THURBER ENGINEERING LTD.

PRELIMINARY FOUNDATION INVESTIGATION REPORT
HIGHWAY 401 WIDENING, HIGHWAY 16 TO MAITLAND ROAD
401W-416N RAMP CULVERT REHABILITATION, SITE NO. 16X-0259/C0
GWP 4024-20-00 / ASSIGNMENT NO. 4019-E-0010.2

Geocres No.: 31B-102

Report to:

MTO c/o AECOM Canada Ltd.

Latitude: 44.7470666°
Longitude: -75.4885296°

January 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 proposed rehabilitation of the structural culvert beneath the W-N Ramp which connects the eastbound lanes on Highway 401 to the northbound lanes on Highway 416. The culvert, Site No. 16-259/C, is located beneath the ramp approximately 45 m south of the south abutment of the Highway 401 Underpass below the W-N Ramp, near the town of Prescott, Ontario.

This section of the report presents the factual findings obtained from a preliminary 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 which included:

- Report prepared by Jacques, Whitford Limited titled, "*Report on Foundation Investigation, W.P. 374-89-00, Concrete Culvert, Site 16-259, Ramp W-N, Sta. 21+338.8, Site 16-260, Ramp N-W, Sta. 11+400, Hwy. 401-416 Interchange, District 9, Ottawa*", dated August 17, 1992 (Geocres No. 31B-67); and,

- Letter report prepared by Jacques, Whitford Limited titled, "*Addendum to Jacques Whitford Report No. 10212 dated August 17, 1992, W.P. 374-89-00, Site 16-259 and Site 16-260, Concrete Culverts, Ramps W-N and N-W, Hwy 401/416 Interchange*", dated January 7, 1998 (Geocres No. 31B-67).

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 construction 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

The site is located near the southern limit of the Highway 401 and Highway 416 Interchange. Johnstown Creek flows roughly from west to east beneath the interchange ramps and Highway 401 to its outlet into the St. Lawrence River at Johnstown. The culvert addressed in this report is located beneath the W-N Ramp connecting Highway 401 eastbound lanes to the Highway 416 northbound lanes. The culvert is approximately 45 m south of the south abutment of the Highway 401 Underpass below the W-N Ramp. For project purposes, the W-N Ramp and culvert are herein described as oriented north-south and east-west, respectively.

The land adjacent to the site typically consists of forests, wet ground and agricultural fields. The terrain is relatively flat apart from the existing highway and interchange embankments and associated drainage ditches. The areas near the culvert inlet and outlet were noted to be poorly drained.

Highway 401 in this area consists of a four-lane divided freeway with paved shoulders and a median barrier and median stormwater system. A guiderail is present along the south side of the highway. The W-N Ramp consists of one travelled lane with partially paved shoulders and guiderails on both sides.

A site visit was carried out on March 29, 2021 to observe the existing conditions. Within the vicinity of the culvert, the embankment side slopes are at approximately 2H:1V and are generally grass-covered, with bushes and small trees growing around the culvert ends. At the time of the site visit, the embankments did not show any visible signs of distress or other performance issues. A subsequent site visit was carried out on May 5, 2021 to survey the top of the existing culvert and the water level in Johnstown Creek.

Based on the available project background documents including the photos and recent documented inspection records, the culvert consists of a concrete, twin barrel, rigid frame, closed bottom, box culvert, constructed in 1998. The culvert is approximately 51.2 m long, has a total internal span of 6.0 m, and an approximate internal height of 2.5 m above the stream bed. The culvert structure includes a headwall at each end as well as wing walls in all four quadrants.

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies on the border of the physiographic regions known as the Smith's Falls Limestone Plain and the Glengarry Till Plain.

The Smith's Falls Limestone Plain is characterized by typically shallow bedrock but including a few localized deep areas of highly variable soils consisting of clays, sands, and gravels. The Glengarry Till Plain 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. Both areas are known to be underlain by limestone/dolostone and sandstone bedrock.

