



THURBER ENGINEERING LTD.

**PRELIMINARY FOUNDATION INVESTIGATION REPORT
HIGHWAY 401 WIDENING, HIGHWAY 16 TO MAITLAND ROAD
MAITLAND ROAD U/P REPLACEMENT, SITE NO. 16X-0126/B0
GWP 4024-20-00 / ASSIGNMENT NO. 4019-E-0010.2**

SITE NO. 16X-0126/B0

Geocres No.: 31B12-001

Report to:

MTO c/o AECOM Canada Ltd.

Latitude: 44.652573°
Longitude: -75.626314°

March 2024
Thurber File No.: 29381



TABLE OF CONTENTS

PART 1. FACTUAL INFORMATION

1	INTRODUCTION.....	1
2	BACKGROUND AND SITE DESCRIPTION	1
2.1	General.....	1
2.2	Site Geology.....	2
3	SITE INVESTIGATIONS AND FIELD TESTING.....	2
4	LABORATORY TESTING	3
5	GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS	4
5.1	Surficial Materials	4
5.2	Granular Fill.....	4
5.3	Glacial Till.....	5
5.4	Bedrock	5
5.5	Groundwater.....	6
6	MISCELLANEOUS	8

STATEMENT OF LIMITATIONS AND CONDITIONS



Appendices

Appendix A.	Borehole Location Plan and Stratigraphic Drawing
Appendix B.	Record of Borehole Sheets
Appendix C.	Laboratory Testing
Appendix D.	Site Photographs



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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 proposed replacement of the Highway 401 Underpass at Maitland Road (Site No. 16X-0126/B0), located approximately 8.5 km east of County Road 29 in Brockville, ON, in the Township of Augusta within the Leeds & Grenville County, Ontario.

This section of the report presents the factual findings obtained from a preliminary foundation investigation completed at the site. A historical foundation investigation report was not available for this site within the online Geocres Library.

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 foundation design and replacement of the structure was developed during 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

Maitland Road crosses over Highway 401 approximately 8.5 km east of Brockville, Ontario, and 2 km north of Maitland, Ontario. The location of the structure is shown on the inset Key Plan on Drawing No. 1 in Appendix A. For project orientation purposes, Maitland Road will be described as oriented north-south and Highway 401 as oriented east-west.



The existing structure carries two through lanes of Maitland Road in each direction over Highway 401 and has a total span length of 34.0 m and a width of 17.0 m. Cast-in-place concrete parapet walls with single railings are present along the east and west edges of the structure deck. Steel guiderails supported on wooden posts are present at all four quadrants and extend up to 25 m north and 75 m south behind the abutments. The embankment side slopes are inclined at approximately 2.0H:1V. All embankment side slopes are vegetated with grasses, shrubs, and small trees. No signs of instability of the embankments were noted during the field investigation.

At this site, Highway 401 consists of a two through lanes in each direction, a W-N/S off-ramp and N/S-E on-ramp in the eastbound direction, and an E-E/W off-ramp and E/W-W on-ramp connecting to Concession Road 2 in the westbound direction. The median shoulders are paved and the outside shoulders are partially paved and granular. The east and west bound lanes are separated by a median about 7 m wide with a centreline barrier. Traffic volume on Highway 401 is understood to have been approximately 35,800 to 36,500 AADT in 2016.

The site is in a semi-rural setting, with nearby dwellings to the northeast and southwest. A carpool parking lot, accessible from Concession Road 2, is present to the northwest. Otherwise, there is predominantly undeveloped land with a mix of densely vegetated areas with deciduous trees and shrubs and agricultural land to the north. Overhead utility lines run parallel to Maitland Road along the east structure side. Storm water drainage in the area is to roadside ditches.

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), the site lies in the physiographic regions known as the Smith's Falls Limestone Plain. The Smith's Falls Limestone Plain is characterized by typically shallow bedrock but includes a few localized deep areas of highly variable soils consisting of clays, sands, and gravels. The area is known to be underlain by limestone and sandstone bedrock.

3 SITE INVESTIGATIONS AND FIELD TESTING

A site investigation and field-testing program was carried out between December 20, 2022 and April 17, 2023, and consisted of three boreholes: one near each proposed abutment of the new Maitland Road structure (Boreholes 126-23-01 and 126-23-02) and one within the Highway 401 median (Borehole 126-22-03). The median Borehole was put down with a truck-mounted CME 75 drill rig and the abutment boreholes were put down off-road with a track-mounted CME 55 drill rig, both 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 the location of electrical and fibre optic utilities within the project limits.

The borehole coordinates, elevations, and termination depths are provided below 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 elevations 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 NAD83, Zone 9.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
126-23-01	Proposed South Abutment	4 946 199.1 (44.652453°)	374 127.2 (-75.625915°)	108.0	7.4
126-23-02	Proposed North Abutment	4 946 258.3 (44.65299°)	374 081.8 (-75.626480°)	108.2	6.9
126-22-3	Proposed Pier	4 946 212.7 (44.652579°)	374 094.9 (-75.626321°)	105.2	4.8

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in general accordance with ASTM D 1586. The boreholes were advanced to total depths ranging from 4.8 m to 7.4 m (base elevation 101.3 m to 100.4 m). A 32mm diameter standpipe piezometer was installed in Borehole 126-23-02 following completion of the drilling to allow for subsequent groundwater level measurements. The details for the standpipe piezometer are illustrated on the 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 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.

