



THURBER ENGINEERING LTD.

**PRELIMINARY FOUNDATION INVESTIGATION REPORT
HIGHWAY 401 WIDENING, HIGHWAY 16 TO MAITLAND ROAD
CPR OVERHEAD, SITE NO. 16X-0129
GWP 4024-20-00, ASSIGNMENT NO.: 4019-E-0010.2**

SITE NO. 16X-0129/B0

Geocres No.: 31B-113

Report to:

MTO c/o AECOM Canada Ltd.

Latitude: 44.735912°
Longitude: -75.505909°

October 2023
Thurber File No.: 29381



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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 10 bridges and four structural culverts.

This report addresses the Highway 401 overhead structure over a former Canadian Pacific Railway (CPR) line, now used as a recreational trail, located approximately 2.0 km east of the town of Prescott in the Township of Augusta within Leeds and Grenville County, Ontario.

This section of the report presents the factual findings obtained from a foundation investigation completed at the site and was informed by existing subsurface information pertinent to the site, obtained from the MTO's Foundation Library (Geocres No. 31B00-013).

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

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

2 BACKGROUND AND SITE DESCRIPTION

2.1 General

The Highway 401 overhead structure crosses over a now-abandoned CPR line approximately 2.0 km east of the Edward Street Interchange and the community of Prescott, Ontario. For project orientation purposes, Highway 401 will be described as oriented east-west and the CPR line as oriented north-south.



At the CPR overhead, Highway 401 has two through lanes in each direction. The outside and median shoulders are fully paved. Concrete jersey barriers are present along the median and concrete barrier wall along the outside shoulders. In the area of the structure the Highway 401 median is approximately 9 m wide from edge of lane to edge of lane. Galvanized W-beam guiderails supported on metal posts extend beyond the concrete barrier walls up to about 1.1 km from the abutments. Concrete wingwalls are present at all four quadrants. The embankment side slopes are inclined at approximately 2.1H:1V and are vegetated with grasses and some shrubs. No signs of global instability of the embankment were noted during the field investigation.

The CPR overhead structure is skewed at approximately 30 degrees and has a span of approximately 11 m. The rails have been removed and the ground surface of the former rail line now has a granular surface. CAD drawings provided by AECOM indicate an unpaved path located in the southeast quadrant parallels the eastbound embankment toe. The drawings also indicate two centreline culverts located at approximately 22 m and 93 m from the west and east abutments, respectively.

The site is in a semi-rural setting, and the area directly adjacent to the CPR overhead is undeveloped land with a mix of cleared private properties and densely vegetated areas with deciduous trees and shrubs. A low-lying marsh dominated with grasses, sparse trees, and ponded water is found in the southwest and northwest quadrants of the structure. A tri-chord overhead sign is located in the eastbound lane approximately 68 m east of the structure. The terrain is relatively flat, apart from the existing highway embankments and associated ditches, which are relatively rugged.

Photographs showing general conditions in the project area at the time of the field investigation are presented in Appendix D.

2.2 Site Geology

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984) and the Ontario Geological Survey maps (MRD228), the site lies on the border of the physiographic regions known as the Glengarry Till Plain and the Edwardsburg Sand Plain. The Glengarry Till Plain is characterized by typically undulating to rolling surface containing well-formed drumlins, intervening clay flats, and stony glacial tills with a high proportion of limestone pieces. The Edwardsburg Sand Plain is characterized by a slightly undulating sand plain of glaciofluvial origin. The bedrock in both areas is generally limestone, dolostone, and calcareous sandstone.

The Ontario Geological Survey maps (MRD126) suggest the site is underlain by dolostone and sandstone. Map P.2722ⁱ indicates that the bedrock in the project area is of Oxford Formation that consists of sub lithographic to fine crystalline dolostone.

2.3 Geocres Report 31B00-013

The historic foundation report for this site is based on a field investigation completed in 1959 prior to the construction of the existing overhead. The field investigation included a total of six boreholes. Relatively consistent conditions were observed across the site. A sand deposit with



some gravel was observed at ground surface and extended to depths ranging from 1.5 m to 3.3 m. It was underlain by a stiff clay with a thickness ranging from 9.5 m to 11.3 m. The clay was underlain by a thin layer of silty fine sand and a dense sandy silt glacial till deposit which was approximately 2.3 m thick where fully penetrated. Two boreholes cored bedrock which was observed at a depth of 15.5 m and 16.3 m below ground surface and was logged as limestone. A direct conversion of elevation suggests the surface of the bedrock is at 70.8 m.

Consolidation testing indicated that the clay deposit was over-consolidated to the point that addition of the proposed fills would not exceed the pre-consolidation pressure thus soil settlement would be limited to recompression.

Given the lack of identifiable features in the Borehole Location sketch, the information from Geocres Report 31B00-013 has been utilized herein only to establish general context.

3 SITE INVESTIGATIONS AND FIELD TESTING

A site investigation and field-testing program was carried out between December 13 and 15, 2022, and consisted of two on-road boreholes identified as 129-22-01 and 129-22-02 put down near the structure abutments. The boreholes were advanced using a truck mounted CME 55 drill rig equipped with hollow stem augers, NW casing, and NQ coring equipment. Thurber contacted Ontario One Call in advance of the field investigation to obtain utility locates/clearances in the vicinity of the borehole locations. In addition, MTO was contacted to obtain Electrical and Fibre Optic locates for the project limits.

The borehole coordinates, elevations, and termination depths are provided in Table 3-1. The as-drilled elevations of all boreholes were surveyed by Thurber with a Trimble Catalyst DA1 antenna with centimeter accuracy. The elevations were surveyed relative to available MTO benchmarks and existing site features and were cross-referenced with elevations on the original design drawings. The borehole coordinates and elevation are shown on the Borehole Location and Soil Strata Drawings in Appendix A and on the individual Record of Borehole sheets included in Appendix B. The borehole coordinates are referenced to MTM Zone 9.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
129-22-01	WBL, west of West Abutment	4,955,585.5 (44.735948°)	383,515.3 (-75.506123°)	96.5	28.9
129-22-02	EBL, east of East Abutment	4,955,578.1 (44.735878°)	383,547.5 (-75.505718°)	96.6	28.3

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Tests (SPT) in general accordance with ASTM D 1586. In-situ shear vane testing was carried out within the cohesive strata, where possible, using an MTO 'N' sized vane in general accordance with ASTM D 2573. Coring was required to advance the boreholes past the existing cobbles and boulders and into bedrock. A standpipe piezometer was installed in



Borehole 129-22-02 to allow for measurements of the groundwater level after drilling. The details of the standpipe piezometer are illustrated on the respective Record of Borehole sheet provided in Appendix B.

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

Following completion of the field investigation, Borehole 129-22-01 was decommissioned in general accordance MOE requirements (O.Reg. 903, as amended) and capped with cold patch asphalt to reinstate the pavement surface. The standpipe piezometer in Borehole 129-22-02 was decommissioned in accordance with MOE requirements on April 26, 2023.