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

3 SITE INVESTIGATIONS AND FIELD TESTING

The original foundation investigation for design of Culvert 16-259/C was carried out in May 1992. An additional field investigation took place in September 1997 following a change in the preferred alignment of the culvert. The current investigation was carried out in April 2021 to collected additional subsurface information near the existing culvert outlet. Summaries of the investigations are provided in the following sections.

3.1 Previous Investigations (1992 & 1997)

Field investigations were carried out as part of the planning and design of the then-proposed Highway 401 and Highway 416 interchange. Borehole 92-3 was put down in May 1992 as part of the first investigation for the subject culvert (Geocres No. 31B-67). Following a realignment of the design of the culvert, Borehole 97-1 was put down as part of a subsequent investigation carried out in September 1997. Both investigations employed a track-mounted CME 55 drill rig to advance the boreholes.

The locations of the 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 then surveyed.

The northing, easting and elevation of the boreholes referenced 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	Northing[1] (Latitude)	Easting[1] (Longitude)	Ground Surface[2] Elevation (m)	Termination Depth (m)
92-3	Inlet (West)	4 956 816.3 (44.746868)	384 857.7 (-75.488981)	84.1	4.0
97-1	Outlet (East)	4 956 831.3 (44.746996)	384 917.7 (-75.488221)	84.3	1.2

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 culvert.

Soil samples were obtained at selected intervals using split spoon samplers in conjunction with Standard Penetration Testing (SPT) during the investigations. In Borehole 92-3, the bedrock was cored approximately 1.6 m with NQ sized coring equipment.

A standpipe piezometer was installed in Borehole 92-3 prior to backfilling. It has been assumed that the standpipe piezometer was removed or abandoned prior to construction of the ramp and culvert.

3.2 Current (2021) Investigation

The current site investigation was carried out in the Spring of 2021. One borehole (Borehole 259-21-1) was put down at the outlet (east side) of the 16-259/C culvert site between April 19 and 20, 2021. The borehole was put down with a Hilti D250 Portable drill rig equipped with tri-cone and rotary diamond drilling equipment.

The location of the 2021 borehole was surveyed by Thurber for both location and elevation with a Trimble Catalyst DA1 antenna with centimeter accuracy. The northing, easting and elevation of the borehole is 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.

Table 3-2: Borehole Summary

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
259-21-1	Outlet (East)	4 956 812.1 (44.746829)	384 919.7 (-75.488202)	84.6	4.0

Soil samples were obtained using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). As part of the portable rig equipment, a half-weight hammer (32 kg) was used for split spoon sampling. SPT “N” values shown on the Record of Borehole log were adjusted to reflect values that would have been obtained using a hammer of standard weight. Borehole 259-21-1 was advanced approximately 3 m into bedrock, with NQ sized coring equipment. The borehole was backfilled in accordance with MOE requirements (O.Reg 903, as amended).

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 consisted of natural moisture content determination and grain size distribution testing of soil samples. 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 carried out on a selected bedrock sample. The 1992 investigation included natural moisture content determination and an Atterberg Limit test carried out on soil samples.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and 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 for the 2021 investigation 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 (October 2020). Terminology from the historic Geocres information may vary from current practice.

In general, the site is underlain by a deposit of clay to silty clay on the west side the culvert, overlying a deposit of sandy silt to silty sand which is, in turn, underlain by bedrock consisting of interbedded dolostone and limestone bedrock.

The sections below describe subsurface conditions encountered at the time the boreholes were advanced. Since the boreholes were put down up to several metres away from the culvert, it should be noted that surficial deposits at the culvert may differ from that described below. Furthermore, the deposits described in Boreholes 92-3 and 97-1 would likely have been disturbed, altered, or completely removed during the construction of the W-N Ramp and culvert structure.

5.1 Surficial Deposits

At the time of the 1992 investigation, about 300 mm of topsoil was encountered at the ground surface in Borehole 92-3 near the culvert inlet.

5.2 Clay and Sand

A deposit of clay and sand with a trace of gravel was reported beneath the topsoil on the log for Borehole 92-3. The layer was approximately 600 mm thick with a base elevation of 83.5 m. One SPT conducted within this layer gave a value of 1 blow per 0.3 m of penetration indicating a very soft consistency.

