.28 - 2021.04.29 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page													
82.6	GRAVELLY SILTY SAND to SILT , some gravel and sand Grey-brown to grey Very dense Frequent cobbles/boulders GLACIAL TILL		19	SS	REF		83						FI	
21.4	Interbedded LIMESTONE and DOLOSTONE Fresh Grey Fine grained Very strong		1	RUN			82						3	RUN #1 TCR=100% SCR=70% RQD=48%
			2	RUN			81						1	UCS = 217 MPa RUN #2 TCR=100% SCR=100% RQD=86%
			3	RUN			80						1	RUN #3 TCR=100% SCR=100% RQD=90%
78.9							79						2	
25.1	End of Borehole Flushmount 19 mm diameter PVC monitoring well installed. Well Readings: Date: Depth (m): Elev. (m): 2021/07/01 9.9 94.1 2022/12/20 9.4 94.6													

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22

RECORD OF BOREHOLE No 308-21-2

1 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.760258°, Long: -75.494698°
N 4 958 297.8 E 384 386.8 ORIGINATED BY JP
HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2021.05.03 - 2021.05.04 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
105.1														
0.0	ASPHALT (200 mm)						105							
0.2	SILTY SAND, some gravel Grey-brown to brown Compact to dense FILL		1	SS	37									
			2	SS	27		104							
103.7														
1.4	SAND, some silt Grey-brown to brown Compact to dense FILL		3	SS	25		103							
			4	SS	27									
							102							
			5	SS	45									
			6	SS	48		101							
			7	SS	50		100							
			8	SS	22		99							
			9	SS	25		98							
							97							
97.3			10	SS	34									
7.8	SILTY SAND some gravel Brown to grey Dense to very dense Frequent cobbles/boulders GLACIAL TILL													
							96							
			11	SS	REF									

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 308-21-2

2 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.760258°, Long: -75.494698°
N 4 958 297.8 E 384 386.8 ORIGINATED BY JP
HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2021.05.03 - 2021.05.04 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page													
	SILTY SAND some gravel Brown to grey Dense to very dense Frequent cobbles/boulders GLACIAL TILL Grey below 10.7 m		12	SS	58		95							18 38 32 12
							94							
			13	SS	REF		93							
							92							
			14	SS	55		91							26 37 29 8
							90							
			15	SS	REF		89							
			16	SS	REF		88							
			1	NQ	-		87							
			17	SS	REF		86							

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+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

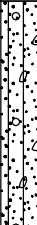

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22

RECORD OF BOREHOLE No 308-21-2

3 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.760258°, Long: -75.494698°
N 4 958 297.8 E 384 386.8 ORIGINATED BY JP
HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2021.05.03 - 2021.05.04 CHECKED BY MJK

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 (%)		
								20 40 60 80 100										20 40 60		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
	Continued From Previous Page																			
83.6	SILTY SAND some gravel Brown to grey Dense to very dense Frequent cobbles/boulders GLACIAL TILL		2	NQ	-		85										7 34 49 10			
			3	NQ	-		84													
21.5	Interbedded LIMESTONE and DOLOSTONE Fresh Grey Fine grained Very strong Vertical fracture 21.5 to 21.7 m		1	RUN			83										RUN #1 TCR=100% SCR=52% RQD=52% RUN #2 TCR=100% SCR=98% RQD=92% RUN #3 TCR=100% SCR=100% RQD=96%			
			2	RUN			82													
			3	RUN			81													
79.9								80												
25.2	End of Borehole																			

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22



Appendix B.2

Original (1991/1992) Investigation

RECORD OF BOREHOLE No 91-1

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 406.3 E: 384 191.4 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE April 21, 1991 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100			W _p
93.4	Ground Surface														GR:SA SI CL
92.9	Topsoil						May 93								
0.5	Sand trace to some silt Very Loose Reddish-Brown		1	SS	1		March, 30, 1992								
							Seal								
	Sand and Gravel, some silt Dense to Very Dense Brown		2	SS	33										
			3	SS	39		92								
			4	SS	52		91								49 40 (11)
			5	SS	34		90								
89.5	Clayey Silt						Piezometer								
4.1	Soft to Firm Brown		6	SS	19		89								
88.6	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial Till) Compact Grey		7	SS	80/10cm										7 45 (48)
4.8	End of Borehole														



RECORD OF BOREHOLE No 91-2

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 374.3 E: 384 230.6 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing COMPILED BY C.K.K.
 DATUM Geodetic DATE April 23, 1991 CHECKED BY G.J.K.

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					
96.7	Ground Surface																GR SA SI CL
0.1	Topsoil		1	SS	2		May 10, 1991, March 30, 1992										
	Clayey Silt		2	SS	2		96										0 0 75 25
95.3	Soft to Firm Brown																
1.4	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial Till) Very Dense		3	SS	81		95 Native Backfill						o				
			4	SS	23	0 cm	94						o				16 44 (40)
			5	SS	40	8 cm	93						o				
	Brown						Seal										
	Grey		6	SS	30	cm	92						o				
							91 Sand Backfill										
			7	SS	155		90 Piezometer						o				
88.8			8	SS	130		89						o				
7.9	End of borehole																

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 354.1 E: 384 251.1 ORIGINATED BY Y.L.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing COMPILED BY C.K.K.
DATUM Geodetic DATE April 23, 24, 1991 CHECKED BY G.J.K.

[illegible]

RECORD OF BOREHOLE No 91-4

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 330.8 E: 384 283.9 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing, Rock Coring COMPILED BY C.K.K.
 DATUM Geodetic DATE April 17 to 19, 1991 CHECKED BY G.J.K.