Following completion of the field investigation, Boreholes 126-23-01 and 126-22-03 were decommissioned in general accordance with MOE requirements (O.Reg. 903, as amended). Borehole 126-22-03 was capped with cold patch asphalt to reinstate the pavement surface of the median. The standpipe piezometer at Borehole 126-23-02 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. One Unconfined Compressive Strength (UCS) Test was conducted on a recovered core sample of bedrock from Borehole 126-23-01.



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 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 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 site was underlain by granular fill overlying native glacial till which is, in turn, underlain by limestone bedrock.

5.1 Surficial Materials

Borehole 126-22-03 was advanced through the Highway 401 median and encountered 200 mm of asphalt.

Topsoil was encountered at the ground surface of Boreholes 126-23-01 and 126-23-02 with thicknesses of 75 and 150 mm, respectively.

5.2 Granular Fill

Granular fill consisting of silty sand with varying amounts of gravel was encountered below the topsoil in Boreholes 126-23-01 and 126-23-02 and below the asphalt in Borehole 126-22-03. The silty sand fill ranged in thickness from 0.7 m to 1.3 m (base Elev. 107.2 m to 104.0 m). Standard Penetration Test (SPT) N-values obtained ranged from 10 to 43 blows for 0.3 m of penetration, indicating a compact to dense relative density.

The recorded moisture contents within the fill ranged from 5 to 21%. The results of gradation analyses completed on one sample of the silty sand fill are illustrated on Figure C1 of Appendix C. The results of the tests are summarized below and on the Record of Boreholes sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	7
Sand	69
Silt	24
Clay	



5.3 Glacial Till

A native deposit of glacial till consisting of a heterogenous mixture of gravel, sand and fines with occasional cobbles and boulders was encountered beneath the silty sand fill in all boreholes. The glacial till ranged in thickness from 0.6 to 3.2 m (base Elev. 104.4 to 103.4 m).

SPTs conducted in this layer gave N-values ranging from 12 blows per 0.3 m of penetration to refusal at 100 blows per for 75 mm of penetration but were generally greater than about 40 blows per 0.3 m of penetration, indicating a dense to very dense relative density.

The recorded moisture content of samples of the glacial till ranged from 1 to 18%. Results of Atterberg Limit testing carried out on the fines portion of one sample of the glacial till are illustrated in Figure C2 of Appendix C. The results of this test are summarized below and on the Record of Borehole sheet in Appendix B. The laboratory results indicate that the fines portion exhibit low plastic behaviour (ML).

Parameter	Value
Liquid Limit	15
Plastic Limit	13
Plasticity Index	2

The results of gradation analyses completed on three samples of the glacial till are illustrated on Figure C3 of Appendix C. The results of the tests are summarized below and on the Record of Boreholes sheets in Appendix B.

Soil Particle	Percentage (%)	
Gravel	19 – 49	
Sand	25 – 37	
Silt	34	16 – 29
Clay	10	

5.4 Bedrock

Bedrock was proven by coring in all three boreholes. The bedrock surface ranges from Elevation 103.4 m to 104.4 m. The bedrock encountered consisted of slightly weathered, strong, fine grained, grey limestone. Bedrock logs are provided in Appendix B and photographs of the bedrock cores are provided in Appendix C. The table below summarizes the depths and elevations of the bedrock surface.

Table 5-1: Summary of Bedrock

Location	Borehole	Ground Surface Elevation (m)	Depth Below Existing Grade (m)	Top of Bedrock Elevation (m)
Proposed South Abutment	126-23-01	108.0	4.0	104.0
Proposed North Abutment	126-23-02	108.2	3.8	104.4
Proposed Pier	126-23-03	105.2	1.8	103.4

The rock core quality and strength are summarized in Table 5-2 below. Based on the RQD, the bedrock quality is classified as fair to excellent (CFEM, 2006). The result of an unconfined compressive strength test (UCS) was 149 MPa, indicating that the tested sample of bedrock is very strong (CFEM, 2006). The results of the UCS testing are included in Appendix C.

Table 5-2: Bedrock Details

Parameter	Range
Total Core Recovery (TCR), %	100
Solid Core Recovery (SCR), %	86 – 100
Rock Quality Designation (RQD), %	50 – 100
Fracture Index (fractures per 0.3 m) ¹	0 – 6
Unconfined Compressive Strength (UCS) ⁽²⁾ , MPa	149

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

(2) Sample tested from Boreholes 166-22-02

5.5 Groundwater

A standpipe piezometer was installed in Borehole 126-23-02 to allow for measurement of the stabilized groundwater level. The measured groundwater levels are summarized in Table 5-3.

Table 5-3: Groundwater Level Observations

Borehole No.	Bottom of Screen Elev. (m)	Screened Unit	Depth (mbgs) ¹	Groundwater Elevation (m)	Date of Measurement
126-23-02	101.3	Limestone Bedrock	2.5	105.7	April 18, 2023
			3.5	104.7	April 19-2023
			2.8	105.4	April 26-2023

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



It should be noted that the values shown above are considered short-term 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.



6 MISCELLANEOUS

The 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 or relative to structure feature elevations provided on as-built drawings. 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. Traffic control and water supply were provided by T.G. Carroll Cartage Limited of Carp, Ontario.