5.3 Silty Clay

A native silty clay deposit was encountered beneath the clay and sand deposit in Borehole 92-3. The layer was approximately 1.7 m thick with the bottom of the deposit at Elevation of 81.8 m.

SPT tests conducted within this layer gave N-values ranging from 4 to 10 blows per 0.3 m of penetration. Pocket penetrometer tests carried out on split spoon samples as part of the 1992 investigation indicated a shear strength of about 200 kPa. The silty clay was described as having a firm to hard consistency.

The moisture contents of the two samples tested were 35 and 45%. The results of Atterberg Limits testing carried out on one sample from Borehole 92-3 are summarized below and are illustrated

on Figure C2 Appendix C. The laboratory results indicate that the material is a silty clay of intermediate plasticity (CI).

Summary of Atterberg Limit Testing – Silty Clay

Parameter	Value
Liquid Limit	49
Plastic Limit	21
Plasticity Index	28

5.4 Sandy Silt to Silty Sand

A thin deposit of grey sandy silt was encountered beneath the silty clay in Borehole 92-3. A deposit of brown sand to silty sand, some gravel was encountered at ground surface near the culvert outlet in Borehole 97-1 and Borehole 259-21-1. The thickness of the deposit ranged from 0.2 to 1.2 m with a base elevation ranging from 83.7 to 81.7 m.

An SPT conducted within this layer gave an N-value 21 blows for 0.3 m of penetration, indicating a compact relative density. The deposit was described as loose on the Record of Borehole for 97-1 and compact on the log for Borehole 92-3.

The moisture content of the two samples tested were about 23%. The results of a grain size analysis conducted on a sample of this material from Borehole 259-21-1 are summarized below and are illustrated on Figure C1 in Appendix C.

Summary of Grain Size Distribution Testing – Silty Sand

Soil Particle	Percentage (%)
Gravel	14
Sand	58
Silt	19
Clay	9

5.5 Bedrock

Bedrock was proven by coring at Boreholes 92-3 and 259-21-1 at Elevations of 81.7 m and 83.7 m, respectively. Borehole 97-1 encountered the assumed bedrock surface (inferred based on auger refusal) at Elevation 83.1 m. Based on the subsurface information, the bedrock surface slopes or steps up to the east. The bedrock encountered in the 1992 investigation was described as limey dolostone with shaley partings. The bedrock was reported to be of excellent quality with a Rock Quality Designation (RQD) value of 100%.

The bedrock encountered in the current investigation consisted of slightly weathered, very strong, grey interbedded sandstone and dolostone. The RQD ranged from 31% to 51%, the Solid Core Recovery (SCR) ranged from 90% to 100%, and the Total Core Recovery (TCR) ranged from 90% to 100%. Photographs of the bedrock cores are provided in Appendix C.

5.6 Groundwater

The groundwater level measured in the standpipe piezometer installed during the 1992 field investigation is presented in Table 5-1. The Johnstown Creek level was measured during a recent site visit carried out on May 5, 2021, and is also presented in Table 5-1.

Table 5-1: Summary of Groundwater Levels

Borehole No.	Bottom of Screen Elevation (m)	Screened Unit	Depth (mbgs)	Groundwater Elevation (m)	Date of Measurement
92-3	80.1	Bedrock	0.1	84.0	1992/05/15
Johnstown Creek Surface Level (Existing Inlet)				84.3	2021/05/05
Johnstown Creek Surface Level (Existing Outlet)				84.3	2021/05/05

These observations are considered short term and it should be noted that the groundwater and creek water level at other times of the year may be different and seasonal fluctuations of the levels are to be expected. In particular, the groundwater and creek level may be at a higher elevation after periods of significant and/or prolonged precipitation.

6 MISCELLANEOUS

It is noted that the information provided herein is partially based on investigations completed prior to construction of the Highway 401/416 Interchange. It is likely that conditions have changed on site during the intervening years.