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 and Atterberg Limits 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. Unconfined Compressive Strength (UCS) testing was conducted on two bedrock core samples from Borehole 129-22-02.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all 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 on 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 Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions will vary between and beyond borehole locations. 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 Engineering Services Manual (April 2022).

In general, the encountered stratigraphy consisted of granular fill over a native deposit of sand underlain by silty clay to clayey silt over glacial till. The glacial till was composed of sandy gravel, cobbles, and boulders and was underlain by dolostone bedrock.



5.1 Pavement Structure

A layer of asphaltic concrete approximately 355 mm thick was encountered at both borehole locations. The asphalt was underlain by gravelly sand fill containing trace fines. This gravelly sand was layer was 0.2 m to 0.3 m thick (base elevation 96.0 m to 95.8 m).

The recorded moisture content of a sample of the gravelly sand fill was 2%. The results of a gradation analysis completed on the sample are illustrated on Figure C1 of Appendix C. The results of the test are summarized below and on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	28
Sand	65
Silt	7
Clay	

5.2 Sand Fill

Sand fill was encountered beneath the gravelly sand in both boreholes. The sand fill was 9.2 m to 9.3 m thick (base elevation 86.7 m to 86.6 m). SPT N-values in the sand fill ranged from 3 to 64 blows per 0.3 m of penetration, indicating a variable relative density ranging from very loose to very dense.

The recorded moisture content of samples of the sand fill ranged from 4 to 20%. The results of gradation analyses completed on five samples of the fill are illustrated on Figure C2 of Appendix C. The results of the tests are summarized below and on the Record of Borehole sheets in Appendix B. The results from the gradation analysis carried out on a sample from the lower portion of the east embankment (Borehole 129-22-02) contained some gravel.

Soil Particle	Percentage (%)
Gravel	0 – 10
Sand	78 – 93
Silt	7 – 12
Clay	

A 0.2 m thick layer of sandy silt containing organics was encountered below the sand fill in both boreholes. The recorded moisture content of samples of this layer ranged from 44 to 58%.

5.3 Sand (SP-SM)

A native deposit of sand containing trace fines was encountered below the sandy silty in the boreholes. The layer ranged in thickness from 0.6 m to 1.3 m (base elevation 85.8 m to 85.2 m). SPT N-values in the layer ranged from 8 to 16 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The recorded moisture content of samples of the native sand ranged from 18 to 22%. The results of a gradation analysis completed on one sample of the layer are illustrated on Figure C3 of Appendix C. The results of the tests are summarized below and on the Record of Borehole sheet in Appendix B.

Soil Particle	Percentage (%)
Gravel	0
Sand	92
Silt	8
Clay	

5.4 Silty Clay (CI) to Clayey Silt (CL)

A deposit of silty clay to clayey silt was encountered beneath the sand in both boreholes. The thickness of the layer ranged from 11.8 m to 13.7 m (base elev. 73.4 m to 72.1 m). SPT N-values ranged from weight-of-hammer (WH) to 43 blows per 0.3 m of penetration but were generally less than 10 blows. Numerous attempts were made to carry out in-situ undrained shear strength testing; however, the vane was unable to be turned, and the material is inferred to have undrained shear strengths greater than 102 kPa, indicating a very stiff consistency.

Recorded moisture contents ranged from 16 to 41% and generally decreased with depth. Atterberg Limit testing was completed on four samples of the layer. Results are illustrated in Figure C4 of Appendix C. The results of these tests are summarized below and on the Record of Borehole sheets in Appendix B. The laboratory results indicate that the silty clay to clayey silt generally ranged in plasticity from intermediate (CI) to low (CL) with depth.

Parameter	Value
Liquid Limit	25 – 45
Plastic Limit	16 – 23
Plasticity Index	7 – 22

The results of gradation analyses completed on three samples of the layer are illustrated on Figure C5 of Appendix C. The results of the tests are summarized below and on the Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	0 – 3
Sand	0 – 2
Silt	41 – 68
Clay	28 – 59

5.5 Sandy Gravel (GM) Glacial Till

A native deposit of glacial till consisting of sandy gravel containing fines and frequent cobbles and boulders was encountered below the silty clay to clayey silt deposit in both boreholes. The glacial till deposit is 1.5 m to 2.0 m thick (base elev. 71.4 m to 70.6 m). Coring techniques were required to penetrate the layer.

The recorded moisture content of samples of the deposit recovered with a split-spoon sampler ranged from 1% to 8%. The results of a gradation analysis completed on a sample obtained from the upper portion of the deposit in Borehole 129-22-02 are illustrated on Figure C6 of Appendix C. The results of the tests are summarized above and on the Record of Borehole sheet in Appendix B.

Soil Particle	Percentage (%)
Gravel	47
Sand	30
Silt	23
Clay	

5.6 Bedrock

Bedrock was proven by coring in the boreholes. The depth to bedrock from the existing road grade ranged from 25.2 m to 25.9 m (base elevations 71.4 m to 70.6 m). The bedrock encountered consisted of slightly weathered to fresh, fine-grained, grey dolostone interbedded with sandstone. In general, the discontinuities were rough, undulating bedding joints. Bedrock logs are provided in Appendix B, and photographs of the bedrock cores are provided in Appendix C. The rock core quality and strength are summarized in Table 5-1.

Table 5-1: Bedrock Details

Parameter	Range
Total Core Recovery (TCR), %	100
Solid Core Recovery (SCR), %	71 – 93
Rock Quality Designation (RQD), %	63 – 93
Fracture Index (fractures per 0.3 m) ⁽¹⁾	0 – 7
Unconfined Compressive Strength (UCS), MPa	213 – 224

Note: (1) Indicated as "FI" on Borehole Logs

Based on the RQD, the bedrock quality is classified as fair to excellent (CFEM, 2006). The results of unconfined compressive strength testing were 213 MPa and 224 MPa, indicating that the bedrock is very strong (CFEM, 2006).



5.7 Groundwater

A 19 mm diameter standpipe piezometer was installed in Borehole 129-22-02 to allow for subsequent measurements of the groundwater level. The measured groundwater levels are summarized in Table 5-2. Surface water was present on portions of the surrounding lowland areas to the northeast and northwest of the site. Based on historic aerial photographs, surface water is present in these areas for much of the year. The groundwater level provided in the table below may represent a slightly artesian pressure in the silty clay at the site.

Table 5-2: Groundwater Level Observations

Borehole No.	Bottom of Screen Elev. (m)	Screened Unit	Depth (mbgs)¹	Groundwater Elevation (m)	Date of Measurement
129-22-02	76.3	Clayey Silt	8.1	88.5	April 26, 2023

Notes: (1) Indicates depth below top of embankment at Highway 401 grade.

