



**THURBER** ENGINEERING LTD.

**FINAL**  
**FOUNDATION INVESTIGATION REPORT**  
**HIGHWAY 17 TWINNING, RENFREW AREA**  
**O'BRIEN ROAD INTERCHANGE**  
**WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009**

Geocres No.: 31F-216

Report to:

**Ministry of Transportation Ontario**

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**PART 1. FACTUAL INFORMATION**

**1 INTRODUCTION**

Thurber Engineering Ltd. (Thurber) has been engaged by the Ministry of Transportation Ontario (MTO) under Assignment No. 4018-E-0009 to carry out Foundation Investigations to support the design of the Highway 17 Twinning Project which extends from Scheel Drive westerly to 3 km west of Bruce Street in the Renfrew area.

This report addresses the proposed O'Brien Road (Highway 60) Interchange at Highway 17 in Renfrew, Ontario. The existing Highway 17 alignment will become the future Highway 17 westbound lanes, new eastbound lanes and interchange ramps will be constructed. New structures are required to convey Highway 17 over O'Brien Road.

This section of the report presents the factual findings obtained from a foundation investigation completed at the future Highway 17/O'Brien Road Interchange. Thurber carried out the investigation under Ministry of Transportation (MTO) Retainer Agreement No. 4068-09-00, Assignment No. 4018-E-0009.

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 was developed in the course of the current investigation.

Previous foundation information from a preliminary investigation completed in 2003 for the currently proposed structures was available under Geocres 31F-128.

**2 SITE DESCRIPTION**

**2.1 General**

The site is located on Highway 17 at the existing O'Brien Road (also know as Highway 60) intersection northeast of the Town of Renfrew. At the location of the proposed structures, Highway 17 is oriented southeast to northwest with O'Brien Road oriented in a southwest to northeast direction terminating at the T-intersection with Highway 17. For project purposes,



Highway 17 and O'Brien Road are herein described as oriented east-west and north-south respectively.

The land use adjacent to the site generally consists of low-density commercial to the south and west and forests and agricultural fields to the north and east. The terrain is relatively flat near the existing intersection with land west of the intersection gradually sloping downward toward the Bonnechere River valley northwest of the site. A small tributary creek within a 14 m deep ravine crosses O'Brien Road approximately 250 m southwest of the intersection and crosses Highway 17 approximately 150 m west of the intersection. The creek flows towards the Bonnechere River.

Highway 17 in this area consists of a two-lane undivided highway with paved shoulders and a posted speed limit of 90 km/hr. The AADT for this section of Highway 17 was 11,000 and 14,200 to the west and east of the intersection in 2008. O'Brien Road has one lane in each direction and had a reported AADT of 6550 in 2008. The T-intersection is controlled with traffic lights. A west bound left turn lane is present on Highway 17. A west to south ramp and a south to east ramp facilitate right turn movements.

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

## **2.2 Site Geology**

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies within the physiographic region known as the Ottawa Valley Clay Plains. The Ottawa Valley Clay Plains are characterized primarily by clay plains deposited by the Champlain Sea (Leda Clay) interrupted by ridges of rock or sand. Base mapping by the Ontario Geological Survey indicates the bedrock in the area is carbonate metasedimentary rocks, marble, calc-silicate rocks, skarn, tectonic breccias of the Grenville Supergroup and Flinton Group.

## **3 SITE INVESTIGATION AND FIELD TESTING**

The current site investigation and field-testing program was carried out between September 9<sup>th</sup>, 2019 and March 10<sup>th</sup>, 2020. The field investigation consisted of advancing 19 boreholes identified as Boreholes OBR19-1 through OBR19-16 and Boreholes CV-7, CV-8 and CV-9. Boreholes OBR19-10 and OBR19-11 were completed as Seismic Cone Penetration Tests (SCPTu). Additional details regarding the SCPTu testing equipment and methodology are provided in Appendix E. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

Previously drilled Boreholes BRN-1, BRN-2, BRN-4 and BRN-5 were completed by Thurber in December 2003 as part of a preliminary investigation for the structures required for the twinning of Highway 17. Data from these boreholes has been fully incorporated into this report.

The locations of 2019/2020 boreholes were surveyed by Thurber for both location and elevation with a Trimble Catalyst DA1 antenna with centimeter accuracy. The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in



Appendix A, the individual Record of Borehole sheets in Appendix B, and in Table 3-1 below. The site is located within MTM Zone 9.

**Table 3-1: Borehole Summary**

<b>Borehole No.</b>	<b>Drilled Location</b>	<b>Northing (Latitude)</b>	<b>Easting (Longitude)</b>	<b>Ground Surface Elevation (m)</b>	<b>Termination Depth (m)</b>
BRN-1	EBL O/P West Abutment	5 038 049.1 (45.482273)	293 357.3 (-76.646373)	129.8	27.1
BRN-2	WBL O/P East Abutment	5 038 074.4 (45.482502)	293 421.5 (-76.645553)	128.4	27.4
BRN-4	WBL O/P West Abutment	5 038 084.7 (45.482594)	293 399.3 (-76.645837)	128.4	27.4
BRN-5	EBL O/P East Abutment	5 038 028.3 (45.482086)	293 364.2 (-76.646285)	129.8	28.2
OBR19-1	EBL O/P West Abutment	5 038 041.3 (45.482202)	293 345.5 (-76.646524)	129.9	26.9
OBR19-2	EBL O/P East Abutment	5 038 037.1 (45.482166)	293 370.9 (-76.646199)	129.8	25.2
OBR19-3	WBL O/P West Abutment	5 038 071.2 (45.482472)	293 371.2 (-76.646196)	129.9	30.5
OBR19-4	WBL O/P East Abutment	5 038 055.8 (45.482335)	293 400.5 (-76.645821)	130.2	28.9
OBR19-5	WBL O/P West Abutment	5 038 081.2 (45.482563)	293 388.9 (-76.645971)	129.8	25.3
OBR19-6	WBL O/P East Abutment	5 038 067.6 (45.482441)	293 414.2 (-76.645645)	130.0	25.2
OBR19-7	O'Brien Rd 10+050 Cut	5 038 025.6 (45.482061)	293 335.9 (-76.646647)	129.8	20.4
OBR19-8	O'Brien Rd 10+000 Cut	5 038 049.6 (45.482278)	293 383.7 (-76.646036)	130.0	20.4
OBR19-9	O'Brien Rd 9+950 Cut	5 038 085.1 (45.482598)	293 413.7 (-76.645653)	128.3	18.9
OBR19-10	WBL O/P West Abutment	5 038 072.3 (45.482482)	293 367.7 (-76.646241)	129.9	15.0
OBR19-11	EBL O/P East Abutment	5 038 038.5 (45.482178)	293 374.5 (-76.646153)	129.8	18.0
OBR19-12	W-S Ramp Cut	5 038 043.4 (45.482219)	293 182.2 (-76.648626)	131.5	12.8
OBR19-13	W-S Ramp Cut	5 038 088.3 (45.482623)	293 159.3 (-76.648907)	131.8	12.8
OBR19-14	W-S Ramp Cut	5 038 130.9 (45.483006)	293 126.1 (-76.649333)	132.2	14.3
OBR19-15	W-S Ramp Cut	5 038 164.8 (45.483311)	293 088.4 (-76.649816)	129.1	12.8



Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
OBR19-16	W-S Ramp Cut	5 038 190.7 (45.483542)	293 049.7 (-76.650316)	127.9	15.2
CV-7	W-S Ramp Fill / Culvert	5 037 953.0 (45.481406)	293 202.0 (-76.648358)	117.0	6.2
CV-8	W-S Ramp Fill / Culvert	5 037 972.4 (45.481581)	293 214.7 (-76.648196)	116.5	7.9
CV-9	W-S Ramp Fill / Culvert	5 038 001.6 (45.481843)	293 212.5 (-76.648224)	116.2	9.3

The current investigation was carried out using both truck and track-mounted CME 55 drill rigs equipped with hollow-stem augers and rotary diamond drilling equipment.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). In-situ vane shear testing was completed in cohesive soils with an MTO 'N' sized vane. Select boreholes were advanced approximately 3 m into bedrock, with NQ sized coring equipment.

Standpipe piezometers, 19 mm in diameter, were installed in Boreholes BRN-1, BRN-2, BRN-4, OBR19-1, OBR19-2, OBR19-6, OBR19-9, OBR19-12 and CV-8. Monitoring wells, 38 mm and 50 mm in diameter, were installed in Boreholes OBR19-3 and OBR19-15, respectively. The installation details are illustrated on the respective Record of Borehole sheets provided in Appendix B. The boreholes were backfilled in accordance with MOE requirements (O.Reg 903, as amended). The monitoring wells installed in 2019 are to be utilized during an upcoming hydrogeological study and will be subsequently decommissioned by Thurber.

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

Laboratory testing was selected in accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. At least 25% of the recovered soil samples were subjected to grain size distribution analysis and Atterberg limits tests, where appropriate. The testing was carried out 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 carried out on selected bedrock samples. Chemical analysis for determination of pH, conductivity, resistivity, sulphide, sulphate and chloride was carried out on soil samples from Boreholes OBR19-1, OBR19-2, OBR19-4 and OBR19-5.



The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory 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. The SCPTu data is provided in Appendix E. 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. Cohesive soils from the 2019/2020 boreholes are described per current MTO protocols.

In general terms, the site was found to have a surficial layer of topsoil or asphalt/fill overlying a native silty clay to clayey silt deposit, which is underlain by a deposit of silty sand to sand with silt over glacial till over bedrock.

### **5.1 Topsoil**

Topsoil was encountered at surface in boreholes CV-8, and OBR19-12 through OBR19-16 which were drilled along the proposed W-S ramp and in boreholes OBR19-9, and BRN-2 through BRN-4 which were drilled north of the existing westbound lanes. Where encountered the topsoil thickness was found to range between 50 mm and 150 mm. The topsoil thickness may vary between or beyond the borehole locations.

### **5.2 Asphalt**

Asphalt was encountered in boreholes OBR19-1, OBR19-2, OBR19-3, OBR19-4, OBR19-5, OBR19-7, OBR19-8, BRN-1 and BRN-5 which were drilled through the existing paved shoulder or paved gore areas. The asphalt was found to range between 75 mm and 150 mm in thickness.

### **5.3 Fill**

A granular fill layer consisting of gravel with sand to silty sand with gravel was encountered at surface or below the asphalt in select boreholes on the existing highway platform near the intersection. A clay/silt/sand mixed fill was encountered either below the asphalt or upper granular fill in most boreholes drilled at the existing intersection. The underside of the granular fill was encountered at depths ranging from 0.8 m to 1.5 m (Elevations 128.3 m to 129.4 m). The thickness of the clay/silt/sand fill ranged from 0.6 m to 1.0 m and it extended to elevations ranging from 128.2 m to 129.1 m.

SPT tests conducted in the clay/silt/sand fill layer gave N-values ranging from 6 to 15 blows, indicating a firm to stiff consistency.



The moisture content of the fill samples tested ranged from 2 to 29%. The results of grain size analysis tests conducted on eight samples of the fill material are summarized below and are illustrated on Figures C1 to C2 in Appendix C.

**Summary of Grain Size Distribution Testing – Granular Fill**

Soil Particle	Percentage (%)
Gravel	34 – 57
Sand	38 – 57
Silt and Clay	4 – 18

**Summary of Grain Size Distribution Testing – Mixed Fill**

Soil Particle	Percentage (%)
Gravel	7 – 21
Sand	23 – 27
Silt	29 – 42
Clay	24 – 27

The results of Atterberg Limits testing carried out on the fines from two samples of the mixed clay/sand fill material are summarized below and are illustrated on Figure C16 in Appendix C. The laboratory results indicate that the fines from the mixed fill material is generally a clay of intermediate to low plasticity (CI to CL).

**Summary of Atterberg Limit Testing – Mixed Clay/Sand Fill**

Parameter	Value
Liquid Limit	32 – 39
Plastic Limit	17
Plasticity Index	15 – 22

**5.4 Silty Clay (CI/CH) to Clayey Silt (CL)**

A native deposit generally ranging in composition from silty clay to clayey silt was encountered below the fill or topsoil in Boreholes OBR19-1 through OBR19-9 and BRN-1 through BRN-5. Within these boreholes, this layer ranged in thickness from 7.1 m to 11.2 m with an underside elevation ranging from 117.4 m to 122.0 m. Sand and silty sand seams were noted throughout this deposit with thicknesses ranging from a few millimeters to upwards of 300 mm. The frequency of the sand seams increased with depth.

SPT tests conducted within this layer gave N-values ranging from weight of hammer to 23. In-situ shear vane tests in several locations indicated undrained shear strengths of 34 to greater than 100 kPa indicating a firm to very stiff consistency. Sensitivity ranged from 2.2 to 10.0.



The undrained shear strength of the deposit inferred from the SCPTu data ranged from about 50 to 200 kPa.

The moisture content of the samples tested ranged from 16 to 47%. The results of twenty-eight grain size analysis tests conducted on samples of this material are summarized below and are illustrated on Figures C3 to C7 in Appendix C.

#### Summary of Grain Size Distribution Testing – Silty Clay to Clayey Silt

Soil Particle	Percentage (%)
Gravel	0 – 1
Sand	0 – 24
Silt	50 – 70
Clay	22 – 48

The results of Atterberg Limits testing carried out on twenty-six samples of this material are summarized below and are illustrated on Figure C17 to C20 in Appendix C. The laboratory results indicate that the material is generally a silty clay of intermediate to low plasticity (CI to CL). There was one test result (OBR19-6 SS5) indicating a clay of high plasticity (CH) as well as one test result (BRN-3 SS10) indicating a silt/clayey silt (CL-ML). In general, the upper portion of this layer was found to have a higher plasticity than the lower portion. It should be noted in accordance with the MTO Guideline for Foundation Engineering Services (October 2020) this cohesive deposit could be described as a “clayey silt” where Atterberg limits tests indicate a CL material.

#### Summary of Atterberg Limit Testing – Silty Clay to Clayey Silt

Parameter	Value
Liquid Limit	19 – 57
Plastic Limit	13 – 22
Plasticity Index	5 – 35

### 5.5 Silty Sand to Sand with Silt to Gravel with Silt and Sand (SP-SM, SM, SW-SM, GP)

A glaciofluvial deposit of silty sand to sand with silt to gravel with silt and sand was encountered in all boreholes. This sand deposit was encountered beneath the clay/clayey silt in Boreholes OBR19-1 through OBR19-9 and BRN-1 through BRN-5 and at/near surface in Boreholes OBR19-12 through OBR19-16 and CV-7 through CV-9. In Boreholes OBR19-12, OBR19-13 and OBR19-14 this deposit had a noticeably greater gravel content with OBR19-14 having occasional to frequent cobbles. Clay seams were noted in numerous boreholes particularly in the upper portions of this unit. Silt layers were observed in Borehole BRN-2. Organic material was observed near ground surface in Borehole CV-8.

In the boreholes drilled in vicinity of the existing intersection which fully penetrated this layer, the thickness ranged from 8.5 m to 16.7 m and the underside of this layer ranged from elevation 103.3



m to 108.1 m. In boreholes drilled along the proposed W-S ramp the observed thicknesses ranged from 3.1 m to greater than 14.2 m and the underside elevation ranged from 110.9 m to 119.7 m.

SPT tests conducted in this layer gave N-values ranging from 2 to greater than 100 blows for 125 mm of penetration, indicating a very loose to very dense relative density, but was typically compact to dense.

The moisture content of this unit ranged from 3 to 44%. The results of grain size distribution testing carried out on forty-one samples of the sand are summarized below and are illustrated on Figures C8 to C14 in Appendix C.

#### Summary of Grain Size Distribution Testing – Glaciofluvial Sand

Soil Particle	Percentage (%)
Gravel	0 – 62
Sand	32 – 92
Silt and Clay	5 – 47

### 5.6 Clayey Silt (CL)

A clayey silt layer was observed beneath the silty sand to sand with silt in Borehole OBR 19-15. The layer was observed to be at least 3.3 m thick. The base was at elevation 116.4 m. There is silty sand below the clayey silt.

SPT test results ranged from 3 to 17. An undrained shear strength of 84 kPa was measured indicating a stiff consistency. The sensitivity was determined to be 8.0.

Moisture content test results ranged from 11% to 55%. The liquid limit was found to be 32% and the plastic limit 19%, indicating a CL classification, see Figure C21 in Appendix C. Grain size distribution test results on one sample indicated it contained 2% sand, 64% silt and 34% clay sized particles, see Figure C15 in Appendix C.

### 5.7 Gravel, Cobbles and Boulders, Glacial Till

A basal till deposit consisting of gravel, cobbles and boulders was encountered beneath the sand deposit in Boreholes OBR19-4, BRN-2, BRN-5 and CV-9. Penetration through this layer required the use of coring techniques. Where encountered the thickness ranged from 0.4 m to 3.3 m and the elevation of the underside of the layer ranged from 104.5 m to 110.5 m. Boulders up to 800 mm and 500 mm in size were cored in Boreholes OBR19-4 and BRN-2, respectively.

SPT tests were generally not completed due to the high frequency of cobbles and boulders. One SPT test was conducted at the surface of this layer in Borehole OBR19-4 and gave an N-value of 34, indicating a dense relative density for the soil matrix. This single sample was predominately gravel and had a moisture content of 5%.



## 5.8 Refusal and Bedrock

Boreholes OBR19-2, OBR19-5 and OBR19-6 were terminated on SPT refusal. Bedrock was proven by coring in Boreholes BRN-1, BRN-2, BRN-4, BRN-5, OBR19-1, OBR19-3, OBR19-4, CV-7, CV-8 and CV-9. The bedrock encountered consisted of slightly weathered to fresh, medium strong, white to grey marble. Photographs of the bedrock cores are provided in Appendix C. The following table summarizes the rock core quality:

**Summary of Rock Core Quality**

Parameter	Range	Average
Total Core Recovery (TCR), %	63 to 100	98
Solid Core Recovery (SCR), %	19 to 100	75
Rock Quality Designation (RQD), %	0 to 100	76
Fracture Index	0 to >10	-

Based on the average RQD value, the bedrock is classified as fair quality. Unconfined compressive strength (UCS) testing was carried out on three samples of the bedrock in Boreholes OBR19-1, OBR19-3 and OBR19-4; the results ranged from 36 MPa to 40 MPa. Based on the unconfined compressive strength testing the bedrock is medium strong. It should be noted that the UCS values provided on the 2003 borehole logs were estimated from point load tests which can significantly overestimate the bedrock strength.

A summary of the bedrock surface information is provided in Table 5-1 below:

**Table 5-1: Summary of Bedrock Depth/Elevation**

Borehole No.	Depth to Bedrock Surface (mbgs)	Bedrock Surface Elevation (m)
BRN1	23.9	105.9
BRN2	23.9	104.5
BRN4	24.5	103.9
BRN5	25.3	104.5
OBR19-1	23.2	106.7
OBR19-2	25.2*	104.6*
OBR19-3	26.6	103.3
OBR19-4	25.4	104.8
OBR19-5	25.3*	104.5*
OBR19-6	25.2*	104.8*
CV-7	3.1	113.9
CV-8	4.2	112.3
CV-9	5.7	110.5

**Note:** \* - Inferred from SPT Refusal, which could also occur due to boulders and cobbles



## 5.9 Groundwater

Standpipe piezometers and monitoring wells with diameters ranging from 19 mm to 50 mm were installed in eight of the current boreholes and three previously drilled boreholes. Groundwater levels recorded in the piezometers are presented in Table 5-2 below:

**Table 5-2: Summary of Groundwater Levels**

Borehole No.	Bottom of Screen Elevation (m)	Depth (mbgs)	Groundwater Elevation (m)	Date of Measurement
OBR19-1	106.7	19.3	110.6	2019.09.26
		19.3	110.6	2020.04.21
OBR19-2	104.6	19.9	109.9	2019.09.26
		19.6	110.2	2020.04.21
OBR19-3	103.3	20.1	109.8	2019.09.26
		20.1	109.8	2020.04.21
OBR19-6	105.0	20.1	109.9	2019.09.26
		20.2	109.8	2020.04.21
OBR19-9	109.9	Dry to 18.4	Dry to 109.9	2020.04.21
OBR19-12	118.8	Dry to 12.6	Dry to 118.9	2020.04.21
OBR19-15	119.8	8.0	121.1	2020.02.07
		Dry to 6.3	Dry to 122.8	2020.04.21
CV-8	112.3	Dry to 4.2	Dry to 112.3	2019.11.26
		3.6	112.9	2020.04.21
		Dry to 4.2	Dry to 112.3	2020.09.29
BRN-1	106.0	19.7	110.1	2003.10.22
		19.4	110.4	2003.12.16
		19.4	110.4	2004.02.04
BRN-2	101.0	19.3	109.1	2003.10.22
		19.1	109.3	2003.12.16
		18.9	109.5	2004.02.04
		19.3	109.1	2020.04.21
BRN-4	101.0	18.9	109.5	2003.12.16
		18.7	109.7	2004.02.04



At the time of the site visits and field investigation carried out for the proposed W-S Ramp crossing of the Bonnechere River tributary creek, east of O'Brien Road, nominal surficial creek flow, less than about 0.3 m deep, was observed.

These observations are considered short term and it should be noted that the groundwater level at the time of construction may be different 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.

### 5.10 Analytical Testing

Four samples of the native soils were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, resistivity and conductivity. The analysis results are summarized in Table 5-3. Copies of the test results are provided in Appendix C.

**Table 5-3: Results of Chemical Analysis**

<b>Borehole</b>	<b>OBR19-1</b>	<b>OBR19-2</b>	<b>OBR19-4</b>	<b>OBR19-5</b>	<b>CV-9</b>
Sample	SS5	SS3	SS4	SS3	SS3
Depth (m)	3.0 – 3.6	1.5 – 2.1	2.3 – 2.9	1.5 – 2.1	1.5 – 2.1
Chloride (µg/g)	277	36	434	74	11
Sulphate (µg/g)	35	13	53	2460	10
Sulphide (%)	0.03	0.03	0.03	0.03	< 0.02
pH (-)	7.4	7.6	7.6	7.9	8.0
Resistivity (Ohm-cm)	1,800	5,440	1,140	239	9,750
Conductivity (µS/cm)	555	184	876	4180	103



## 6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features. The as-drilled locations and ground surface elevation of the boreholes were surveyed by Thurber following completion of the field program. The elevation survey was carried out with reference to geodetic elevation benchmarks provided by the MTO.

Marathon Underground of Greely, Ontario and Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied and operated the drilling equipment and carried out the drilling, soil sampling, in-situ testing, piezometer installation and borehole decommissioning. ConeTec of Toronto, Ontario completed the cone penetration tests onsite. The field investigation was supervised on a full-time basis by Sean O'Bryan, Nick Weil and Michel Johnston of Thurber. Overall supervision of the investigation program was provided by Justin Gray, 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 Thurber's laboratory in Oakville. Analytical testing was completed by Parcel Laboratories in Ottawa.

Overall project management and direction of the field program was provided by Fred Griffiths, P.Eng. Interpretation of the factual data and preparation of this report were carried out by Justin Gray, P.Eng. and Fred Griffiths, P.Eng. The report was reviewed by P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



Justin Gray, P.Eng.  
Geotechnical Engineer



Matt Kennedy, M.Sc.(Eng.), P.Eng.  
Senior Geotechnical Engineer



Dr. Fred Griffiths, P.Eng.  
Senior Geotechnical Engineer,  
Senior Associate

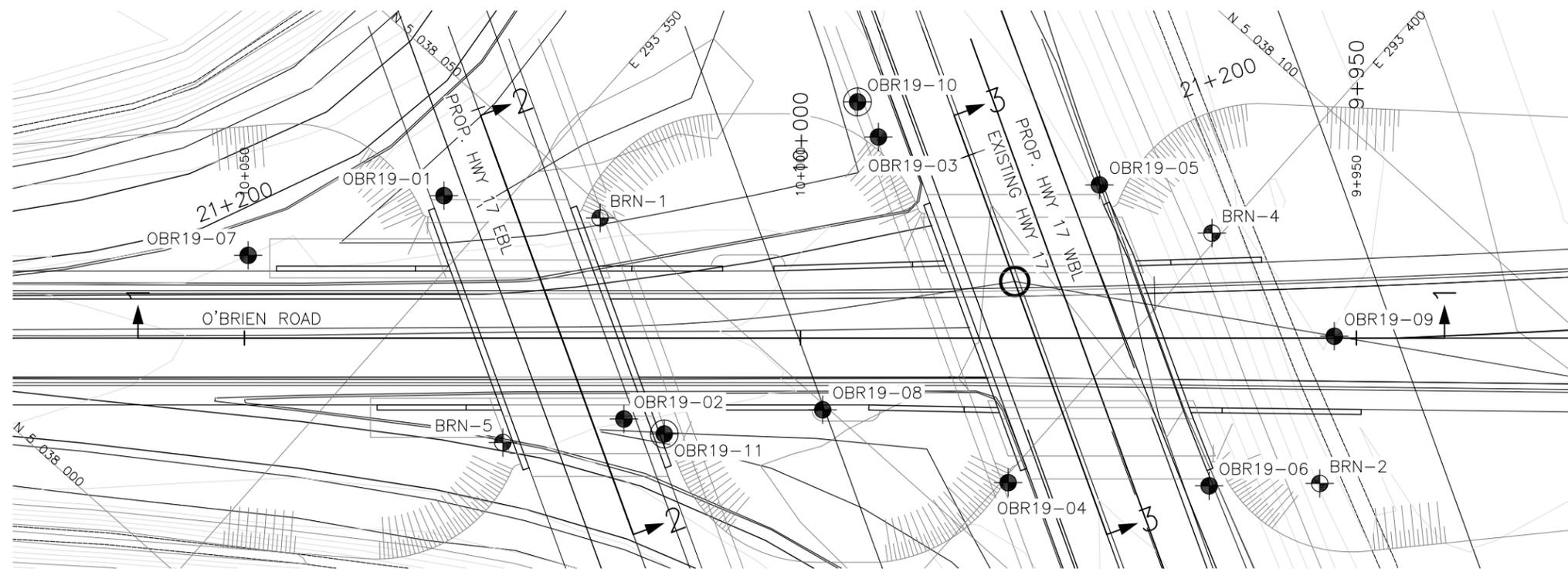


Dr. P.K. Chatterji, P.Eng.  
MTO Review Principal,  
Senior Geotechnical Engineer

**Appendix A.**

**Borehole Location Plan and Stratigraphic Drawings**

MINISTRY OF TRANSPORTATION, ONTARIO



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

LICENSED PROFESSIONAL ENGINEER

*F. J. GRIFFITHS*

Aug 20, 2021

PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER

*P. K. CHATTERJI*

Aug 20, 2021

PROVINCE OF ONTARIO

CONT No  
WP No 4068-09-00

HIGHWAY 17 TWINNING  
O'BRIEN ROAD  
BRIDGES  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Ontario

THURBER ENGINEERING LTD.

KEYPLAN

NO	ELEVATION	NORTHING	EASTING
BRN-2	128.4	5 038 074.4	293 421.5
BRN-4	128.4	5 038 084.7	293 399.3
BRN-5	129.8	5 038 028.3	293 364.2

**LEGEND**

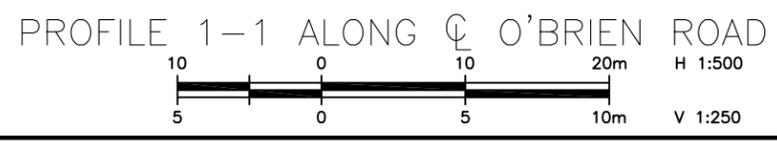
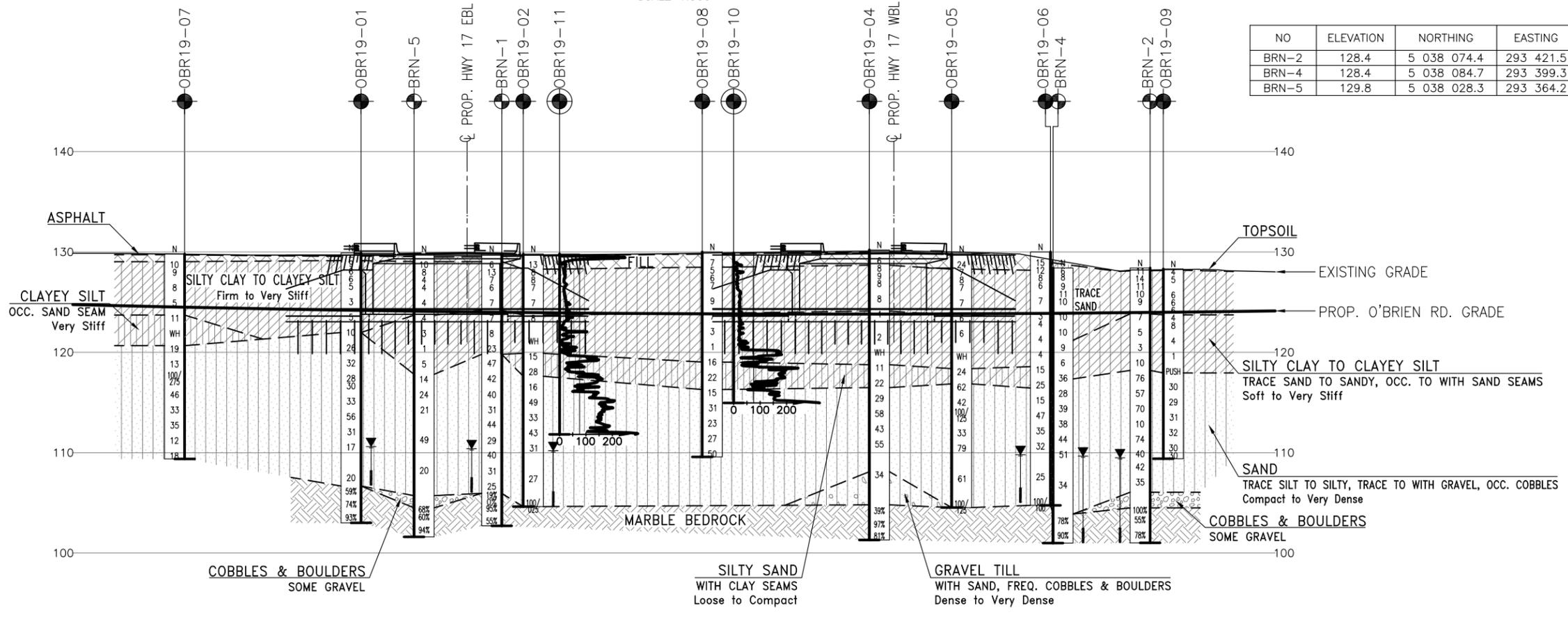
	Borehole/SCPT (2019 Investigation)
	Borehole (2003 Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
OBR19-01	129.9	5 038 041.3	293 345.5
OBR19-02	129.8	5 038 037.1	293 370.9
OBR19-03	129.9	5 038 071.2	293 371.2
OBR19-04	130.2	5 038 055.8	293 400.5
OBR19-05	129.8	5 038 081.2	293 388.9
OBR19-06	130.0	5 038 067.6	293 414.2
OBR19-07	129.8	5 038 025.6	293 335.9
OBR19-08	130.0	5 038 049.6	293 383.7
OBR19-09	128.3	5 038 085.1	293 413.7
OBR19-10	129.9	5 038 072.3	293 367.7
OBR19-11	129.8	5 038 038.5	293 374.5
BRN-1	129.8	5 038 049.1	293 357.3

**-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.

**GEORES No. 31F-216**



REVISIONS	DATE	BY	DESCRIPTION

DESIGN	JG	CHK -	CODE	LOAD	DATE	AUG 2021
DRAWN	MFA	CHK JG	SITE	STRUCT	DWG	1

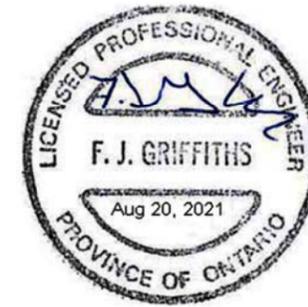
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METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