The field investigation was supervised on a full-time basis by Ibrahim Khan, EIT and Richard Howarth, C.Tech., under the direction of Katya 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, Ontario.

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 completed out by Ibrahim Khan, EIT and Katya Walker, P.Eng. The report was reviewed by Matt Kennedy, 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.

4. USE OF THE REPORT

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

5. INTERPRETATION OF THE REPORT

- a) **Nature and Exactness of Soil and Contaminant Description:** Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) **Reliance on Provided Information:** The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) **Design Services:** The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) **Construction Services:** During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

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

7. INDEPENDENT JUDGEMENTS OF CLIENT

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



Appendix A.

Borehole Location Plan and Stratigraphic Drawing

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

CONT No
GWP No 4024-20-00

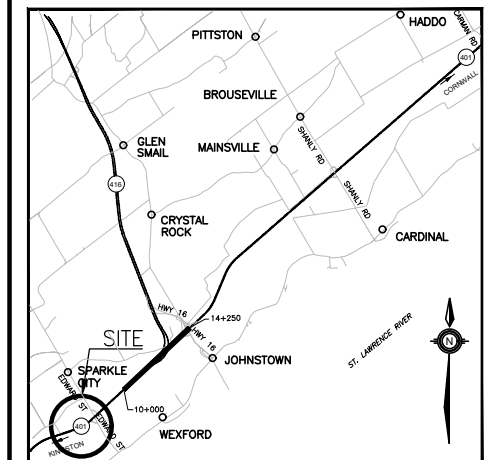


HIGHWAY 401
MAITLAND ROAD
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET |









THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

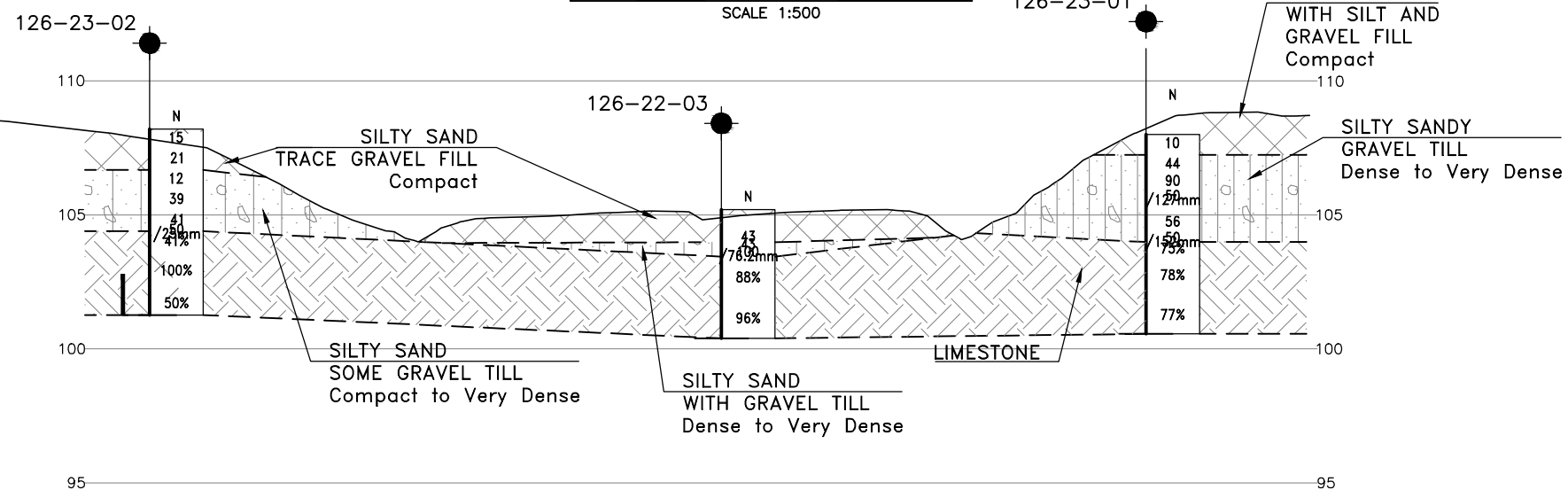
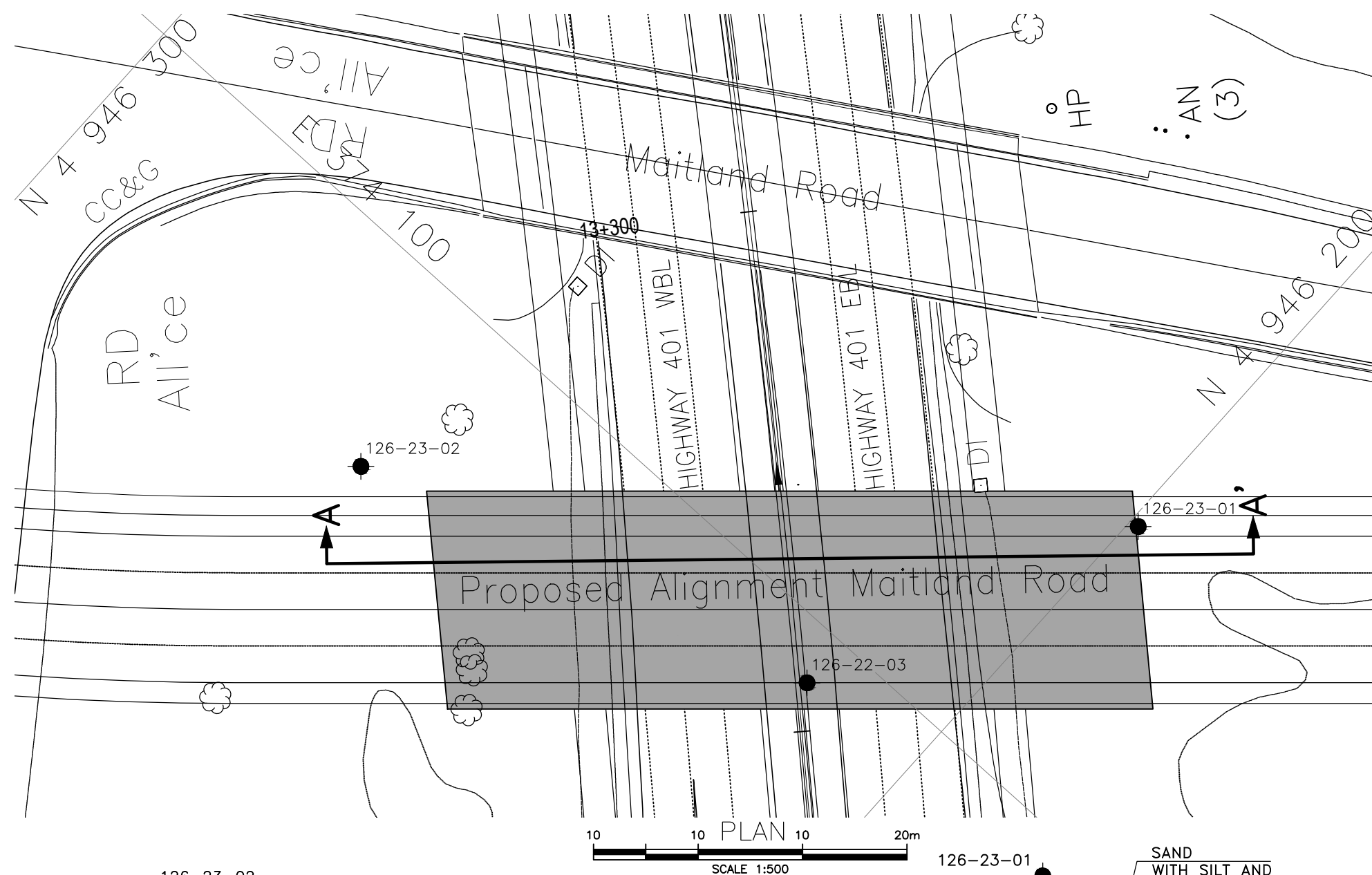
	Borehole (Current Investigation)
	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
	Exposed Bedrock Surface Point Elevation