It should be noted that the values shown above are considered short-term readings and may not reflect groundwater levels at the time of construction, and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.



6 MISCELLANEOUS

The borehole locations reflect existing site features and access constraints. The as-drilled locations and ground surface elevations were measured by Thurber. George Downing Estate Drilling Ltd. of Hawkesbury, Ontario, supplied and operated the drill rig used to drill, test, sample, install a standpipe piezometer, and decommission the boreholes. Traffic control and water were provided by T.G. Carroll Cartage Ltd. of Carp, Ontario.

The field work was supervised on a full-time basis by I. Khan, E.I.T., under the direction of K. Walker, P.Eng. 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 data and preparation of this report were carried out by A. de Oliveira, E.I.T, I. Khan, E.I.T., and M. Kennedy, P.Eng. The report was reviewed by Fred Griffiths, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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REFERENCES

ⁱ <http://www.geologyontario.mndm.gov.on.ca/index.html>

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.

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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

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- 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.

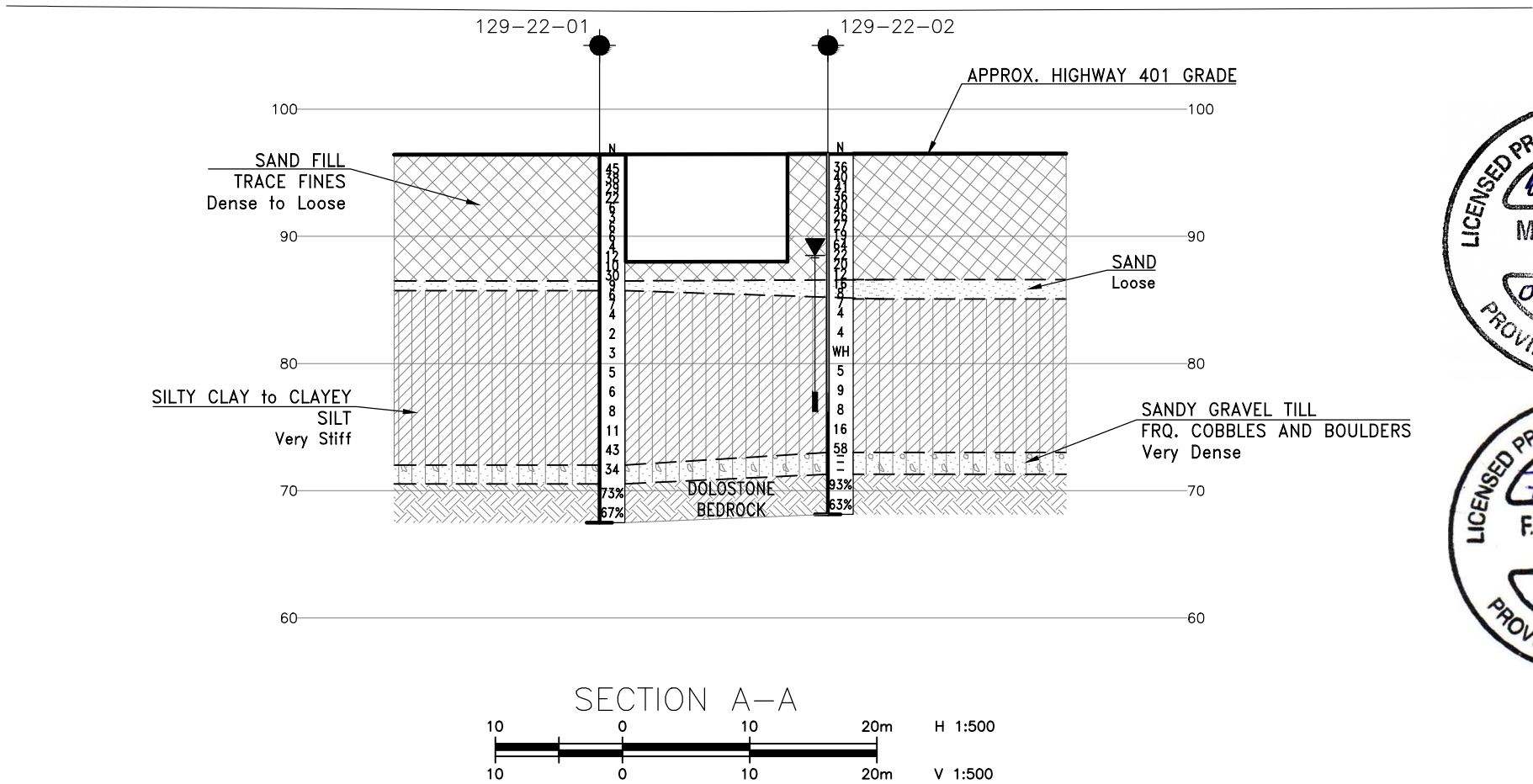
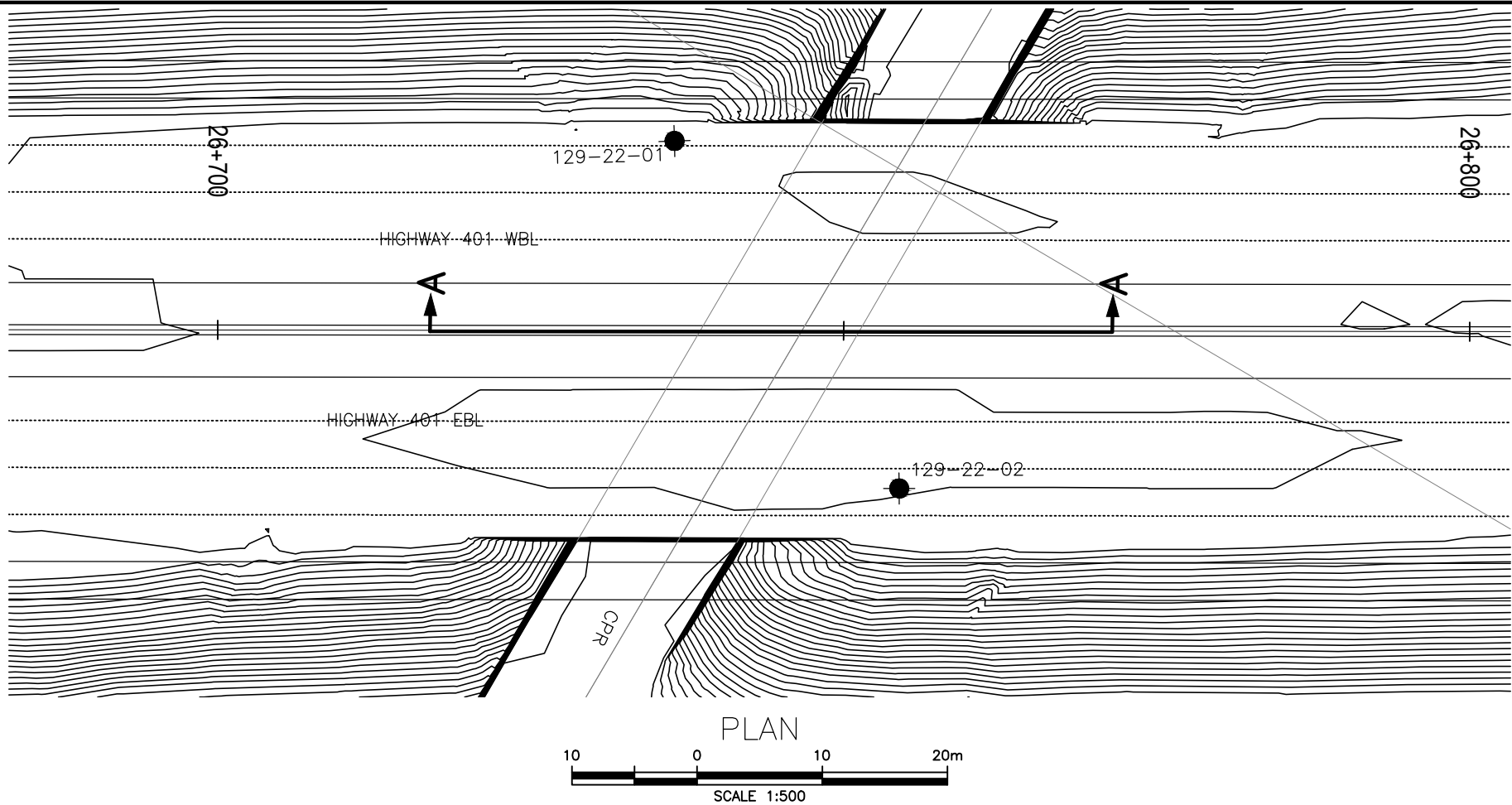
7. INDEPENDENT JUDGEMENTS OF CLIENT