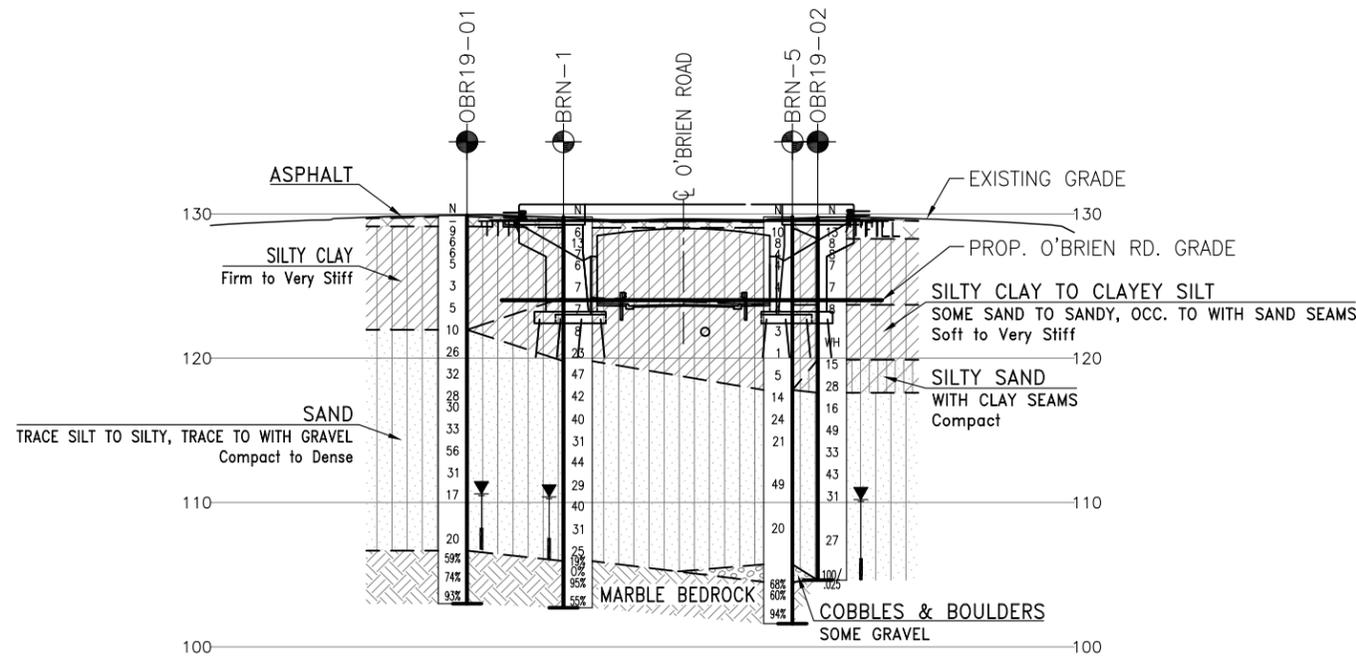
CONT No  
WP No 4068-09-00

HIGHWAY 17 TWINNING  
O'BRIEN ROAD  
BRIDGES  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



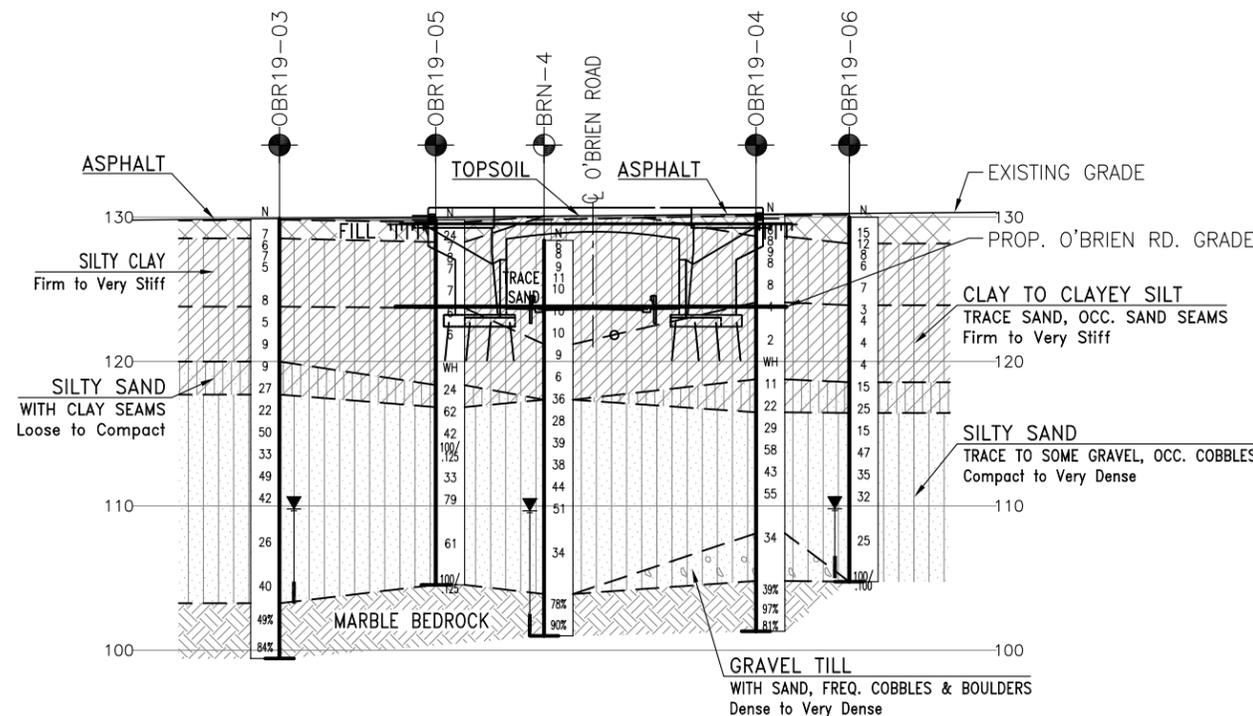
KEYPLAN



PROFILE 2-2 ALONG  $\phi$  HIGHWAY 17 EBL



NO	ELEVATION	NORTHING	EASTING
BRN-2	128.4	5 038 074.4	293 421.5
BRN-4	128.4	5 038 084.7	293 399.3
BRN-5	129.8	5 038 028.3	293 364.2



PROFILE 3-3 ALONG  $\phi$  HIGHWAY 17 WBL



LEGEND

- Borehole/SCPT (2019 Investigation)
- Borehole (2003 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
OBR19-01	129.9	5 038 041.3	293 345.5
OBR19-02	129.8	5 038 037.1	293 370.9
OBR19-03	129.9	5 038 071.2	293 371.2
OBR19-04	130.2	5 038 055.8	293 400.5
OBR19-05	129.8	5 038 081.2	293 388.9
OBR19-06	130.0	5 038 067.6	293 414.2
OBR19-07	129.8	5 038 025.6	293 335.9
OBR19-08	130.0	5 038 049.6	293 383.7
OBR19-09	128.3	5 038 085.1	293 413.7
OBR19-10	129.9	5 038 072.3	293 367.7
OBR19-11	129.8	5 038 038.5	293 374.5
BRN-1	129.8	5 038 049.1	293 357.3

-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.

GEORES No. 31F-216

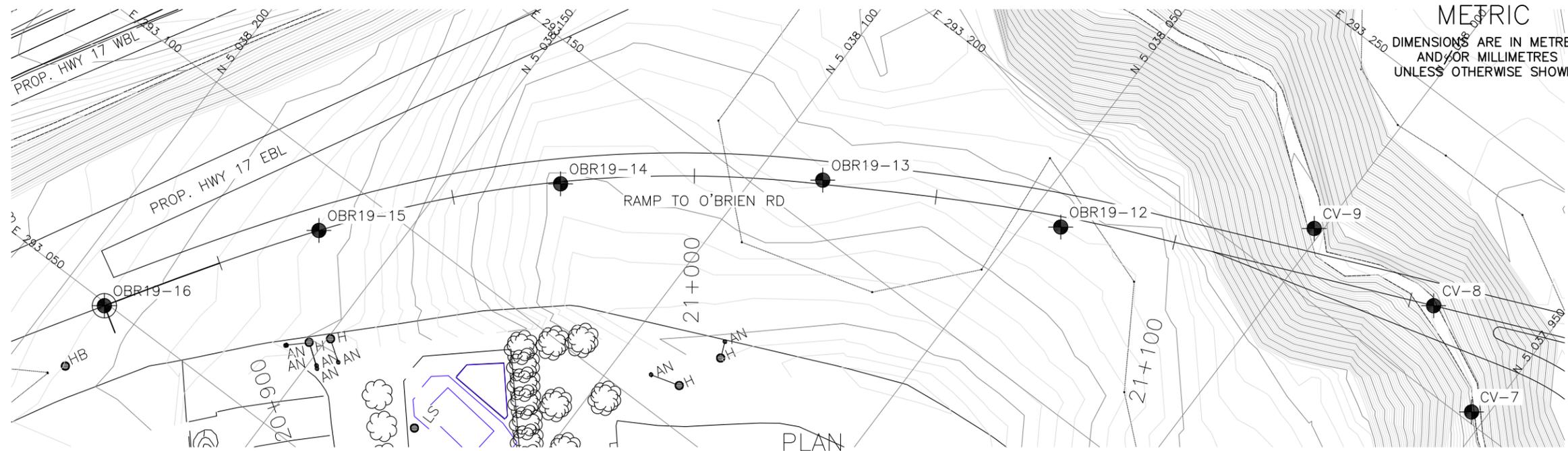
REVISIONS	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE	LOAD	DATE
JG	-			AUG 2021

DRAWN	CHK	SITE	STRUCT	DWG
MFA	JG			2



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

CONT No  
WP No 4068-09-00

HIGHWAY 17 TWINNING  
O'BRIEN ROAD  
W-S RAMP  
BOREHOLE LOCATIONS AND SOIL STRATA

**Ontario**



**KEYPLAN**

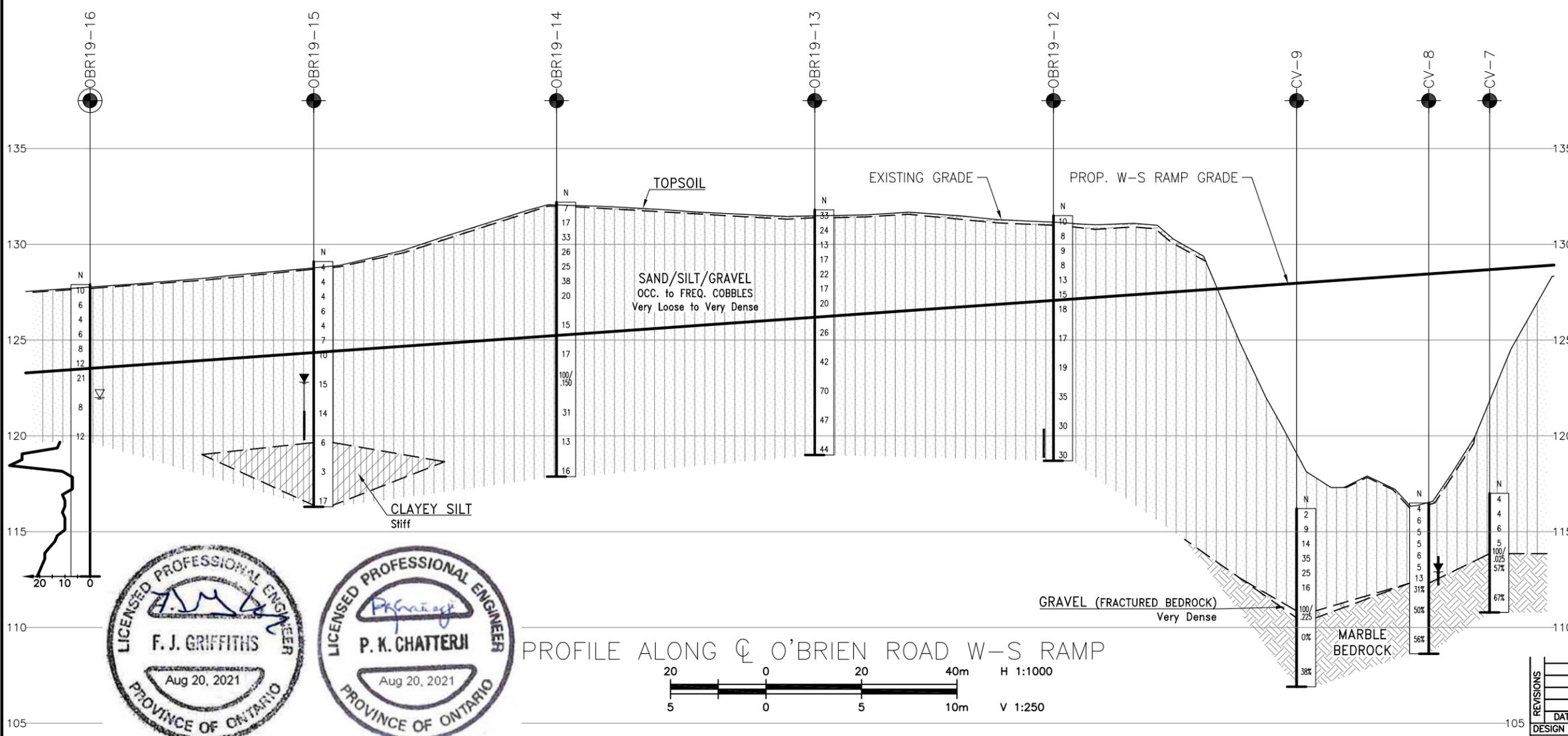
**LEGEND**

- Borehole/DCPT (2019 Investigation)
- Borehole (2003 Investigation)
- Blows /0.3m (Std Pen Test, 475J/blow)
- Blows /0.3m (60' Cone, 475J/blow)
- Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- Auger Refusal

NO	ELEVATION	NORTHING	EASTING
OBR19-12	131.5	5 038 043.4	293 181.2
OBR19-13	131.8	5 038 088.3	293 159.3
OBR19-14	132.2	5 038 130.9	293 126.1
OBR19-15	129.1	5 038 164.8	293 088.4
OBR19-16	127.9	5 038 190.7	293 049.4
CV-7	117.0	5 037 953.0	293 202.0
CV-8	116.5	5 037 972.4	293 214.7
CV-9	116.2	5 038 001.6	293 212.5

- 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. 31F-216**



PROFILE ALONG  $\phi$  O'BRIEN ROAD W-S RAMP



**REVISIONS**

NO	DATE	BY	DESCRIPTION

DESIGN: JG, CHK: MFA, CODE: SITE, LOAD: STRUCT, DATE: AUG 2021, 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).

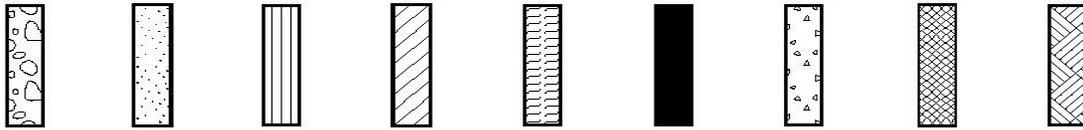
### DYNAMIC CONE PENETRATION TEST (DCPT):

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

**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 (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.

**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
<b>COARSE GRAINED SOIL</b>	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.
<b>FINE GRAINED SOILS</b>	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 clayey silts of low plasticity, gravelly clays, sandy 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.
<b>HIGHLY ORGANIC SOILS</b>		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 OBR19-01

1 OF 3

METRIC

WP# 4068-09-00 LOCATION O'Brien Road N 5 038 041.3 E 293 345.5 ORIGINATED BY SOB  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ coring COMPILED BY MW  
 DATUM Geodetic DATE 2019.09.09 - 2019.09.10 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80			100
129.9	Pavement Surface													
0.0 0.1	ASPHALT (75 mm)													
	CLAY (Cl) with sand and gravel Brown (FILL)		1	GS	-									21 23 29 27
129.1	SILTY CLAY (Cl) Very Stiff Brown		2	SS	9									
			3	SS	6									0 1 59 40
			4	SS	6									
			5	SS	5									
			6	SS	3									
			7	SS	5									0 7 56 37
122.0	SILTY SAND to SAND with silt Compact to Dense Brown		8	SS	10									
7.9			9	SS	26									0 86 14 (SI+CL)

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

Continued Next Page

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

### RECORD OF BOREHOLE No OBR19-01

2 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.482202°, Long: -76.646524°  
O'Brien Road N 5 038 041.3 E 293 345.5 ORIGINATED BY SOB  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ coring COMPILED BY MW  
 DATUM Geodetic DATE 2019.09.09 - 2019.09.10 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>			WATER CONTENT (%)
	Continued From Previous Page													
	SILTY SAND to SAND with silt Compact to Dense Brown		10	SS	32									
			11	SS	28									
			12	SS	30									
			13	SS	33									
			14	SS	56									0 91 9 (SI+CL)
			15	SS	31									
			16	SS	17									

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

Continued Next Page

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

### RECORD OF BOREHOLE No OBR19-01

3 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.482202°, Long: -76.646524° O'Brien Road N 5 038 041.3 E 293 345.5 ORIGINATED BY SOB  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ coring COMPILED BY MW  
 DATUM Geodetic DATE 2019.09.09 - 2019.09.10 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
Continued From Previous Page														
106.7	<b>SILTY SAND to SAND</b> with silt Compact to Dense Brown		17	SS	20									0 79 21 (SI+CL)
23.2	<b>MARBLE BEDROCK</b> Slightly Weathered to Fresh White, Grey and Red Medium Strong -Vertical fractures throughout  -Silt seam from 24.6 m to 24.8 m		1	RUN										FI 6 2 >10 3 1 4 1 3 3 3 1 0 0 3
103.0	<b>End of Borehole</b> Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2019.09.26 19.3 110.6 2020.04.21 19.3 110.6 2020.09.29 19.5 110.4		3	RUN										RUN #1 TCR=100% SCR=19% RQD=59% UCS=37.8MPa  RUN #2 TCR=100% SCR=70% RQD=74%  RUN #3 TCR=100% SCR=93% RQD=93%

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

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

### RECORD OF BOREHOLE No OBR19-02

1 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.482166°, Long: -76.646199° O'Brien Road N 5 038 037.1 E 293 370.9 ORIGINATED BY SOB  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA/NW casing COMPILED BY JP  
 DATUM Geodetic DATE 2019.09.11 - 2019.09.11 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT		
129.8	Pavement Surface												
0.0 0.1	ASPHALT (75 mm)												
129.0	GRAVEL with silt and sand Brown (FILL)		1	GS									57 38 5 (SH+CL)
0.8	CLAYEY SILT with sand Stiff Brown (FILL)		2	SS	13								
128.3	SILTY CLAY (CI) Very Stiff Brown to Grey		3	SS	8								
1.5			4	SS	8								
			5	SS	7								0 1 61 38
			6	SS	7								
123.7	CLAYEY SILT(CL) with sand seams Very Stiff Brown to Grey		7	SS	8								
6.1			8	SS	WH								0 4 59 37
119.9													

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

Continued Next Page

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



### RECORD OF BOREHOLE No OBR19-02

3 OF 3

METRIC

WP# 4068-09-00 LOCATION O'Brien Road N 5 038 037.1 E 293 370.9  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA/NW casing  
 DATUM Geodetic DATE 2019.09.11 - 2019.09.11

ORIGINATED BY SOB  
 COMPILED BY JP  
 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page													
	<b>SILTY SAND to SAND</b> with silt Compact to Dense Brown		16	SS	27									0 92 8 (SI+CL)
104.6	End of Borehole on Inferred Bedrock Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2019.09.26 19.9 109.9 2020.04.21 19.6 110.2 2020.09.29 19.9 109.9		17	SS	100/	25mm								

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

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





### RECORD OF BOREHOLE No OBR19-03

3 OF 4

METRIC

WP# 4068-09-00 LOCATION Lat: 45.482472°, Long: -76.646196° O'Brien Road N 5 038 071.2 E 293 371.2 ORIGINATED BY SOB  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA/NW casing/ NQ coring COMPILED BY JP  
 DATUM Geodetic DATE 2019.09.18 - 2019.09.19 CHECKED BY FG

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						
Continued From Previous Page														
103.3	<b>SILTY SAND (SM)</b> Compact to Dense Brown		16	SS	26		20	40	60	80	100			
26.6			17	SS	40		20	40	60	80	100			
	<b>MARBLE BEDROCK</b> Slightly Weathered Grey and White Medium Strong Coarse Grained		1	RUN										
			2	RUN										

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

Continued Next Page

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

RUN #1  
 TCR=100%  
 SCR=84%  
 RQD=49%

RUN #2  
 TCR=100%  
 SCR=97%  
 RQD=84%  
 UCS=39.7MPa

**RECORD OF BOREHOLE No OBR19-03**

4 OF 4

**METRIC**

WP# 4068-09-00 LOCATION Lat: 45.482472°, Long: -76.646196°  
O'Brien Road N 5 038 071.2 E 293 371.2 ORIGINATED BY SOB  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA/NW casing/ NQ coring COMPILED BY JP  
 DATUM Geodetic DATE 2019.09.18 - 2019.09.19 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	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						
99.4	Continued From Previous Page <b>MARBLE BEDROCK</b> Slightly Weathered Grey and White													
30.5	Medium Strong Coarse Grained  End of Borehole Monitoring well consists of 38mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2019.09.26 20.1 109.8 2020.04.21 20.1 109.8 2020.09.29 20.3 109.6													

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

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





**RECORD OF BOREHOLE No OBR19-04**

3 OF 3

**METRIC**

WP# 4068-09-00 LOCATION Lat: 45.482335°, Long: -76.645821°  
O'Brien Road N 5 038 055.8 E 293 400.5 ORIGINATED BY SOB  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ coring COMPILED BY MW  
 DATUM Geodetic DATE 2019.09.12 - 2019.09.13 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
Continued From Previous Page														
108.1	<b>SILTY SAND</b> Compact to Very Dense Brown													
22.1	<b>GRAVEL</b> with Sand, frequent cobbles and boulders ( <b>TILL</b> ) Dense to Very Dense  - 800mm boulder at elevation 107.4 m		16	SS	34									
104.8	<b>MARBLE BEDROCK</b> Slightly Weathered to Fresh Grey Medium Strong Coarse Grained, some banding		1	RUN										
25.4			2	RUN										
			3	RUN										
101.3														
28.9	End of Borehole													

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

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



### RECORD OF BOREHOLE No OBR19-05

2 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.482563°, Long: -76.645971° O'Brien Road N 5 038 081.2 E 293 388.9 ORIGINATED BY SOB  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA/NW casing COMPILED BY JP  
 DATUM Geodetic DATE 2019.09.16 - 2019.09.16 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT		
	Continued From Previous Page												
118.4	<b>SILTY CLAY (CI)</b> , occasional sand seam Very Stiff Brown to Grey		9	SS	WH								
11.4	<b>SILTY SAND</b> with clay seams Compact Brown		10	SS	24								
116.8	<b>SILTY SAND</b> with gravel Dense to Very Dense Brown		11	SS	62								30 50 20 (SI+CL)
			12	SS	42								
			13	SS	100/ 125mm								
			14	SS	33								
			15	SS	79								

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

Continued Next Page

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

### RECORD OF BOREHOLE No OBR19-05

3 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.482563°, Long: -76.645971°  
O'Brien Road N 5 038 081.2 E 293 388.9 ORIGINATED BY SOB  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA/NW casing COMPILED BY JP  
 DATUM Geodetic DATE 2019.09.16 - 2019.09.16 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
Continued From Previous Page						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE WATER CONTENT (%) 20 40 60								
107.7	SILTY SAND with gravel Dense to Very Dense Brown													
22.1	SILTY SAND Very Dense Grey		16	SS	61									0 88 12 (SI+CL)
104.5			17	SS	100/									
25.3	End of Borehole on Inferred Bedrock				125mm									

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29



### RECORD OF BOREHOLE No OBR19-06

2 OF 3

METRIC

WP# 4068-09-00 LOCATION O'Brien Road N 5 038 067.6 E 293 414.2  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA/NW casing  
 DATUM Geodetic DATE 2019.09.17 - 2019.09.17  
 ORIGINATED BY SOB  
 COMPILED BY JP  
 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w
Continued From Previous Page																
118.6	CLAYEY SILT (CL), occasional sand seam Very Stiff Brown		10	SS	4								o			
114	SILTY SAND with clay seams Compact Brown		11	SS	15									o		
116.4			12	SS	25								o			0 53 35 12
13.6	SILTY SAND Compact to Dense Brown		13	SS	15									o		
			14	SS	47								o			0 82 18 (SI+CL)
			15	SS	35									o		
			16	SS	32								o			

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

Continued Next Page

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







**RECORD OF BOREHOLE No OBR19-07 3 OF 3 METRIC**

WP# 4068-09-00 LOCATION Lat: 45.482061°, Long: -76.646647° ORIGINATED BY SOB  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA COMPILED BY MW  
 DATUM Geodetic DATE 2019.09.09 - 2019.09.09 CHECKED BY FG

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	Continued From Previous Page															
109.4	Silty SAND Compact to Very Dense Brown		15	SS	18											
20.4	End of Borehole															

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

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

### RECORD OF BOREHOLE No OBR19-08

1 OF 3

METRIC

WP# 4068-09-00 LOCATION O'Brien Road N 5 038 049.6 E 293 383.7 ORIGINATED BY SOB  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA COMPILED BY MW  
 DATUM Geodetic DATE 2019.09.11 - 2019.09.11 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
130.0	Pavement Surface														
0.0 0.1	ASPHALT (75 mm)														
129.2	SAND with silt and gravel Compact Brown (FILL)		1	GS										43 51 6 (SH+CL)	
0.8	CLAY with sand Firm Brown (FILL)		2	SS	7		129								
128.5	SILTY CLAY (CI) Very Stiff Brown		3	SS	5		128								
1.5			4	SS	6		127								
			5	SS	7									0 1 59 40	
			6	SS	9		126								
							125								
							124								
123.9	CLAYEY SILT (CL) Stiff to Very Stiff Brown		7	SS	7		123								
6.1			8	SS	3		122								
							121								
			9	SS	1										

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

Continued Next Page

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



**RECORD OF BOREHOLE No OBR19-08**

3 OF 3

**METRIC**

WP# 4068-09-00 LOCATION Lat: 45.482278°, Long: -76.646036° ORIGINATED BY SOB  
 HWY 17 BOREHOLE TYPE CME 55 Truckmount, HSA COMPILED BY MW  
 DATUM Geodetic DATE 2019.09.11 - 2019.09.11 CHECKED BY FG

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
	Continued From Previous Page															
109.6	<b>SILTY SAND</b> Compact to Dense Brown		16	SS	50											
20.4	End of Borehole															

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

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



### RECORD OF BOREHOLE No OBR19-09

2 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.482598°, Long: -76.645653° O'Brien Road N 5 038 085.1 E 293 413.7 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE CME 55 Trackmount, HSA COMPILED BY JG  
 DATUM Geodetic DATE 2020.03.09 - 2020.03.10 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	20 40 60			
Continued From Previous Page															
117.9	SILTY SAND, with 50 mm clay seams Compact Brown		1	ST	PUSH		118								
10.4			10	SS	30										
			11	SS	29										
114.7	SAND with silt Compact to Dense Brown						115								
13.6			12	SS	31										
			13	SS	32										
			14	SS	30										
			15	SS	30										
109.4	End of Borehole Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2020.04.21 dry to 18.4m						110								
18.9															

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 2/17/29

Continued Next Page

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

**RECORD OF BOREHOLE No OBR19-09**

3 OF 3

**METRIC**

WP# 4068-09-00 LOCATION Lat: 45.482598°, Long: -76.645653°  
O'Brien Road N 5 038 085.1 E 293 413.7 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE CME 55 Trackmount, HSA COMPILED BY JG  
 DATUM Geodetic DATE 2020.03.09 - 2020.03.10 CHECKED BY FG

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ kn/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	20			40	60	80	100	W <sub>p</sub>					
	Continued From Previous Page 2020.09.29 18.4 109.9																	

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

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

### RECORD OF BOREHOLE No OBR19-12

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.482219°, Long: -76.648626° O'Brien Road W-S Ramp N 5 038 043.4 E 293 181.2 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE CME 55 Trackmount, HSA COMPILED BY JP  
 DATUM Geodetic DATE 2020.02.07 - 2020.02.07 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
131.5	Ground Surface													
0.0	TOPSOIL (150mm)													
0.2	SAND with silt to SAND with silt and gravel Loose to Dense Brown		1	SS	10							o		
			2	SS	8							o		
			3	SS	9							o		10 83 7 (SI+CL)
			4	SS	8							o		
			5	SS	13							o		
			6	SS	15							o		
			7	SS	18							o		22 69 9 (SI+CL)
			8	SS	17							o		
			9	SS	19							o		
			10	SS	35							o		

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

Continued Next Page

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

### RECORD OF BOREHOLE No OBR19-12

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.482219°, Long: -76.648626°  
O'Brien Road W-S Ramp N 5 038 043.4 E 293 181.2 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE CME 55 Trackmount, HSA COMPILED BY JP  
 DATUM Geodetic DATE 2020.02.07 - 2020.02.07 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page													
	<b>SAND</b> with silt to <b>SAND</b> with silt and gravel Loose to Dense Brown		11	SS	30									
118.7														
12.8	End of Borehole  Borehole Dry Upon Completion Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2020.04.21 dry to 12.6m 2020.09.29 dry to 12.6m													

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29



### RECORD OF BOREHOLE No OBR19-13

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.482623°, Long: -76.648907°  
O'Brien Road W-S Ramp N 5 038 088.3 E 293 159.3 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE CME 55 Trackmount, HSA COMPILED BY JP  
 DATUM Geodetic DATE 2020.02.06 - 2020.02.06 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa 20 40 60 80 100									
	Continued From Previous Page																
	SAND with silt to SAND with silt and gravel Compact to Very Dense Brown		11	SS	47		121										
								120									
119.0			12	SS	44												
12.8	End of Borehole Borehole dry upon completion						119										

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20  
15 10 5 0 (-) STRAIN AT FAILURE

### RECORD OF BOREHOLE No OBR19-14

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.483006°, Long: -76.649333° O'Brien Road W-S Ramp N 5 038 130.9 E 293 126.1 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE CME 55 Trackmount, HSA COMPILED BY JP  
 DATUM Geodetic DATE 2020.02.05 - 2020.02.05 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80			100
132.2	Ground Surface													
0.9	TOPSOIL (50 mm)													
	Silty SAND Loose to Compact Brown		1	SS	7									
			2	SS	17									
130.7														
1.5	SAND with silt and gravel to GRAVEL with silt and sand Occasional to Frequent Cobbles Compact to Very Dense Brown		3	SS	33									
			4	SS	26									
			5	SS	25									
			6	SS	38									
	-grinding while augering		7	SS	20									
			8	SS	15									
	-poor sample recovery below elevation 126 m		9	SS	17									
			10	SS	100/ 150mm									
	-very heavy grinding while augering													

36 55 9  
(SH+CL)

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

Continued Next Page

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



### RECORD OF BOREHOLE No OBR19-15

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.483311°, Long: -76.649816° O'Brien Road W-S Ramp N 5 038 164.8 E 293 088.4 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE CME 55 Trackmount, HSA COMPILED BY JP  
 DATUM Geodetic DATE 2020.02.06 - 2020.02.06 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
129.1	Ground Surface													
0.0	TOPSOIL (50 mm)													
	SILTY SAND to SAND with silt Loose to Compact Brown		1	SS	4							o		
			2	SS	4							o		
			3	SS	4							o		
			4	SS	6							o		
			5	SS	4							o		
			6	SS	7							o		
			7	SS	10							o		
			8	SS	15							o		
			9	SS	14							o		
			10	SS	6							o		
119.7	CLAYEY SILT (CL) Stiff Brown												o	