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	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
98.4	Ground Surface														GR SA SI CL
0.1	Topsoil					Seal									
0.2	Sand trace to some silt, Very Loose Brown	1	SS	1		98									
	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial Till) Compact to Very Dense Brown Grey	2	SS	21		Native Backfill									
		3	SS	89		March 30, 1992									
		4	SS	42		96									
		5	SS	32		Backfill									
		6	SS	45		Piezometer									
		7	SS	59		95									
		8	SS	202/18 cm		94									
		9	SS	189/20 cm		93									
		10	SS	240/14 cm		92									7 44 41 8
		11	SS	240/14 cm		91									
		12	SS	184		90									
						89									
						88									
						87									
						86									
						85									
						84									
						83									
82.4						Seal									
16.0	Bedrock Limy Dolostone Good to Excellent	13	NQ RC	REC 95%		Sand 82 Backfill									RQD = 85%
		14	NQ RC	REC 96%		Piezometer 81									RQD = 96%
80.0															
18.4	End of borehole														



RECORD OF BOREHOLE No 91-5

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 313.2 E: 384 315.9 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing COMPILED BY C.K.K.
 DATUM Geodetic DATE April 24 to 26, 1991 CHECKED BY G.J.K.

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					
98.0	Ground Surface																GR SA SI CL
0.1	Topsoil		1	SS	6												
96.9	Sand, trace to some silt Loose Brown																
1.1	Het. Mixture of Sandy Silt, some clay and gravel, Brown & Grey occ. boulders Grey (Glacial Till) Dense to Very Dense		2	SS	61												
			3	SS	43												
			4	SS	124												22 27 (51)
			5	SS	85/ 12cm												
			6	SS	140/ 12 cm												
			7	SS	200/ 12 cm												
89.4			8	SS	150/ 10 cm												
8.6	End of borehole																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 91-6

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 297.7 E: 384 348.1 ORIGINATED BY Y.L.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing COMPILED BY C.K.K.
DATUM Geodetic DATE April 25 to 26, 1991 CHECKED BY G.J.K.

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					
98.3	Ground Surface																
	Topsoil						98										
0.3	Sand, trace to some silt						May 10, 1991, March 30, 1992										
97.3	Loose Brown		1	SS	6		97										
1.0	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial Till)						Native Backfill										
	Loose to Very Dense Brown Grey		2	SS	50/8		96										
							Seal										
			3	SS	64		95										
							94						o				
			4	SS	45		Sand Backfill										
							93						o				
							92										
			5	SS	88		91						o				
			6	SS	132		90										
			7	SS	99		Piezometer										
							89										
			8	SS	130/15cm		88						o				
							87										
86.3			9	SS	68								o				
12.0	End of borehole																



RECORD OF BOREHOLE No 91-7

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 284.8 E: 384 385.8 ORIGINATED BY Y.L.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
DATUM Geodetic DATE April 29, 1991 CHECKED BY G.J.K.

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					
97.7	Ground Surface															
0.1	Topsoil															
0.3	Sand trace to some silt, Brown		1	SS	10											
	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial Till) Compact to Very Dense		2	SS	37											
			3	SS	15											
			4	SS	35											
			5	SS	65											
			6	SS	57											
92.5			7	SS	44											
5.2	End of borehole															



RECORD OF BOREHOLE No 91-8

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 277.5 E: 384 414.4

ORIGINATED BY Y.L.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger

COMPILED BY C.K.K.

DATUM Geodetic DATE April 29, 1991

CHECKED BY G.J.K.

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			VALUES	20 40 60 80 100					
							○ UNCONFINED + FIELD VANE	WATER CONTENT (%)					
							● QUICK TRIAXIAL x LAB VANE						
97.5	Ground Surface												
0.1	Topsoil												
0.2	Sand trace to some silt, Loose, Brown		1	SS	4	Seal	May 10, 1991, March 30, 1992						
	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial till) Brown		2	SS	9	Native Backfill				○			
			3	SS	39	Seal				○			
			4	SS	92	Sand Backfill				○			
94.2			5	SS	50/	Piezometer				○			
3.3	End of Borehole				15 cm								

RECORD OF BOREHOLE No 92-1

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 282.1 E: 384 396.5 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE March 30, 1992 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			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	W _p	W	W _L		
98.0	Ground Surface																
0.2	Topsoil																
97.1	Sand, trace to some silt																
0.9	Compact Brown		1	SS	16												
	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial Till)		2	SS	16												
	Compact to Very Dense		3	SS	77												
	Brown Grey		4	SS	46												
			5	SS	84												
			6	SS	100/13 cm												
			7	SS	59												
			8	SS	58												
			9	SS	48												
87.7			10	SS	187/23 cm												
10.3	End of Borehole																

RECORD OF BOREHOLE No 92-2

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 376.0 E: 384 223.6
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger
 DATUM Geodetic DATE March 30, 1992
 ORIGINATED BY Y.L.
 COMPILED BY C.K.K.
 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
96.7	Ground Surface																
0.1	Topsoil		1	SS	3												
	Clayey Silt		2	SS	36												
	Soft to Firm																
	Brown		3	SS	55												
95.0																	
1.7	Het. Mixture of Sandy																
94.4	Silt, tract to some																
	gravel, occ. boulders																
2.3	(Glacial Till)																
	Dense to Very																
	Dense																
	End of Borehole																

RECORD OF BOREHOLE No 92-3

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 387.2 E: 384 213.9 ORIGINATED BY Y.L.
 DIST HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE March 30, 1992 CHECKED BY G.J.K.

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					
96.2																
0.1	Topsoil					96										
	Sand, some silt, trace gravel Compact Brown		1	SS	20											
94.5						95										
			2	SS	64											
1.7	Het. Mixture of Sandy Silt to Silty Sand, some gravel, occ. boulders (Glacial Till) Very Dense Brown					94										
92.7						93										
			3	SS	183											
3.5	End of Borehole No groundwater seepage during drilling															



Appendix C.