NO	ELEVATION	NORTHING	EASTING
126-23-01	108.0	4 946 199.1	374 127.2
126-23-02	108.2	4 946 258.3	374 081.8
126-22-03	105.2	4 946 212.7	374 094.9

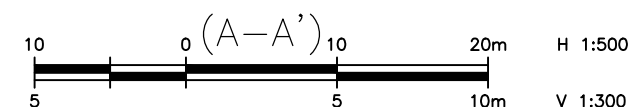
-NOTES-

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

GEOCRES No. 31B12-001



PROFILE ALONG PROPOSED MAITLAND ROAD



REVISIONS								
	DATE	BY	DESCRIPTION					
DESIGN	AO	CHK	KW	CODE	LOAD		DATE	MARCH 2024
DRAWN	JW	CHK	MJK	SITE	16X-0166	STRUCT	DWG	1



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 126-23-01

1 OF 1

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.652453°, Long: -75.625915°
HWY 401 BOREHOLE TYPE CME 55 Track Mount / HSA / NW Casing / NQ Coring
DATUM Geodetic DATE 2023.04.17 - 2023.04.17

ORIGINATED BY RH
COMPILED BY RH
CHECKED BY KW

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		
108.0	Ground Surface													
0.0 0.1	TOPSOIL (75 MM)		1	SS	10									
107.2	SILTY SAND trace gravel contains organics moist FILL													
0.8	SILTY SANDY GRAVEL dense to very dense brown brown moist GLACIAL TILL		2	SS	44		107							
			3	SS	90		106							46 25 29 (SI+CL)
			4	SS	50									
					127mm									
			5	SS	56		105							
104.0			6	SS	50		104							
4.0	LIMESTONE BEDROCK grey slightly weathered thinly bedded		1	RUN	152mm								FI	RUN #1 TCR=100% SCR=88% RQD=75%
			2	RUN			103						6	RUN #2 TCR=100% SCR=95% RQD=78% UCS=148.7MPa
							102						4	RUN #3 TCR=100% SCR=96% RQD=77%
			3	RUN			101						2	
100.6													2	
7.4	End of Borehole													
	A representative open-hole groundwater level measurement was not obtained due to the introduction of water during drilling.													