0 85 15  
(SI+CL)

3 86 11  
(SI+CL)

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

Continued Next Page

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

### RECORD OF BOREHOLE No OBR19-15

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.483311°, Long: -76.649816° O'Brien Road W-S Ramp N 5 038 164.8 E 293 088.4 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE CME 55 Trackmount, HSA COMPILED BY JP  
 DATUM Geodetic DATE 2020.02.06 - 2020.02.06 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
	Continued From Previous Page														
	<b>CLAYEY SILT (CL)</b> Stiff Brown		11	SS	3		119								
							118							0 2 64 34	
							117		8.0						
116.4			12	SS	17										
116.3	<b>SILTY SAND</b> Compact Brown														
12.8	End of Borehole Monitoring well consists of 50mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2020.02.07 8.0 121.1 2020.04.21 6.3 122.8 2020.09.29 6.9 122.2														

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

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



### RECORD OF BOREHOLE No OBR19-16

2 OF 2

**METRIC**

WP# 4068-09-00 LOCATION Lat: 45.483542°, Long: -76.650316°  
O'Brien Road W-S Ramp N 5 038 190.7 E 293 049.4 ORIGINATED BY NW  
 HWY 17 BOREHOLE TYPE CME 55 Trackmount, HSA COMPILED BY JP  
 DATUM Geodetic DATE 2020.02.05 - 2020.02.05 CHECKED BY FG

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	20			40	60	80	100					
	Continued From Previous Page																
	DCPT continued																
112.7	DCPT ended																
15.2	End of Borehole																

DOUBLE LINE 24726 O'BRIEN ROAD GINT.GPJ 2012TEMPLATE(MTO).GDT 21/7/29

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

### RECORD OF BOREHOLE No CV-7

1 OF 1

**METRIC**

WP# 4068-09-00 LOCATION Lat: 45.481406°, Long: -76.648358°  
Culvert 21+155 Ramp N 5 037 953.0 E 293 202.0 ORIGINATED BY MJJ  
 HWY 17 BOREHOLE TYPE CME45 Track COMPILED BY MW  
 DATUM Geodetic DATE 2019.10.15 - 2019.10.15 CHECKED BY FG

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
						20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>				
117.0	<b>SAND</b> with silt Very Loose to Loose Brown		1	SS	4												
			2	SS	4												
			3	SS	6												
			4	SS	5												
113.9			5	SS	100/												
3.1	<b>MARBLE BEDROCK</b> Slightly Weathered Grey and White Medium Strong to Strong Highly fractured with calcite infill from 3.6 m to 3.8 m		1	RUN	25 mm												
			2	RUN													
110.8																	
6.2	End of Borehole																

DOUBLE LINE 24726 CULVERT 21+055 RAMP GINT.GPJ 2012TEMPLATE(MTO).GDT 6/5/20

### RECORD OF BOREHOLE No CV-8

1 OF 1

**METRIC**

WP# 4068-09-00 LOCATION Lat: 45.481581°, Long: -76.648196°  
Culvert 21+155 Ramp N 5 037 972.4 E 293 214.7 ORIGINATED BY MJJ  
 HWY 17 BOREHOLE TYPE CME45 Track COMPILED BY MW  
 DATUM Geodetic DATE 2019.10.16 - 2019.10.16 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20
116.5																		
0.0	<b>TOPSOIL</b>																	
0.1	Silty SAND, organics to 1.2 m Loose Brown		1	SS	4													2 76 22 (SI+CL)
			2	SS	6													
			3	SS	5													
			4	SS	5													
			5	SS	6													
			6	SS	5													
			7	SS	13													1 78 21 (SI+CL)
112.3	<b>MARBLE BEDROCK</b> Slightly Weathered White/Grey Medium Strong to Strong Foliated		1	RUN														RUN #1 TCR=100% SCR=77% RQD=31%
4.2			2	RUN														RUN #2 TCR=100% SCR=100% RQD=50%
			3	RUN														RUN #3 TCR=100% SCR=90% RQD=56%
108.6	End of Borehole Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.5m slotted screen WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2019.11.26 dry - 2020.04.21 3.6 112.9																	
7.9																		

DOUBLE LINE 24726 CULVERT 21+055 RAMP GINT.GPJ 2012TEMPLATE(MTO).GDT 6/5/20

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

### RECORD OF BOREHOLE No CV-9

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Lat: 45.481843°, Long: -76.648224° Culvert 21+155 Ramp N 5 038 001.6 E 293 212.5 ORIGINATED BY MJJ  
 HWY 17 BOREHOLE TYPE CME45 Track COMPILED BY MW  
 DATUM Geodetic DATE 2019.10.15 - 2019.10.15 CHECKED BY FG

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
					20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)			GR SA SI CL
					20 40 60 W P W W L PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT								
116.2													
0.0	<b>SILTY SAND</b> , trace gravel Very Loose to Dense Brown	1	SS	2									
		2	SS	9								7 75 18 (SI+CL)	
		3	SS	14									
		4	SS	35								4 82 14 (SI+CL)	
		5	SS	25									
		6	SS	16									
110.9													
5.3	<b>GRAVEL</b> , (fractured bedrock) Very Dense Black/Grey/Red	7	SS	100/								FI	
110.5				225 mm								>10	
5.7	<b>MARBLE BEDROCK</b> Slightly Weathered White/Grey medium strong Moderately fractured Moderately weathered from 5.9 m to 7.7 m	1	RUN									>10	RUN #1 TCR=63% SCR=31% RQD=0%
												>10	
												7	
												8	
												9	
												6	
												7	
		2	RUN									6	RUN #2 TCR=100% SCR=67% RQD=38%
												5	
												8	
106.9													
9.3	End of Borehole												

DOUBLE LINE 24726 CULVERT 21+055 RAMP GINT.GPJ 2012TEMPLATE(MTO).GDT 6/5/20



### RECORD OF BOREHOLE No BRN-1

2 OF 3

METRIC

G.W.P. 647-92-00 LOCATION (N 5 038 049.1 E 293 357.3) O'Brien Road ORIGINATED BY JL  
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, Casing and Washboring, NQ Coring COMPILED BY SS  
 DATUM Geodetic DATE 06.10.03 - 07.10.03 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w		
10.0	<b>SAND</b> , trace silt, trace to some gravel Dense Brown Moist to Wet (SP)           Compact, wet		9	SS	47		119					18 56 26 (SI+CL)
			10	SS	42		118					
			11	SS	40		117					
			12	SS	31		116					
			13	SS	44		115					
			14	SS	29		114					
							113					
							112					
							111					
							110					

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Continued Next Page

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

### RECORD OF BOREHOLE No BRN-1

3 OF 3

METRIC

G.W.P. 647-92-00 LOCATION (N 5 038 049.1 E 293 357.3) O'Brien Road ORIGINATED BY JL  
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, Casing and Washboring, NQ Coring COMPILED BY SS  
 DATUM Geodetic DATE 06.10.03 - 07.10.03 CHECKED BY AEG

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			T <sub>N</sub> VALUES	20	40					
			15	SS	40									
						109								
			16	SS	31									
						108								
106.9						107								
22.9	Silty SAND, trace gravel Compact Grey Wet (SM)		17	SS	25									
105.9						106								
23.9	MARBLE (BEDROCK) Fresh to slightly weathered, light grey, moderately strong		1	RUN									FI	RUN 1# TCR=100%, SCR=81%, RQD=19%, UCS=46.4MPa
			2	RUN									3	RUN 2# TCR=100%, SCR=57%, RQD=0%, UCS=MPa
			3	RUN									1	RUN 3# TCR=97%, SCR=83%, RQD=95%, UCS=56.5MPa
			4	RUN									1	RUN 4# TCR=100%, SCR=89%, RQD=55%, UCS=73.7MPa
						105								
						104								
						103								
102.7														
27.1	END OF BOREHOLE AT 27.09m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													
	WATER LEVEL READINGS DATE DEPTH (m) 22/10/03 19.72 16/12/03 19.38 04/02/04 19.41													

ONTMT4 7450BRN.GPJ 19/08/04

+<sup>3</sup> × 3<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15 5  
 10 (%) STRAIN AT FAILURE

### RECORD OF BOREHOLE No BRN-2

1 OF 3

METRIC

G.W.P. 647-92-00 LOCATION (N 5 038 074.4 E 293 421.5) O'Brien Road ORIGINATED BY SL  
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, Casing and Washboring, NQ Coring COMPILED BY SS  
 DATUM Geodetic DATE 01.10.03 - 02.10.03 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT		
128.4 128.8 0.1	<b>TOPSOIL (50mm)</b> Silty CLAY, trace rootlets to 1.4m Very Stiff to Stiff Brown Moist to Wet (CI)		1	SS	11							
			2	SS	14							
			3	SS	11							
			4	SS	10							
	with sand laminations		5	SS	9							
123.8			6	SS	7							0 8 70 22
4.6	Silty CLAY with interbedded silty sand Firm Brown Wet (CL)		7	SS	5							
	becoming grey below 6.1m		8	SS	3							
			9	SS	10							0 17 56 27

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Continued Next Page

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

### RECORD OF BOREHOLE No BRN-2

2 OF 3

METRIC

G.W.P. 647-92-00 LOCATION (N 5 038 074.4 E 293 421.5) O'Brien Road ORIGINATED BY SL  
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, Casing and Washboring, NQ Coring COMPILED BY SS  
 DATUM Geodetic DATE 01.10.03 - 02.10.03 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W			LIQUID LIMIT W <sub>L</sub>	
118.2														
10.2	SAND, fine grained, trace silt, trace gravel Very Dense to Dense Brown Moist to Wet (SP)		10	SS	76									
					11	SS	57							
					12	SS	70							0 90 6 4
					13	SS	10							
	some silt (SM) Compact													
			14	SS	74									
110.1														
18.3	SAND, trace silt, occasional silt and silty sand layers Dense Brown Wet  (SP/SM)		15	SS	40							0 60 33 7		
			16	SS	42									

ONTMT4 7450BRN GPJ 19/08/04

Continued Next Page

+<sup>3</sup> × 3 : Numbers refer to Sensitivity  $\frac{20}{15} \frac{5}{10}$  (%) STRAIN AT FAILURE

### RECORD OF BOREHOLE No BRN-2

3 OF 3

METRIC

G.W.P. 647-92-00 LOCATION (N 5 038 074.4 E 293 421.5) O'Brien Road ORIGINATED BY SL  
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, Casing and Washboring, NQ Coring COMPILED BY SS  
 DATUM Geodetic DATE 01.10.03 - 02.10.03 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
106.0	medium grained, with silty fine sand seams  Auger refusal at 22.4m.		17	SS	35										
22.4	<b>Cobbles and Boulders</b> , some gravel, maximum size 500mm		1	RUN											
104.5			2	RUN											
23.9	<b>MARBLE (BEDROCK)</b> Fresh to slightly weathered, light grey, strong		3	RUN											
			4	RUN											
			5	RUN											
101.0	<b>END OF BOREHOLE AT 7.57m.</b> Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 2.13m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) 22/10/03 19.30 16/12/03 19.08 04/02/04 18.91														

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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  $\frac{20}{15} \times \frac{5}{10}$  (%) STRAIN AT FAILURE

### RECORD OF BOREHOLE No BRN-4

1 OF 3

METRIC

G.W.P. 647-92-00 LOCATION (N 5 038 084.7 E 293 399.3) O'Brien Road ORIGINATED BY SL  
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, Casing and Washboring, NQ Coring COMPILED BY SS  
 DATUM Geodetic DATE 02.12.03 - 03.12.03 CHECKED BY AEG

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	W <sub>P</sub>
128.4 0.0	TOPSOIL (100mm)																	
128.1 0.3	Silty CLAY, trace sand Firm Brown Moist (CI)		1	SS	6													
			2	SS	8													
	Stiff below 1.5m depth		3	SS	9													
			4	SS	11													
	occasional oxide staining		5	SS	10													0 0 54 45
			6	SS	10													
			7	SS	10													
121.2 7.2	Silty CLAY, trace sand Stiff to Firm Brown Moist (CL)		8	SS	9													
			9	SS	6													0 10 57 33
	with thin sand seams below 9.1m																	

ONTMT4\_7450BRN.GPJ 19/08/04

Continued Next Page

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



## RECORD OF BOREHOLE No BRN-4 3 OF 3 METRIC

G.W.P. 647-92-00 LOCATION (N 5 038 084.7 E 293 399.3) O'Brien Road ORIGINATED BY SL  
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, Casing and Washboring, NQ Coring COMPILED BY SS  
 DATUM Geodetic DATE 02.12.03 - 03.12.03 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60						80
								SHEAR STRENGTH kPa								
								○ UNCONFINED + FIELD VANE								
								● QUICK TRIAXIAL × LAB VANE								
								20	40	60	80	100	20	40	60	GR SA SI CL
106.6	Silty SAND, trace gravel, occasional cobbles Dense Grey Moist		16	SS	34										1 86 13 (S+CL)	
21.8																
103.9																
24.5	MARBLE (BEDROCK) Fresh to slightly weathered, light grey, strong		1	RUN											4 RUN 1# TCR=96%, SCR=81%, RQD=78%, UCS=92.7MPa	
103.9																3 RUN 2# TCR=100%, SCR=100%, RQD=90%, UCS=80.1MPa
101.0	END OF BOREHOLE AT 27.41m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 2.13m slotted screen.															
27.4																
	WATER LEVEL READINGS: DATE DEPTH (m) 04/02/04 18.74 16/12/03 18.90															

ONTMT4\_7450BRN.GPJ 19/08/04

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

### RECORD OF BOREHOLE No BRN-5

1 OF 3

METRIC

G.W.P. 647-92-00 LOCATION (N 5 038 028.3 E 293 364.2) O'Brien Road ORIGINATED BY JL  
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, Casing and Washboring, NQ Coring COMPILED BY SS  
 DATUM Geodetic DATE 17.12.03 - 17.12.03 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W P	W					
129.8	ASPHALT (150 mm)	[Hatched]													
0.2	Clayey SILT, sandy, some gravel Dark Brown (FILL)	[Cross-hatched]	1	GS											
129.0	Silty CLAY, occasional oxide staining Stiff to Firm Brown (CI)  some sand seams/ partings below 3.0m	[Diagonal lines]	1	SS	10										
			2	SS	8										
			3	SS	4										0 1 52 47
			4	SS	4										
			5	SS	4										
123.7	Silty CLAY, some sand to sandy, occasional sand seams Firm to Soft Brown-Grey (CL)	[Diagonal lines]	6	SS	4										
6.1			7	SS	3										
			8	SS	1										0 12 54 34

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Continued Next Page

+<sup>3</sup> × 3: Numbers refer to Sensitivity  
 20  
 15 5  
 10 (%) STRAIN AT FAILURE

### RECORD OF BOREHOLE No BRN-5

2 OF 3

METRIC

G.W.P. 647-92-00 LOCATION (N 5 038 028.3 E 293 364.2) O'Brien Road ORIGINATED BY JL  
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, Casing and Washboring, NQ Coring COMPILED BY SS  
 DATUM Geodetic DATE 17.12.03 - 17.12.03 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60						80
117.8	SAND, fine to medium grained, trace to some silt Compact Brown (SP)		9	SS	5											
118																
117																
116					11	SS	24									0 80 20 (SI+CL)
115																
114					12	SS	21									
113																
112																
111	occasional gravel		13	SS	49									Casing with washboring		
110																

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Continued Next Page

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

**RECORD OF BOREHOLE No BRN-5**

3 OF 3

**METRIC**

G.W.P. 647-92-00 LOCATION (N 5 038 028.3 E 293 364.2) O'Brien Road ORIGINATED BY JL  
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, Casing and Washboring, NQ Coring COMPILED BY SS  
 DATUM Geodetic DATE 17.12.03 - 17.12.03 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20	40	60					
105.7			14	SS	20										
24.1	Cobbles and Boulders, some gravel Start coring at 24.97m.														
104.5															
25.3	MARBLE (BEDROCK) Fresh to slightly weathered, light grey, strong		1	RUN										1 RUN 1# TCR=100%, SCR=92%, RQD=68%, UCS=70.6MPa	
			2	RUN										2 RUN 2# TCR=96%, SCR=94%, RQD=60%, UCS=55.8MPa	
			3	RUN										1 RUN 3# TCR=98%, SCR=98%, RQD=94%, UCS=95.2MPa	
101.6															
28.2	END OF BOREHOLE AT 28.19 m.														

ONTMT4 7450BRN.GPJ 19/08/04

+<sup>3</sup>, x<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15 5  
 10 (%) STRAIN AT FAILURE

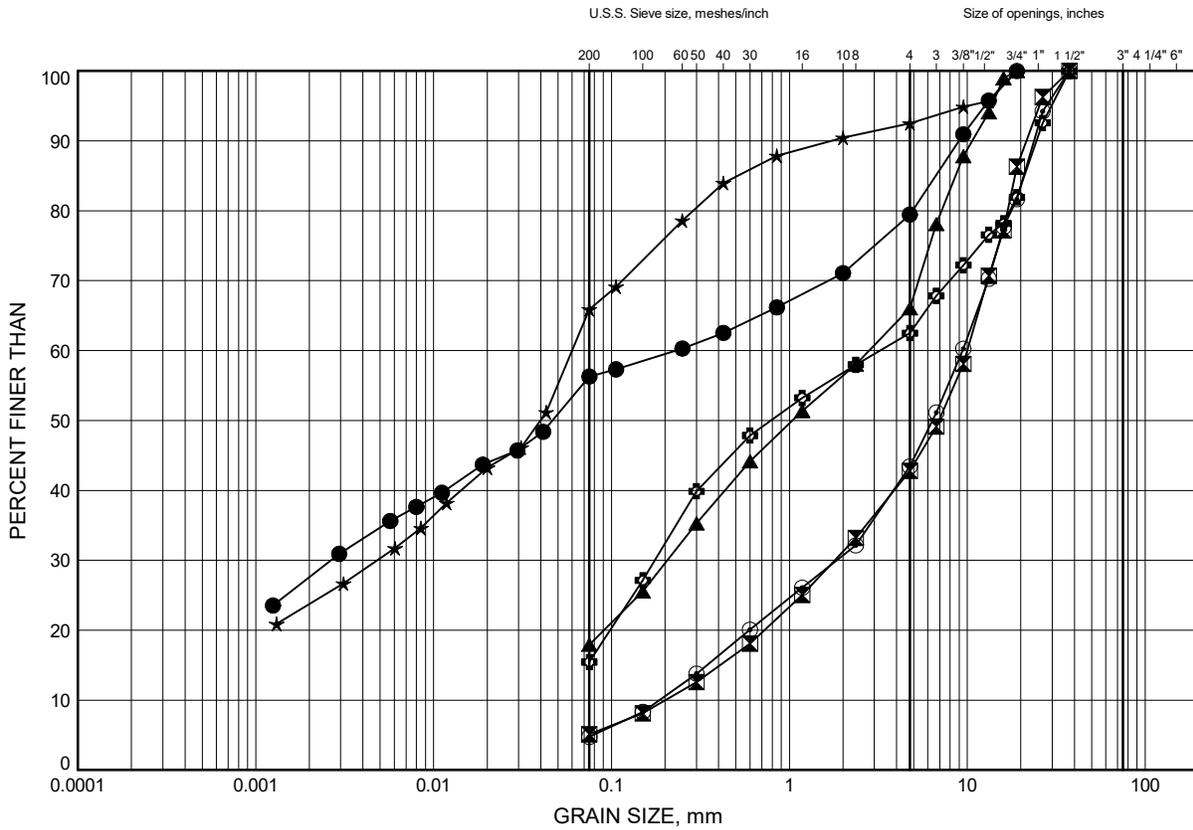
**Appendix C.**  
**Laboratory Testing**

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

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C1

## Fill



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-01	0.4	129.5
⊠	OBR19-02	0.4	129.4
▲	OBR19-03	0.4	129.5
★	OBR19-03	1.1	128.8
⊙	OBR19-04	0.4	129.8
⊕	OBR19-05	1.1	128.7

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 14/4/20

Date April 2020  
WP# 4068-09-00

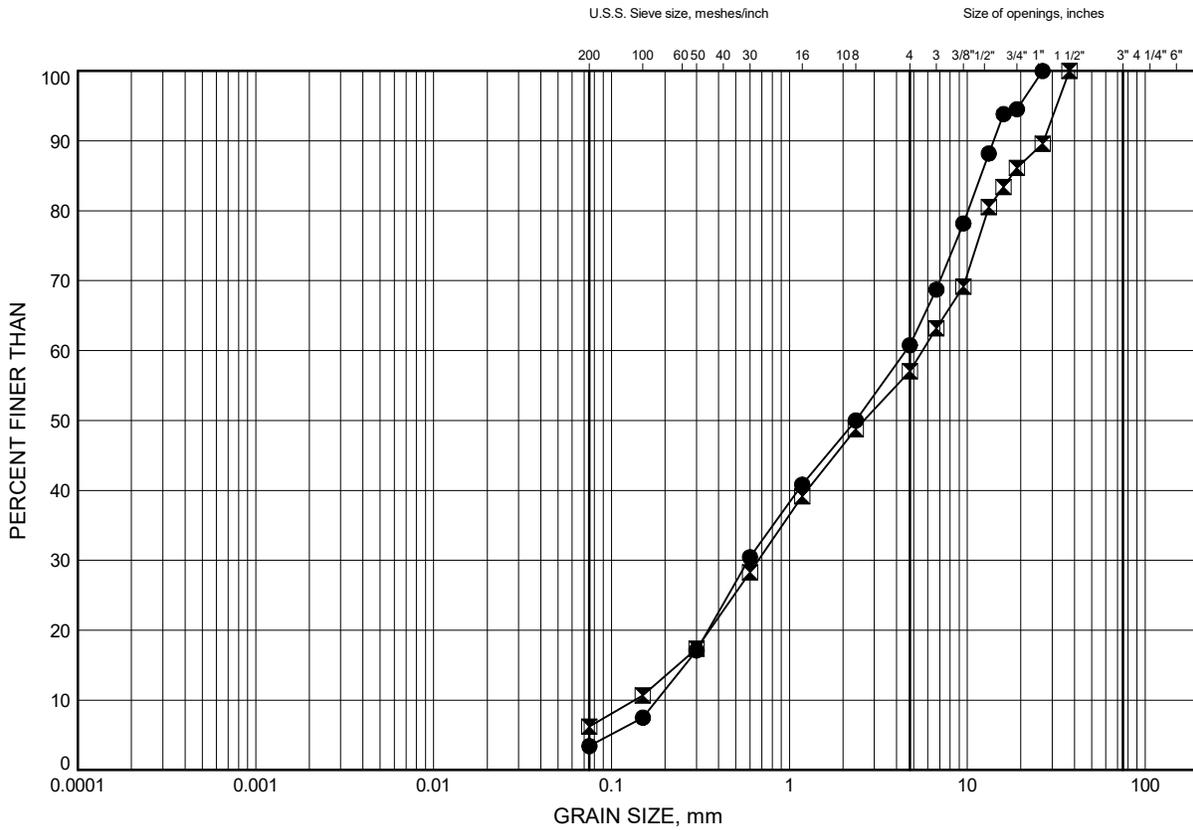


Prep'd JG  
Chkd. FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C2

## Fill



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-06	0.3	129.7
⊠	OBR19-08	0.4	129.6

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 14/4/20

Date .. April 2020 ..  
 WP# .. 4068-09-00 ..

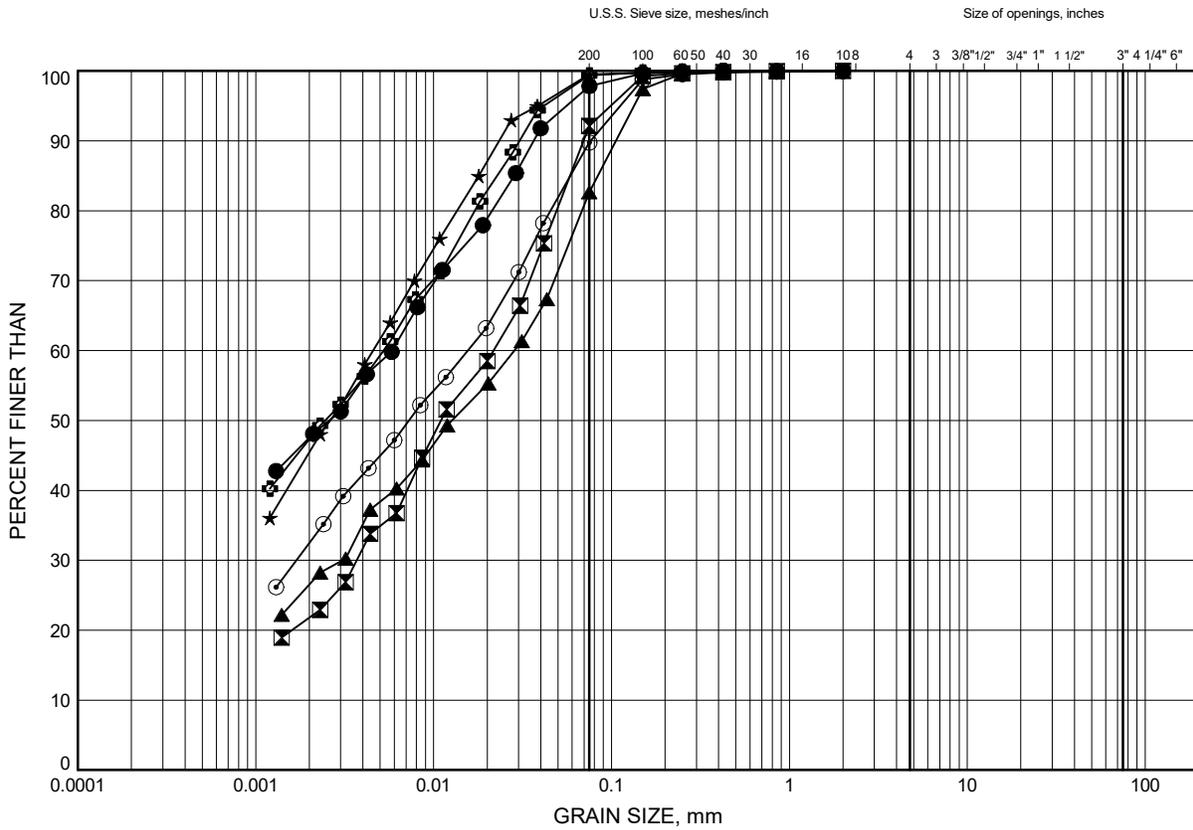


Prep'd ..... JG .....  
 Chkd. .... FG .....

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C3

## Silty Clay to Clayey Silt



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BRN-1	4.9	124.9
⊠	BRN-2	4.9	123.5
▲	BRN-2	9.5	118.9
★	BRN-4	3.4	125.0
⊙	BRN-4	9.5	118.9
⊕	BRN-5	2.6	127.2

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date April 2020  
WP# 4068-09-00

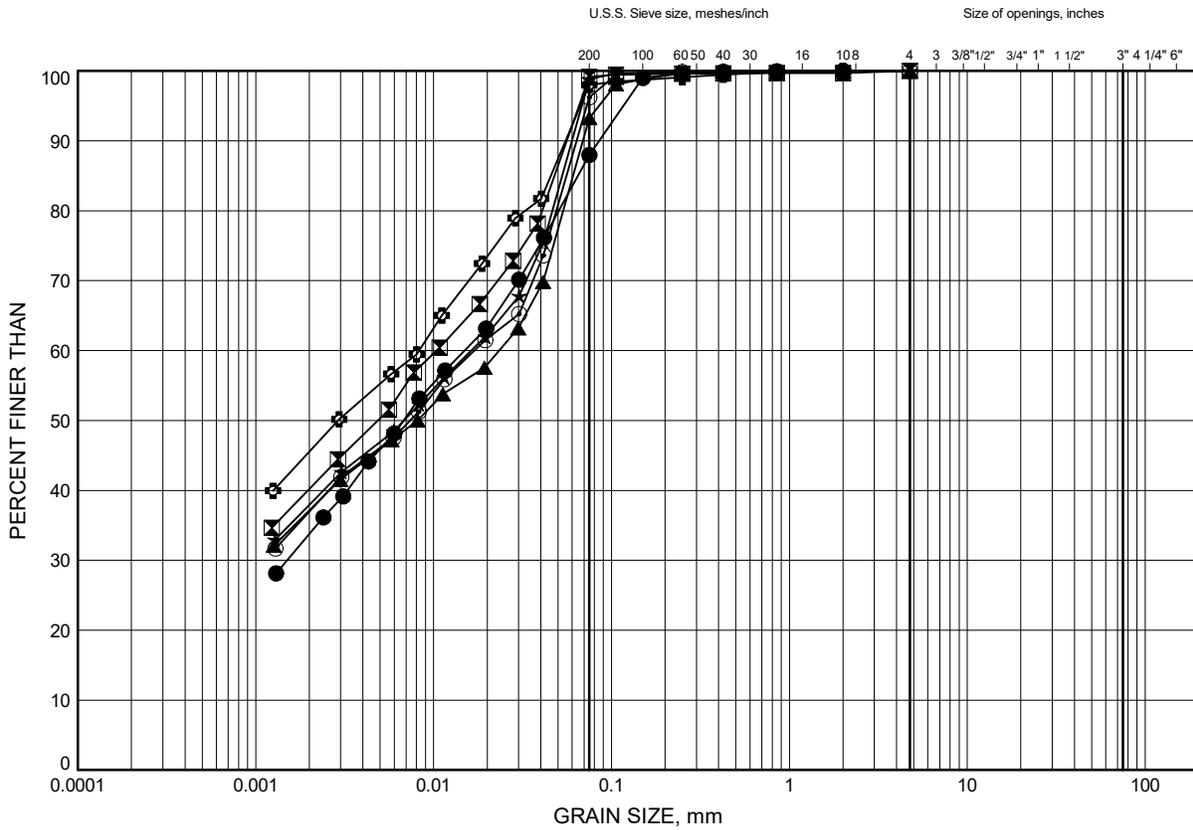


Prep'd JG  
Chkd. FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C4

## Silty Clay to Clayey Silt



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BRN-5	9.5	120.4
⊠	OBR19-01	1.8	128.1
▲	OBR19-01	6.4	123.5
★	OBR19-02	3.4	126.4
⊙	OBR19-02	8.7	121.1
⊕	OBR19-03	2.6	127.3

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date    April 2020  
 WP#    4068-09-00