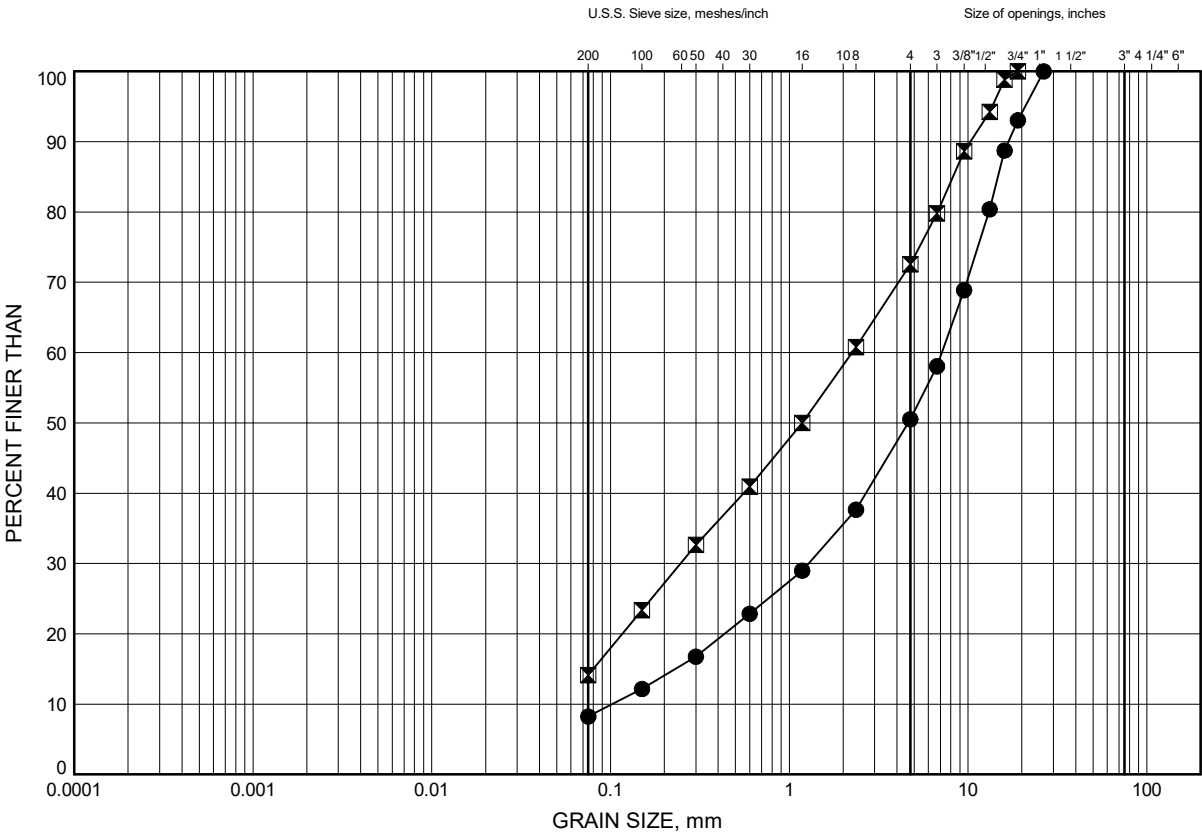
Laboratory Testing



Appendix C.1
Particle Size Analysis Figures (2021)
Atterberg Limit Test Results (2021)

GRAIN SIZE DISTRIBUTION

UPPER EMBANKMENT FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	308-21-1	0.5	103.5
⊠	308-21-1	1.1	102.9