The 2021 borehole location was selected by Thurber relative to existing site features. The 2021 elevation survey of the borehole, Johnstown Creek and the culvert was carried out by Thurber with reference to geodetic elevation benchmarks provided by the MTO. Marathon Underground of Greely, Ontario supplied and operated the drilling equipment and carried out the drilling, soil sampling, in-situ testing, and borehole decommissioning.

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 Sarah Harrold, EIT and 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.

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.

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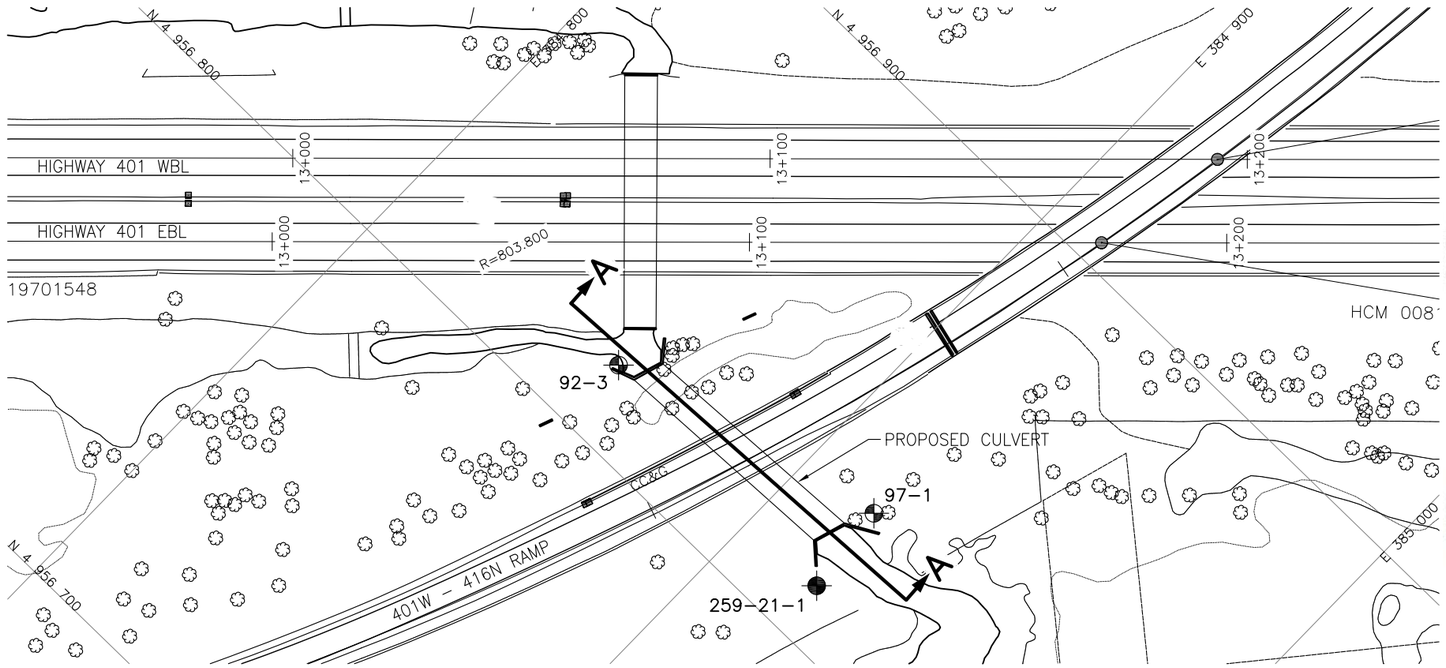
Appendix A.