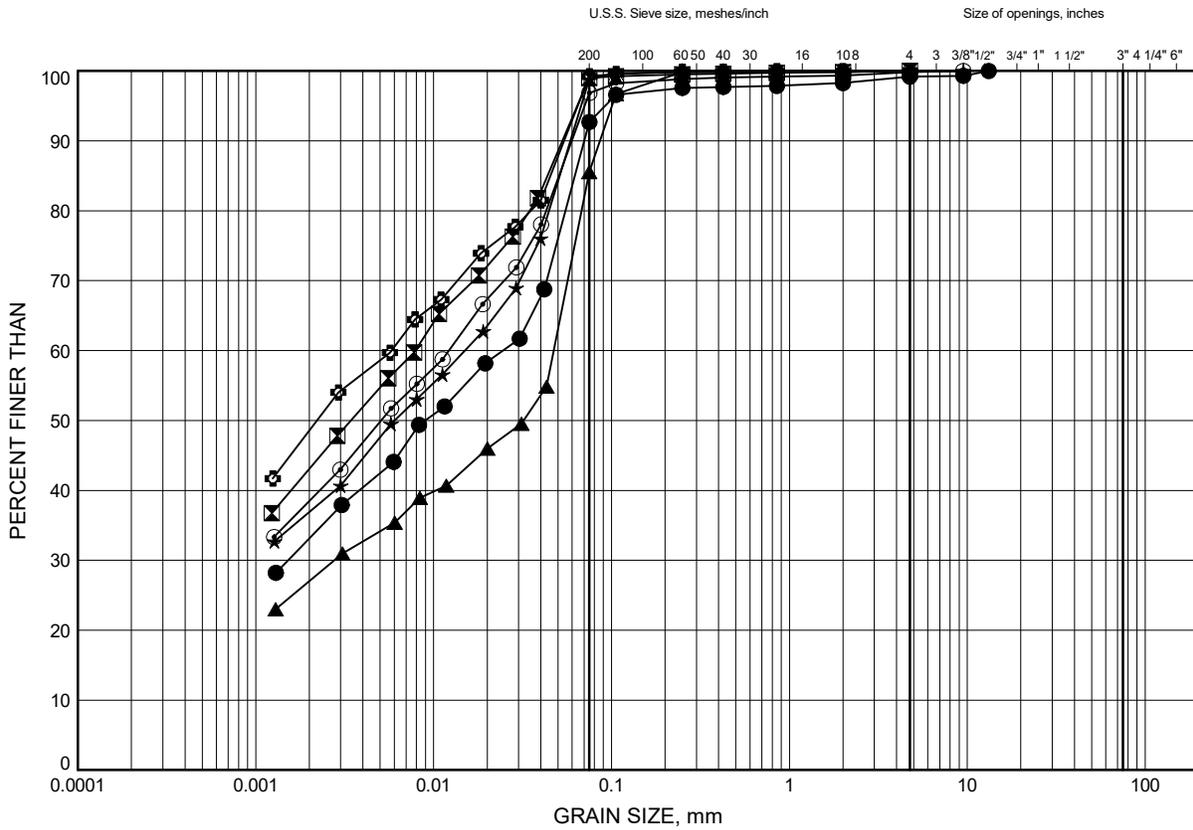


Prep'd    JG  
 Chkd.    FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C5

## Silty Clay to Clayey Silt



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-03	8.7	121.2
⊠	OBR19-04	3.4	126.8
▲	OBR19-04	10.2	120.0
★	OBR19-05	4.9	124.9
⊙	OBR19-05	7.9	121.9
⊕	OBR19-06	3.4	126.6

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date April 2020  
 WP# 4068-09-00

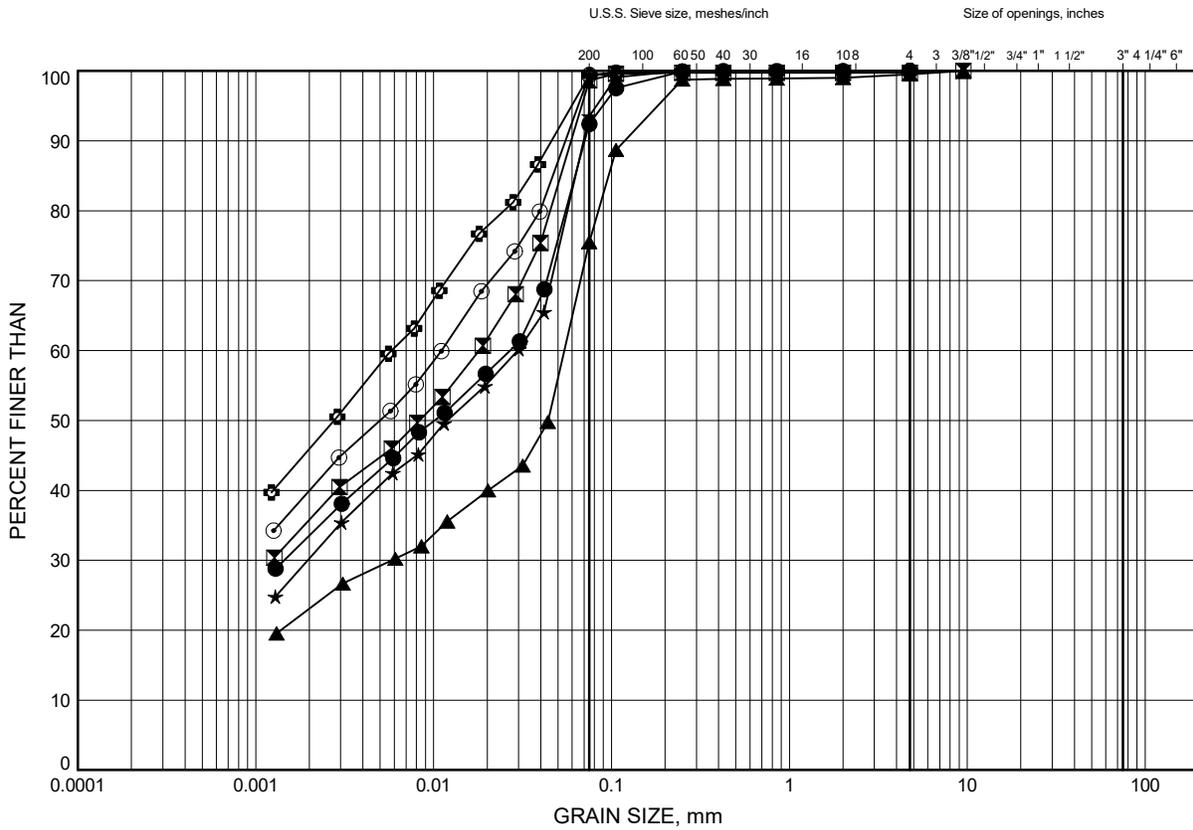


Prep'd JG  
 Chkd. FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C6

## Silty Clay to Clayey Silt



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-06	7.2	122.8
⊠	OBR19-07	1.8	128.0
▲	OBR19-07	6.4	123.4
★	OBR19-07	7.9	121.9
⊙	OBR19-08	3.4	126.6
⊕	OBR19-09	2.6	125.7

GRAIN SIZE DISTRIBUTION - THURBER - 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date    April 2020  
WP#    4068-09-00

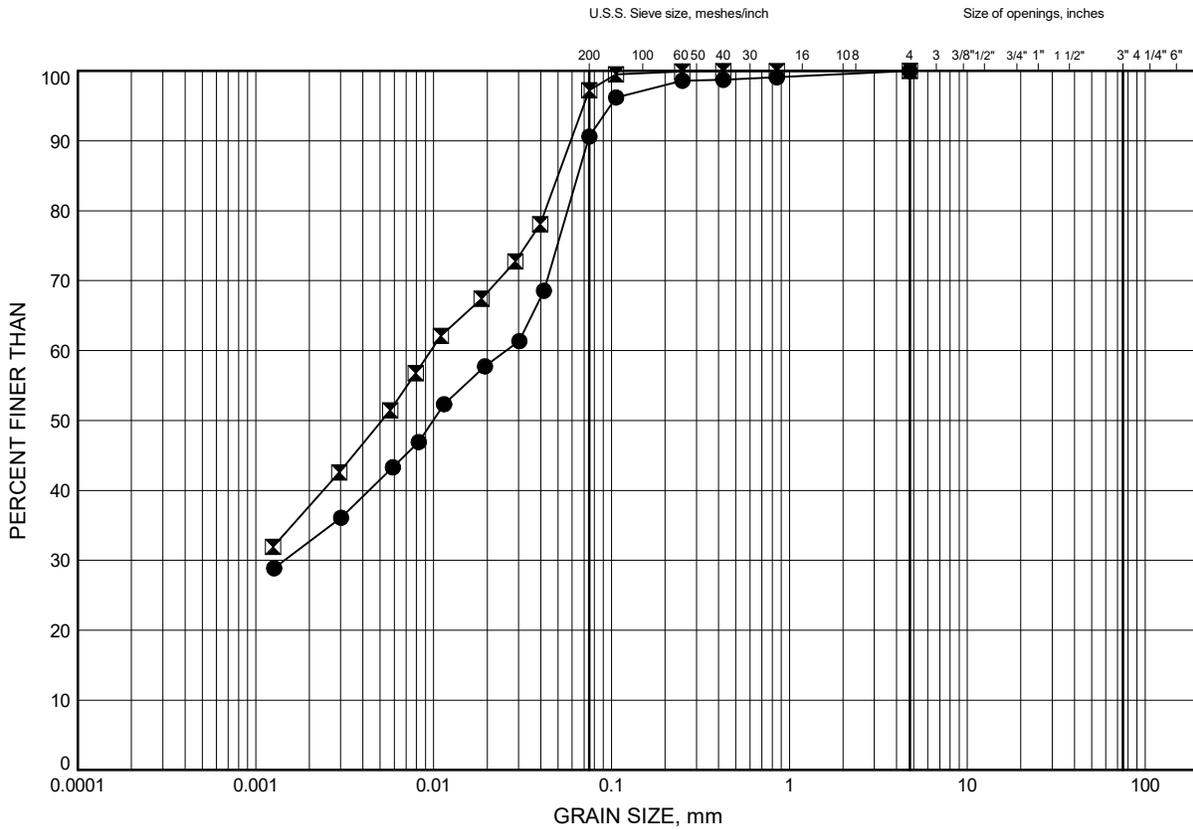


Prep'd    JG  
Chkd.    FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C7

## Silty Clay to Clayey Silt



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-09	5.6	122.7
⊠	OBR19-09	8.7	119.6

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date April 2020  
WP# 4068-09-00

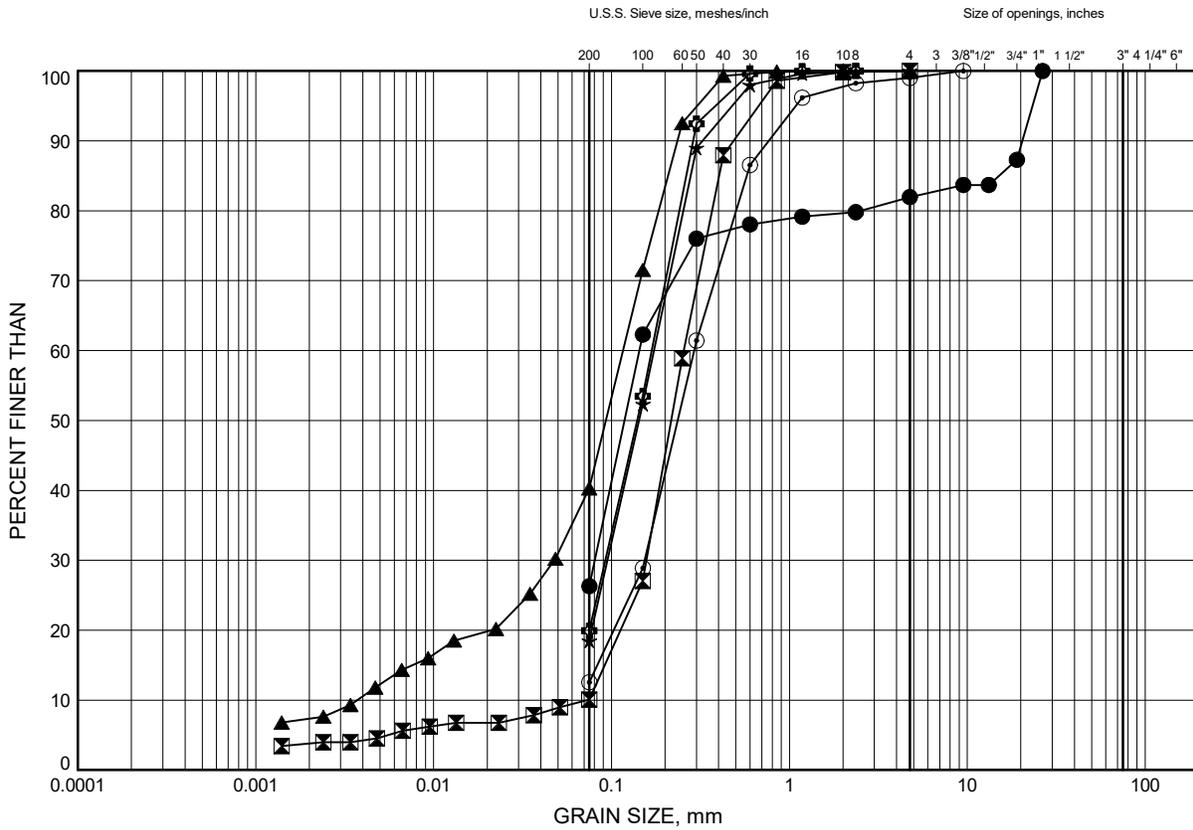


Prep'd JG  
Chkd. FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C8

## Silty Sand to Sand with Silt to Gravel with Silt and Sand



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BRN-1	11.0	118.8
⊠	BRN-2	14.0	114.3
▲	BRN-2	18.6	109.8
★	BRN-4	14.0	114.4
⊙	BRN-4	21.6	106.8
⊕	BRN-5	14.0	115.8

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date    April 2020  
WP#    4068-09-00

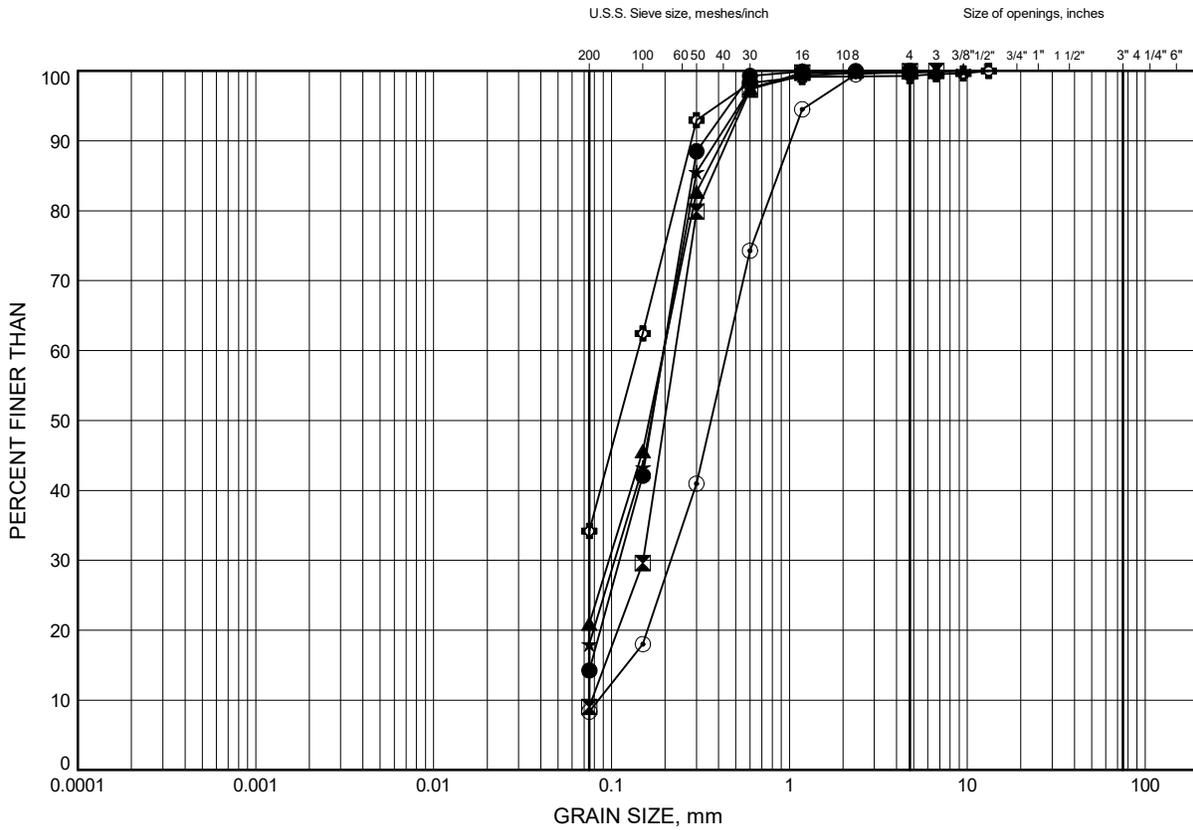


Prep'd    JG  
Chkd.    FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C9

## Silty Sand to Sand with Silt to Gravel with Silt and Sand



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-01	9.4	120.5
⊠	OBR19-01	16.3	113.6
▲	OBR19-01	22.4	107.5
★	OBR19-02	14.8	115.0
⊙	OBR19-02	22.4	107.4
⊕	OBR19-03	13.3	116.6

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date April 2020  
 WP# 4068-09-00

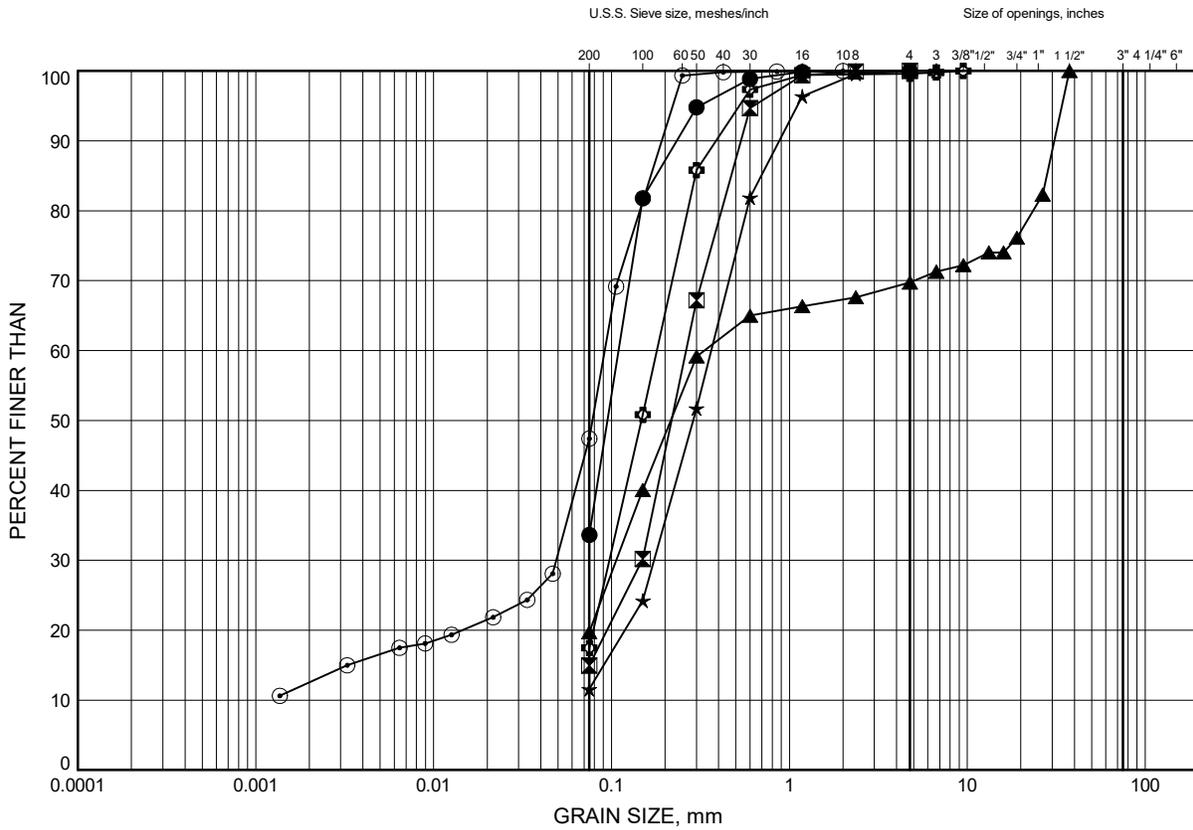


Prep'd JG  
 Chkd. FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C10

## Silty Sand to Sand with Silt to Gravel with Silt and Sand



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-04	13.3	116.9
⊠	OBR19-04	19.4	110.8
▲	OBR19-05	13.3	116.5
★	OBR19-05	22.4	107.4
⊙	OBR19-06	13.3	116.7
⊕	OBR19-06	16.3	113.7

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date April 2020  
WP# 4068-09-00

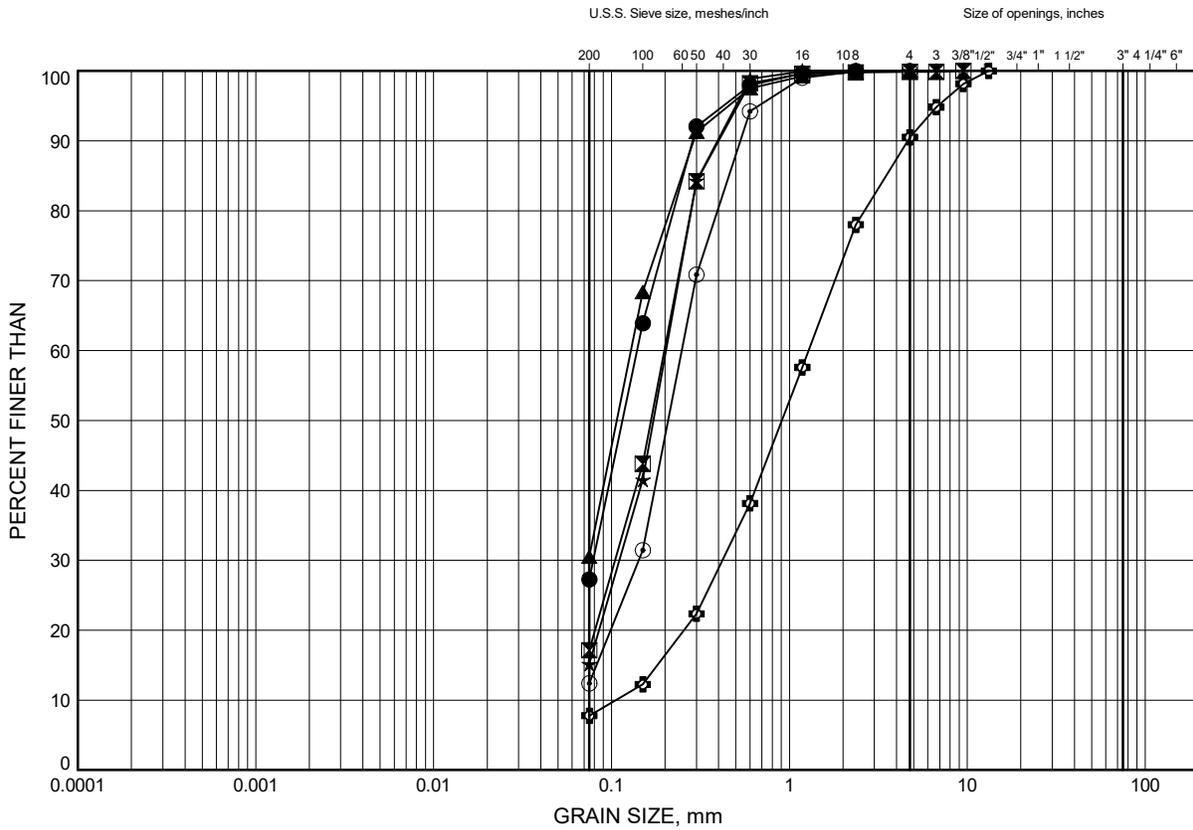


Prep'd JG  
Chkd. FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C11

## Silty Sand to Sand with Silt to Gravel with Silt and Sand



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-07	12.4	117.4
⊠	OBR19-07	18.6	111.2
▲	OBR19-08	12.5	117.5
★	OBR19-08	17.1	112.9
⊙	OBR19-09	14.8	113.5
◊	OBR19-12	1.8	129.7

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date April 2020  
 WP# 4068-09-00

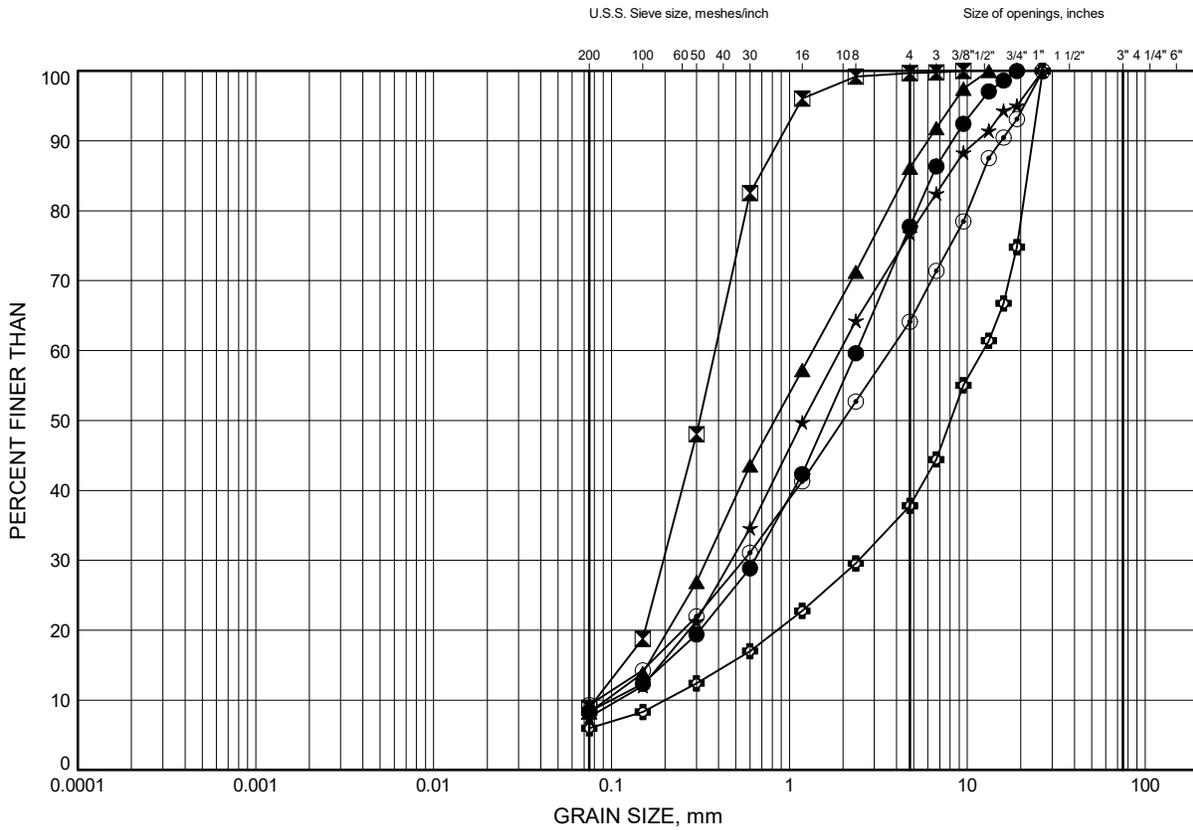


Prep'd JG  
 Chkd. FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C12

## Silty Sand to Sand with Silt to Gravel with Silt and Sand



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-12	4.9	126.6
⊠	OBR19-12	11.0	120.5
▲	OBR19-13	3.4	128.4
★	OBR19-13	7.9	123.9
⊙	OBR19-14	2.6	129.6
⊕	OBR19-14	11.0	121.2

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date April 2020  
 WP# 4068-09-00

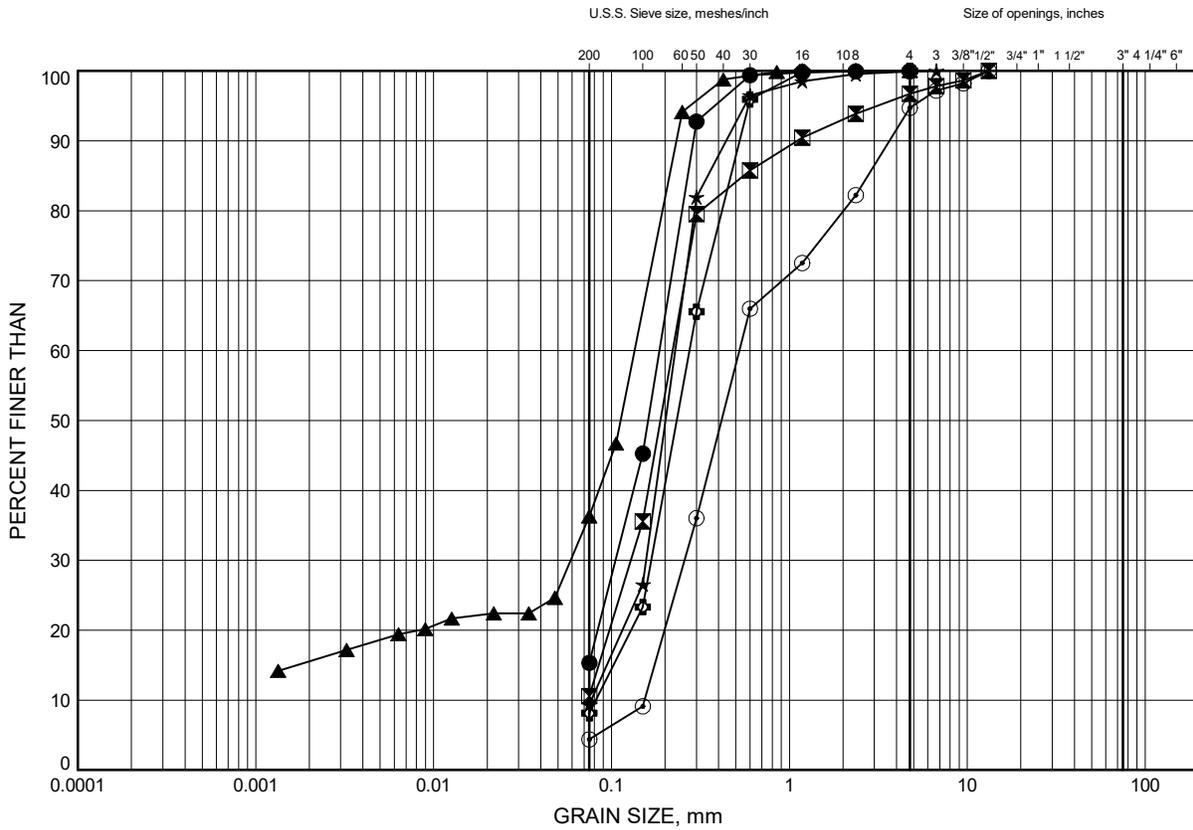


Prep'd JG  
 Chkd. FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C13

## Silty Sand to Sand with Silt to Gravel with Silt and Sand



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-15	1.8	127.3
⊠	OBR19-15	6.4	122.7
▲	OBR19-16	2.6	125.3
★	OBR19-16	4.9	123.0
⊙	OBR19-16	7.9	120.0
⊕	CV-7	1.8	115.2

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date April 2020  
 WP# 4068-09-00