DOUBLE LINE 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 2012TEMPLATE(MTO).GDT 3-19-24

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

RECORD OF BOREHOLE No 126-23-02

1 OF 1

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.65299°, Long: -75.62648° HWY 401 & Maitland - MTM z9 N 4 946 258.3 E 374 081.8 ORIGINATED BY RH
 HWY 401 BOREHOLE TYPE CME 55 Track Mount / HSA / NW Casing / NQ Coring COMPILED BY RH
 DATUM Geodetic DATE 2023.04.17 - 2023.04.17 CHECKED BY KW

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						PLASTIC LIMIT W _P NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
108.2	Ground Surface							20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

DOUBLE LINE 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 2012TEMPLATE(MTO).GDT 3-19-24

RECORD OF BOREHOLE No 126-22-03

1 OF 1

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.652579°, Long: -75.626321°
HWY 401 BOREHOLE TYPE CME 75 Truck Mount / HSA / NW Casing / NQ Coring
DATUM Geodetic DATE 2022.12.20 - 2022.12.20

ORIGINATED BY RH
COMPILED BY RH
CHECKED BY KW

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
105.2	Ground Surface												
0.0	ASPHALT (200 mm)												
0.2	SILTY SAND some gravel dense brown FILL												
104.0			1A	SS	43								
1.2	GRAVEL and SAND, some fines occasional cobbles and boulders dense to very dense brown		1B	SS	43								
103.4			2	SS	100								
1.8	GLACIAL TILL LIMESTONE BEDROCK grey slightly weathered coarse grained				76.2mm								
			1	RUN									
			2	RUN									
100.4													
4.8	End of Borehole A representative open-hole groundwater level measurement was not obtained due to the introduction of water during drilling.												

DOUBLE LINE 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 2012TEMPLATE(MTO).GDT 3-19-24



Appendix C.

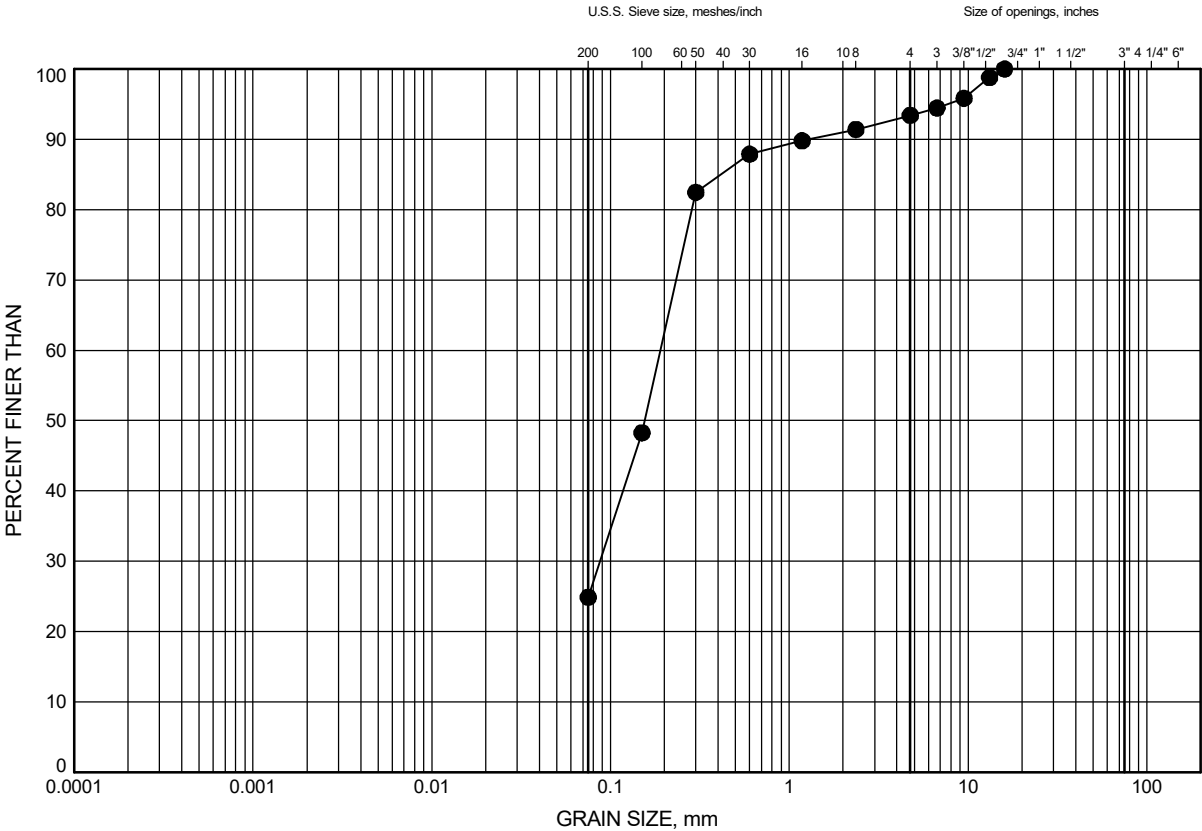
Laboratory Testing



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

GRAIN SIZE DISTRIBUTION

FILL: Silty Sand trace Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	126-23-02	0.4	107.8

GRAIN SIZE DISTRIBUTION - THURBER 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 9-6-23