Borehole Location Plan and Stratigraphic Drawing

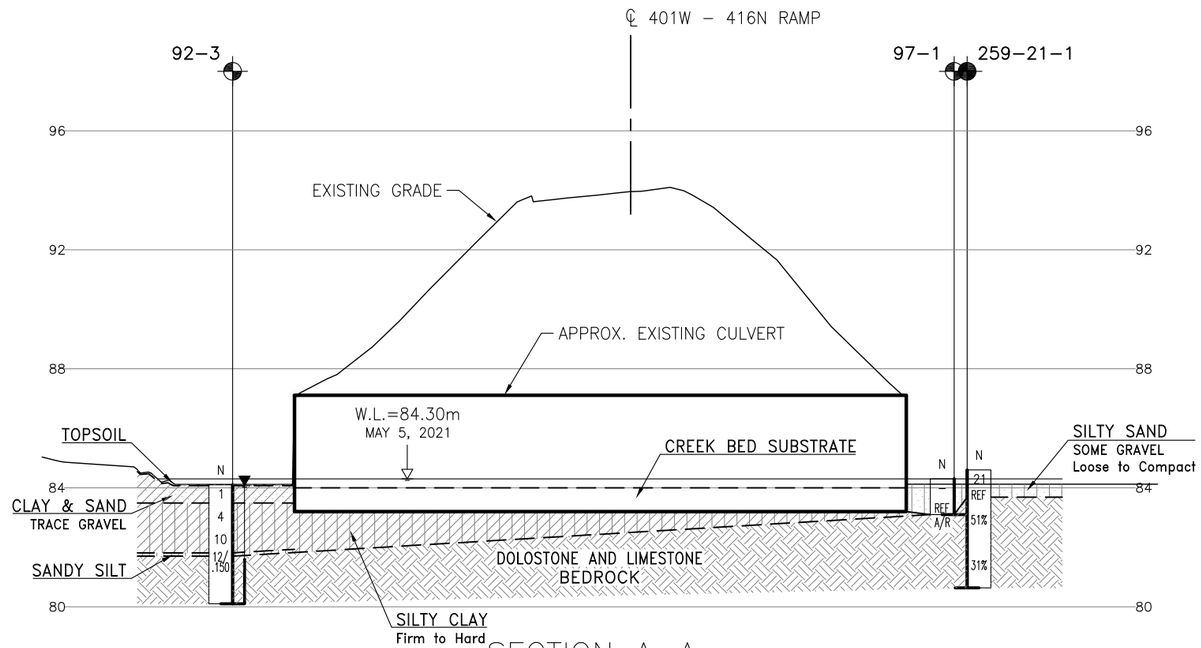
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

25 0 25 50m

SCALE 1:1250



SECTION A-A

10 0 10 20m H 1:500

4 0 4 8m V 1:200

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

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Jan 23, 2023
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
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Jan 23, 2023
PROVINCE OF ONTARIO

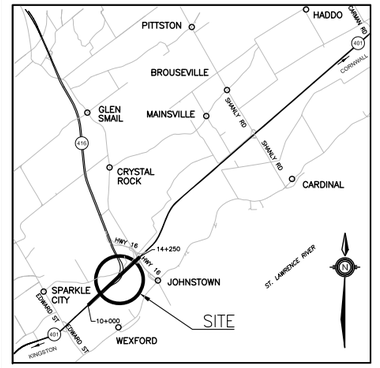
CONT No
GWP No 4024-20-00

SHEET

HIGHWAY 401
401W - 416N RAMP
CULVERT REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario

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)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
259-21-1	84.6	4 956 812.1	384 919.7
92-3	84.1	4 956 816.3	384 857.7
97-1	84.3	4 956 831.3	384 917.7

-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. 31B-102

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	MJK	CHK -	CODE	LOAD	DATE JAN 2023
DRAWN	MFA	CHK MK	SITE 16-259/C	STRUCT	DWG 1

FILENAME: H:\Drafting\29000\29381\TED-29381-BHPP(16-259C).dwg
PLOTDATE: 1/24/2023 8:26 AM

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Appendix B.

Record of Borehole Sheets (Current and 1992/1997 Investigations)

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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.