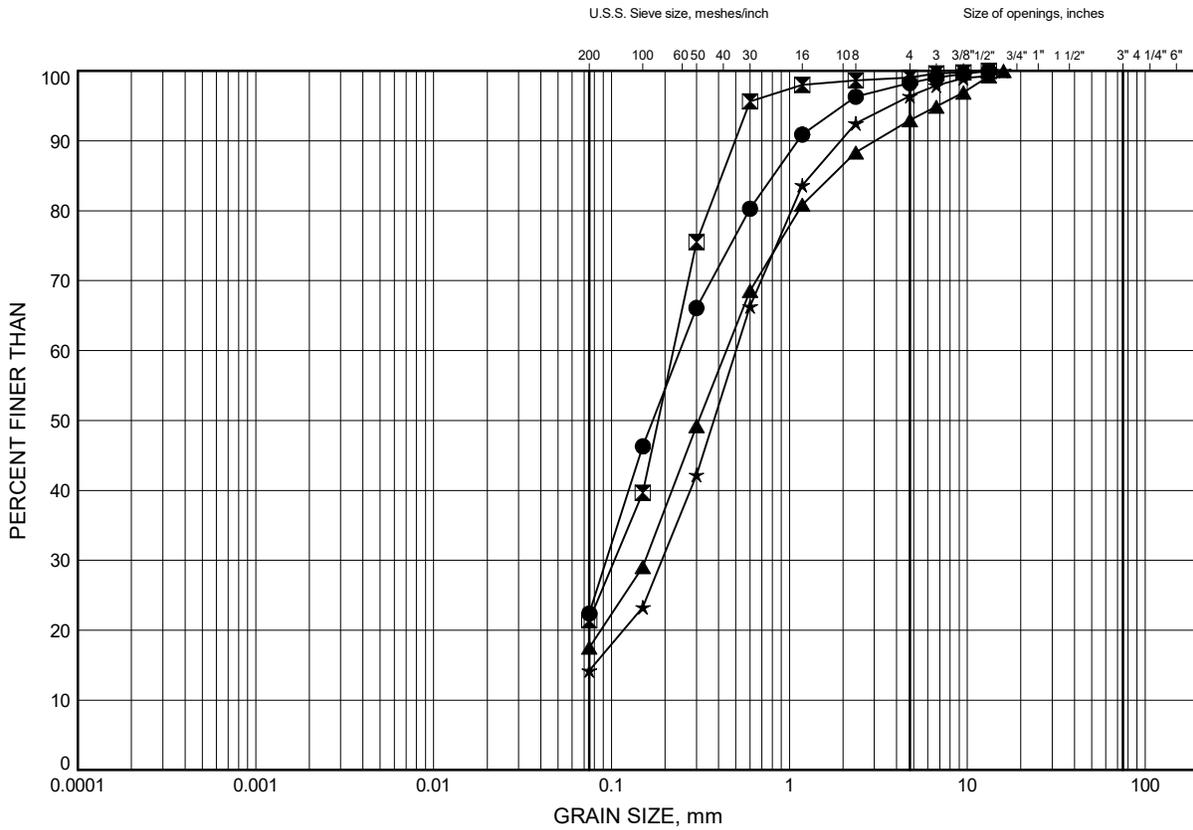


Prep'd JG  
 Chkd. FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C14

## Silty Sand to Sand with Silt to Gravel with Silt and Sand



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CV-8	0.3	116.2
⊠	CV-8	3.9	112.6
▲	CV-9	1.1	115.1
★	CV-9	2.6	113.6

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date April 2020  
WP# 4068-09-00

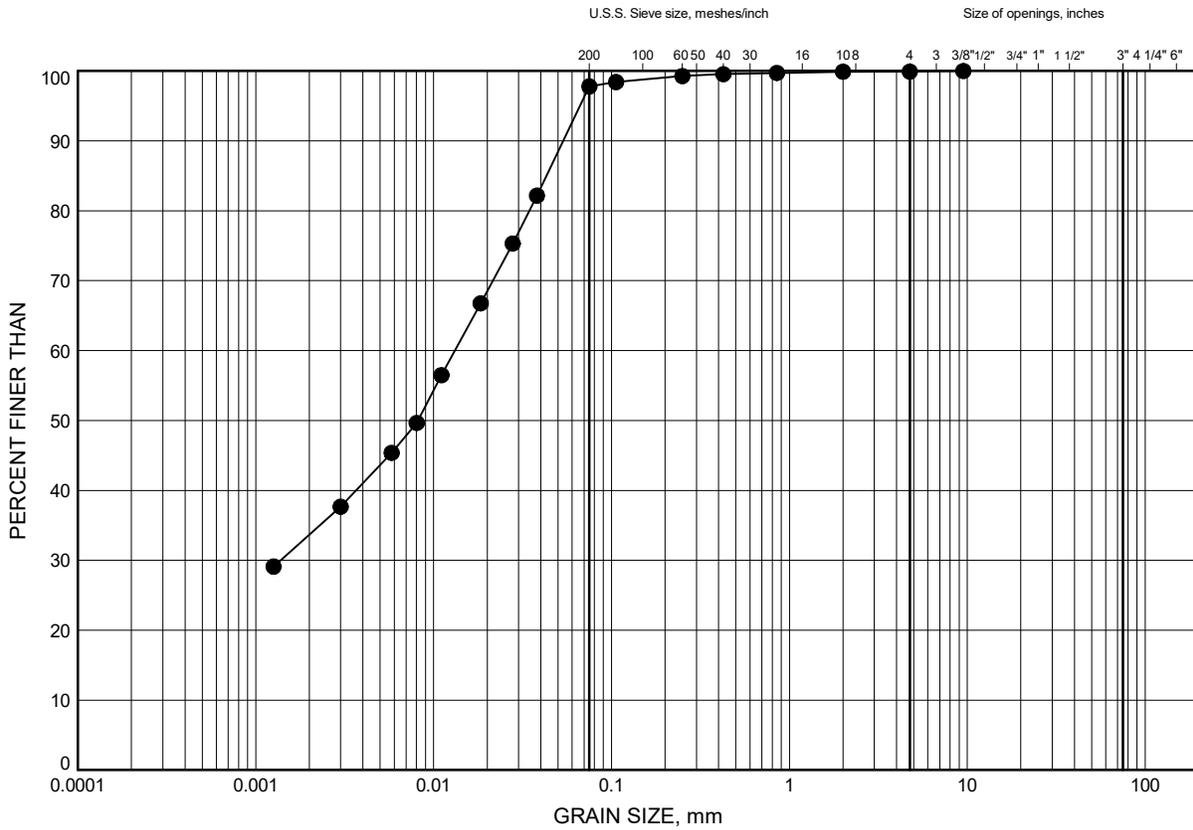


Prep'd JG  
Chkd. FG

Highway 17 Twinning  
**GRAIN SIZE DISTRIBUTION**

FIGURE C15

**Clayey Silt**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-15	11.0	118.1

GRAIN SIZE DISTRIBUTION - THURBER 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date April 2020  
 WP# 4068-09-00

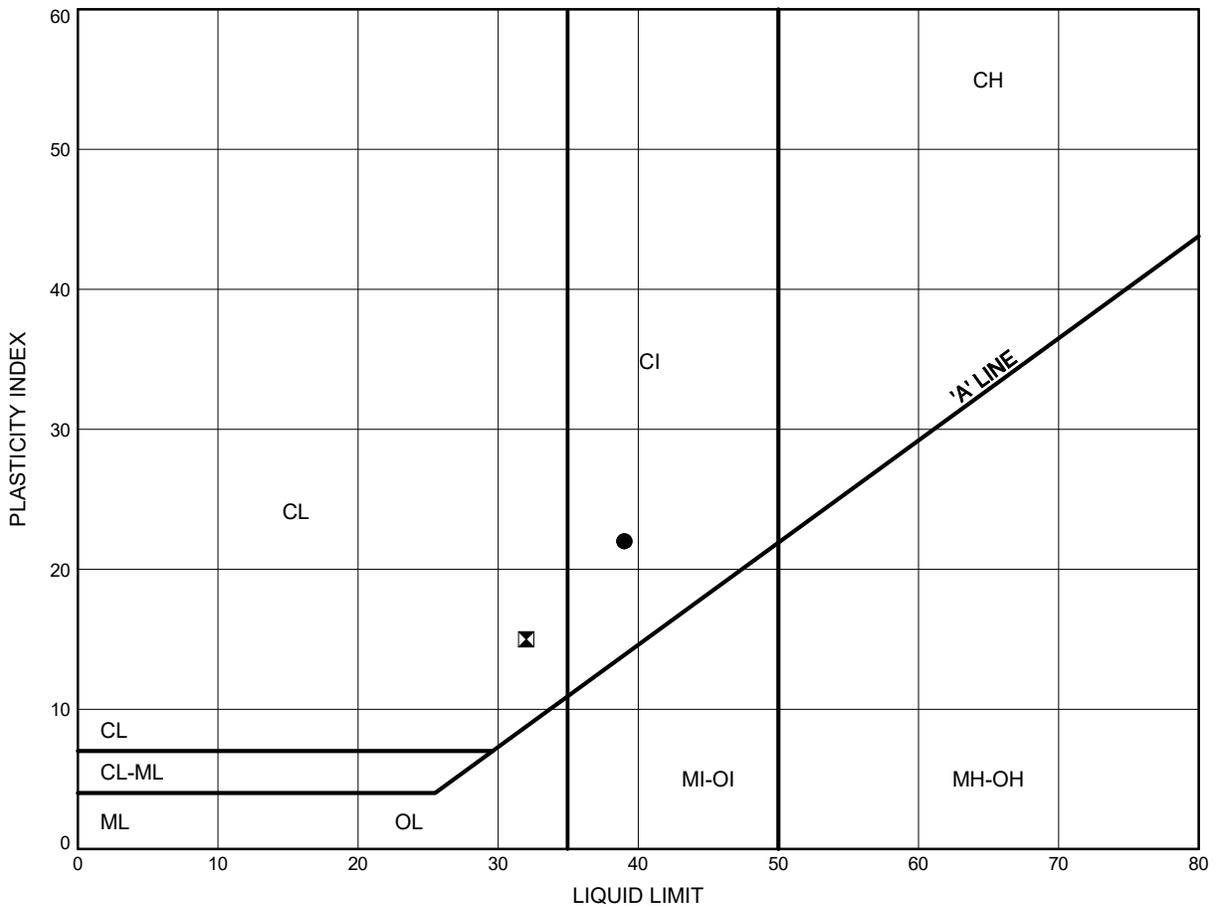


Prep'd JG  
 Chkd. FG

# Highway 17 Twinning ATTERBERG LIMITS TEST RESULTS

FIGURE C16

Fill



### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-01	0.4	129.5
⊠	OBR19-03	1.1	128.8

THURBALT 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date .. April 2020 ..  
 WP# .. 4068-09-00 ..

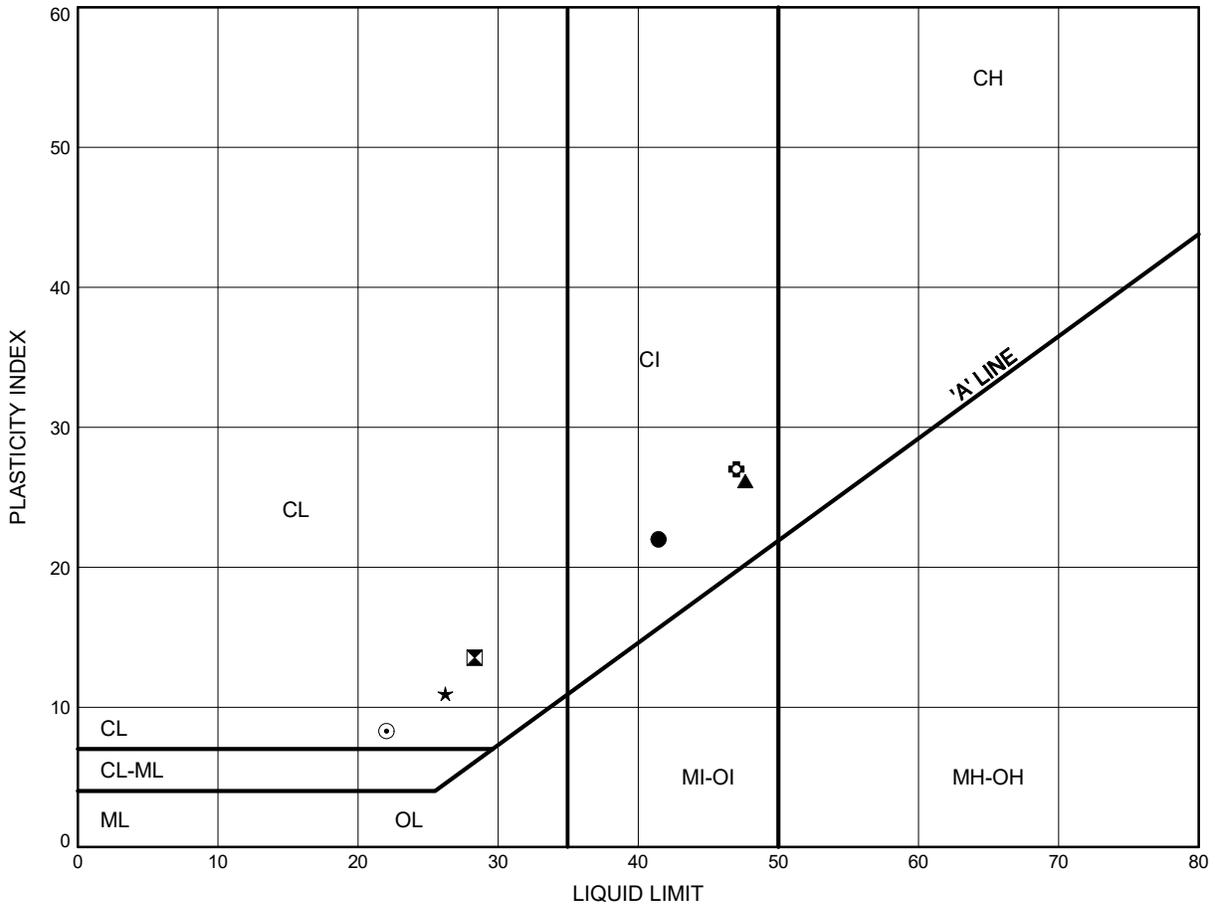


Prep'd ..... JG .....  
 Chkd. .... FG .....

Highway 17 Twinning  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C17

Silty Clay to Clayey Silt



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BRN-1	4.9	124.9
⊠	BRN-2	4.9	123.5
▲	BRN-4	3.4	125.0
★	BRN-4	9.5	118.9
⊙	BRN-5	9.5	120.4
⊕	OBR19-01	1.8	128.1

Date April 2020  
 WP# 4068-09-00

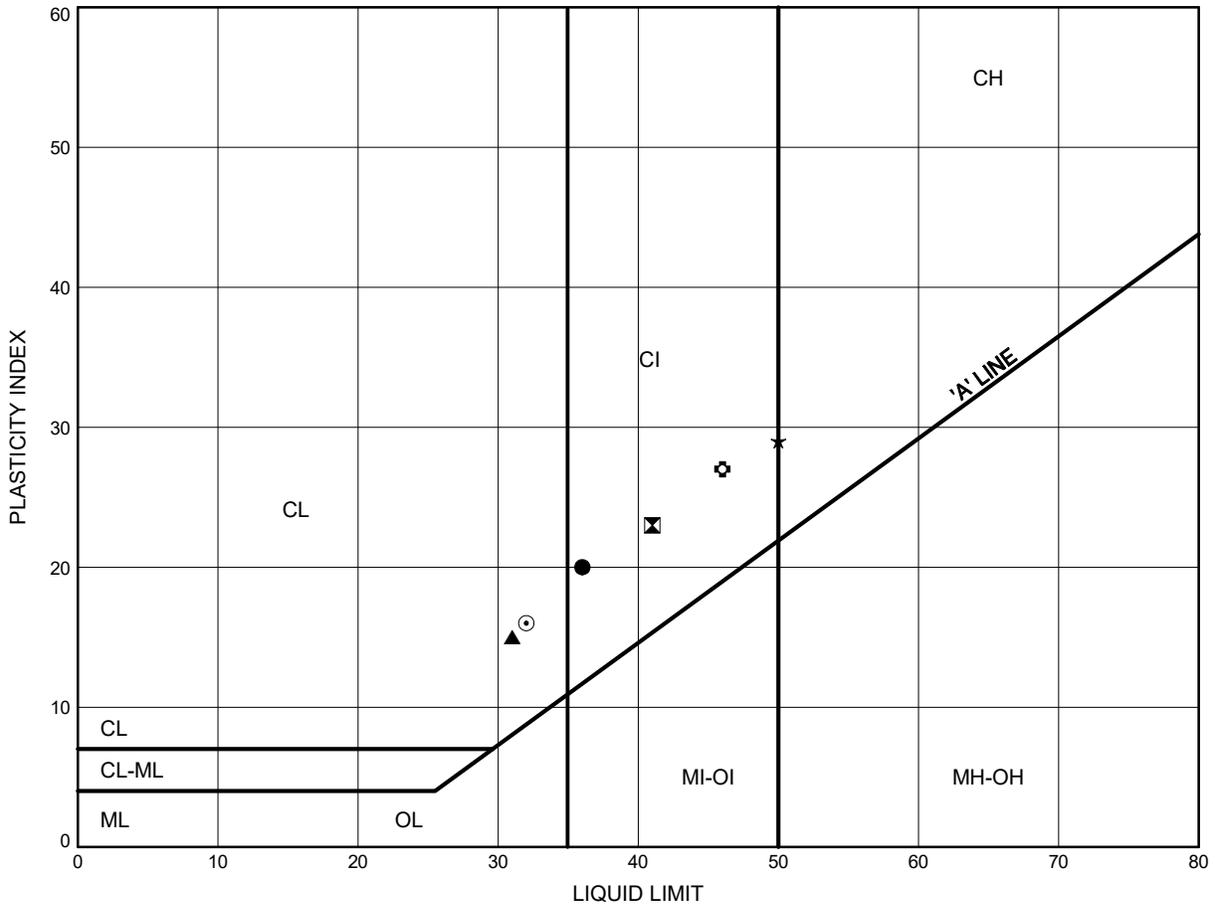


Prep'd JG  
 Chkd. FG

Highway 17 Twinning  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C18

Silty Clay to Clayey Silt



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-01	6.4	123.5
⊠	OBR19-02	3.4	126.4
▲	OBR19-02	8.7	121.1
★	OBR19-03	2.6	127.3
⊙	OBR19-03	8.7	121.2
⊕	OBR19-04	3.4	126.8

THURBALT 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date April 2020  
 WP# 4068-09-00

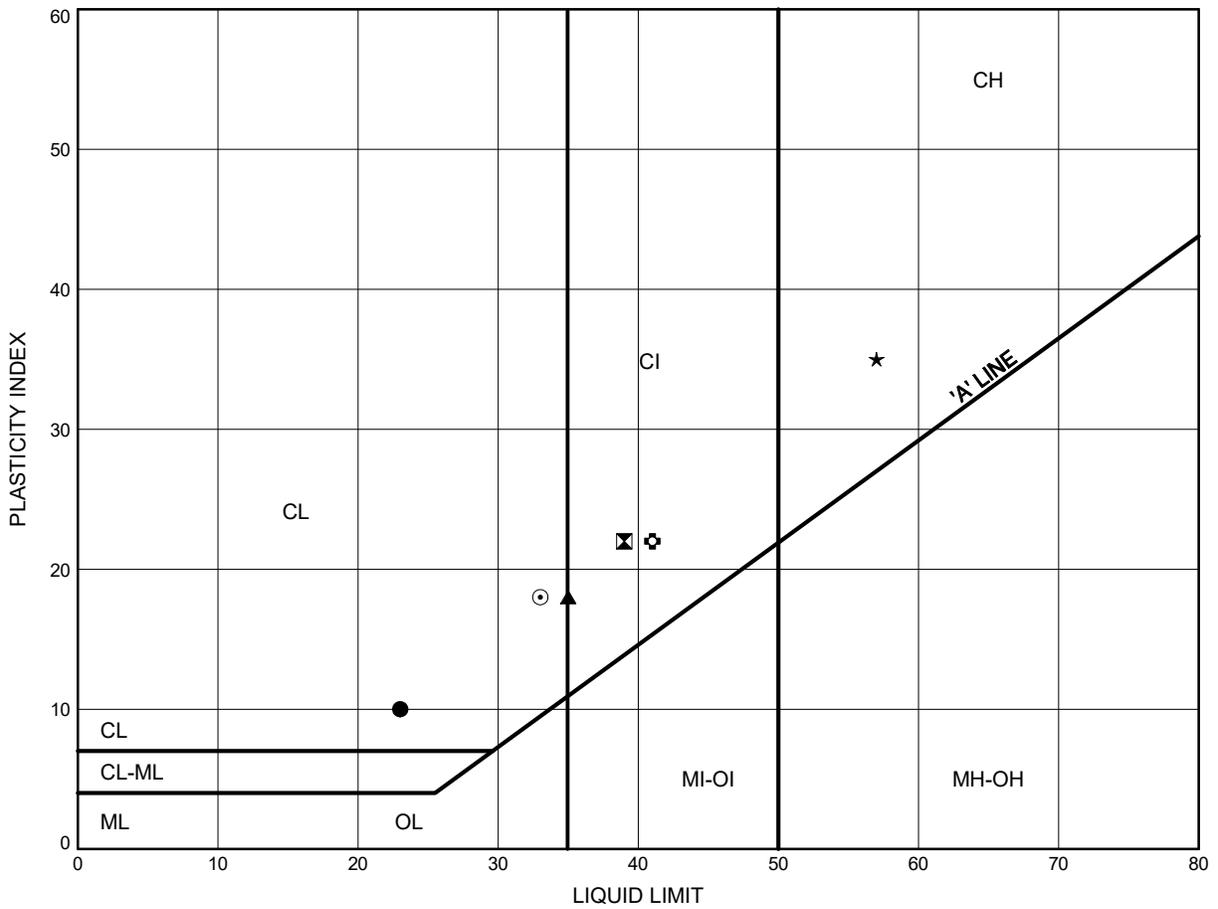


Prep'd JG  
 Chkd. FG

Highway 17 Twinning  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C19

Silty Clay to Clayey Silt



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-04	10.2	120.0
⊠	OBR19-05	4.9	124.9
▲	OBR19-05	7.9	121.9
★	OBR19-06	3.4	126.6
⊙	OBR19-06	7.2	122.8
⊕	OBR19-07	1.8	128.0

THURBALT 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date April 2020  
 WP# 4068-09-00

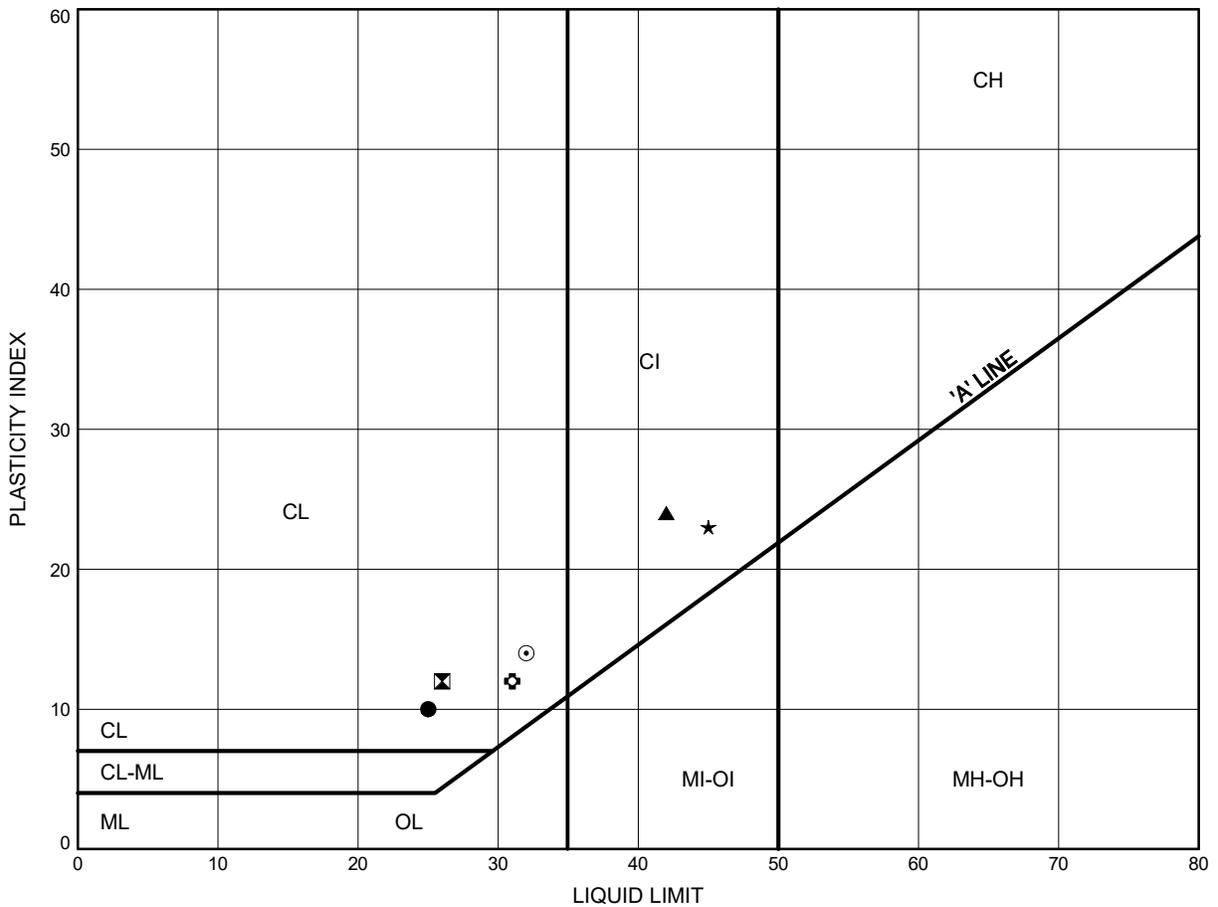


Prep'd JG  
 Chkd. FG

Highway 17 Twinning  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C20

Silty Clay to Clayey Silt



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-07	6.4	123.4
⊠	OBR19-07	7.9	121.9
▲	OBR19-08	3.4	126.6
★	OBR19-09	2.6	125.7
⊙	OBR19-09	5.6	122.7
⊕	OBR19-09	8.7	119.6

Date .. April 2020 ..  
 WP# .. 4068-09-00 ..

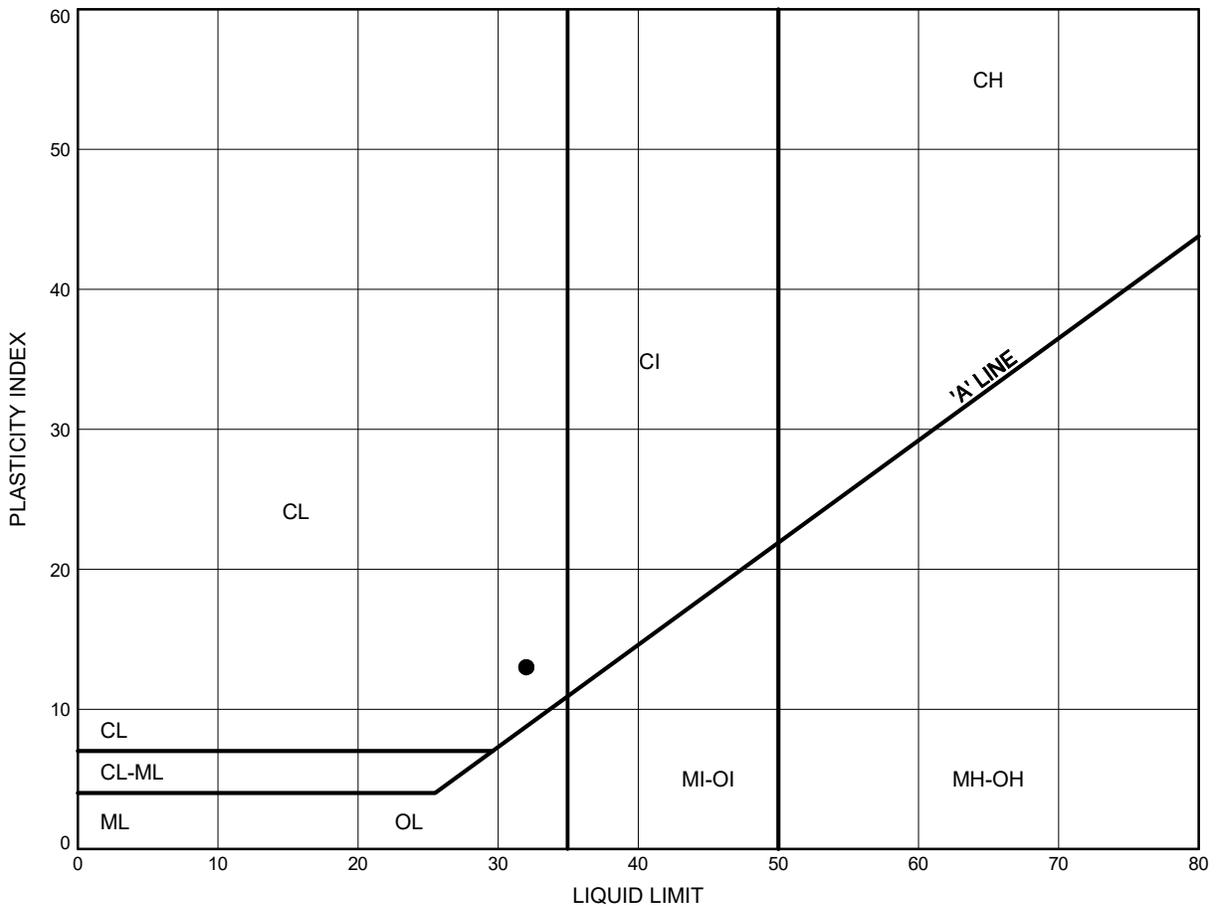


Prep'd .. JG ..  
 Chkd. .. FG ..