Date September 2023
GWP# 4024-20-00

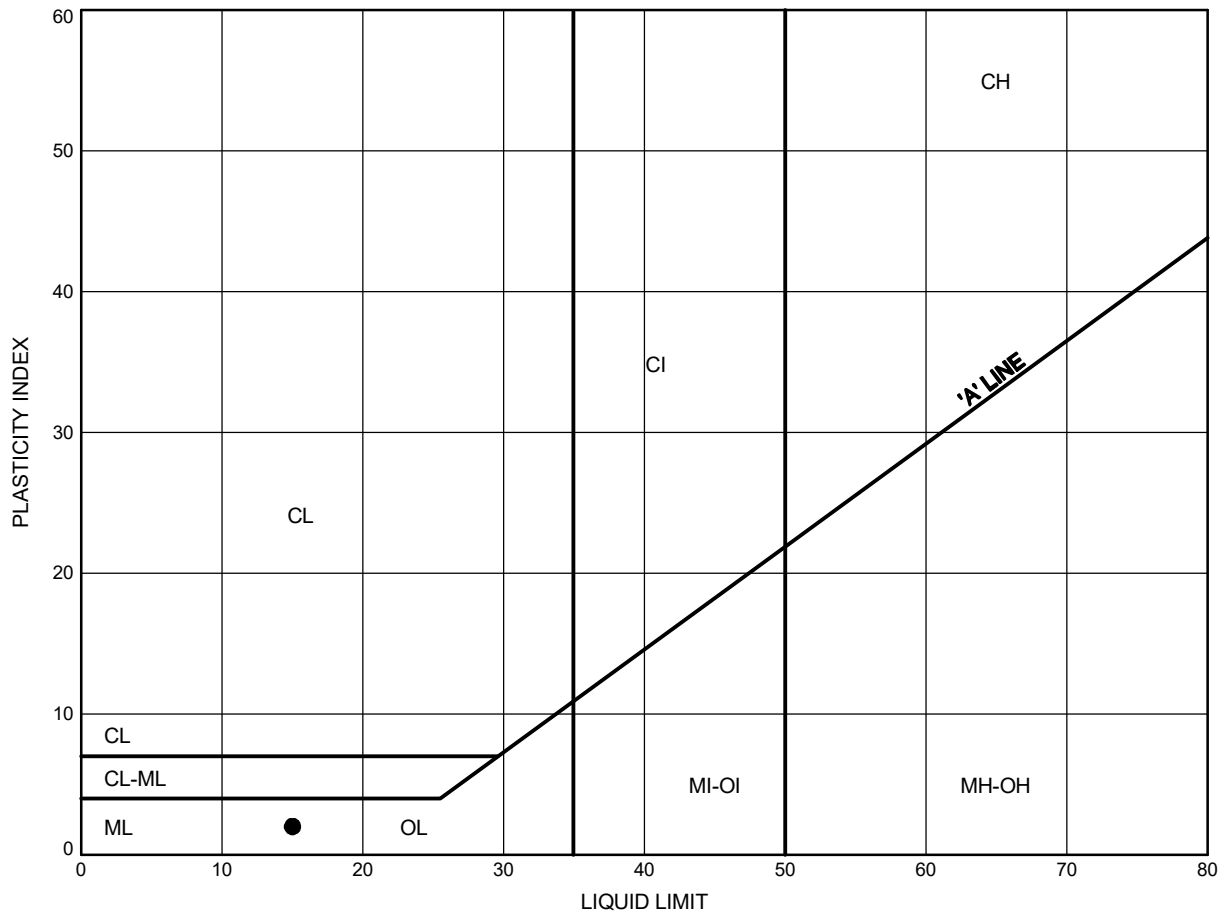


Prep'd RH
Chkd. KW

Highway 401 Underpass at Maitland Road (Site No. 16X-0126)
ATTERBERG LIMITS TEST RESULTS

FIGURE C2

GLACIAL TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	126-23-02	3.4	104.8