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

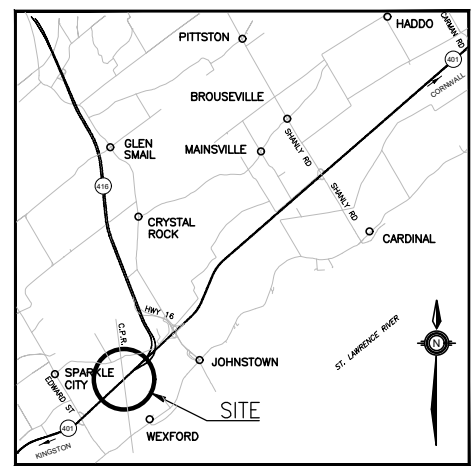


CONT No
GWP No 4024-20-00

HIGHWAY 401
CPR OVERHEAD
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
129-22-01	96.5	4 955 585.5	383 515.3
129-22-02	96.6	4 955 578.1	383 547.5

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-113

REVISIONS	DATE	BY	DESCRIPTION



Appendix B.

Record of Borehole Sheets



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 129-22-01

1 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.735948°, Long: -75.506123° Highway 401 & CPR, Edwardsburgh, MTM z9: N 4 955 585.5 E 383 515.3 ORIGINATED BY IK
 HWY 401 BOREHOLE TYPE CME 55 Truck Mount / HSA / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.12.15 - 2022.12.15 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)										
96.5	Ground Surface							20	40	60	80	100		W _p	W	W _L		GR	SA	SI	CL		
0.0	ASPHALT (355 mm)							20	40	60	80	100											
96.1																							
0.4	GRAVELLY SAND, trace fines		1	GS	-		96							○					28	65	7	(SI+CL)	
95.8	Brown																						
0.7	FILL (BASE) -----																						
	SAND, trace fines		1	SS	45									○									
	Dense to loose																						
	Brown																						
	FILL																						
			2	SS	38		95							○									
			3	SS	29		94							○									
			4	SS	22		93							○						0	92	8	(SI+CL)
			5	SS	6		92							○									
		7	SS	6		91							○										
		8	SS	6		90							○										
		9	SS	4		89							○							0	93	7	(SI+CL)
		10	SS	12		88							○										
		11	SS	10		87							○										
87.4																							
9.1	SAND, some fines and gravel		12	SS	30		87						○										
	Dense																						
	Grey																						
	FILL													○									
86.6																							

Continued Next Page

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

DOUBLE LINE 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 2012TEMPLATE(MTO).GDT 10-30-23

RECORD OF BOREHOLE No 129-22-01

2 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.735948°, Long: -75.506123° Highway 401 & CPR, Edwardsburgh, MTM z9: N 4 955 585.5 E 383 515.3 ORIGINATED BY IK
 HWY 401 BOREHOLE TYPE CME 55 Truck Mount / HSA / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.12.15 - 2022.12.15 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL LIMIT MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) W _P W W _L				
	Continued From Previous Page						20	40	60	80	100	20	40	60		
86.4	SILTY SAND with Organics		13	SS	9											
10.1	SAND (SP-SM), trace fines Loose Grey															
85.8																
10.7	SILTY CLAY (CI) to CLAYEY SILT (CL) Very stiff Grey		14	SS	6											
			15	SS	7											
			16	SS	4											
			17	SS	2											
			18	SS	3											
			19	SS	5											

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

DOUBLE LINE 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 2012TEMPLATE(MTO).GDT 10-30-23

METRIC

[illegible]

DOUBLE LINE 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 2012TEMPLATE(MTO).GDT 10-30-23

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 129-22-02

1 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.735878°, Long: -75.505718° Highway 401 & CPR, Edwardsburgh, MTM z9: N 4 955 578.1 E 383 547.5 ORIGINATED BY IK
 HWY 401 BOREHOLE TYPE CME 55 Truck Mount / HSA / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2022.12.13 - 2022.12.14 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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
96.6	Ground Surface													
0.0	ASPHALT (355 mm)													
96.2														
0.4	GRAVELLY SAND, trace fines													
96.0	Brown													
0.6	FILL (BASE)													
	SAND, trace fines		1	SS	36									
	Dense to compact													
	Brown													
	FILL													
			2	SS	40									0 91 9 (SI+CL)
			3	SS	41									
			4	SS	36									
			5	SS	40									
			6	SS	26									0 91 9 (SI+CL)
			7	SS	27									
			8	SS	19									
			9	SS	64									
89.0														
7.6	SAND, some fines and gravel													
	Compact		10	SS	22									
	Brown													
	FILL													
			11	SS	20									10 78 12 (SI+CL)
			12	SS	12									
86.7														

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity 20
15 10 5 0
(%) STRAIN AT FAILURE

DOUBLE LINE 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 2012TEMPLATE(MTO).GDT 10-30-23

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

METRIC

[illegible]

DOUBLE LINE 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 2012TEMPLATE(MTO).GDT 10-30-23

+³, ×³: Numbers refer to Sensitivity



Appendix C.