Highway 17 Twinning  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C21

Clayey Silt



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OBR19-15	11.0	118.1

THURBALT 24726 O'BRIEN ROAD GINT.GPJ 27/4/20

Date April 2020  
 WP# 4068-09-00



Prep'd JG  
 Chkd. FG

**Appendix C.2**  
**Analytical Testing Results**

## Certificate of Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B4S5  
Attn: Chris Murray

Client PO:  
Project: 24726  
Custody: 49171

Report Date: 24-Sep-2019  
Order Date: 18-Sep-2019

**Order #: 1938289**

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

<b>Parcel ID</b>	<b>Client ID</b>
1938289-01	OBR 19-01, SS5 (10'-12')
1938289-02	OBR 19-04, SS4 (7'6"-9'6")

Approved By:



Dale Robertson, BSc  
Laboratory Director

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO:

Report Date: 24-Sep-2019

Order Date: 18-Sep-2019

Project Description: 24726

### Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	23-Sep-19	23-Sep-19
Conductivity	MOE E3138 - probe @25 °C, water ext	24-Sep-19	24-Sep-19
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	19-Sep-19	19-Sep-19
Resistivity	EPA 120.1 - probe, water extraction	24-Sep-19	24-Sep-19
Solids, %	Gravimetric, calculation	18-Sep-19	18-Sep-19

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO:

Report Date: 24-Sep-2019

Order Date: 18-Sep-2019

Project Description: 24726

<b>Client ID:</b>	OBR 19-01, SS5 (10'-12')	OBR 19-04, SS4 (7'6"-9'6")	-	-
<b>Sample Date:</b>	09-Sep-19 09:00	12-Sep-19 09:00	-	-
<b>Sample ID:</b>	1938289-01	1938289-02	-	-
<b>MDL/Units</b>	Soil	Soil	-	-

**Physical Characteristics**

% Solids	0.1 % by Wt.	79.2	78.0	-	-
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**General Inorganics**

Conductivity	5 uS/cm	555	876	-	-
pH	0.05 pH Units	7.40	7.55	-	-
Resistivity	0.10 Ohm.m	18.0	11.4	-	-

**Anions**

Chloride	5 ug/g dry	277	434	-	-
Sulphate	5 ug/g dry	35	53	-	-

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO:

Report Date: 24-Sep-2019

Order Date: 18-Sep-2019

Project Description: 24726

### Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
<b>General Inorganics</b>									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO:

Report Date: 24-Sep-2019

Order Date: 18-Sep-2019

Project Description: 24726

### Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	275	5	ug/g dry	277			0.9	20	
Sulphate	34.2	5	ug/g dry	34.6			1.3	20	
<b>General Inorganics</b>									
pH	7.39	0.05	pH Units	7.50			1.5	2.3	
Resistivity	18.2	0.10	Ohm.m	17.2			5.6	20	
<b>Physical Characteristics</b>									
% Solids	77.6	0.1	% by Wt.	79.2			2.1	25	

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO:

Report Date: 24-Sep-2019

Order Date: 18-Sep-2019

Project Description: 24726

### Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	372	5	ug/g	277	94.1	82-118			
Sulphate	142	5	ug/g	34.6	108	80-120			

Certificate of Analysis  
**Client: Thurber Engineering Ltd.**  
**Client PO:**

Report Date: 24-Sep-2019

Order Date: 18-Sep-2019

**Project Description: 24726**

**Qualifier Notes:**

None

**Sample Data Revisions**

None

**Work Order Revisions / Comments:**

None

**Other Report Notes:**

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

## Subcontracted Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B4S5

Attn: Chris Murray

Tel: (613) 247-2121  
Fax: (613) 247-2185

Paracel Report No **1938289**

Client Project(s): **24726**

Client PO:

Reference: **Standing Offer**

CoC Number: **49171**

Order Date: 18-Sep-19

Report Date: 23-Sep-19

---

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
1938289-01	OBR 19-01, SS5 (10'-12')	Sulphide, solid
1938289-02	OBR 19-04, SS4 (7'6"-9'6")	Sulphide, solid



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

23-September-2019

**Paracel Laboratories**

Attn : Dale Robertson

300-2319 St.Laurent Blvd.  
Ottawa, ON  
K1G 4K6, Canada

Phone: 613-731-9577  
Fax:613-731-9064

**Date Rec. :** 19 September 2019  
**LR Report:** CA13704-SEP19  
**Reference:** Project#: 1938289

**Copy:** #1

# CERTIFICATE OF ANALYSIS

## Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		20-Sep-19
2: Analysis Start Time		12:49
3: Analysis Completed Date		20-Sep-19
4: Analysis Completed Time		14:35
5: QC - Blank		< 0.02
6: QC - STD % Recovery		113%
7: QC - DUP % RPD		3%
8: RL		0.02
9: OBR 19-01, SS5 (10'-12')	09-Sep-19	0.03
10: OBR 19-01, SS4 (7'6"-9'6")	12-Sep-19	0.03

RL - SGS Reporting Limit

Kimberley Didsbury  
Project Specialist,  
Environment, Health & Safety

## Certificate of Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B4S5  
Attn: Chris Murray

Client PO:  
Project: 24726  
Custody: 49174

Report Date: 3-Oct-2019  
Order Date: 27-Sep-2019

**Order #: 1939628**

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

<b>Parcel ID</b>	<b>Client ID</b>
1939628-01	OBR19-02, SS3(5'-7')
1939628-02	OBR19-05, SS3(5'-7')

Approved By:



Dale Robertson, BSc  
Laboratory Director

Certificate of Analysis  
Client: **Thurber Engineering Ltd.**  
Client PO:

Report Date: 03-Oct-2019  
Order Date: 27-Sep-2019  
Project Description: **24726**

### Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	30-Sep-19	1-Oct-19
Conductivity	MOE E3138 - probe @25 °C, water ext	30-Sep-19	30-Sep-19
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	1-Oct-19	1-Oct-19
Resistivity	EPA 120.1 - probe, water extraction	30-Sep-19	30-Sep-19
Solids, %	Gravimetric, calculation	27-Sep-19	27-Sep-19

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO:

Report Date: 03-Oct-2019

Order Date: 27-Sep-2019

Project Description: 24726

<b>Client ID:</b>	OBR19-02, SS3(5'-7')	OBR19-05, SS3(5'-7')	-	-
<b>Sample Date:</b>	20-Sep-19 09:00	16-Sep-19 09:00	-	-
<b>Sample ID:</b>	1939628-01	1939628-02	-	-
<b>MDL/Units</b>	Soil	Soil	-	-

**Physical Characteristics**

% Solids	0.1 % by Wt.	75.2	76.1	-	-
----------	--------------	------	------	---	---

**General Inorganics**

Conductivity	5 uS/cm	184	4180	-	-
pH	0.05 pH Units	7.55	7.87	-	-
Resistivity	0.10 Ohm.m	54.4	2.39	-	-

**Anions**

Chloride	5 ug/g dry	36	74	-	-
Sulphate	5 ug/g dry	13	2460	-	-

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO:

Report Date: 03-Oct-2019  
 Order Date: 27-Sep-2019  
 Project Description: 24726

**Method Quality Control: Blank**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
<b>General Inorganics</b>									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO:

Report Date: 03-Oct-2019  
 Order Date: 27-Sep-2019  
 Project Description: 24726

**Method Quality Control: Duplicate**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	8.3	5	ug/g dry	8.7			4.6	20	
Sulphate	24.0	5	ug/g dry	24.9			3.6	20	
<b>General Inorganics</b>									
Conductivity	868	5	uS/cm	861			0.8	5	
pH	7.50	0.05	pH Units	7.50			0.0	2.3	
Resistivity	11.5	0.10	Ohm.m	11.6			0.8	20	
<b>Physical Characteristics</b>									
% Solids	81.3	0.1	% by Wt.	80.8			0.6	25	

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO:

Report Date: 03-Oct-2019  
 Order Date: 27-Sep-2019  
 Project Description: 24726

### Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	94.9	5	ug/g	8.7	86.2	82-118			
Sulphate	127	5	ug/g	24.9	102	80-120			

Certificate of Analysis  
Client: **Thurber Engineering Ltd.**  
Client PO:

Report Date: 03-Oct-2019  
Order Date: 27-Sep-2019  
Project Description: **24726**

**Qualifier Notes:**

None

**Sample Data Revisions**

None

**Work Order Revisions / Comments:**

None

**Other Report Notes:**

n/a: not applicable  
ND: Not Detected  
MDL: Method Detection Limit  
Source Result: Data used as source for matrix and duplicate samples  
%REC: Percent recovery.  
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.  
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

## Subcontracted Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B4S5

Attn: Chris Murray

Tel: (613) 247-2121

Fax: (613) 247-2185

Paracel Report No **1939628**

Client Project(s): **24726**

Client PO:

Reference: **Standing Offer**

CoC Number: **49174**

Order Date: 27-Sep-19

Report Date: 4-Oct-19

---

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
1939628-01	OBR19-02, SS3(5'-7')	Sulphide, solid
1939628-02	OBR19-05, SS3(5'-7')	Sulphide, solid



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

04-October-2019

**Paracel Laboratories**

Attn : Dale Robertson

300-2319 St.Laurent Blvd.  
Ottawa, ON  
K1G 4K6, Canada

Phone: 613-731-9577  
Fax:613-731-9064

**Date Rec. :** 01 October 2019  
**LR Report:** CA12036-OCT19  
**Reference:** Project#:1939628

**Copy:** #1

# CERTIFICATE OF ANALYSIS

## Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		04-Oct-19
2: Analysis Start Time		16:08
3: Analysis Completed Date		04-Oct-19
4: Analysis Completed Time		16:27
5: QC - Blank		< 0.02
6: QC - STD % Recovery		111%
7: QC - DUP % RPD		18%
8: RL		0.02
9: OBR19-02, SS3 (5'-7')	20-Sep-19	0.03
10: OBR19-05, SS3 (5'-7')	16-Sep-19	0.03

RL - SGS Reporting Limit

Kimberley Didsbury  
Project Specialist,  
Environment, Health & Safety

## Certificate of Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B 4S5  
Attn: Justin Gray

Client PO: 24726  
Project: Hwy 17, W-N/S Ramp Culvert  
Custody: 49177

Report Date: 20-Oct-2019  
Order Date: 16-Oct-2019

**Order #: 1942180**

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

<b>Parcel ID</b>	<b>Client ID</b>
1942180-01	CV-9, SS3 (5'-7')

Approved By:



Mark Foto, M.Sc.  
Lab Supervisor

Certificate of Analysis  
Client: **Thurber Engineering Ltd.**  
Client PO: 24726

Report Date: 20-Oct-2019

Order Date: 16-Oct-2019

**Project Description: Hwy 17, W-N/S Ramp Culvert**

### Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	17-Oct-19	17-Oct-19
Conductivity	MOE E3138 - probe @25 °C, water ext	17-Oct-19	18-Oct-19
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	18-Oct-19	19-Oct-19
Resistivity	EPA 120.1 - probe, water extraction	17-Oct-19	18-Oct-19
Solids, %	Gravimetric, calculation	17-Oct-19	17-Oct-19

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO: 24726

Report Date: 20-Oct-2019

Order Date: 16-Oct-2019

**Project Description: Hwy 17, W-N/S Ramp Culvert**

<b>Client ID:</b>	CV-9, SS3 (5'-7')	-	-	-
<b>Sample Date:</b>	15-Oct-19 09:00	-	-	-
<b>Sample ID:</b>	1942180-01	-	-	-
<b>MDL/Units</b>	Soil	-	-	-

**Physical Characteristics**

% Solids	0.1 % by Wt.	87.6	-	-	-
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**General Inorganics**

Conductivity	5 uS/cm	103	-	-	-
pH	0.05 pH Units	7.98	-	-	-
Resistivity	0.10 Ohm.m	97.5	-	-	-

**Anions**

Chloride	5 ug/g dry	11	-	-	-
Sulphate	5 ug/g dry	10	-	-	-

Certificate of Analysis  
 Client: **Thurber Engineering Ltd.**  
 Client PO: 24726

Report Date: 20-Oct-2019

Order Date: 16-Oct-2019

**Project Description: Hwy 17, W-N/S Ramp Culvert**

**Method Quality Control: Blank**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
<b>General Inorganics</b>									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO: 24726

Report Date: 20-Oct-2019

Order Date: 16-Oct-2019

Project Description: Hwy 17, W-N/S Ramp Culvert

### Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	120	5	ug/g dry	123			3.1	20	
Sulphate	323	5	ug/g dry	332			2.8	20	
<b>General Inorganics</b>									
Conductivity	114	5	uS/cm	117			2.6	5	
pH	7.30	0.05	pH Units	7.33			0.4	2.3	
Resistivity	87.7	0.10	Ohm.m	85.5			2.6	20	
<b>Physical Characteristics</b>									
% Solids	87.2	0.1	% by Wt.	87.5			0.4	25	

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO: 24726

Report Date: 20-Oct-2019

Order Date: 16-Oct-2019

Project Description: Hwy 17, W-N/S Ramp Culvert

**Method Quality Control: Spike**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	215	5	ug/g	123	91.2	82-118			
Sulphate	421	5	ug/g	332	88.8	80-120			

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 24726

Report Date: 20-Oct-2019

Order Date: 16-Oct-2019

Project Description: Hwy 17, W-N/S Ramp Culvert

**Qualifier Notes:**

None

**Sample Data Revisions**

None

**Work Order Revisions / Comments:**

None

**Other Report Notes:**

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.  
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

## Subcontracted Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B 4S5

Attn: Justin Gray

Tel: (613) 408-6795

Fax: (613) 247-2185

Paracel Report No **1942180**  
Client Project(s): **Hwy 17, W-N/S Ramp Culvert**  
Client PO: **24726**  
Reference: **Standing Offer**  
CoC Number: **49177**

Order Date: 16-Oct-19

Report Date: 20-Oct-19

---

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
1942180-01	CV-9, SS3 (5'-7')	Sulphide, solid



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - KOL 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

23-October-2019

**Paracel Laboratories**

Attn : Dale Robertson

300-2319 St.Laurent Blvd.  
Ottawa, ON  
K1G 4K6, Canada

Phone: 613-731-9577  
Fax:613-731-9064

**Date Rec. :** 17 October 2019  
**LR Report:** CA15376-OCT19  
**Reference:** Project#: 1942180

**Copy:** #1

# CERTIFICATE OF ANALYSIS

## Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		23-Oct-19
2: Analysis Start Time		14:17
3: Analysis Completed Date		23-Oct-19
4: Analysis Completed Time		14:33
5: QC - Blank		< 0.02
6: QC - STD % Recovery		113%
7: QC - DUP % RPD		4%
8: RL		0.02
9: CV-9, SS3 (5'-7')	15-Oct-19	< 0.02

RL - SGS Reporting Limit

Kimberley Didsbury  
Project Specialist,  
Environment, Health & Safety

**Appendix C.3**  
**UCS Test Results**

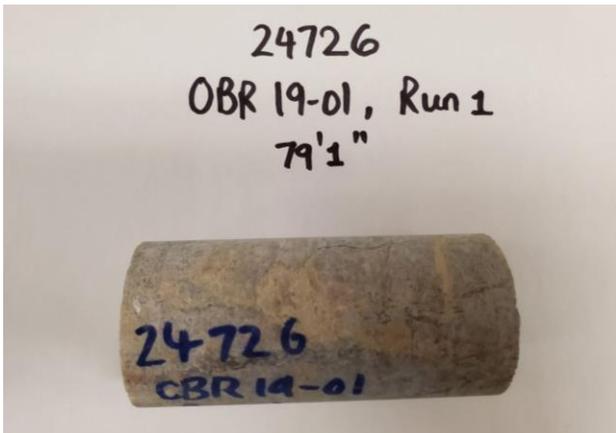
# UNCONFINED COMPRESSION TEST REPORT

## ASTM D7012-14

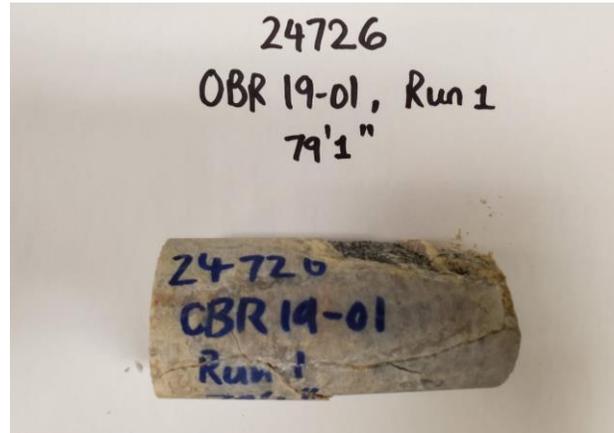
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	OBR 19-01	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 3		
SAMPLE DEPTH:	24.1m		
DESCRIPTION:	Marble		

Avg. Height (cm):	9.7	Weight (g):	479.4
Avg. Diameter (cm):	4.8	Wet Density (kg/m <sup>3</sup> ):	2,731
H. to Dia. Ratio**:	2:1	Dry Density (kg/m <sup>3</sup> ):	2,731
Cross Sectional Area (cm <sup>2</sup> ):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm <sup>3</sup> ):	175.53		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	68.4 kN
UNCONFINED COMPRESSIVE STRENGTH:	37.8 MPa

Note: \* Dimensions of Specimen conform to ASTM D 4543-04.

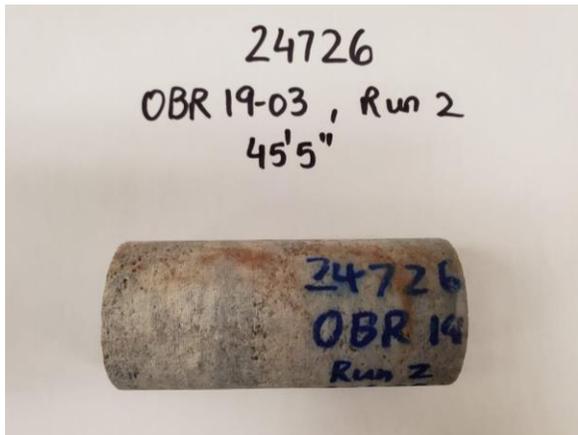
# UNCONFINED COMPRESSION TEST REPORT

## ASTM D7012-14

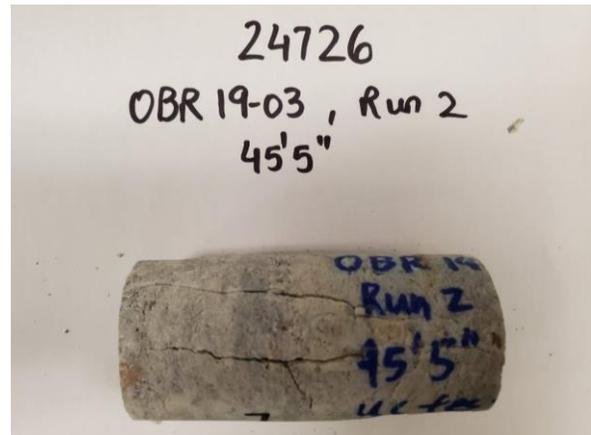
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	OBR 19-03	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 2		
SAMPLE DEPTH:	13.8m		
DESCRIPTION:	Marble		

Avg. Height (cm):	9.8	Weight (g):	476.7
Avg. Diameter (cm):	4.8	Wet Density (kg/m <sup>3</sup> ):	2,688
H. to Dia. Ratio**:	2:1	Dry Density (kg/m <sup>3</sup> ):	2,688
Cross Sectional Area (cm <sup>2</sup> ):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm <sup>3</sup> ):	177.34		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	71.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	39.7 MPa

Note: \* Dimensions of Specimen conform to ASTM D 4543-04.

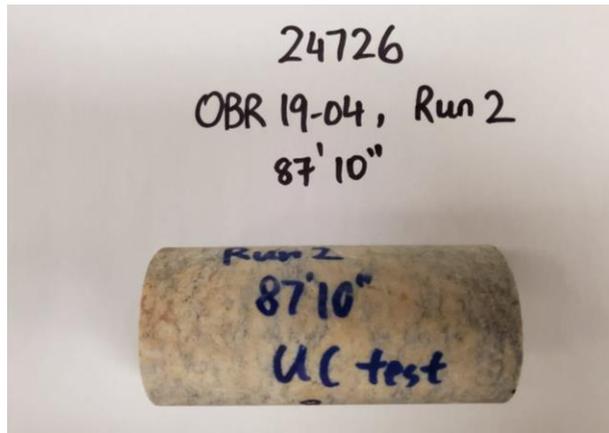
# UNCONFINED COMPRESSION TEST REPORT

## ASTM D7012-14

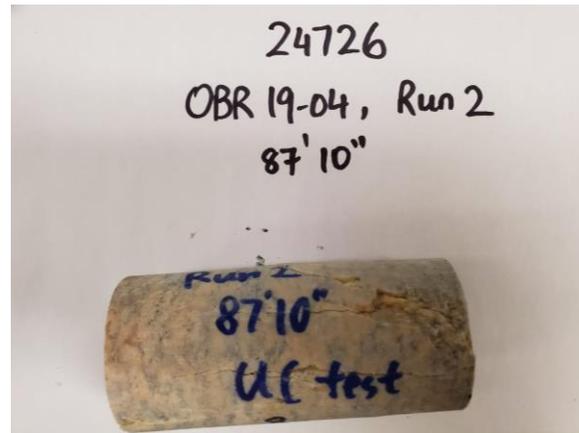
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	OBR 19-04	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 2		
SAMPLE DEPTH:	26.8m		
DESCRIPTION:	Marble		

Avg. Height (cm):	9.7	Weight (g):	476.4
Avg. Diameter (cm):	4.7	Wet Density (kg/m <sup>3</sup> ):	2,831
H. to Dia. Ratio**:	2.1:1	Dry Density (kg/m <sup>3</sup> ):	2,831
Cross Sectional Area (cm <sup>2</sup> ):	17.35	Moisture Content* (%):	N/A
Sample Volume (cm <sup>3</sup> ):	168.29		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	62.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	36.3 MPa

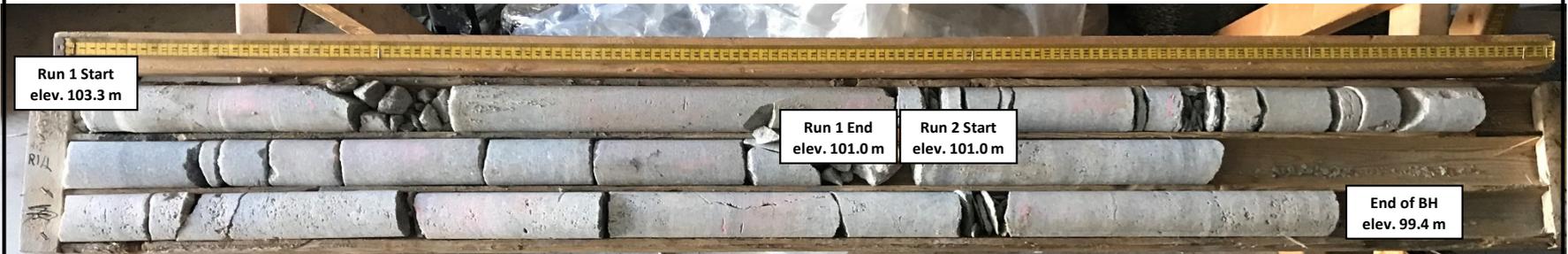
Note: \* Dimensions of Specimen conform to ASTM D 4543-04.

**Appendix C.4**  
**Bedrock Core Photographs**

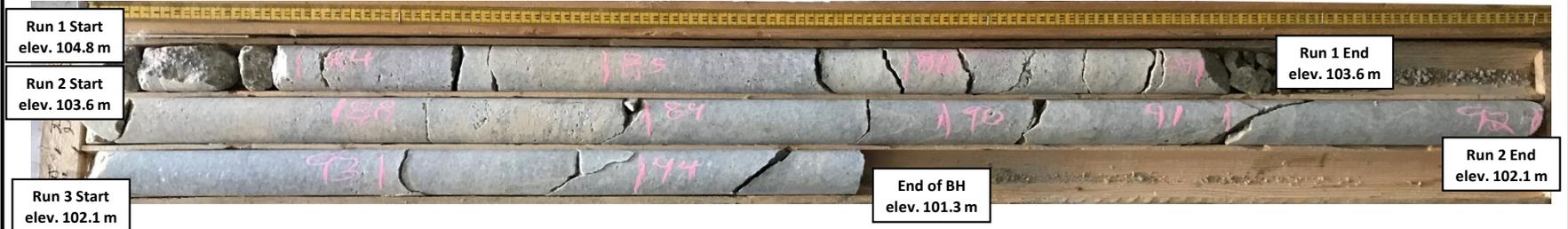
**Borehole OBR19-1**  
**Run 1 to 3 (of 3)**  
**Elevation 106.7 m to 103.0 m**



**Borehole OBR19-3**  
**Run 1 to 2 (of 2)**  
**Elevation 103.3 m to 99.4 m**



**Borehole OBR19-4**  
**Run 1 to 3 (of 3)**  
**Elevation 104.8 m to 101.3 m**



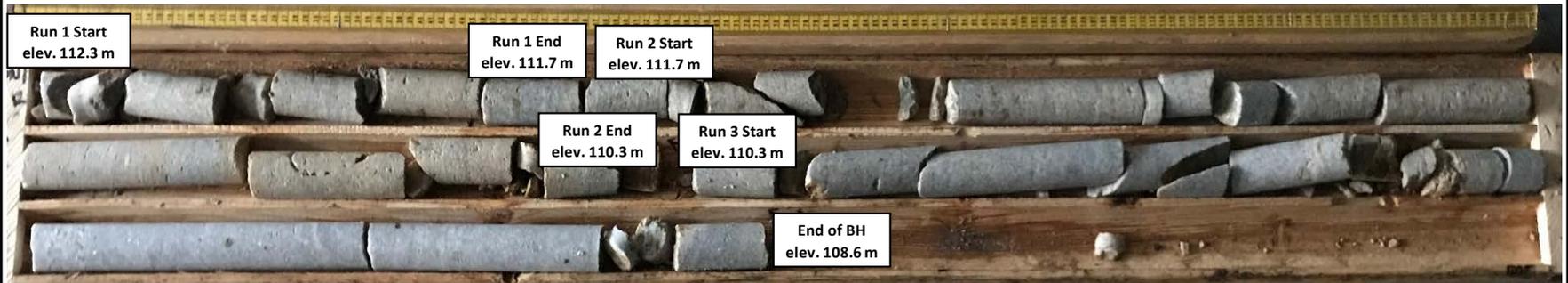
**Geotechnical Investigation**  
**HWY 17 Twinning**  
**Renfrew, Ontario**

**OBR19-4**  
**Project No.: 24726**

**Borehole CV-7**  
**Run 1 to 4 (of 4)**  
**Elevation 113.8 m to 110.8 m**



**Borehole CV-8**  
**Run 1 to 4 (of 4)**  
**Elevation 112.3 m to 108.6 m**



**Borehole CV-9**  
**Run 1 to 3 (of 3)**  
**Elevation 110.5 m to 106.9 m**

Run 1 Start  
elev. 110.5 m



Run 1 End  
elev. 108.5 m

Run 2 Start  
elev. 108.5 m

End of BH  
elev. 106.9 m

**Appendix D.**  
**Site Photographs**



**Photo 1. Looking north from O'Brien Road towards existing intersection (2019/07/03)**



**Photo 2. Looking west from Highway 17 towards existing intersection (2019/07/03)**



**Photo 3. Looking east along W-S Ramp alignment at approximate station 20+950. Borehole OBR19-14 and large surficial boulders in foreground (2020/04/22)**



**Photo 4. Looking south-west in ravine of W-S Ramp at approximate station 21+175 (2020/04/22)**

**Appendix E.**  
**ConeTec Report**

# PRESENTATION OF SITE INVESTIGATION RESULTS

## Highway 17 and O'Brien Road

*Prepared for:*

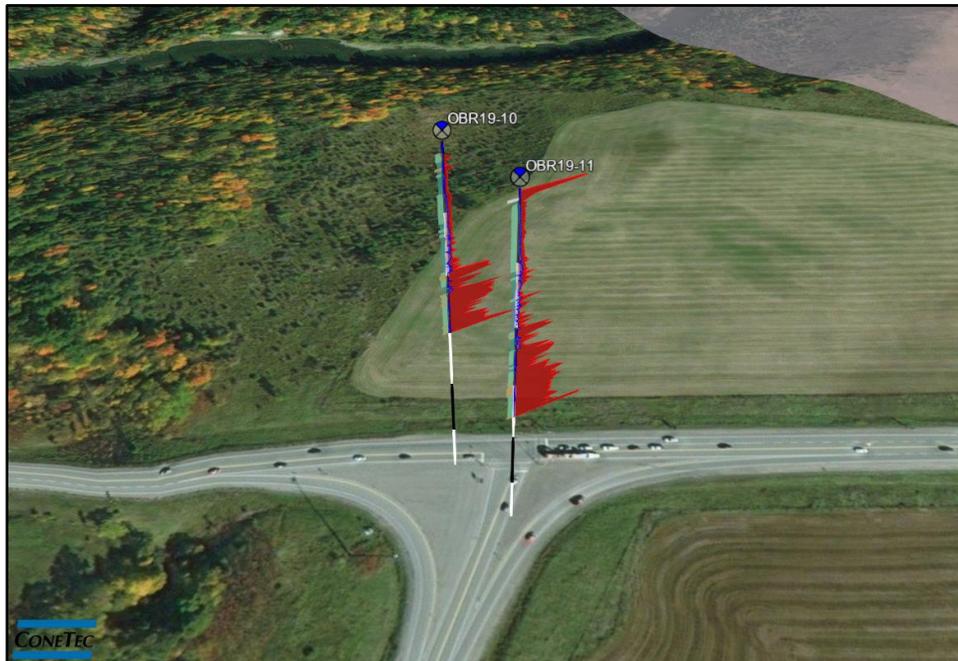
Thurber Engineering Ltd.

ConeTec Job No: 19-05076

Project Start Date: 29-Nov-2019

Project End Date: 29-Nov-2019

Report Date: 05-Dec-2019



*Prepared by:*

ConeTec Investigations Ltd.  
9033 Leslie Street, Unit 15  
Richmond Hill, ON L4B 4K3

Tel: (905) 886-2663  
Fax: (905) 886-2664  
Toll Free: (800) 504-1116

ConeTecON@conetec.com  
www.conetec.com  
www.conetecdataservices.com



### Introduction

The enclosed report presents the results of the site investigation program conducted by ConeTec Investigations Ltd. for Thurber Engineering Ltd. at Highway 17 and Bruce Street, Renfrew, ON. The program consisted of two seismic cone penetration tests (SCPTu).

### Project Information

Project	
Client	Thurber Engineering Ltd.
Project	Highway 17 and O'Brien Road
ConeTec project number	19-05076

An aerial overview from Google Earth including the SCPTu test locations is presented below.



Rig Description	Deployment System	Test Type
CPT track rig (M5T)	14 ton rig cylinder	SCPTu

Coordinates			
Test Type	Collection Method	EPSG Number	Comments
SCPTu	Client Provided	32189	Coordinates and elevations were provided by the client in datum MTM zone 9.

Cone Penetrometers Used for this Project						
Cone Description	Cone Number	Cross Sectional Area (cm <sup>2</sup> )	Sleeve Area (cm <sup>2</sup> )	Tip Capacity (bar)	Sleeve Capacity (bar)	Pore Pressure Capacity (psi)
377:T1000F10U500	377	10	150	1000	10	500
Cone 377 was used for all CPT soundings.						

Cone Penetration Test (CPTu)	
Depth reference	Depths are referenced to the existing ground surface at the time of each test.
Tip and sleeve data offset	0.1 meter This has been accounted for in the CPT data files.
Additional plots	<ul style="list-style-type: none"> <li>Advanced plots with <math>I_c</math>, <math>S_u</math>, <math>\phi</math> and <math>N1(60)</math></li> <li>Seismic shear wave velocity plots</li> <li>Soil Behaviour Type (SBT) scatter plots</li> </ul>

Calculated Geotechnical Parameter Tables	
Additional information	<p>The Normalized Soil Behaviour Type Chart based on <math>Q_{tn}</math> (SBT <math>Q_{tn}</math>) (Robertson, 2009) was used to classify the soil for this project. A detailed set of calculated CPTu parameters have been generated and are provided in Excel format files in the release folder. The CPTu parameter calculations are based on values of corrected tip resistance (<math>q_t</math>) sleeve friction (<math>f_s</math>) and pore pressure (<math>u_2</math>).</p> <p>Effective stresses are calculated based on unit weights that have been assigned to the individual soil behaviour type zones and the assumed equilibrium pore pressure profile.</p> <p>Soils were classified as either drained or undrained based on the <math>Q_{tn}</math> Normalized Soil Behaviour Type Chart (Robertson, 2009). Calculations for both drained and undrained parameters were included for materials that classified as silt mixtures (zone 4) and sand mixtures (zone 5).</p>

## Limitations

This report has been prepared for the exclusive use of Thurber Engineering Ltd. (Client) for the project titled "Highway 17 and O'Brien Road". The report's contents may not be relied upon by any other party without the express written permission of ConeTec Investigations Ltd. (ConeTec). ConeTec has provided site investigation services, prepared the factual data reporting and provided geotechnical parameter calculations consistent with current best practices. No other warranty, expressed or implied, is made.

The information presented in the report document and the accompanying data set pertain to the specific project, site conditions and objectives described to ConeTec by the Client. In order to properly understand the factual data, assumptions and calculations, reference must be made to the documents provided and their accompanying data sets, in their entirety.

Cone penetration tests (CPTu) are conducted using an integrated electronic piezocone penetrometer and data acquisition system manufactured by Adara Systems Ltd., a subsidiary of ConeTec.

ConeTec's piezocone penetrometers are compression type designs in which the tip and friction sleeve load cells are independent and have separate load capacities. The piezocones use strain gauged load cells for tip and sleeve friction and a strain gauged diaphragm type transducer for recording pore pressure. The piezocones also have a platinum resistive temperature device (RTD) for monitoring the temperature of the sensors, an accelerometer type dual axis inclinometer and a geophone sensor for recording seismic signals. All signals are amplified down hole within the cone body and the analog signals are sent to the surface through a shielded cable.

ConeTec penetrometers are manufactured with various tip, friction and pore pressure capacities in 5 cm<sup>2</sup>, 10 cm<sup>2</sup> and 15 cm<sup>2</sup> tip base area configurations in order to maximize signal resolution for various soil conditions. The specific piezocone used for each test is described in the CPT summary table presented in the first appendix. The 15 cm<sup>2</sup> penetrometers do not require friction reducers as they have a diameter larger than the deployment rods. The 10 cm<sup>2</sup> piezocones use a friction reducer consisting of a rod adapter extension behind the main cone body with an enlarged cross sectional area (typically 44 mm diameter over a length of 32 mm with tapered leading and trailing edges) located at a distance of 585 mm above the cone tip.