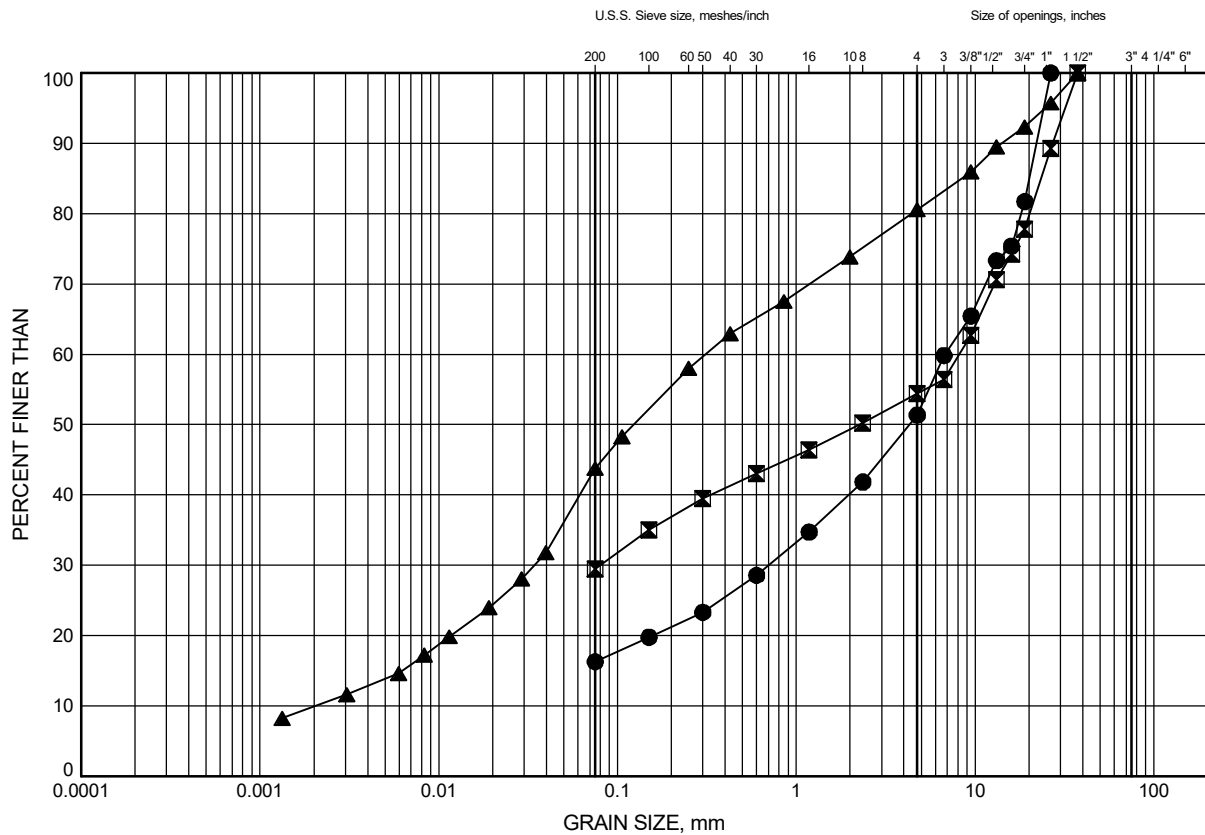
Date September 2023
GWP# 4024-20-00



Prep'd RH
Chkd. KW

GRAIN SIZE DISTRIBUTION

GLACIAL TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	126-22-03	1.3	103.9
⊠	126-23-01	1.7	106.3
▲	126-23-02	3.4	104.8

Date September 2023

GWP# 4024-20-00



Prep'd RH

Chkd. KW



Appendix C.2

UCS Test Results



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

May 3, 2023
File: 122410864

Client: Thurber Engineering, File #29381

Reference: ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core Hwy 401

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

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
239-23-01 Run-3	15'11"-16'6"	203.8	Vertical crack no cone
126-23-01 Run-2	15'2"-16'1"	148.7	Cones on both ends
165-23-02 Run-2	19'2"-20'2"	154.2	Cones on both ends

Sincerely,

Stantec Consulting Ltd.

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



Appendix C.3

Bedrock Core Photographs

Borehole 126-23-01
Runs 1 to 2
Depth 4 to 5.9 m
Elevation 104.0 to 102.1 m
Wet Sample



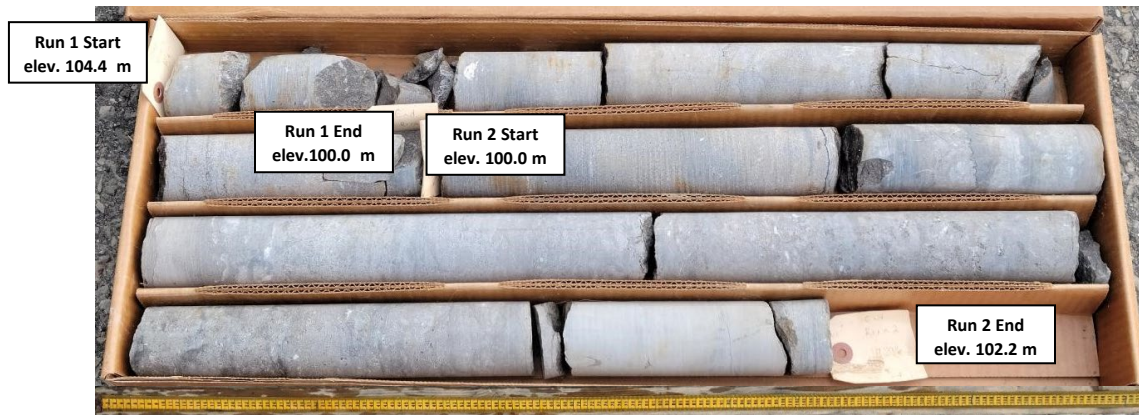
Borehole 126-23-01
Runs 3
Depth 5.9 to 7.4 m
Elevation 102.1 to 100.6 m
Dry Sample



Borehole 126-23-01
Runs 3
Depth 5.9 to 7.4 m
Elevation 102.1 to 100.6 m
Wet Sample



Borehole 126-23-02
Runs 1 to 2
Depth 3.8 to 6.0 m
Elevation 104.4 to 102.2 m
Dry Sample



THURBER ENGINEERING LTD.