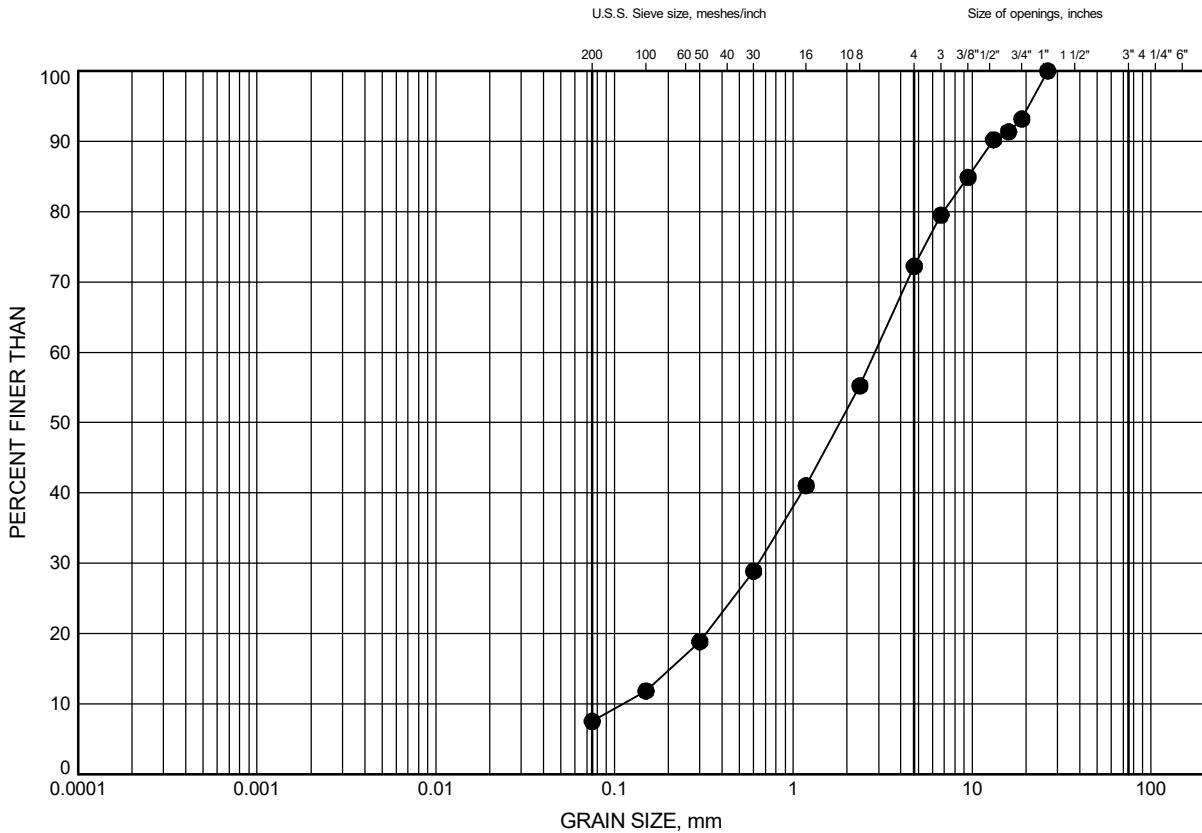
Laboratory Testing



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

GRAIN SIZE DISTRIBUTION

FILL: Gravelly Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	129-22-01	0.5	95.9

Date March 2023

GWP# 4024-20-00

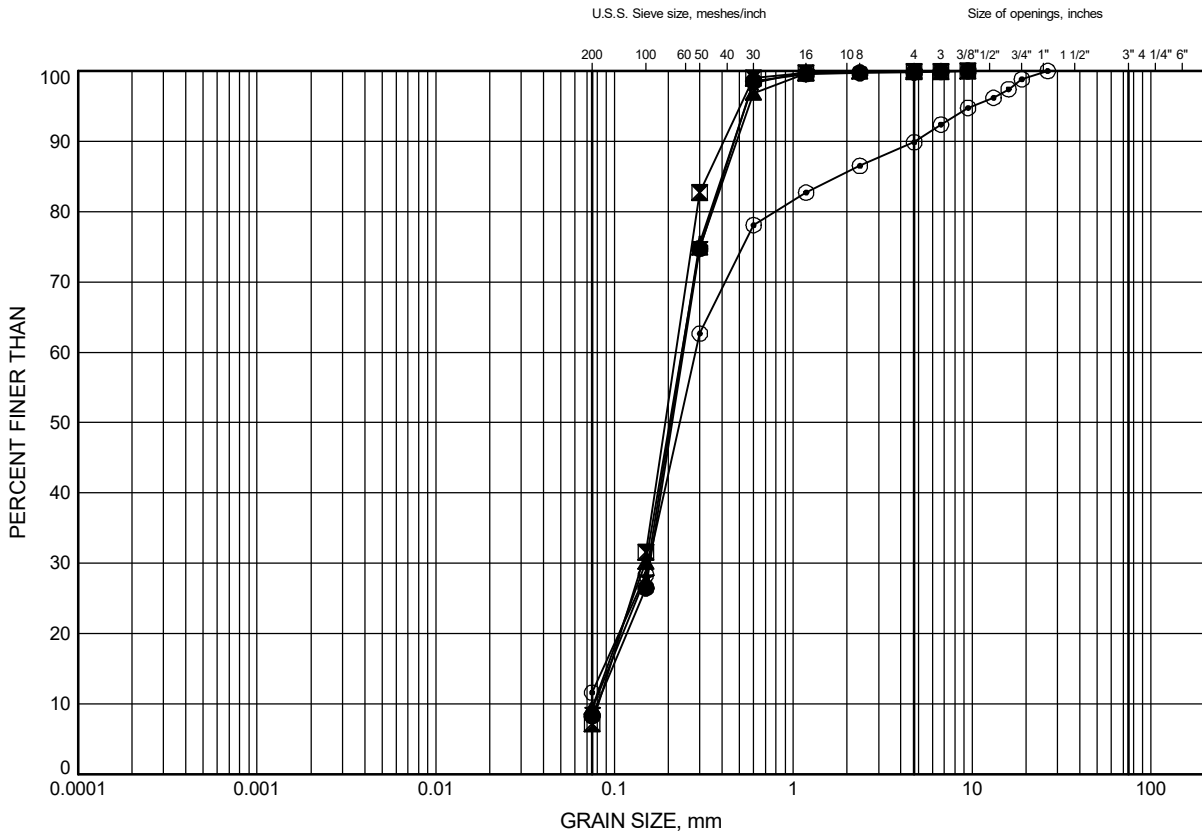


Prep'd RH

Chkd. AO

GRAIN SIZE DISTRIBUTION

FILL: Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	129-22-01	3.4	93.0
⊠	129-22-01	7.2	89.2
▲	129-22-02	1.8	94.7
★	129-22-02	4.9	91.6
⊙	129-22-02	8.7	87.8