The penetrometers are designed with equal end area friction sleeves, a net end area ratio of 0.8 and cone tips with a 60 degree apex angle.

All ConeTec piezocones can record pore pressure at various locations. Unless otherwise noted, the pore pressure filter is located directly behind the cone tip in the "u<sub>2</sub>" position (ASTM Type 2). The filter is 6 mm thick, made of porous plastic (polyethylene) having an average pore size of 125 microns (90-160 microns). The function of the filter is to allow rapid movements of extremely small volumes of water needed to activate the pressure transducer while preventing soil ingress or blockage.

The piezocone penetrometers are manufactured with dimensions, tolerances and sensor characteristics that are in general accordance with the current ASTM D5778 standard. ConeTec's calibration criteria also meets or exceeds those of the current ASTM D5778 standard. An illustration of the piezocone penetrometer is presented in Figure CPTu.

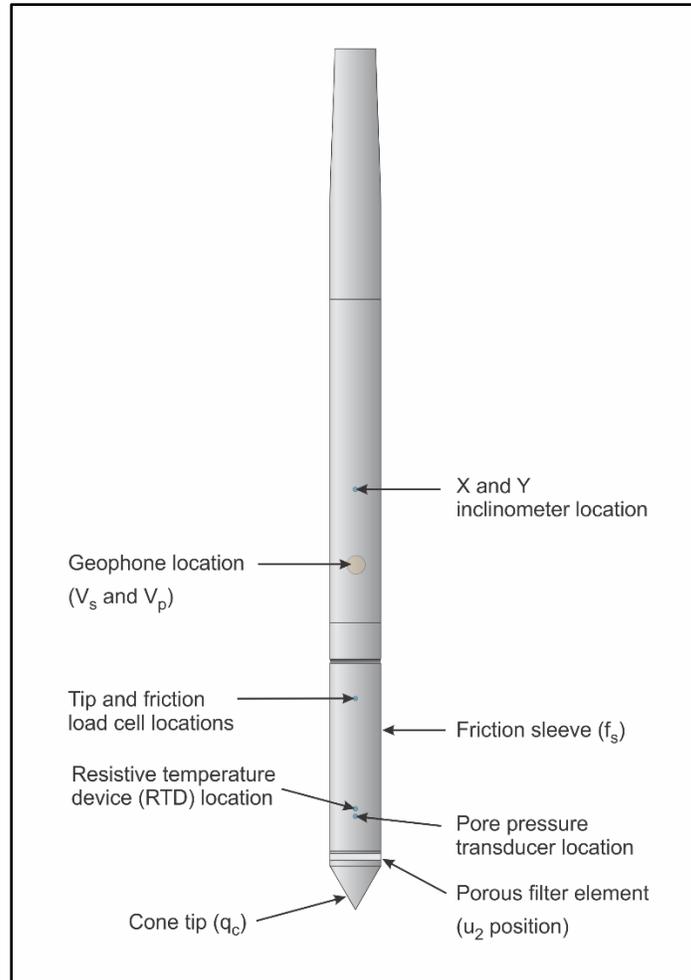


Figure CPTu. Piezocone Penetrometer (15 cm<sup>2</sup>)

The ConeTec data acquisition systems consist of a Windows based computer and a signal conditioner and power supply interface box with a 16 bit (or greater) analog to digital (A/D) converter. The data is recorded at fixed depth increments using a depth wheel attached to the push cylinders or by using a spring loaded rubber depth wheel that is held against the cone rods. The typical recording interval is 2.5 cm; custom recording intervals are possible.

The system displays the CPTu data in real time and records the following parameters to a storage media during penetration:

- Depth
- Uncorrected tip resistance ( $q_c$ )
- Sleeve friction ( $f_s$ )
- Dynamic pore pressure ( $u$ )
- Additional sensors such as resistivity, passive gamma, ultra violet induced fluorescence, if applicable

All testing is performed in accordance to ConeTec's CPT operating procedures which are in general accordance with the current ASTM D5778 standard.

Prior to the start of a CPTu sounding a suitable cone is selected, the cone and data acquisition system are powered on, the pore pressure system is saturated with either glycerine or silicone oil and the baseline readings are recorded with the cone hanging freely in a vertical position.

The CPTu is conducted at a steady rate of 2 cm/s, within acceptable tolerances. Typically one meter length rods with an outer diameter of 38.1 mm are added to advance the cone to the sounding termination depth. After cone retraction final baselines are recorded.

Additional information pertaining to ConeTec's cone penetration testing procedures:

- Each filter is saturated in silicone oil under vacuum pressure prior to use
- Recorded baselines are checked with an independent multi-meter
- Baseline readings are compared to previous readings
- Soundings are terminated at the client's target depth or at a depth where an obstruction is encountered, excessive rod flex occurs, excessive inclination occurs, equipment damage is likely to take place, or a dangerous working environment arises
- Differences between initial and final baselines are calculated to ensure zero load offsets have not occurred and to ensure compliance with ASTM standards

The interpretation of piezocone data for this report is based on the corrected tip resistance ( $q_t$ ), sleeve friction ( $f_s$ ) and pore water pressure ( $u$ ). The interpretation of soil type is based on the correlations developed by Robertson et al. (1986) and Robertson (1990, 2009). It should be noted that it is not always possible to accurately identify a soil behaviour type based on these parameters. In these situations, experience, judgment and an assessment of other parameters may be used to infer soil behaviour type.

The recorded tip resistance ( $q_c$ ) is the total force acting on the piezocone tip divided by its base area. The tip resistance is corrected for pore pressure effects and termed corrected tip resistance ( $q_t$ ) according to the following expression presented in Robertson et al. (1986):

$$q_t = q_c + (1-a) \cdot u_2$$

where:  $q_t$  is the corrected tip resistance

$q_c$  is the recorded tip resistance

$u_2$  is the recorded dynamic pore pressure behind the tip ( $u_2$  position)

$a$  is the Net Area Ratio for the piezocone (0.8 for ConeTec probes)

The sleeve friction ( $f_s$ ) is the frictional force on the sleeve divided by its surface area. As all ConeTec piezocones have equal end area friction sleeves, pore pressure corrections to the sleeve data are not required.

The dynamic pore pressure ( $u$ ) is a measure of the pore pressures generated during cone penetration. To record equilibrium pore pressure, the penetration must be stopped to allow the dynamic pore pressures to stabilize. The rate at which this occurs is predominantly a function of the permeability of the soil and the diameter of the cone.

The friction ratio ( $R_f$ ) is a calculated parameter. It is defined as the ratio of sleeve friction to the tip resistance expressed as a percentage. Generally, saturated cohesive soils have low tip resistance, high friction ratios and generate large excess pore water pressures. Cohesionless soils have higher tip resistances, lower friction ratios and do not generate significant excess pore water pressure.

A summary of the CPTu soundings along with test details and individual plots are provided in the appendices. A set of files with calculated geotechnical parameters were generated for each sounding based on published correlations and are provided in Excel format in the data release folder. Information regarding the methods used is also included in the data release folder.

For additional information on CPTu interpretations and calculated geotechnical parameters, refer to Robertson et al. (1986), Lunne et al. (1997), Robertson (2009), Mayne (2013, 2014) and Mayne and Peuchen (2012).

Shear wave velocity ( $V_s$ ) testing is performed in conjunction with the piezocone penetration test (SCPTu) in order to collect interval velocities. For some projects seismic compression wave velocity ( $V_p$ ) testing is also performed.

ConeTec's piezocone penetrometers are manufactured with a horizontally active geophone (28 hertz) that is rigidly mounted in the body of the cone penetrometer, 0.2 meters behind the cone tip.

Shear waves are typically generated by using an impact hammer horizontally striking a beam that is held in place by a normal load. In some instances an auger source or an imbedded impulsive source maybe used for both shear waves and compression waves. The hammer and beam act as a contact trigger that initiates the recording of the seismic wave traces. For impulsive devices an accelerometer trigger may be used. The traces are recorded using an up-hole integrated digital oscilloscope which is part of the SCPTu data acquisition system. An illustration of the shear wave testing configuration is presented in Figure SCPTu-1.

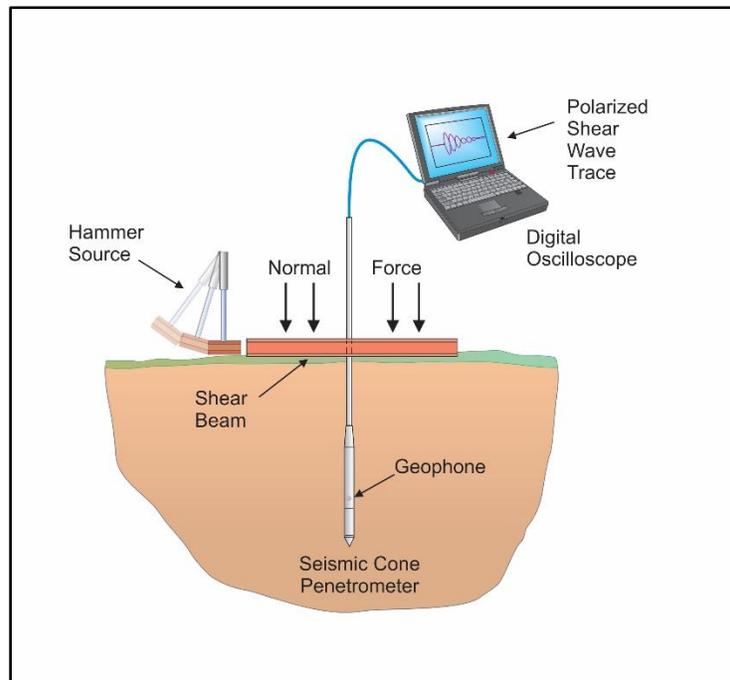


Figure SCPTu-1. Illustration of the SCPTu system

All testing is performed in accordance to ConeTec's SCPTu operating procedures which are in general accordance with the current ASTM D5778 and ASTM D7400 standards.

Prior to the start of a SCPTu sounding, the procedures described in the Cone Penetration Test section are followed. In addition, the active axis of the geophone is aligned parallel to the beam (or source) and the horizontal offset between the cone and the source is measured and recorded.

Prior to recording seismic waves at each test depth, cone penetration is stopped and the rods are decoupled from the rig to avoid transmission of rig energy down the rods. Typically, five wave traces for each orientation are recorded for quality control and uncertainty analysis purposes. After reviewing wave

traces for consistency the cone is pushed to the next test depth (typically one meter intervals or as requested by the client). Figure SCPTu-2 presents an illustration of a SCPTu test.

For additional information on seismic cone penetration testing refer to Robertson et. al. (1986).

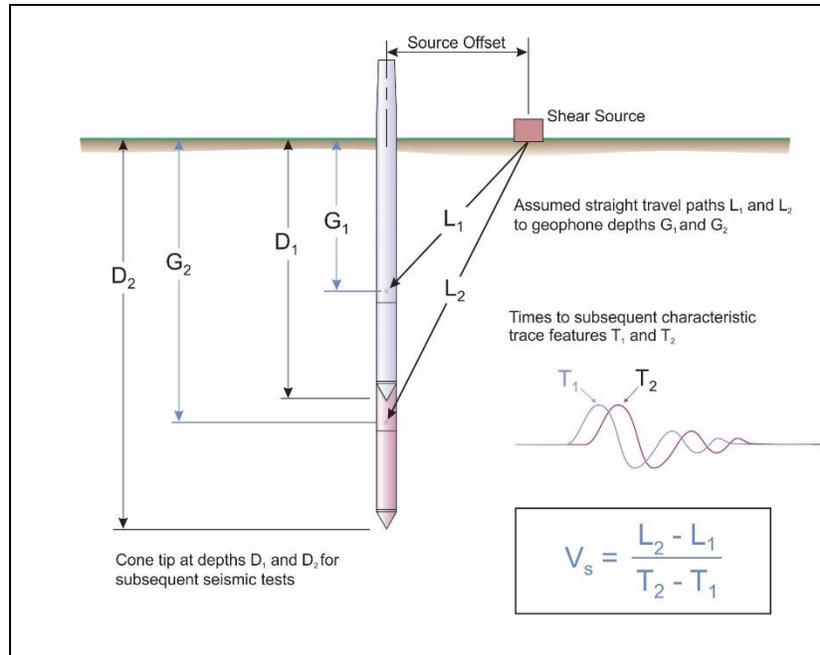


Figure SCPTu-2. Illustration of a seismic cone penetration test

Calculation of the interval velocities are performed by visually picking a common feature (e.g. the first characteristic peak, trough, or crossover) on all of the recorded wave sets and taking the difference in ray path divided by the time difference between subsequent features. Ray path is defined as the straight line distance from the seismic source to the geophone, accounting for beam offset, source depth and geophone offset from the cone tip.

The average shear wave velocity to a depth of 30 meters ( $V_{s30}$ ) has been calculated and provided for all applicable soundings using an equation presented in Crow et al. (2012).

$$V_{s30} = \frac{\text{total thickness of all layers (30m)}}{\sum(\text{layer traveltimes})}$$

The layer travel times refers to the travel times propagating in the vertical direction, not the measured travel times from an offset source.

Tabular results and SCPTu plots are presented in the relevant appendix.

The cone penetration test is halted at specific depths to carry out pore pressure dissipation (PPD) tests, shown in Figure PPD-1. For each dissipation test the cone and rods are decoupled from the rig and the data acquisition system measures and records the variation of the pore pressure ( $u$ ) with time ( $t$ ).

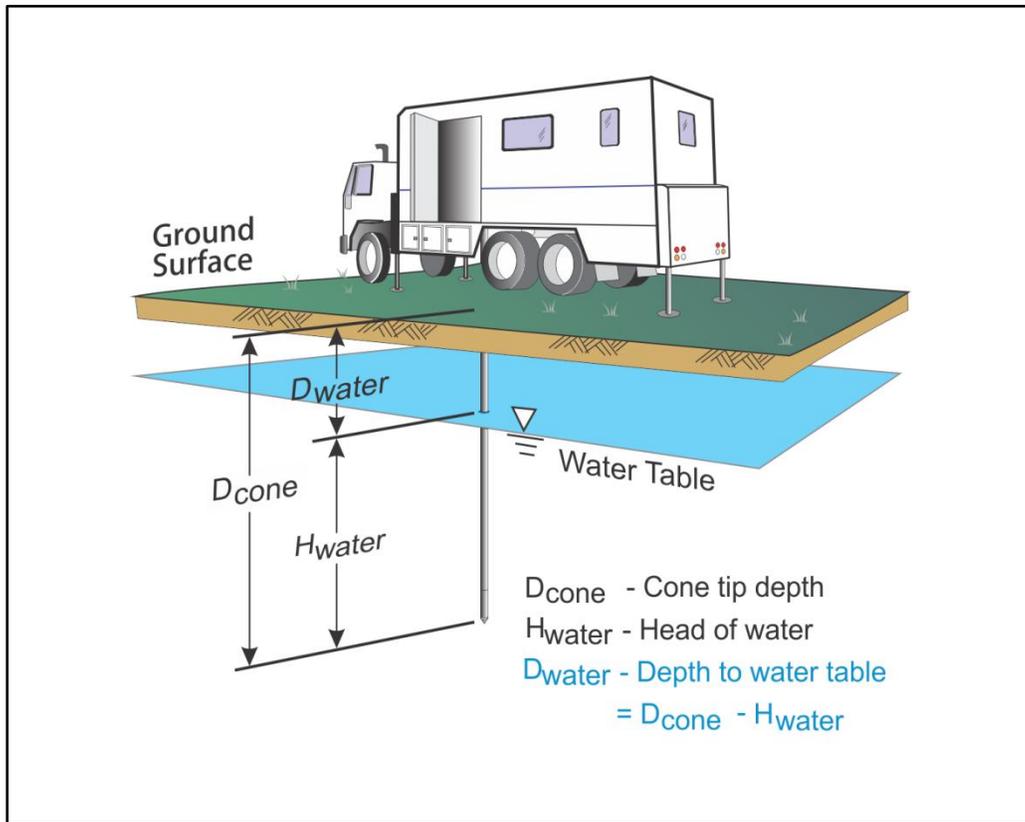


Figure PPD-1. Pore pressure dissipation test setup

Pore pressure dissipation data can be interpreted to provide estimates of ground water conditions, permeability, consolidation characteristics and soil behaviour.

The typical shapes of dissipation curves shown in Figure PPD-2 are very useful in assessing soil type, drainage, in situ pore pressure and soil properties. A flat curve that stabilizes quickly is typical of a freely draining sand. Undrained soils such as clays will typically show positive excess pore pressure and have long dissipation times. Dilative soils will often exhibit dynamic pore pressures below equilibrium that then rise over time. Overconsolidated fine-grained soils will often exhibit an initial dilatatory response where there is an initial rise in pore pressure before reaching a peak and dissipating.

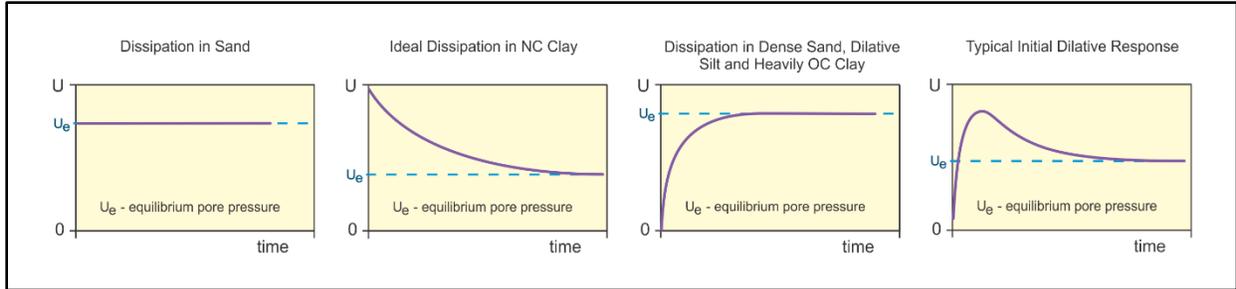


Figure PPD-2. Pore pressure dissipation curve examples

In order to interpret the equilibrium pore pressure ( $u_{eq}$ ) and the apparent phreatic surface, the pore pressure should be monitored until such time as there is no variation in pore pressure with time as shown for each curve in Figure PPD-2.

In fine grained deposits the point at which 100% of the excess pore pressure has dissipated is known as  $t_{100}$ . In some cases this can take an excessive amount of time and it may be impractical to take the dissipation to  $t_{100}$ . A theoretical analysis of pore pressure dissipations by Teh and Houlsby (1991) showed that a single curve relating degree of dissipation versus theoretical time factor ( $T^*$ ) may be used to calculate the coefficient of consolidation ( $c_h$ ) at various degrees of dissipation resulting in the expression for  $c_h$  shown below.

$$c_h = \frac{T^* \cdot a^2 \cdot \sqrt{I_r}}{t}$$

Where:

- $T^*$  is the dimensionless time factor (Table Time Factor)
- $a$  is the radius of the cone
- $I_r$  is the rigidity index
- $t$  is the time at the degree of consolidation

Table Time Factor.  $T^*$  versus degree of dissipation (Teh and Houlsby (1991))

Degree of Dissipation (%)	20	30	40	50	60	70	80
$T^* (u_2)$	0.038	0.078	0.142	0.245	0.439	0.804	1.60

The coefficient of consolidation is typically analyzed using the time ( $t_{50}$ ) corresponding to a degree of dissipation of 50% ( $u_{50}$ ). In order to determine  $t_{50}$ , dissipation tests must be taken to a pressure less than  $u_{50}$ . The  $u_{50}$  value is half way between the initial maximum pore pressure and the equilibrium pore pressure value, known as  $u_{100}$ . To estimate  $u_{50}$ , both the initial maximum pore pressure and  $u_{100}$  must be known or estimated. Other degrees of dissipations may be considered, particularly for extremely long dissipations.

At any specific degree of dissipation the equilibrium pore pressure ( $u$  at  $t_{100}$ ) must be estimated at the depth of interest. The equilibrium value may be determined from one or more sources such as measuring the value directly ( $u_{100}$ ), estimating it from other dissipations in the same profile, estimating the phreatic surface and assuming hydrostatic conditions, from nearby soundings, from client provided information, from site observations and/or past experience, or from other site instrumentation.

For calculations of  $c_h$  (Teh and Houlsby (1991)),  $t_{50}$  values are estimated from the corresponding pore pressure dissipation curve and a rigidity index ( $I_r$ ) is assumed. For curves having an initial dilatatory response in which an initial rise in pore pressure occurs before reaching a peak, the relative time from the peak value is used in determining  $t_{50}$ . In cases where the time to peak is excessive,  $t_{50}$  values are not calculated.

Due to possible inherent uncertainties in estimating  $I_r$ , the equilibrium pore pressure and the effect of an initial dilatatory response on calculating  $t_{50}$ , other methods should be applied to confirm the results for  $c_h$ .

Additional published methods for estimating the coefficient of consolidation from a piezocone test are described in Burns and Mayne (1998, 2002), Jones and Van Zyl (1981), Robertson et al. (1992) and Sully et al. (1999).

A summary of the pore pressure dissipation tests and dissipation plots are presented in the relevant appendix.

## REFERENCES

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- ASTM D5778-12, 2012, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils", ASTM, West Conshohocken, US.
- ASTM D7400-14, 2014, "Standard Test Methods for Downhole Seismic Testing", ASTM, West Conshohocken, US.
- Burns, S.E. and Mayne, P.W., 1998, "Monotonic and dilatatory pore pressure decay during piezocone tests", Canadian Geotechnical Journal 26 (4): 1063-1073.
- Burns, S.E. and Mayne, P.W., 2002, "Analytical cavity expansion-critical state model cone dissipation in fine-grained soils", Soils & Foundations, Vol. 42(2): 131-137.
- Crow, H.L., Hunter, J.A., Bobrowsky, P.T., 2012, "National shear wave measurement guidelines for Canadian seismic site assessment", GeoManitoba 2012, Sept 30 to Oct 2, Winnipeg, Manitoba.
- Jones, G.A. and Van Zyl, D.J.A., 1981, "The piezometer probe: a useful investigation tool", Proceedings, 10<sup>th</sup> International Conference on Soil Mechanics and Foundation Engineering, Vol. 3, Stockholm: 489-495.
- Lunne, T., Robertson, P.K. and Powell, J. J. M., 1997, "Cone Penetration Testing in Geotechnical Practice", Blackie Academic and Professional.
- Mayne, P.W., 2013, "Evaluating yield stress of soils from laboratory consolidation and in-situ cone penetration tests", Sound Geotechnical Research to Practice (Holtz Volume) GSP 230, ASCE, Reston/VA: 406-420.
- Mayne, P.W., 2014, "Interpretation of geotechnical parameters from seismic piezocone tests", CPT'14 Keynote Address, Las Vegas, NV, May 2014.
- Mayne, P.W. and Peuchen, J., 2012, "Unit weight trends with cone resistance in soft to firm clays", Geotechnical and Geophysical Site Characterization 4, Vol. 1 (Proc. ISC-4, Pernambuco), CRC Press, London: 903-910.
- Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J., 1986, "Use of Piezometer Cone Data", Proceedings of InSitu 86, ASCE Specialty Conference, Blacksburg, Virginia.
- Robertson, P.K., 1990, "Soil Classification Using the Cone Penetration Test", Canadian Geotechnical Journal, Volume 27: 151-158.
- Robertson, P.K., 2009, "Interpretation of cone penetration tests – a unified approach", Canadian Geotechnical Journal, Volume 46: 1337-1355.
- Robertson, P.K., Campanella, R.G., Gillespie D and Rice, A., 1986, "Seismic CPT to Measure In-Situ Shear Wave Velocity", Journal of Geotechnical Engineering ASCE, Vol. 112, No. 8: 791-803.
- Robertson, P.K., Sully, J.P., Woeller, D.J., Lunne, T., Powell, J.J.M. and Gillespie, D.G., 1992, "Estimating coefficient of consolidation from piezocone tests", Canadian Geotechnical Journal, 29(4): 551-557.

## REFERENCES

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Sully, J.P., Robertson, P.K., Campanella, R.G. and Woeller, D.J., 1999, "An approach to evaluation of field CPTU dissipation data in overconsolidated fine-grained soils", *Canadian Geotechnical Journal*, 36(2): 369-381.

Teh, C.I., and Housby, G.T., 1991, "An analytical study of the cone penetration test in clay", *Geotechnique*, 41(1): 17-34.

The appendices listed below are included in the report:

- Cone Penetration Test Summary and Standard Cone Penetration Test Plots
- Advanced Cone Penetration Test Plots
- Seismic Cone Penetration Test Plots
- Seismic Cone Penetration Test Tabular Results
- Seismic Cone Penetration Test Shear Wave ( $V_s$ ) Traces
- Soil Behaviour Type (SBT) Scatter Plots
- Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots

# Cone Penetration Test Summary and Standard Cone Penetration Test Plots



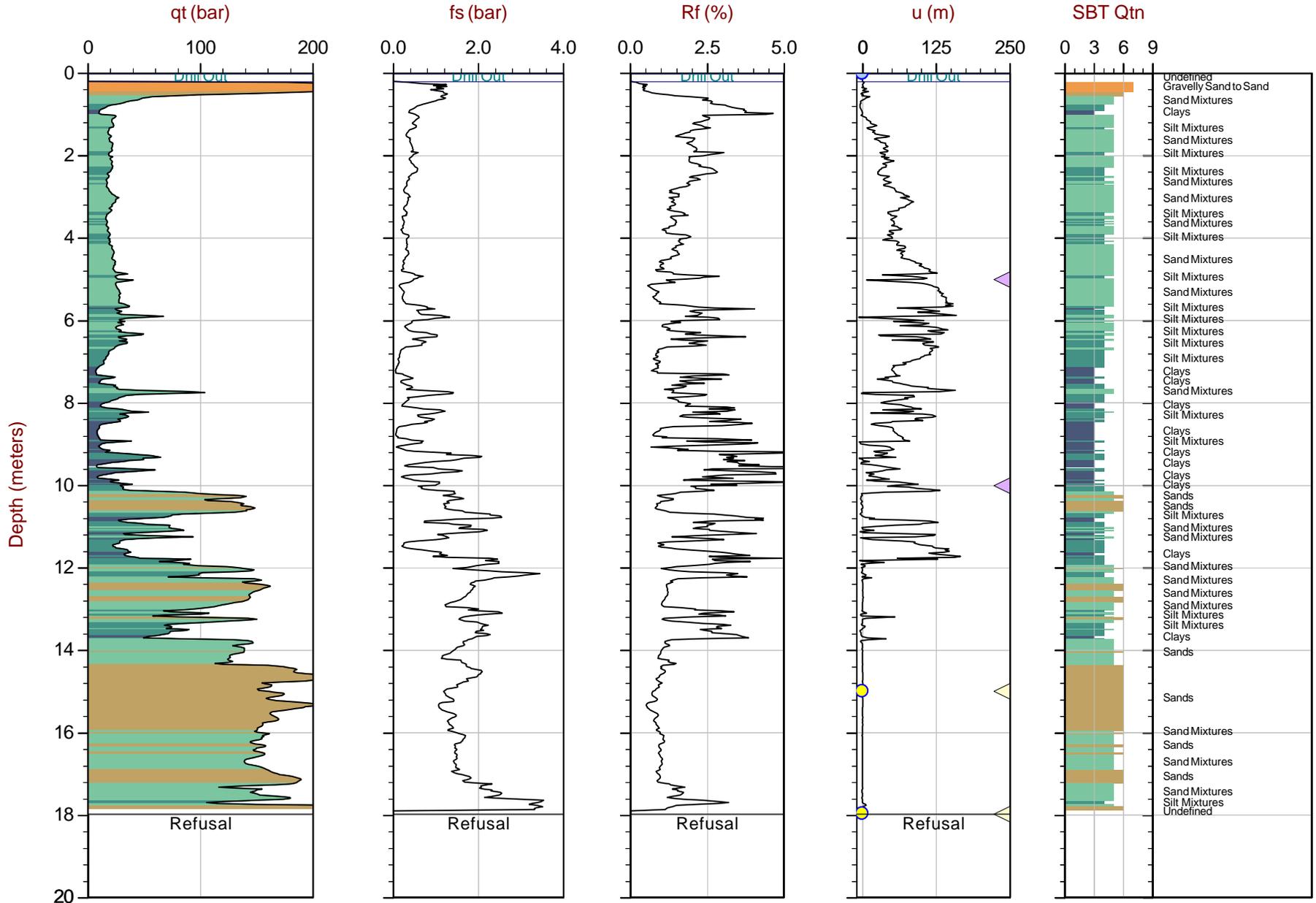
Job No: 19-05076  
Client: Thurber Engineering Ltd.  
Project: Highway 17 and O'Brien Road  
Start Date: 29-Nov-2019  
End Date: 29-Nov-2019

### CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date	Cone	Assumed Phreatic Surface <sup>1</sup> (m)	Final Depth (m)	Northing <sup>2</sup> (m)	Easting <sup>2</sup> (m)	Elevation <sup>3</sup> (m)	Refer to Notation Number
OBR19-10	19-05076_SP10	29-Nov-2019	377:T1000F10U500		14.950	5038072.30	293367.70	129.90	
OBR19-11	19-05076_SP11	29-Nov-2019	377:T1000F10U500		17.975	5038038.50	293374.50	129.80	

1. No phreatic surface detected. Unsaturated conditions were assumed for the calculated parameters.
2. Coordinates and elevations were provided by the client with datum NAD83/MTM Zone 9 North.
3. Elevations are referenced to the existing ground surface at the time of testing.