126-23-02 Maitland

BH 126-23-02
Project No.: 29381

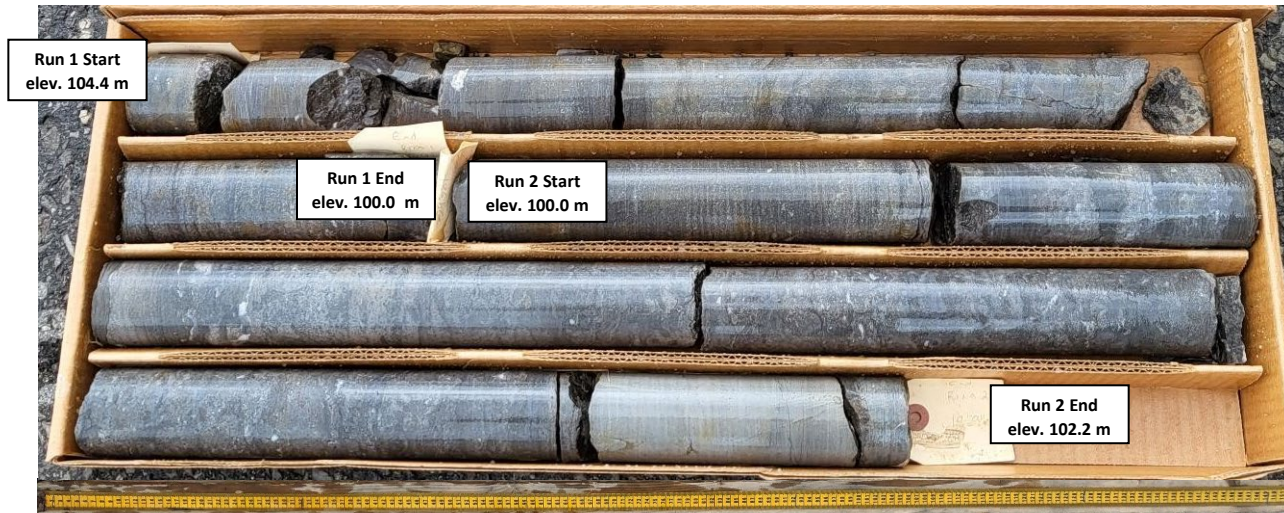
Borehole 126-23-02

Runs 1 to 2

Depth 3.8 to 6.0 m

Elevation 104.4 to 102.2 m

Wet Sample



Borehole 126-23-02
Runs 3
Depth 6.0 to 6.9 m
Elevation 102.2 to 101.3 m
Dry Sample



Borehole 126-23-02
Runs 3
Depth 6.0 to 6.9 m
Elevation 102.2 to 101.3 m
Wet Sample



Borehole 126-23-03

Runs 1

Depth 1.7 to 3.2 m

Elevation 103.5 to 102.0 m

Dry Sample



Borehole 126-23-03

Runs 1

Depth 1.7 to 3.2 m

Elevation 103.5 to 102.0 m

Wet Sample



Borehole 126-23-03

Runs 2

Depth 3.2 to 4.8 m

Elevation 102.0 to 100.4 m

Dry Sample



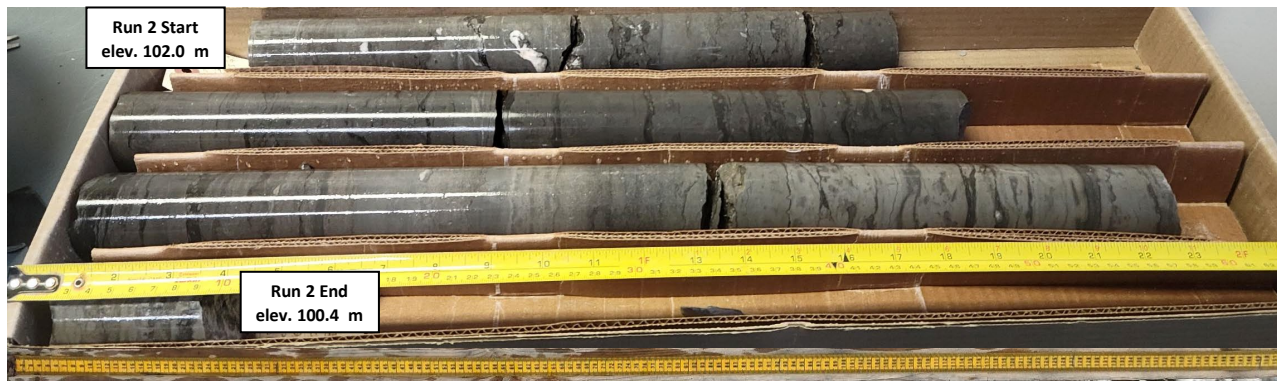
Borehole 126-23-03

Runs 2

Depth 3.2 to 4.8 m

Elevation 102.0 to 100.4 m

Wet Sample





Appendix D.

Site Photographs



Photograph 1: Looking east on Highway 401 at Maitland Road Underpass
[taken on December 20, 2022]



Photograph 2: Looking south from Maitland Road Underpass northeast embankment
[taken on December 20, 2022]



Photograph 3: Looking north from Maitland Road Underpass southwest embankment
[taken on December 20, 2022]



Photograph 4: Looking south along Maitland Road from bridge structure
[taken on December 20, 2022]



Photograph 5: Looking south from Maitland Road Underpass northwest embankment
[taken on April 17, 2023]



Photograph 6: Looking west on Highway 401 at proposed north abutment location
[taken on April 17, 2023]



Photograph 7: Looking north from Maitland Road Underpass southwest embankment
[taken on April 17, 2023]