Date .. March 2023

GWP# .. 4024-20-00

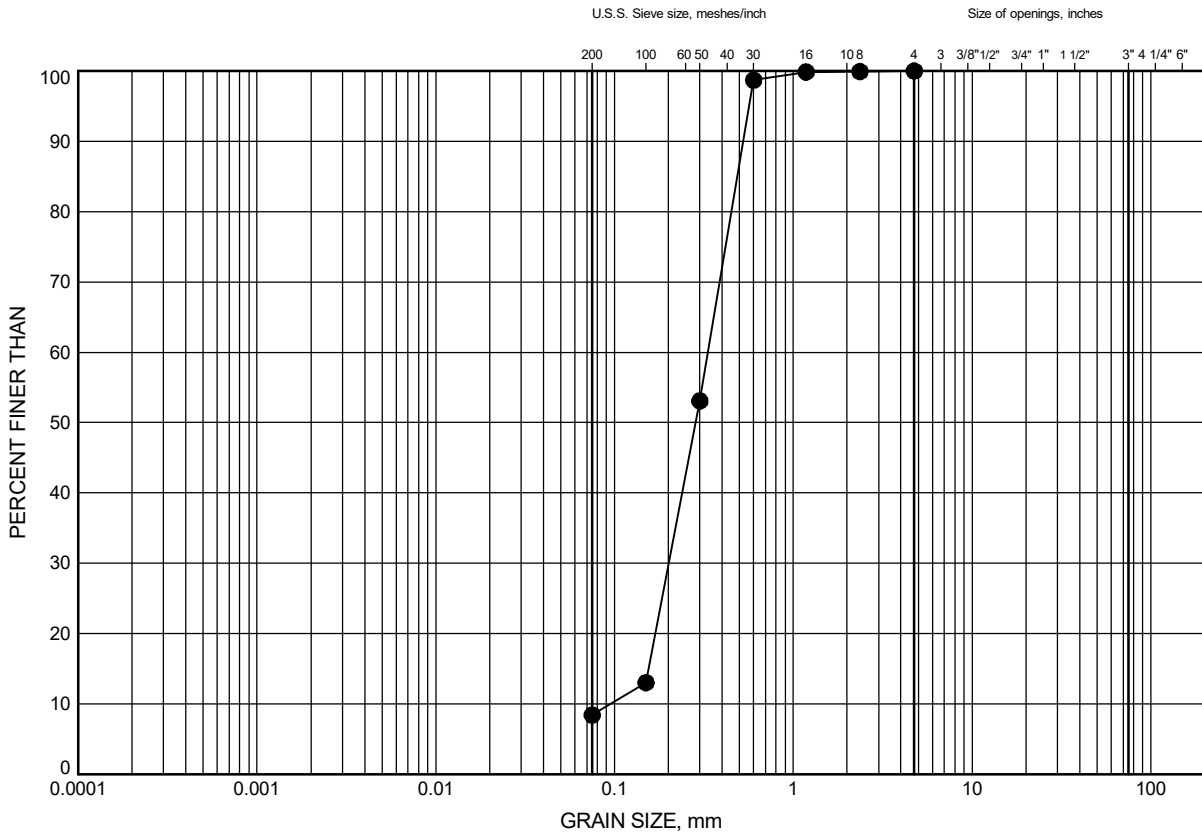


Prep'd .. RH

Chkd. AO

GRAIN SIZE DISTRIBUTION

Sand (SP-SM)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	129-22-02	11.0	85.5

Date March 2023

GWP# 4024-20-00

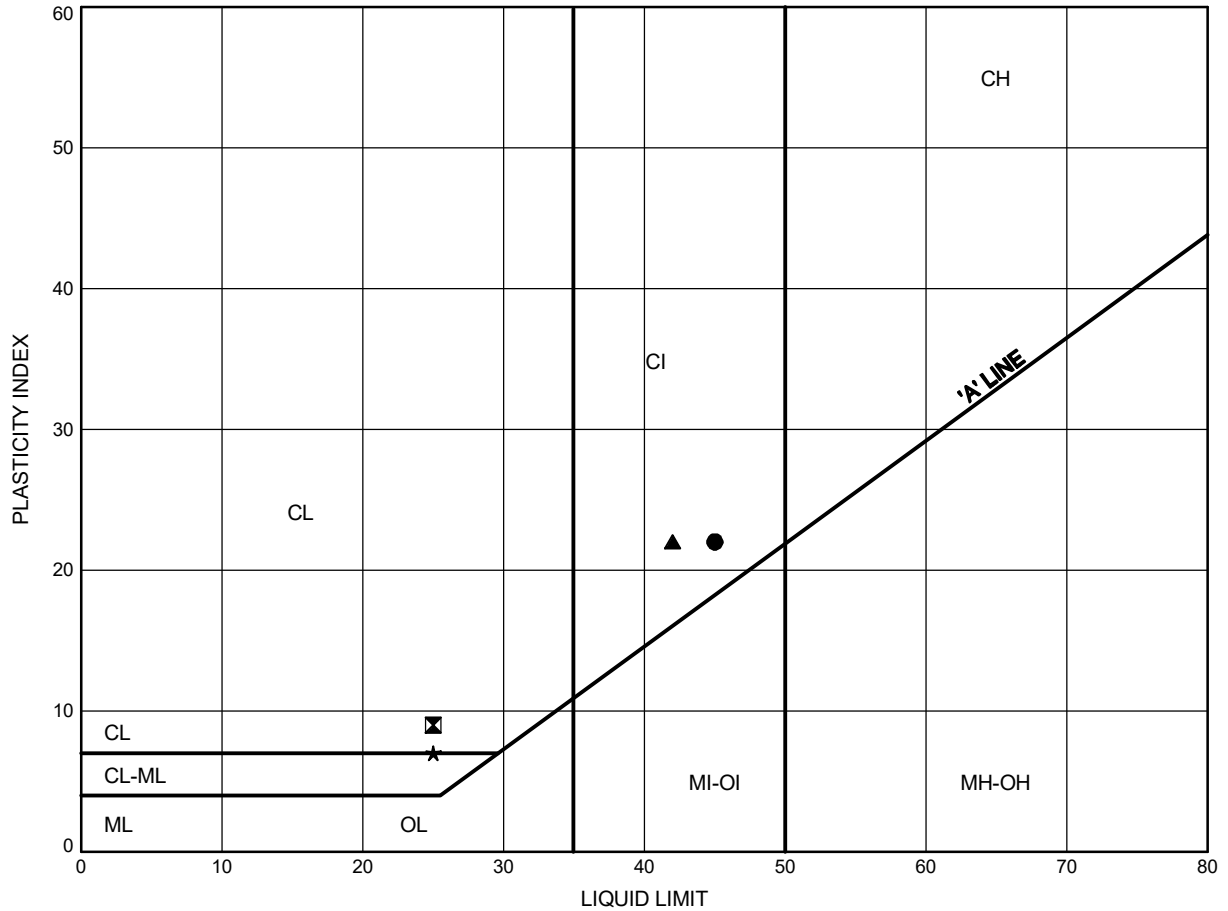


Prep'd RH

Chkd. AO

GRAIN SIZE DISTRIBUTION

Silty Clay (CI) to Clayey Silt (CL to CL-ML)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	129-22-01	17.1	79.3
⊠	129-22-01	21.6	74.8
▲	129-22-02	12.5	84.0
★	129-22-02	20.1	76.4