GRAIN SIZE DISTRIBUTION - THURBER 29381 BOREHOLE LOGS.GPJ 24/6/21

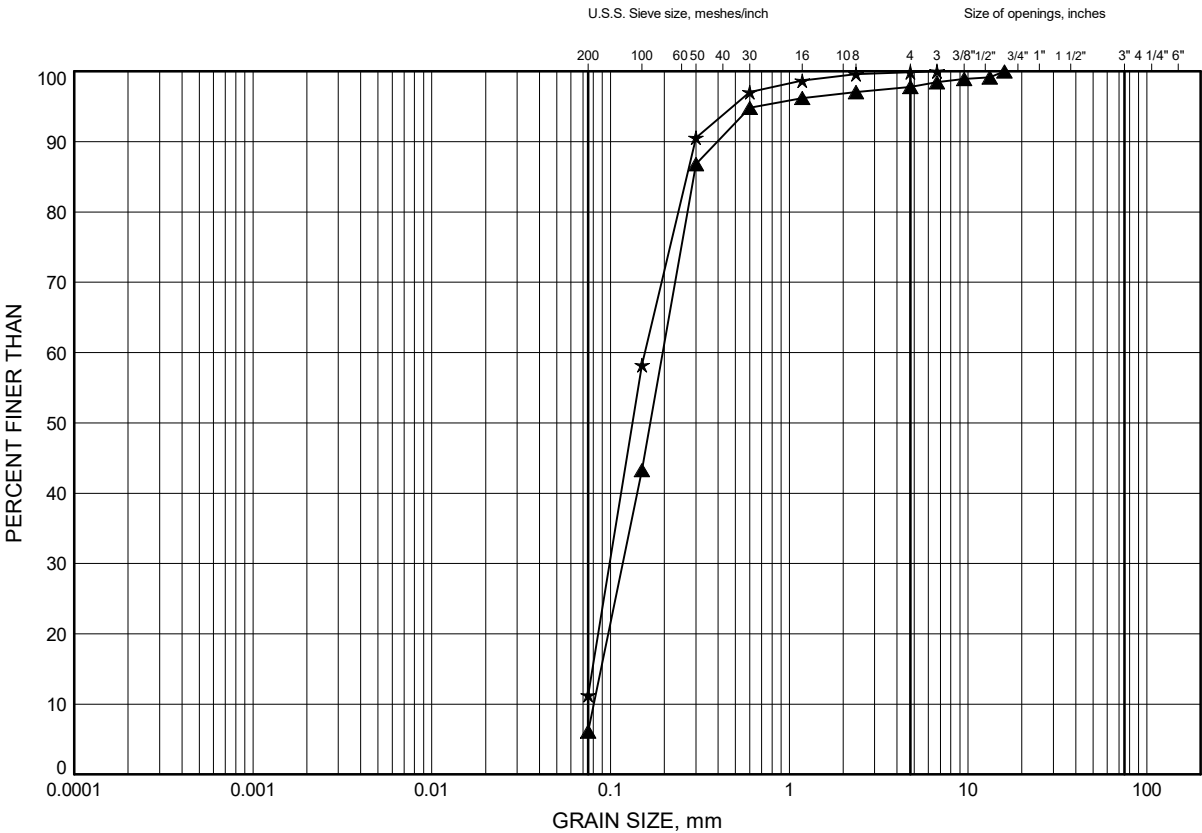
Date November 2021
WP# 4024-20-00



Prep'd SH
Chkd. MJK

GRAIN SIZE DISTRIBUTION

LOWER EMBANKMENT FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
▲	308-21-1	4.9	99.1
★	308-21-2	3.4	101.7

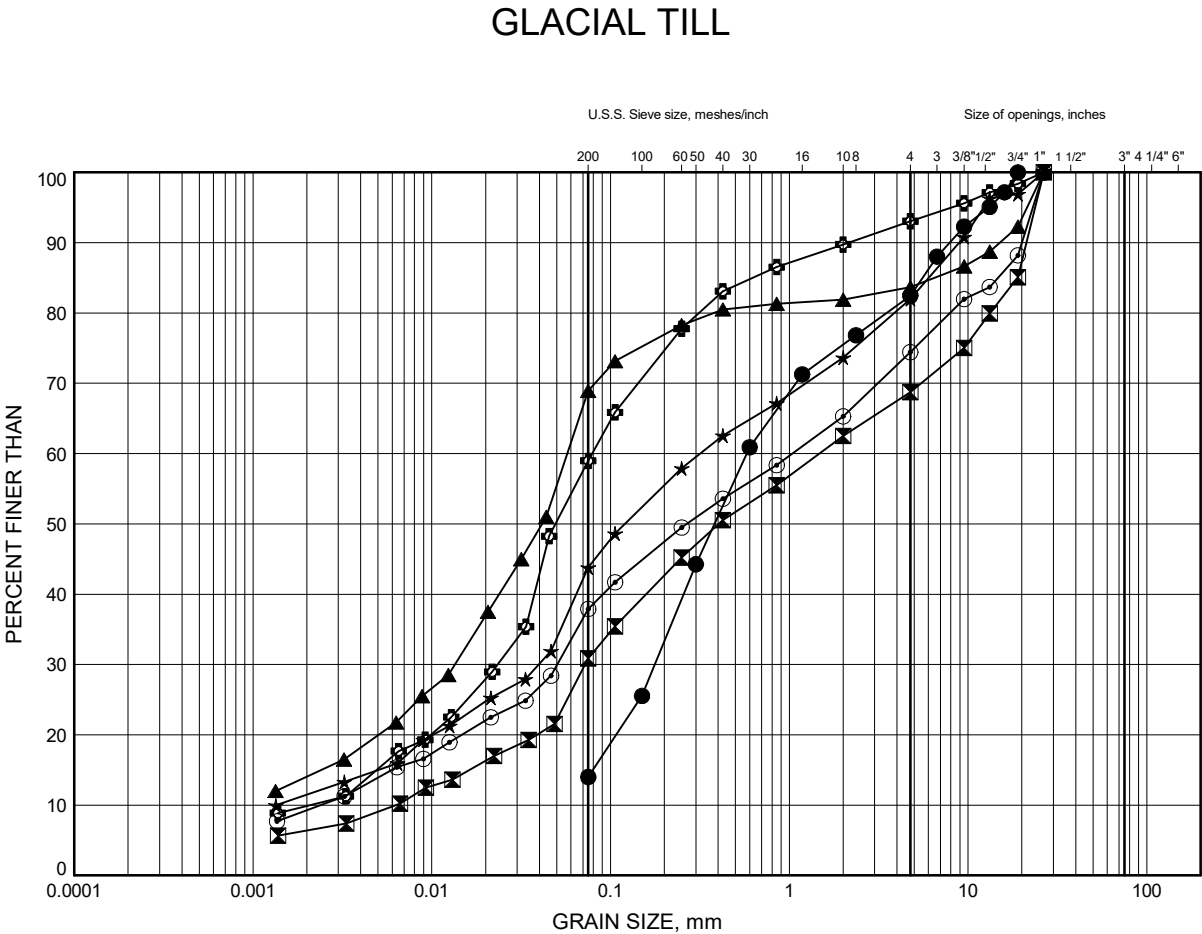
GRAIN SIZE DISTRIBUTION - THURBER 29381 BOREHOLE LOGS.GPJ 24/6/21



Hwy 416 SB Connector N-E (Site No. 16X-0308)

GRAIN SIZE DISTRIBUTION

FIGURE C3



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	308-21-1	9.2	94.8
⊠	308-21-1	14.0	90.0
▲	308-21-1	19.9	84.1
★	308-21-2	10.9	94.2
⊙	308-21-2	14.0	91.1
⊕	308-21-2	21.0	84.1