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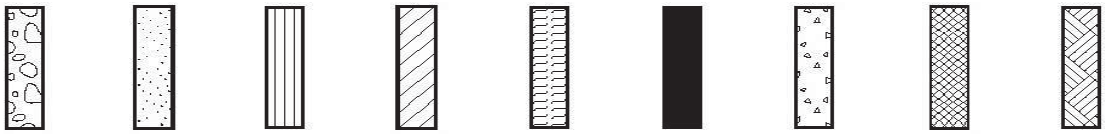
STRATA PLOT:
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



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

THURBER

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

THURBER

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

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Ontario

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RECORD OF BOREHOLE No 259-21-1 1 OF 1 METRIC

GWP# 4024-20-00 LOCATION Lat: 44.746829°, Long: -75.488202° N 4 956 812.1 E 384 919.7 ORIGINATED BY JP

HWY 401 BOREHOLE TYPE Hilti D250 Portable, Tri-Cone/NQ Coring COMPILED BY SH

DATUM Geodetic DATE 2021.04.19 - 2021.04.20 CHECKED BY MJK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
84.6											
0.0	**SILTY SAND**, some gravel Compact Brown Moist to wet		1	SS	21		84	○	○		14 58 19 9
83.7			2	SS	REF				○	FI	
0.9	Interbedded **DOLOSTONE and LIMESTONE** Slightly weathered Thinly bedded Grey Fine to medium grained Vertical fracture 3.4 to 3.7 m Very strong		1	RUN			83			2 4 6 4 2	RUN #1 TCR=90% SCR=90% RQD=51%
			2	RUN			82			4 3 9 8	UCS = 205 MPa RUN #2 TCR=100% SCR=100% RQD=31%
80.6							81			6	
4.0	End of Borehole Note: 1) A half-weight hammer was used for split spoon sampling. SPT "N" values shown have been adjusted to reflect values that would have been obtained using a hammer of standard weight.										

$+^3$, $\times^3$: 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 97-1 1 OF 1 METRIC

W.P. 374-89-00 LOCATION Hwy 401/416 Interchange, Johnstown Creek Culvert ORIGINATED BY CL

DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY CL

DATUM Geodetic DATE 97.09.18 & CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ✖ FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
84.3											
0.0	Loose, brown, SAND, some silt		1	BS			84				
83.1			2	SS		ref					
1.2	End of Borehole Auger Refusal on Inferred Bedrock ref = >50 blows for 150mm										

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

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

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RECORD OF BOREHOLE No 92-3 METRIC

W P 374-89-00 LOCATION Co-ords N: 4 956 816.3 E: 384 857.7 ORIGINATED BY Y.L.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem, N-Casing, Rock Coring COMPILED BY F.J.G.

DATUM Geodetic DATE May 13, 1992 CHECKED BY CKK

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
84.1	Ground Surface						84				
.03	Topsoil										
83.5	Clay, sand, trace gravel, Brown, very Soft		1	SS	1			May 15, 1992			
0.6											
	Silty Clay Brown to Grey Firm to Hard		2	SS	4		83		○		
						Native Backfill					
81.8	Sandy silt Grey, compact		3	SS	10				⊢○		
2.29							82				
2.4	Bedrock Limey Dolostone with shaley partings Excellent		4	SS	2/150mm						
			5	NQ	REC 100%		81				RQD 100%
						Piezometer					
80.1											
4.0	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 ◇ 5 (%) STRAIN AT FAILURE

THURBER

Appendix C.