Date March 2023

GWP# 4024-20-00

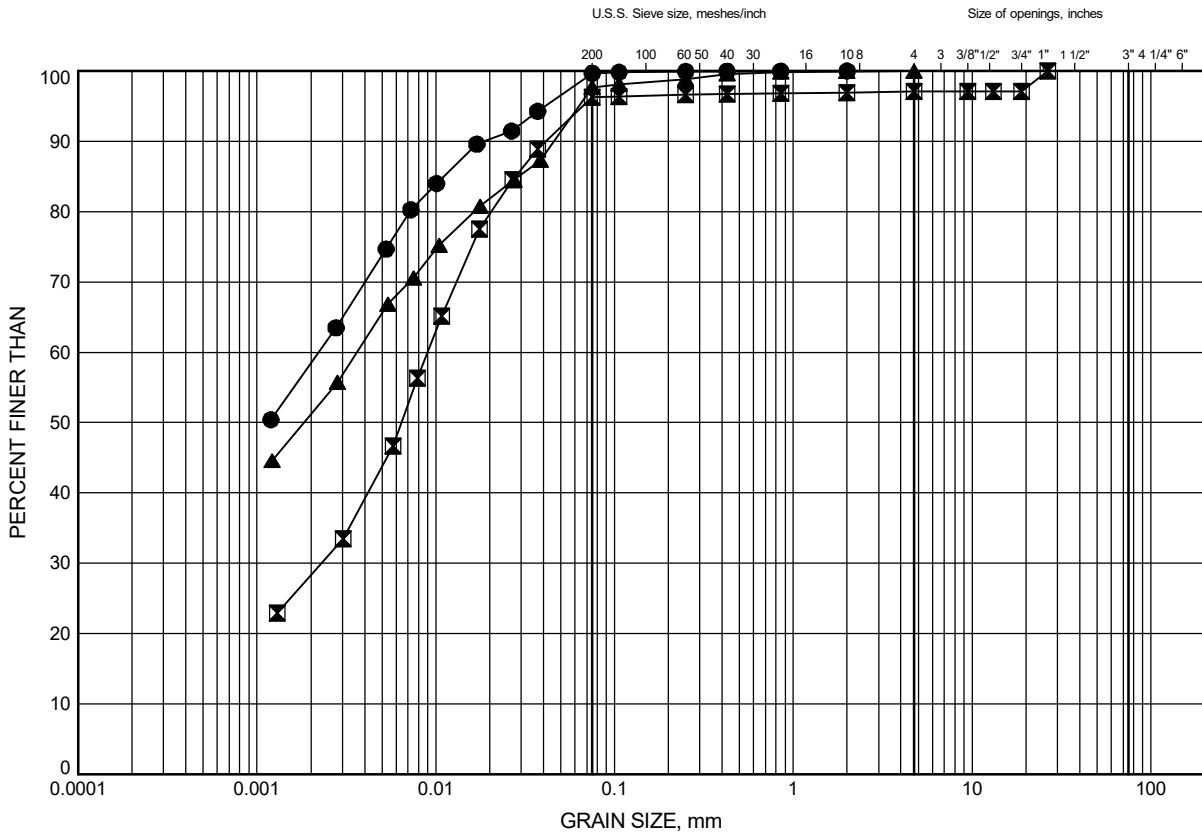


Prep'd RH

Chkd. AO

GRAIN SIZE DISTRIBUTION

Silty Clay (CI) to Clayey Silt (CL to CL-ML)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	129-22-01	17.1	79.3
⊠	129-22-01	21.6	74.8
▲	129-22-02	12.5	84.0

Date March 2023

GWP# 4024-20-00

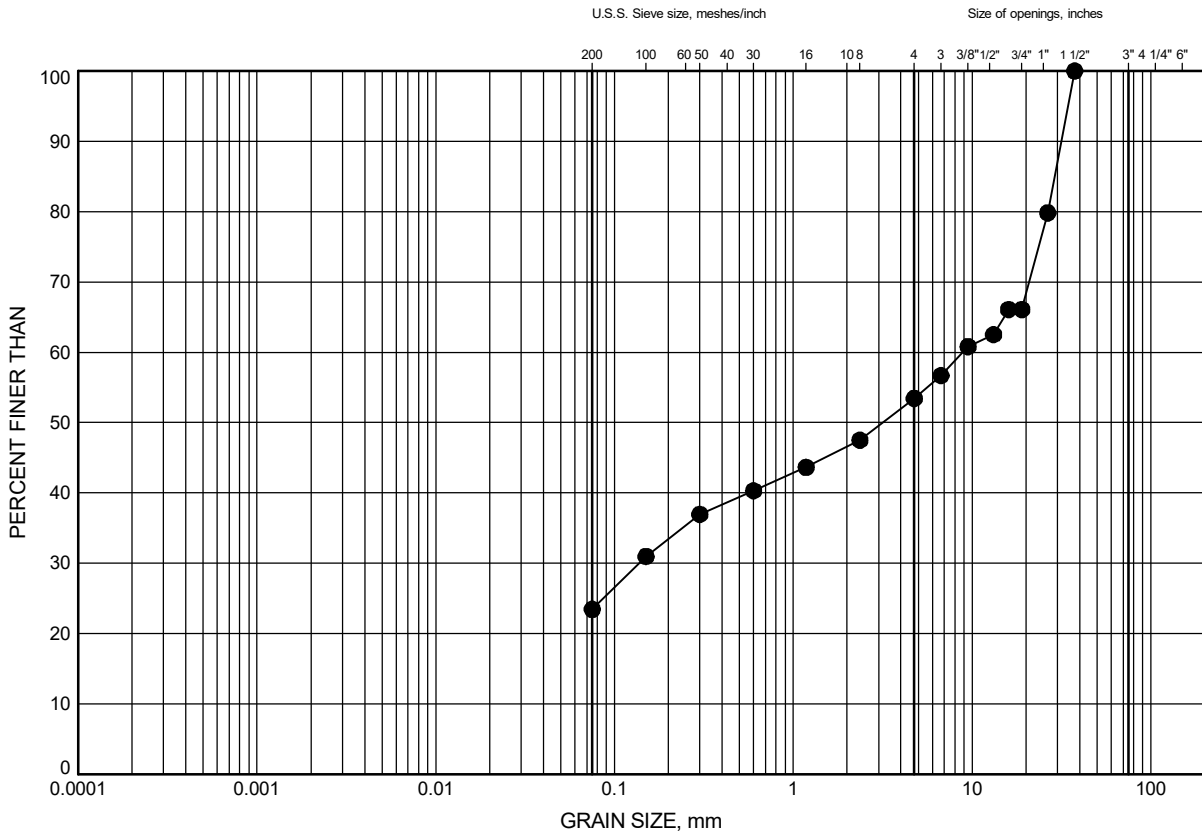


Prep'd RH

Chkd. AO

GRAIN SIZE DISTRIBUTION

GLACIAL TILL: Sandy Gravel (GM)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	129-22-02	23.3	73.2