GRAIN SIZE DISTRIBUTION - THURBER 29381 BOREHOLE LOGS.GPJ 24/6/21

Date November 2021

WP# 4024-20-00



Prep'd SH

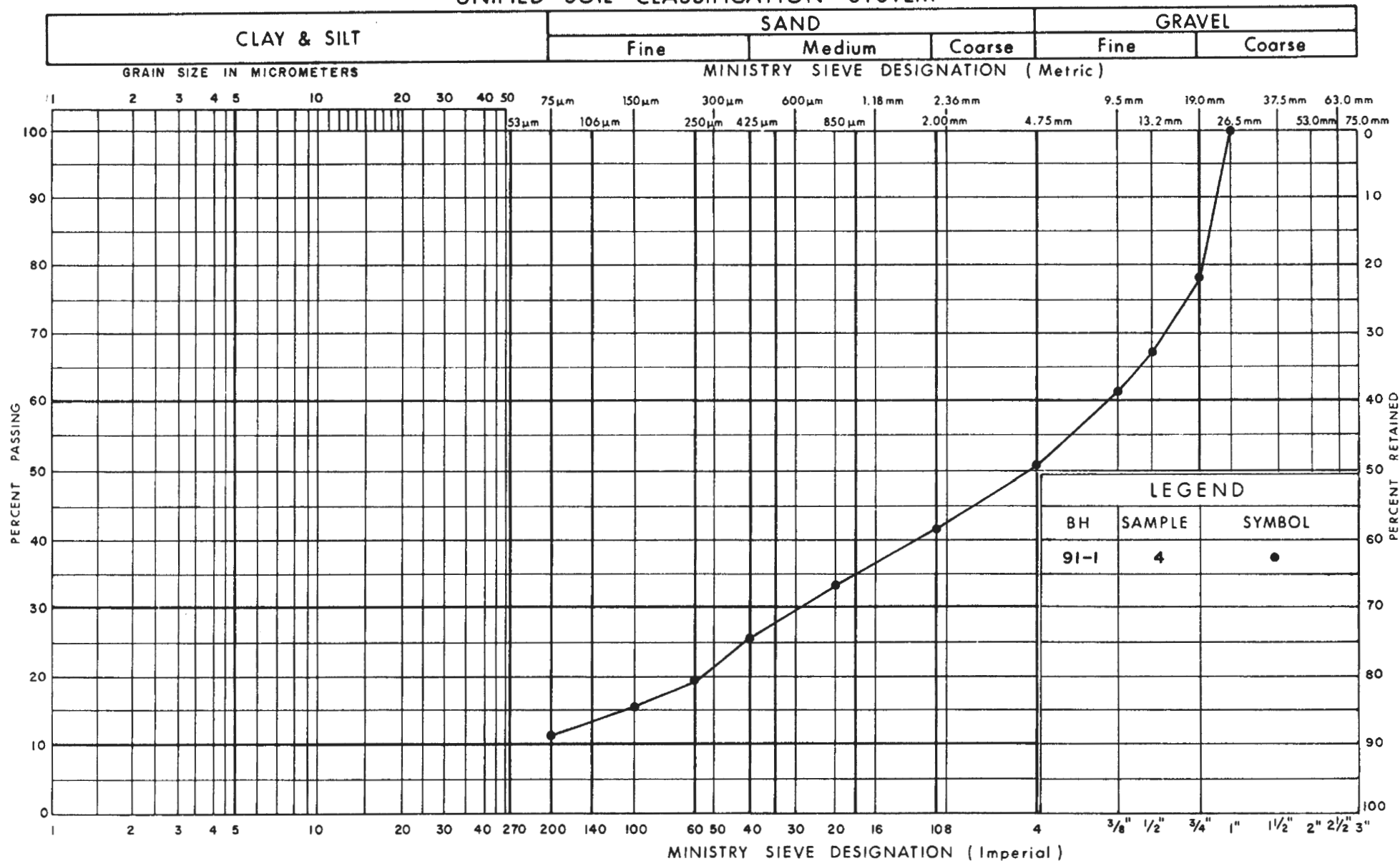
Chkd. MJK



Appendix C.2

Particle Size Analysis Figures (1991)