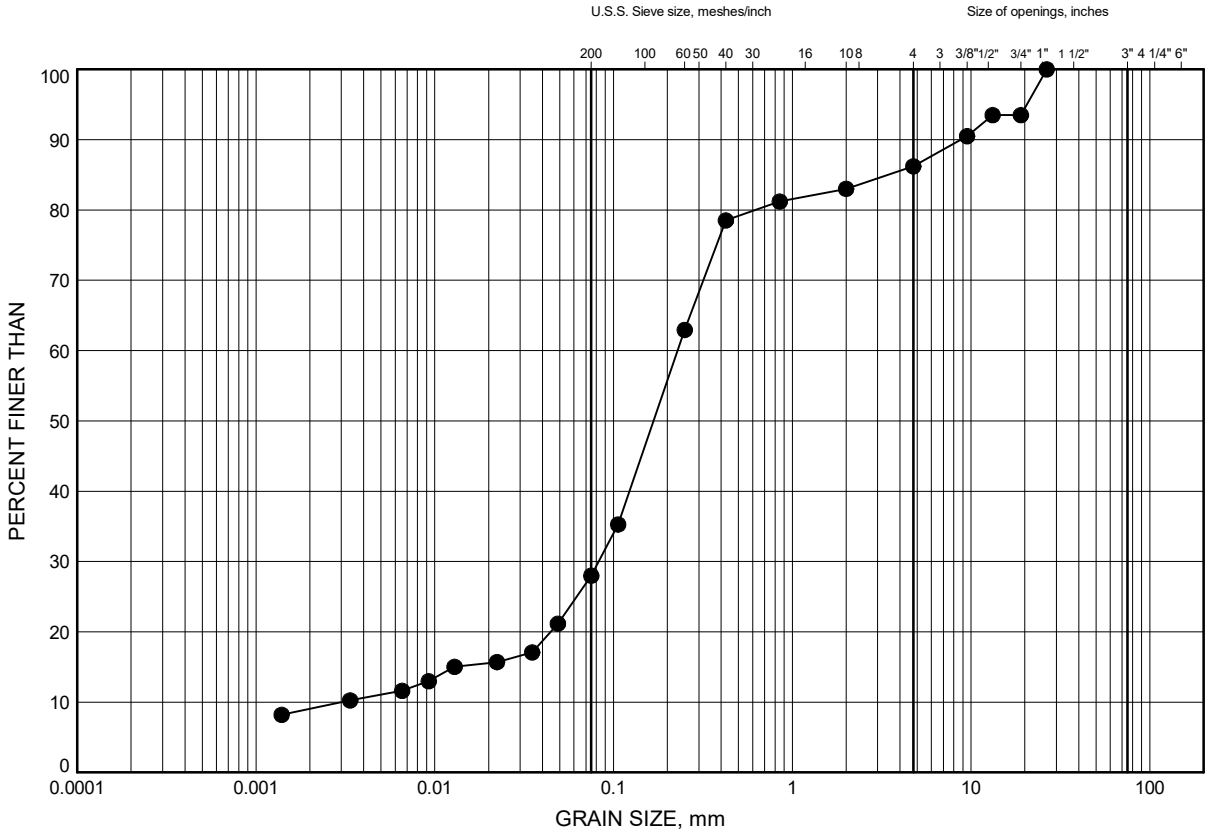
Laboratory Test Results (Current and 1992/1997 Investigations)

401W-416N Ramp Culvert Rehabilitation (Site No. 16X-0259/C0)

GRAIN SIZE DISTRIBUTION

FIGURE C1

SILTY SAND, some gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	259-21-1	0.3	84.3