Date March 2023

GWP# 4024-20-00



Prep'd RH

Chkd. AO



Appendix C.3

UCS Test Results



Stantec Consulting Ltd.
2781 Lancaster Rd, Suite 100 A&B, Ottawa ON K1B 1A7

May 2, 2023
File: 122410864

Client: Thurber Engineering, File #29381

Reference: ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core

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

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
BH129-22-1 Run-1	88'7"-89'3"	212.5	Well-formed cones at both ends
BH129-22-2 Run-1	85'9"-86'3"	224.3	Well-formed cones at both ends.
BH130-22-1 Run-3	86'6"-87'4"	196.3	Vertical cracking throughout, no cones formed
BH131-22-2 Run-2	77'1"-77'10"	237.2	Vertical cracking throughout, no cones formed
BH166-22-2 Run-3	33'8"-34'2"	192.6	Well-formed cones at both ends

Sincerely,

Stantec Consulting Ltd.

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
Fax: 613-722-2799
brian.prevost@stantec.com



Appendix C.4

Bedrock Core Photographs

Borehole 129-22-01

RUN 1

Depth 25.9 m to 27.3 m

Elevation 70.5 m to 69.1 m

Dry Sample

NQ1 – Cobbles and Boulders
elev. 71.2 m to 70.5 m

Run 1 Start
elev. 70.5 m



Run 1 End
elev. 69.1 m

Borehole 129-22-01

RUN 1

Depth 25.9 m to 27.3 m

Elevation 70.5 m to 69.1 m

Wet Sample

NQ1 – Cobbles and Boulders
elev. 71.2 m to 70.5 m

Run 1 Start
elev. 70.5 m



Run 1 End
elev. 69.1 m

Borehole 129-22-01

RUN 2

Depth 27.3 m to 28.9 m

Elevation 69.1 m to 67.5 m

Dry Sample

Run 2 Start
elev. 69.1 m



Run 2 End
elev. 67.5 m

Borehole 129-22-01

RUN 2

Depth 27.3 m to 28.9 m

Elevation 69.1 m to 67.5 m

Wet Sample

Run 2 Start
elev. 69.1 m



Run 2 End
elev. 67.5 m

Borehole 129-22-02
NQ1, NQ2, and NQ3 – Cobbles and Boulders
Depth 23.5 m to 25.2 m
Elevation 73.0 m to 71.3 m
Dry Sample

NQ1, NQ2, and NQ3 – Cobbles and Boulders Start
elev. 73.0 m



NQ1, NQ2, and NQ3 – Cobbles and Boulders End
elev. 71.3 m

Borehole 129-22-02
NQ1, NQ2, and NQ3 – Cobbles and Boulders
Depth 23.5 m to 25.2 m
Elevation 73.0 m to 71.3 m
Wet Sample

NQ1, NQ2, and NQ3 – Cobbles and Boulders Start
elev. 73.0 m



NQ1, NQ2, and NQ3 – Cobbles and Boulders End
elev. 71.3 m

Borehole 129-22-02

RUN 1

Depth 25.2 m to 26.8 m
Elevation 71.3 m to 69.7 m
Dry Sample

Run 1 Start
elev. 71.3 m



Run 1 End
elev. 69.7 m

Borehole 129-22-02

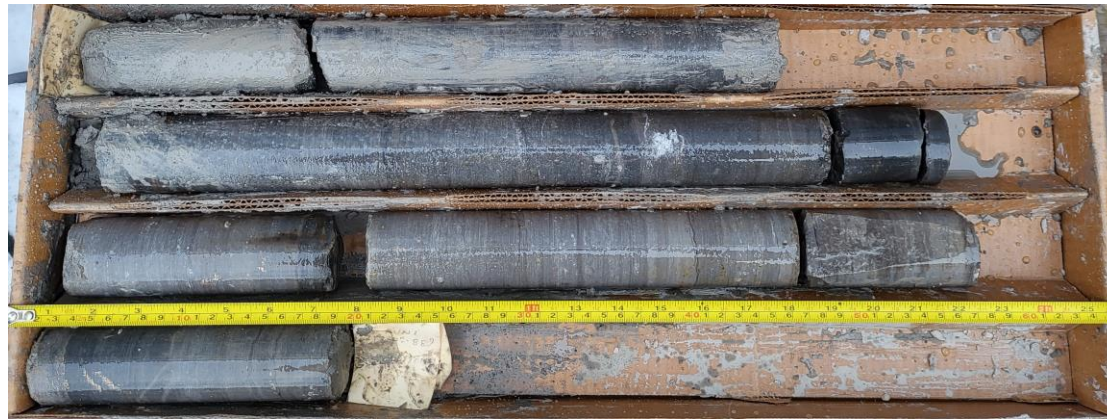
RUN 1

Depth 25.2 m to 26.8 m

Elevation 71.3 m to 69.7 m

Wet Sample

Run 1 Start
elev. 71.3 m



Run 1 End
elev. 69.7 m

Borehole 129-22-02

RUN 2

Depth 26.8 m to 28.3 m

Elevation 69.7 m to 68.2 m

Dry Sample

Run 2 Start
elev. 69.7 m



Run 2 End
elev. 68.2 m

Borehole 129-22-02

RUN 2

Depth 26.8 m to 28.3 m

Elevation 69.7 m to 68.2 m

Wet Sample

Run 2 Start
elev. 69.7 m



Run 2 End
elev. 68.2 m



Appendix D.

Site Photographs



Photograph 1: Looking east at the east embankment, north slope.
[taken on December 18, 2022]



Photograph 2: Looking north at the east embankment, south slope.
[taken on December 18, 2022]



Photograph 3: Looking east at the east embankment, south slope.
[taken on December 13, 2022]



Photograph 4: Looking west at the west embankment, south slope.
[taken on December 13, 2022]



Photograph 5: Looking north at the Highway 401 overhead at CPR
[taken on December 18, 2022]



Photograph 6: Looking east across the bridge deck, eastbound Highway 401 lanes.
[taken on December 13, 2022]