UNIFIED SOIL CLASSIFICATION SYSTEM

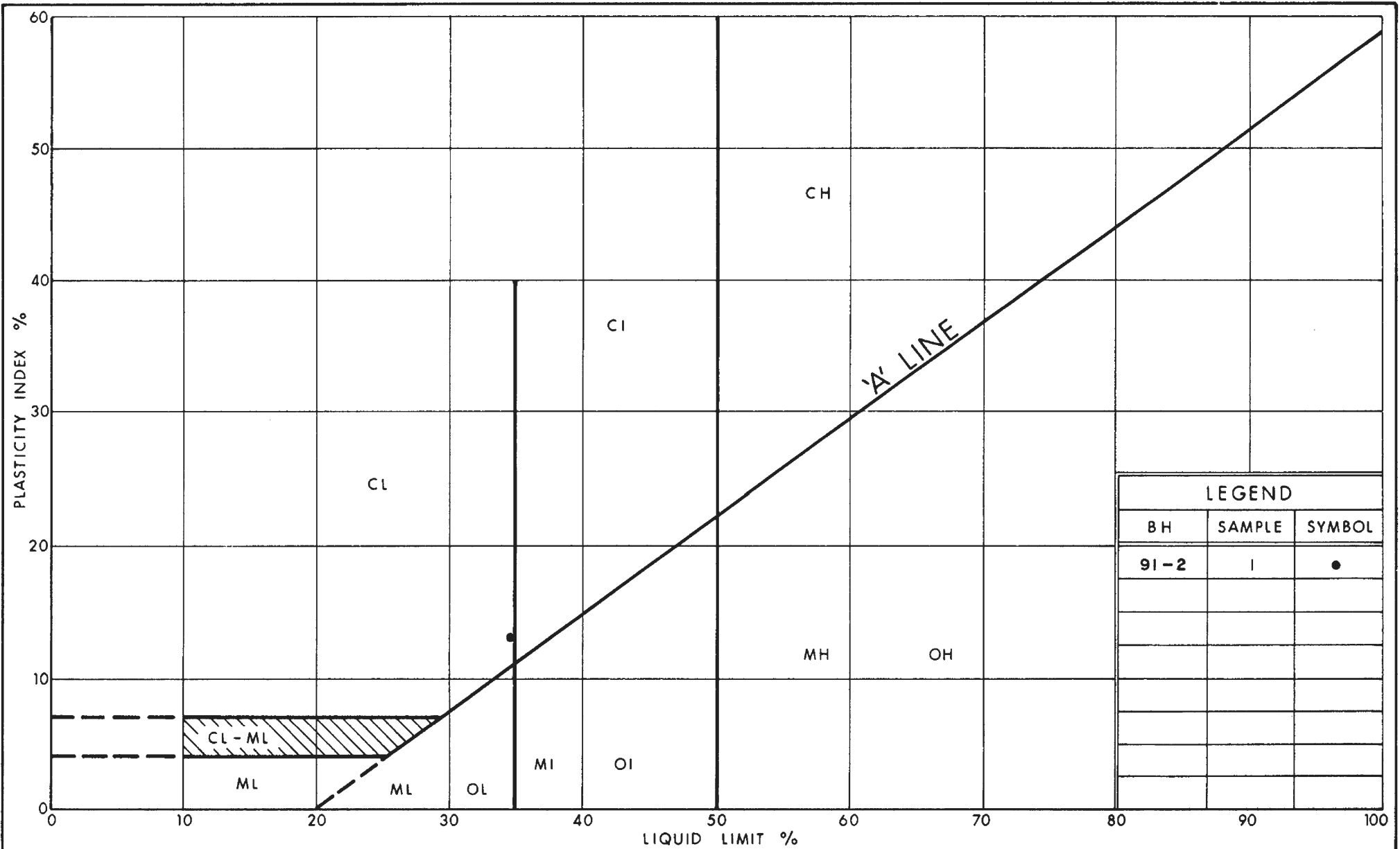


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION SAND & GRAVEL

FIG No C4

W P 177 - 89 - 02



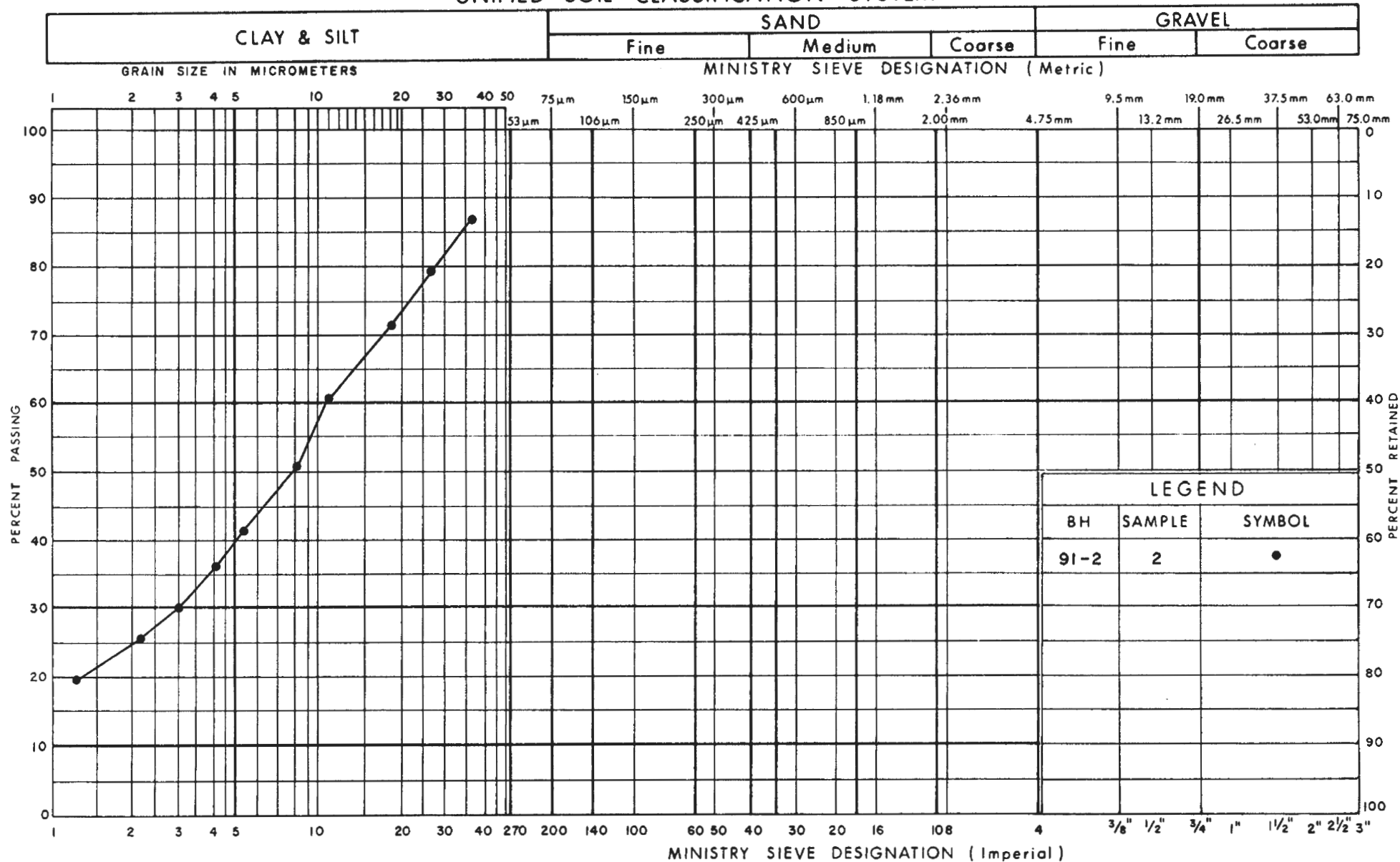
Ministry of