Date December 2021

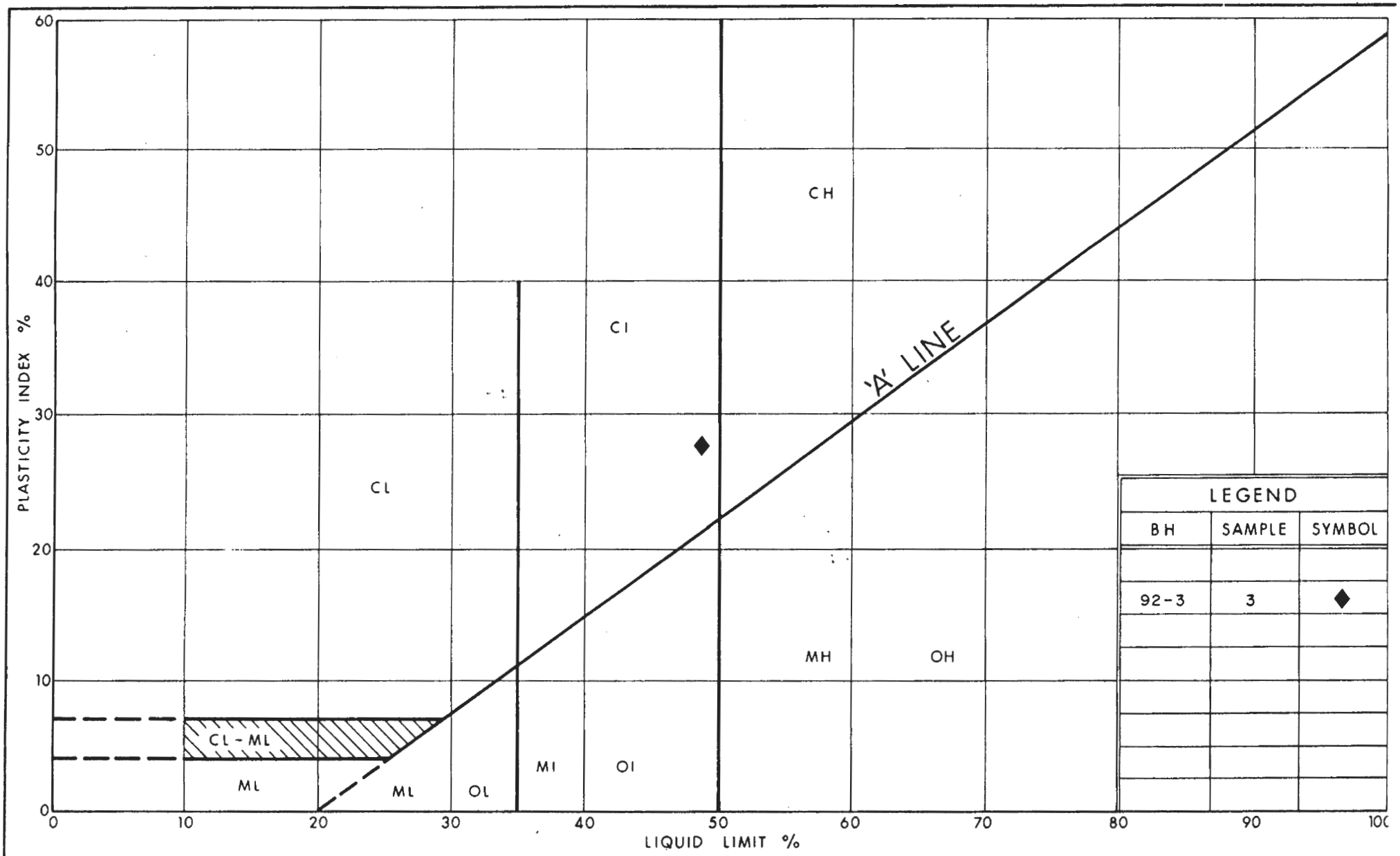
WP# 4024-20-00

THURBER

Prep'd SH

Chkd. MJK

GRAIN SIZE DISTRIBUTION - THURBER 29381 BOREHOLE LOGS.GPJ 3/6/21



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PLASTICITY CHART
SILTY CLAY

FIG No. 2
W P 374-89-00

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

Stantec

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

Borehole 259-21-1

Run 1 to 2 (of 2)

Elevation 83.7 m to 80.6 m

Dry

THURBER ENGINEERING LTD.

Highway 401/416 Interchange
Hwy 401W – 416N Ramp Culvert
(Site No. 16X-0259/C0)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 259-21-1
Project No.: 29381

Borehole 259-21-1

Run 1 to 2 (of 2)

Elevation 83.7 m to 80.6 m

Wet

THURBER ENGINEERING LTD.

Highway 401/416 Interchange
Hwy 401W – 416N Ramp Culvert
(Site No. 16X-0259/C0)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 259-21-1
Project No.: 29381

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Appendix D.

Site Photographs

Photo 1. Looking southwest at the poorly drained ground and Hwy 401 Underpass of the W-N Ramp (2021/03/29).

Photo 2. Looking south at east (outlet) culvert wingwalls (2021/03/29).

Photo 3. Looking west at east (outlet) culvert headwall (2021/03/29).

Photo 4. Looking north at east (outlet) culvert headwall (2021/03/29).