Transportation

PLASTICITY CHART CLAYEY SILT

FIG No C5

W P 177 - 89 - 02

UNIFIED SOIL CLASSIFICATION SYSTEM



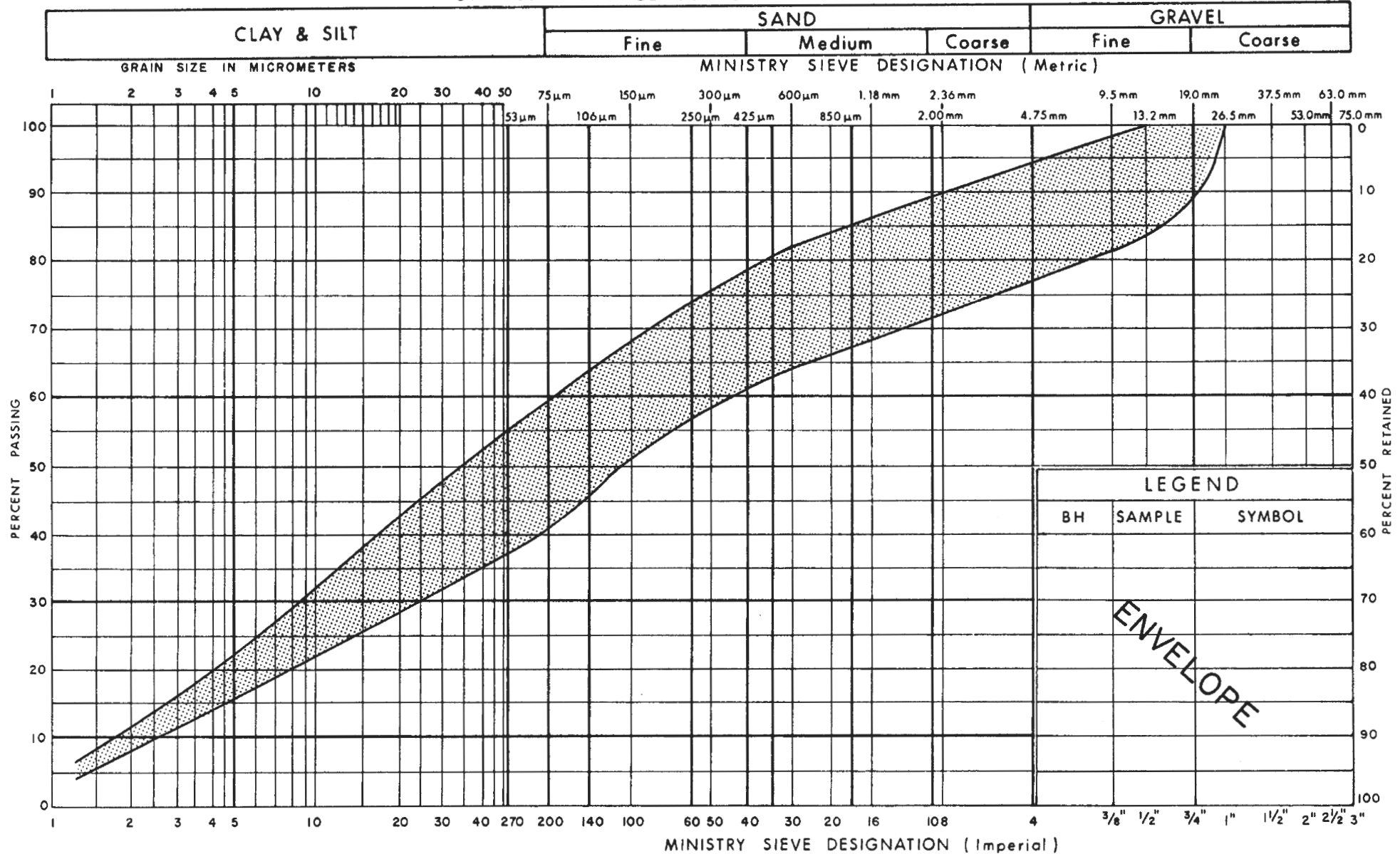
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION CLAYEY SILT

FIG No C6

W P 177-89-02

UNIFIED SOIL CLASSIFICATION SYSTEM

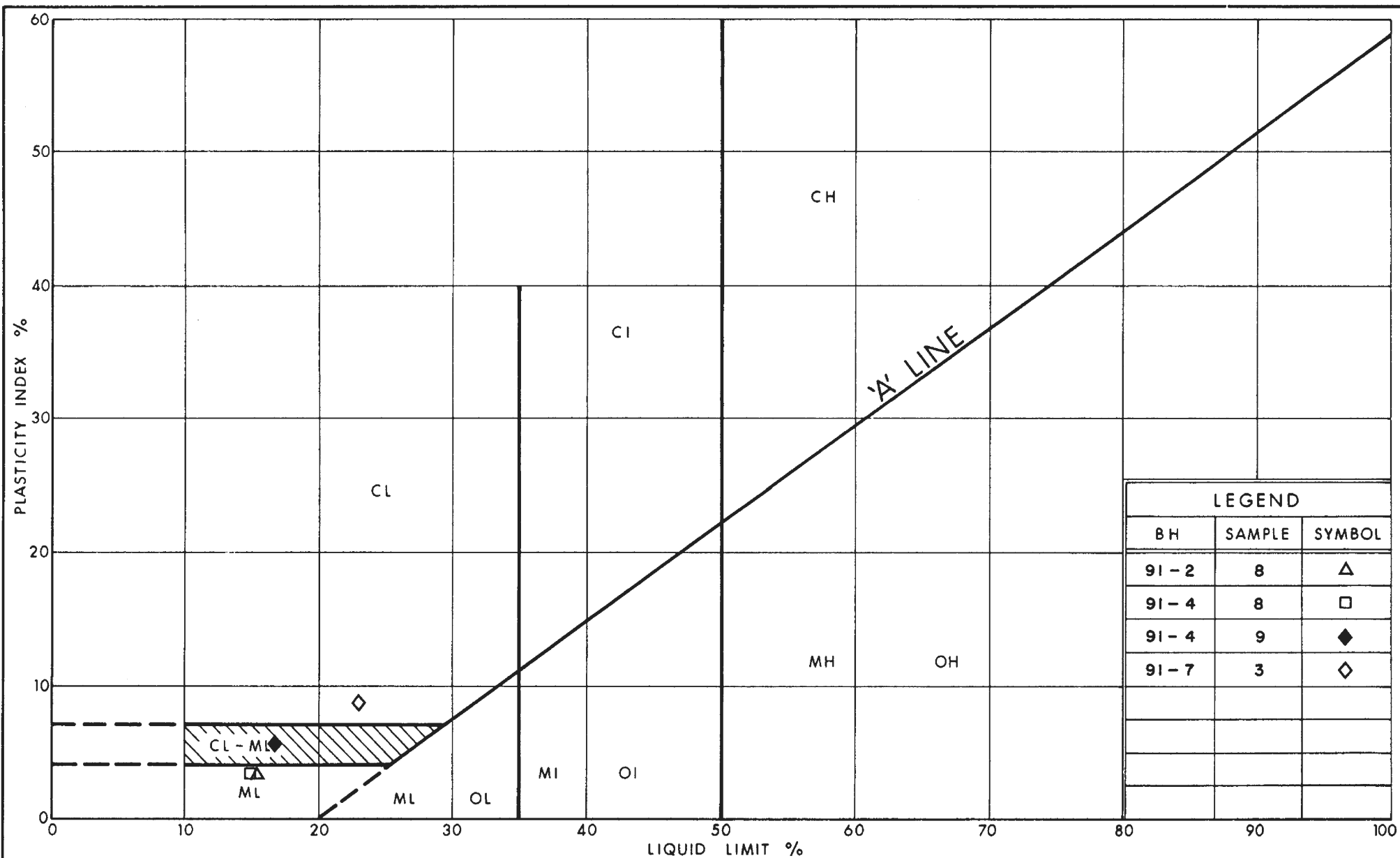


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF SANDY SILT,
SOME CLAY & GRAVEL, OCCASIONAL BOULDERS (Glacial Till)

FIG No C7

W P 177-89-02



Ministry of
Transportation

Ontario

PLASTICITY CHART
HET MIXTURE OF SANDY SILT,
SOME CLAY & GRAVEL, OCCASIONAL BOULDERS (Glacial Till)

FIG No C8

W P 177-89-02



Appendix C.3

UCS Test Results



Stantec

Stantec Consulting Ltd
2781 Lancaster Rd, Suite 100 A&B
Ottawa, ON K1B 1A7
Tel: (613) 738-6075
Fax: (613) 722-2799

May 25, 2021
File: 122410864

Attention: Thurber Engineering, File #29381

Reference: ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core
Highway 401/416 Interchange

The following table summarizes unconfined compressive strength results for five intact rock cores.

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
259-21-1 Run-2	8'6"-9'1"	205.3	Well-formed cone at both ends
306-21-2 Run-1	77'2"-77'9"	219.8	Well-formed cone at both ends
307-21-1 Run-1	55'-55'7"	162.4	Well-formed cone at both ends
308-21-1 Run-2	72'6"-73'3"	216.9	Vertical cracking throughout, no well-formed cones.
250-21-21 Run-2	24'8"-25'3"	181.6	Well-formed cone at both ends

Sincerely,

Stantec Consulting Ltd

Brian Prevost

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
brian.prevost@stantec.com



Appendix C.4

Bedrock Core Photographs

Borehole 308-21-1
Run 1 to 3 (of 3)
Elevation 82.6 m to 78.9 m
Dry

Run 1 Start
elev. 82.6 m

Run 2 Start
elev. 81.9 m

Run 3 Start
elev. 80.4 m

Run 3 End
elev. 78.9 m



THURBER ENGINEERING LTD.

Highway 401/416 Interchange
Hwy 416 SB Connector N-E (Site No. 16X-0308)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 308-21-1
Project No.: 29381

Borehole 308-21-1
Run 1 to 3 (of 3)
Elevation 82.6 m to 78.9 m
Wet

Run 1 Start
elev. 82.6 m

Run 2 Start
elev. 81.9 m

Run 3 Start
elev. 80.4 m

Run 3 End
elev. 78.9 m



Borehole 308-21-2
Run 1 to 3 (of 3)
Elevation 83.6 m to 79.9 m
Dry



THURBER ENGINEERING LTD.

Highway 401/416 Interchange
Hwy 416 SB Connector N-E (Site No. 16X-0308)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 308-21-2
Project No.: 29381

Borehole 308-21-2
Run 1 to 3 (of 3)
Elevation 83.6 m to 79.9 m
Wet



THURBER ENGINEERING LTD.

Highway 401/416 Interchange
Hwy 416 SB Connector N-E (Site No. 16X-0308)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 308-21-2
Project No.: 29381



Appendix D.

Site Photographs



Photo 1. Looking west from east abutment (2021/05/03)



Photo 2. Looking east from west abutment (2021/04/29)



Photo 3. Looking west from west abutment. (2021/04/29)



Photo 4. Looking north from west abutment. (2021/04/28)