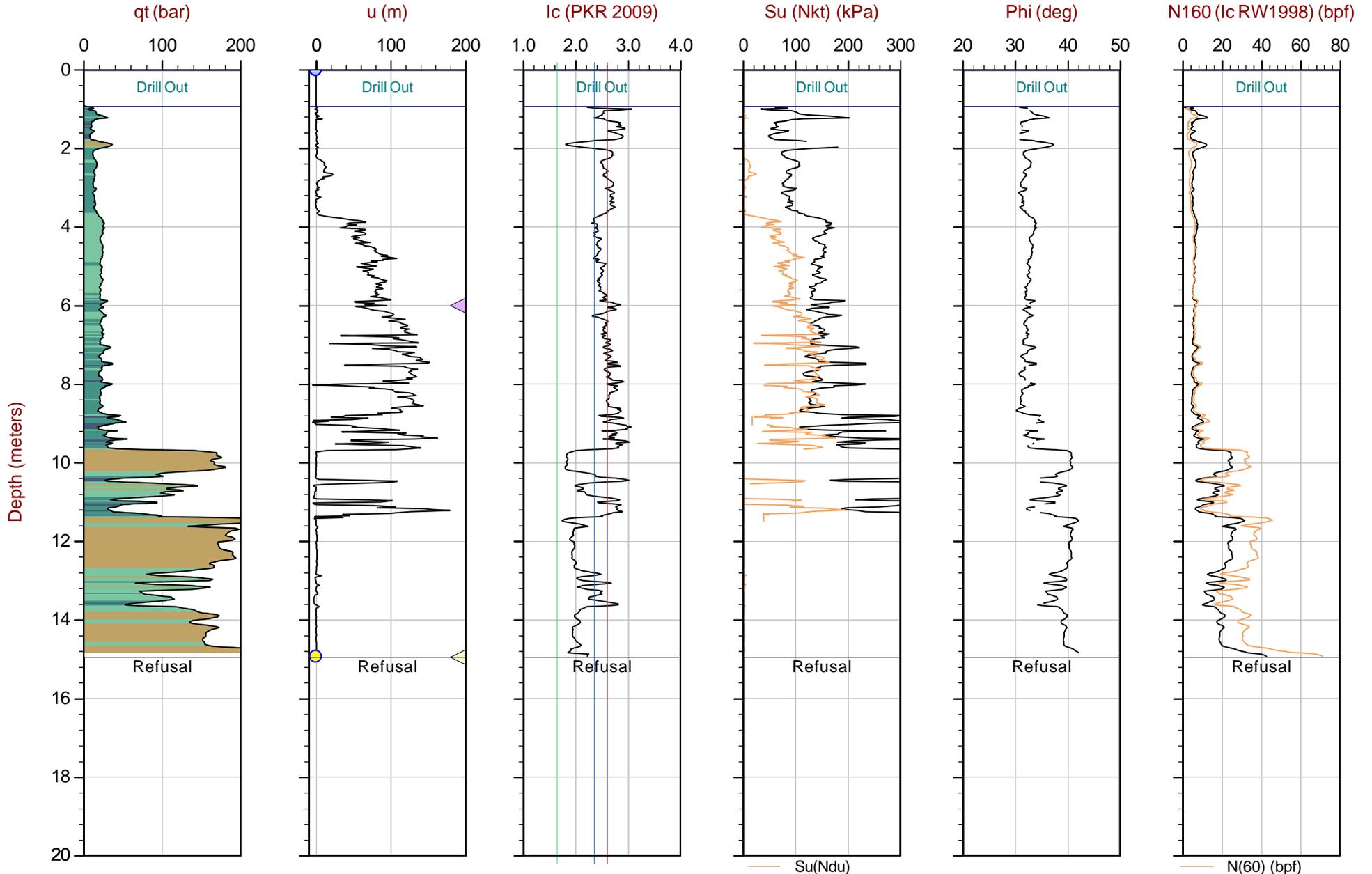
Max Depth: 17.975 m / 58.97 ft  
 Depth Inc: 0.025 m / 0.082 ft  
 Avg Int: EveryPoint  
 Overplot Item: ● Ueq ○ Assumed Ueq

File: 19-05076\_SP11.COR  
 Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010  
 Coords: MTM9 N: 5038038.50m E: 293374.50m Elev: 129.80m  
 Sheet No: 1 of 1

△ Dissipation, Ueq achieved    ◁ Dissipation, Ueq not achieved

## Advanced Cone Penetration Test Plots

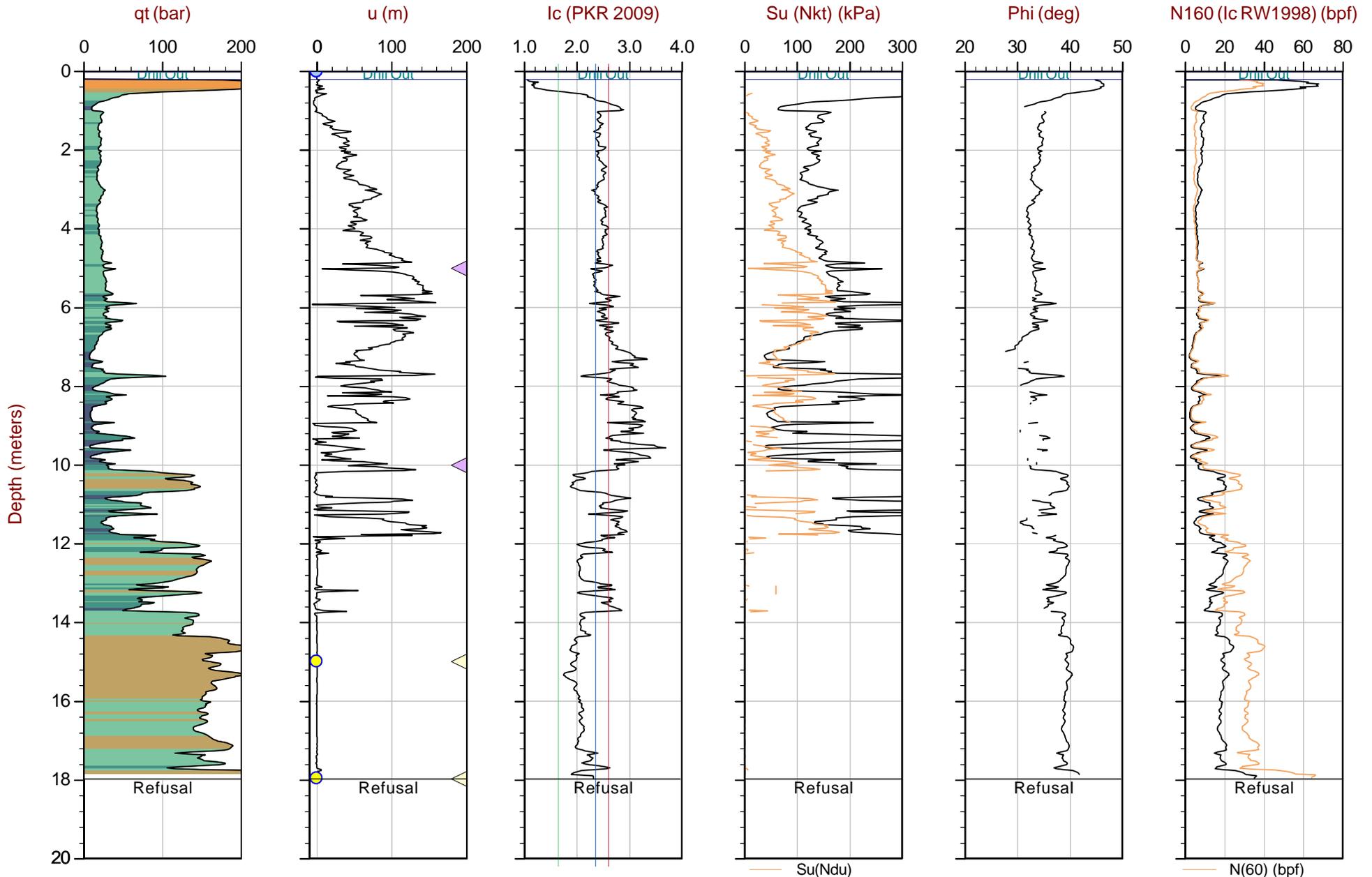


Max Depth: 14.950 m / 49.05 ft  
 Depth Inc: 0.025 m / 0.082 ft  
 Avg Int: EveryPoint  
 Overplot Item: ● Ueq ● Assumed Ueq

File: 19-05076\_SP10.COR  
 Unit Wt: SBTQtn(PKR2009)  
 SuNkt/Ndu: 15.0 / 9.0

SBT: Robertson, 2009 and 2010  
 Coords: MTM9 N: 5038072.30m E: 293367.70m Elev: 129.90m  
 Sheet No: 1 of 1

◁ Dissipation, Ueq achieved ◀ Dissipation, Ueq not achieved



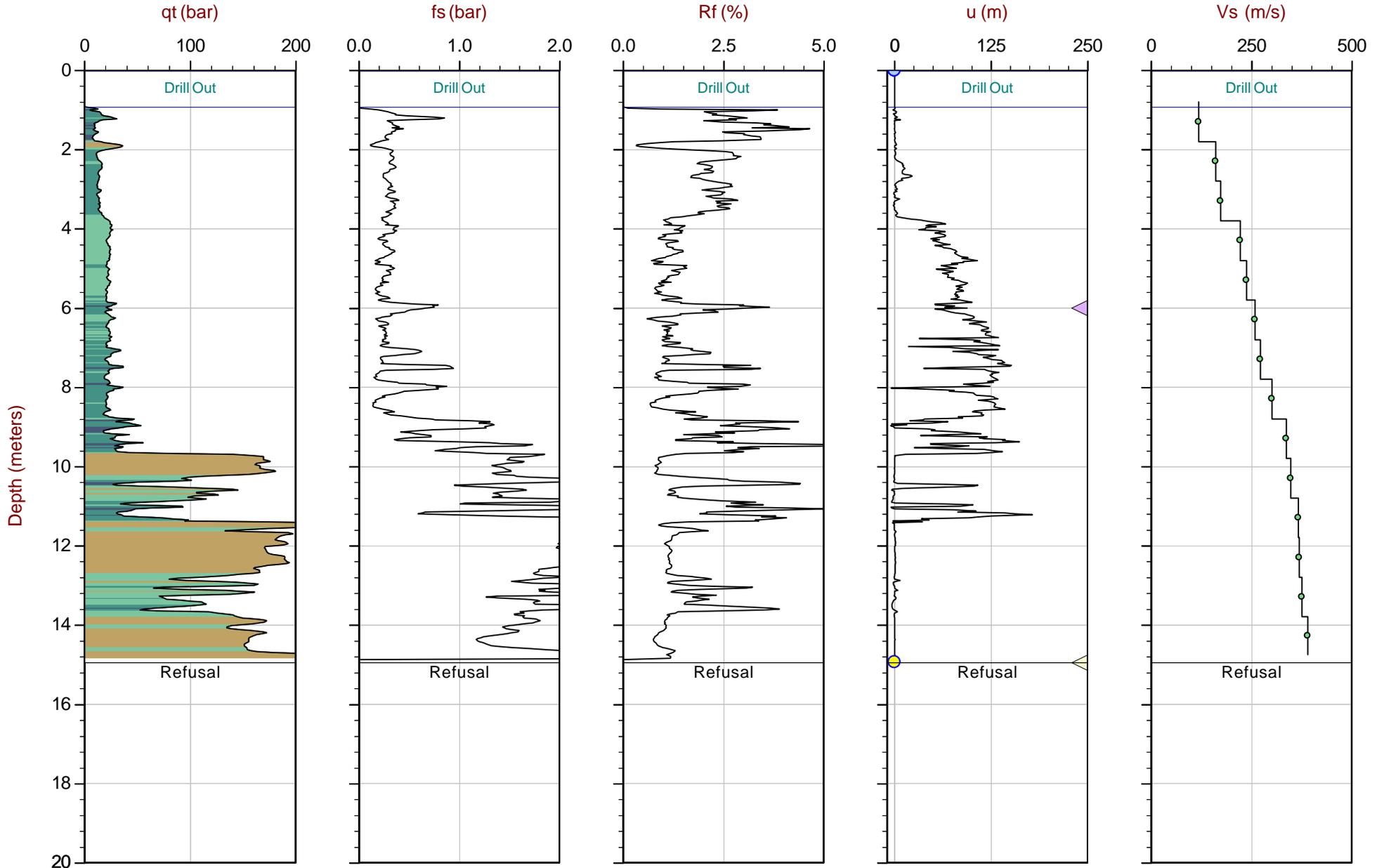
Max Depth: 17.975 m / 58.97 ft  
 Depth Inc: 0.025 m / 0.082 ft  
 Avg Int: EveryPoint  
 Overplot Item: ● Ueq ● Assumed Ueq

File: 19-05076\_SP11.COR  
 Unit Wt: SBTQtn(PKR2009)  
 SuNkt/Ndu: 15.0 / 9.0

SBT: Robertson, 2009 and 2010  
 Coords: MTM9 N: 5038038.50m E: 293374.50m Elev: 129.80m  
 Sheet No: 1 of 1

△ Dissipation, Ueq achieved    ▽ Dissipation, Ueq not achieved

## Seismic Cone Penetration Test Plots



Max Depth: 14.950 m / 49.05 ft  
 Depth Inc: 0.025 m / 0.082 ft  
 Avg Int: Every Point  
 Overplot Item: ● Ueq   ● Assumed Ueq

File: 19-05076\_SP10.COR  
 Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010  
 Coords: MTM9 N: 5038072.30m E: 293367.70m Elev: 129.90m  
 Sheet No: 1 of 1

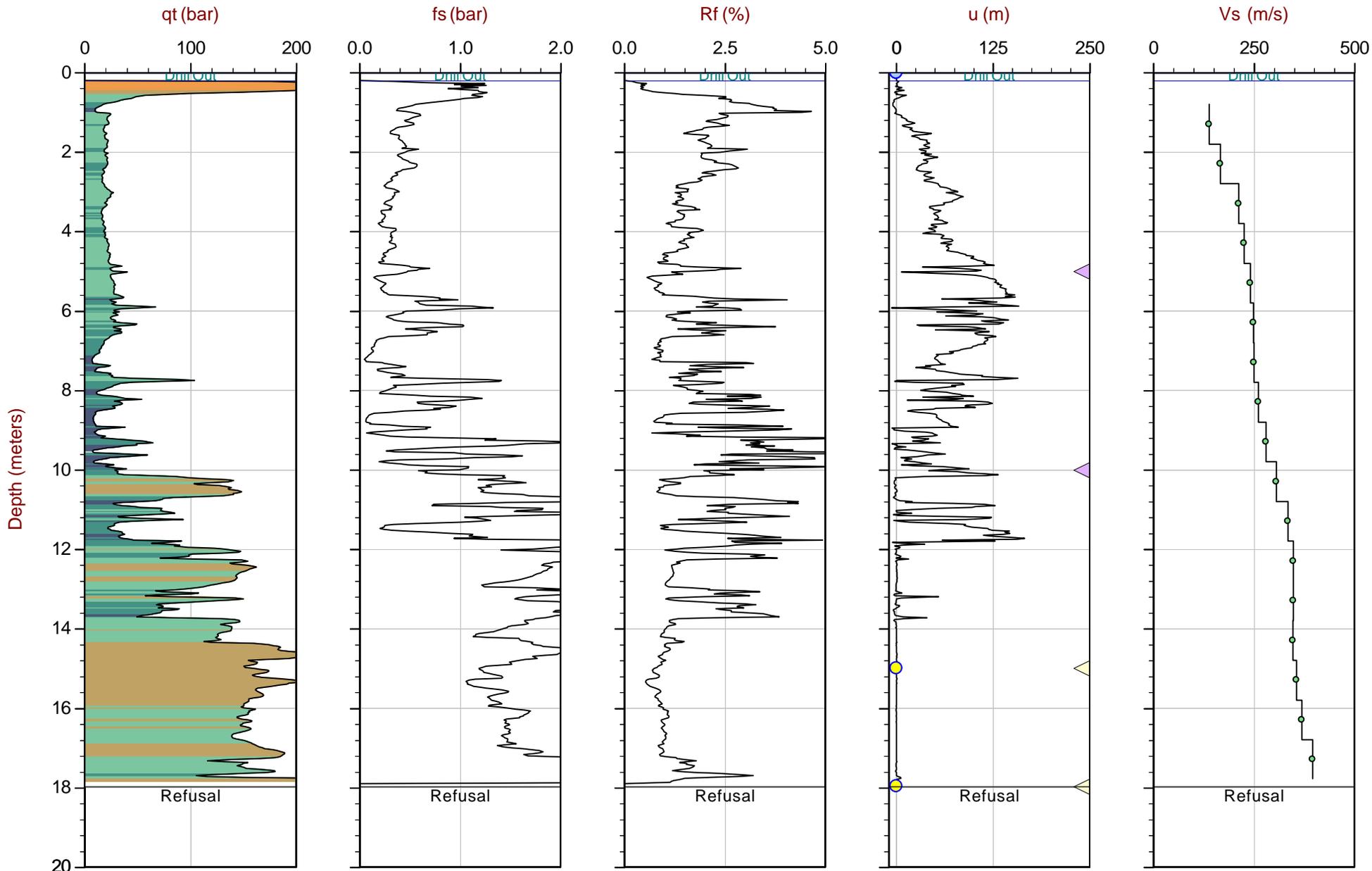
◀ Dissipation, Ueq achieved   ▶ Dissipation, Ueq not achieved



# Thurber

Job No: 19-05076  
Date: 2019-11-29 11:35  
Site: O'Brien Road

Sounding: OBR19-11  
Cone: 377:T1000F10U500



Max Depth: 17.975 m / 58.97 ft  
Depth Inc: 0.025 m / 0.082 ft  
Avg Int: EveryPoint  
Overplot Item: ● Ueq ● Assumed Ueq

File: 19-05076\_SP11.COR  
Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010  
Coords: MTM9 N: 5038038.50m E: 293374.50m Elev: 129.80m  
Sheet No: 1 of 1

△ Dissipation, Ueq achieved    ◀ Dissipation, Ueq not achieved

## Seismic Cone Penetration Test Tabular Results



Job No: 19-05076  
Client: Thurber Engineering Ltd.  
Project: Highway 17 and O'Brien Road  
Sounding ID: OBR19-10  
Date: 29-Nov-2019

Seismic Source: Beam  
Seismic Offset (m): 0.75  
Source Depth (m): 0.00  
Geophone Offset (m): 0.20

**SCPT<sub>u</sub> SHEAR WAVE VELOCITY TEST RESULTS - Vs**

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
1.00	0.80	1.10			
2.00	1.80	1.95	0.85	7.19	119
3.00	2.80	2.90	0.95	5.90	161
4.00	3.80	3.87	0.97	5.62	173
5.00	4.80	4.86	0.99	4.44	222
6.00	5.80	5.85	0.99	4.15	239
7.00	6.80	6.84	0.99	3.83	260
8.00	7.80	7.84	1.00	3.64	273
9.00	8.80	8.83	1.00	3.30	302
10.00	9.80	9.83	1.00	2.95	338
11.00	10.80	10.83	1.00	2.86	349
12.00	11.80	11.82	1.00	2.72	368
13.00	12.80	12.82	1.00	2.70	370
14.00	13.80	13.82	1.00	2.65	377
14.95	14.75	14.77	0.95	2.43	391



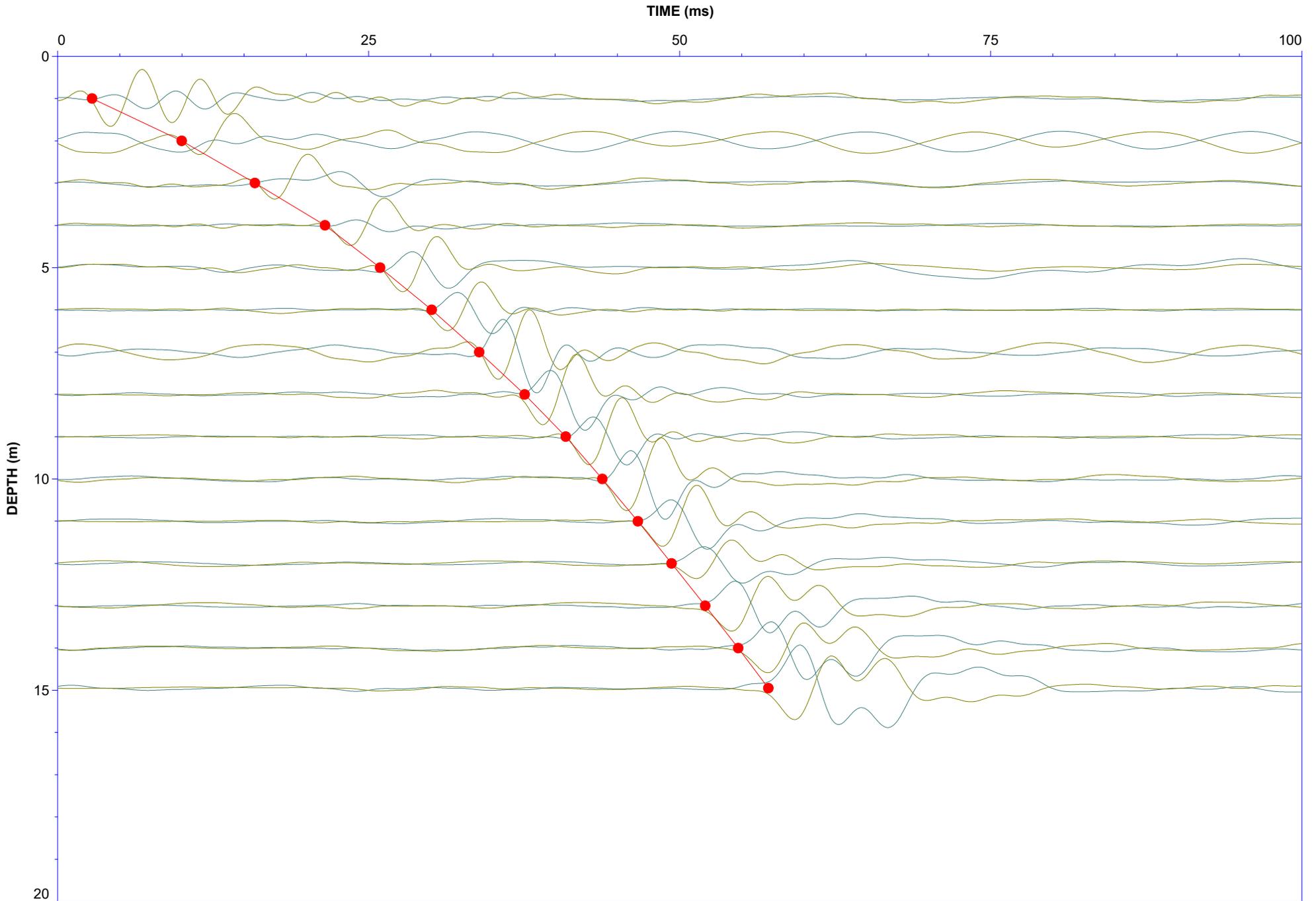
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Client: Thurber Engineering Ltd.  
Project: Highway 17 and O'Brien Road  
Sounding ID: OBR19-11  
Date: 29-Nov-2019

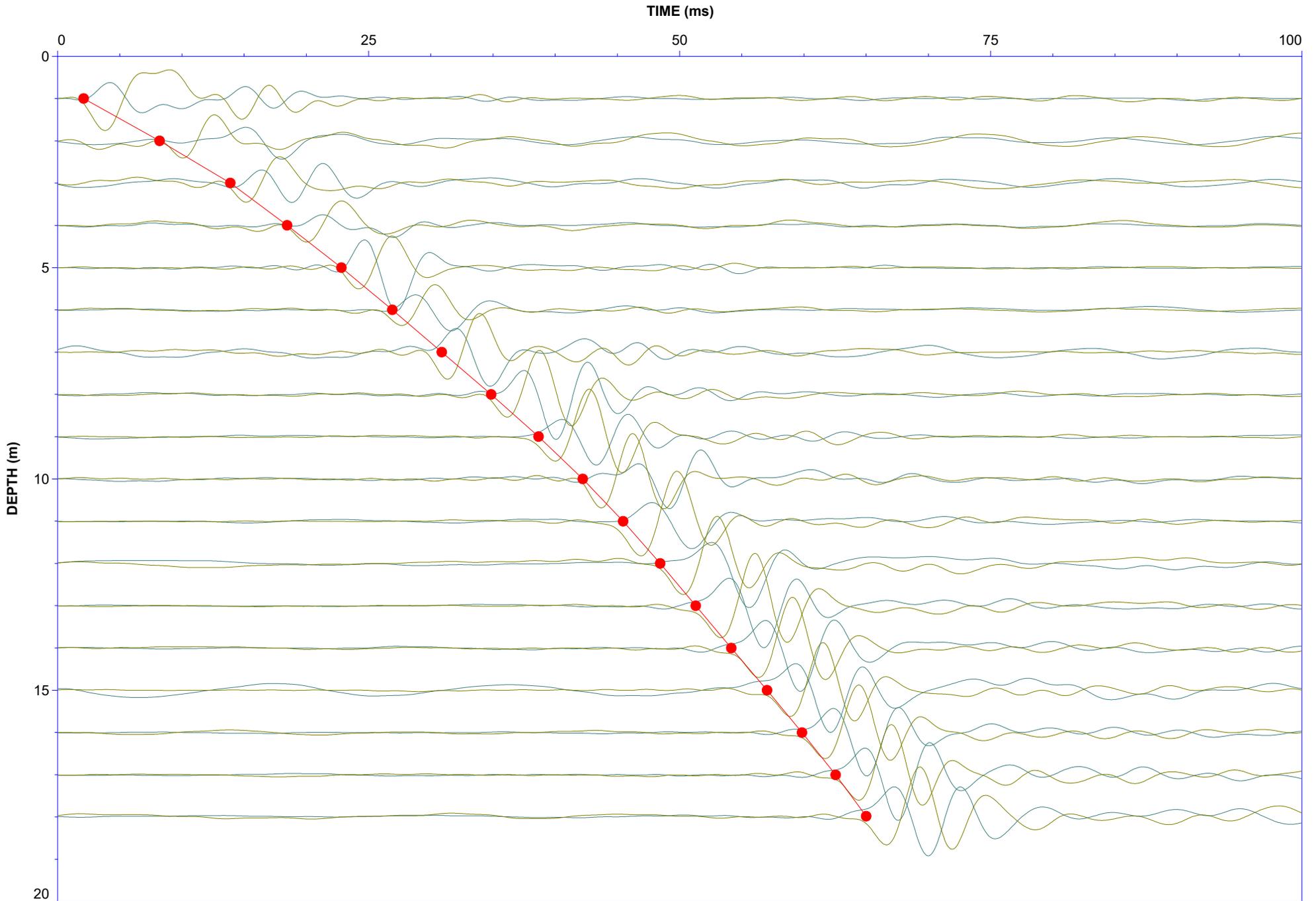
Seismic Source: Beam  
Seismic Offset (m): 0.75  
Source Depth (m): 0.00  
Geophone Offset (m): 0.20

**SCPT<sub>u</sub> SHEAR WAVE VELOCITY TEST RESULTS - Vs**

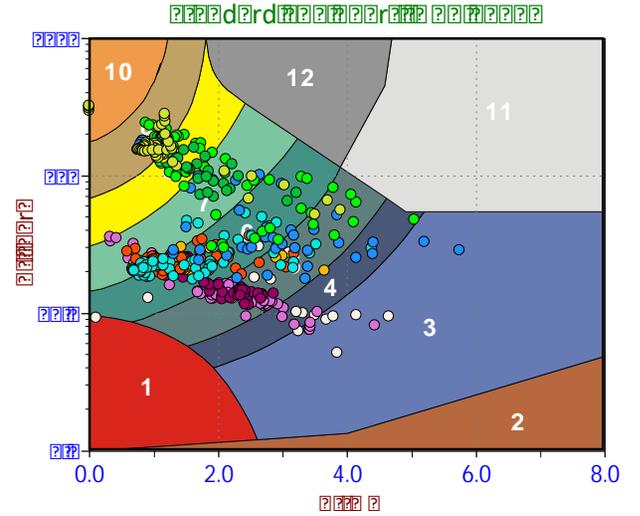
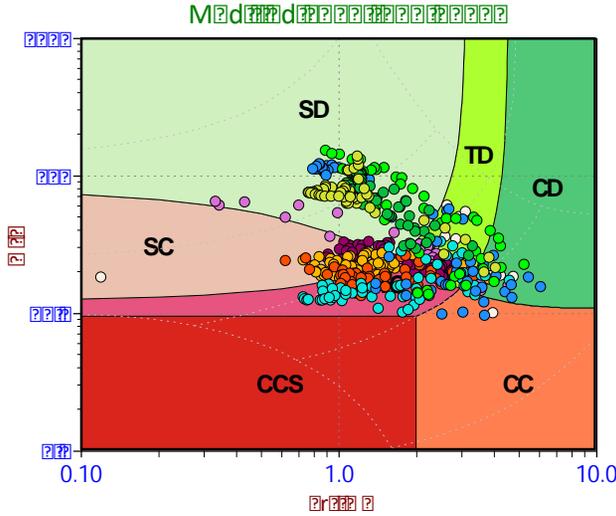
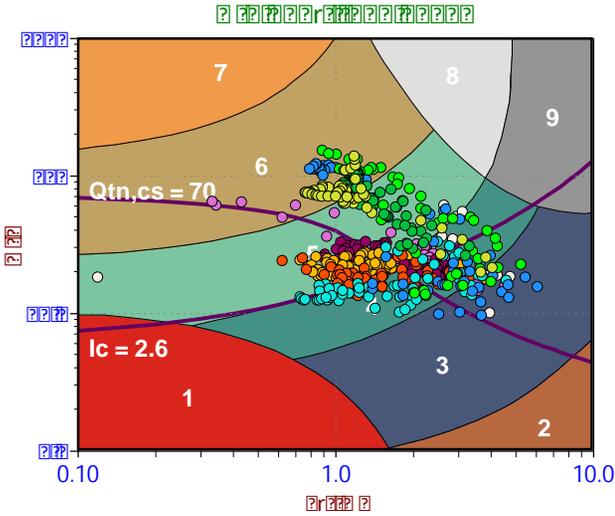
Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
1.00	0.80	1.10			
2.00	1.80	1.95	0.85	6.12	140
3.00	2.80	2.90	0.95	5.68	167
4.00	3.80	3.87	0.97	4.57	213
5.00	4.80	4.86	0.99	4.35	226
6.00	5.80	5.85	0.99	4.10	241
7.00	6.80	6.84	0.99	3.98	250
8.00	7.80	7.84	1.00	3.96	251
9.00	8.80	8.83	1.00	3.81	262
10.00	9.80	9.83	1.00	3.55	281
11.00	10.80	10.83	1.00	3.26	306
12.00	11.80	11.82	1.00	2.97	336
13.00	12.80	12.82	1.00	2.87	348
14.00	13.80	13.82	1.00	2.86	349
15.00	14.80	14.82	1.00	2.87	348
16.00	15.80	15.82	1.00	2.81	356
17.00	16.80	16.82	1.00	2.70	370
17.98	17.78	17.80	0.98	2.46	397

## Seismic Cone Penetration Test Shear Wave ( $V_s$ ) Traces





## Soil Behaviour Type (SBT) Scatter Plots



### Depth Ranges

- >0.0 to 1.5 m
- >1.5 to 3.0 m
- >3.0 to 4.5 m
- >4.5 to 6.0 m
- >6.0 to 7.5 m
- >7.5 to 9.0 m
- >9.0 to 10.5 m
- >10.5 to 12.0 m
- >12.0 to 13.5 m
- >13.5 to 15.0 m
- >15.0 m

### Legend

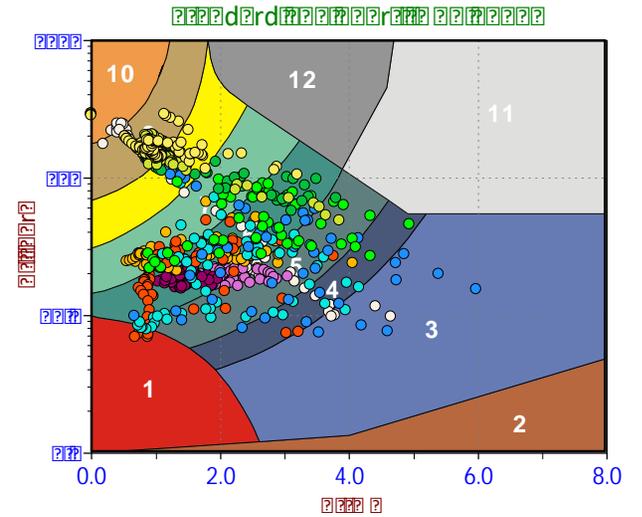
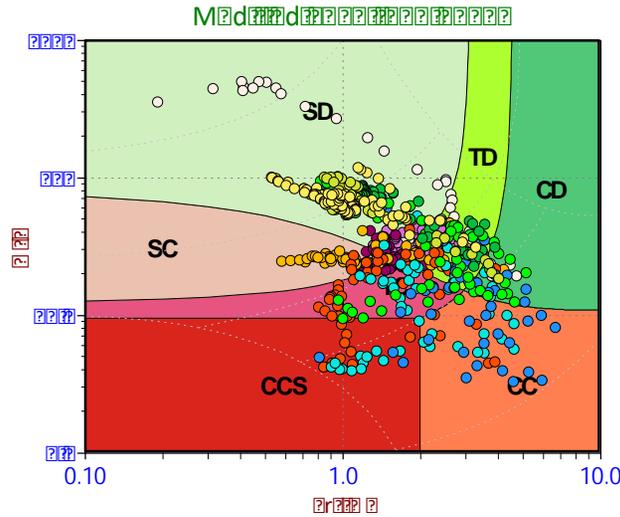
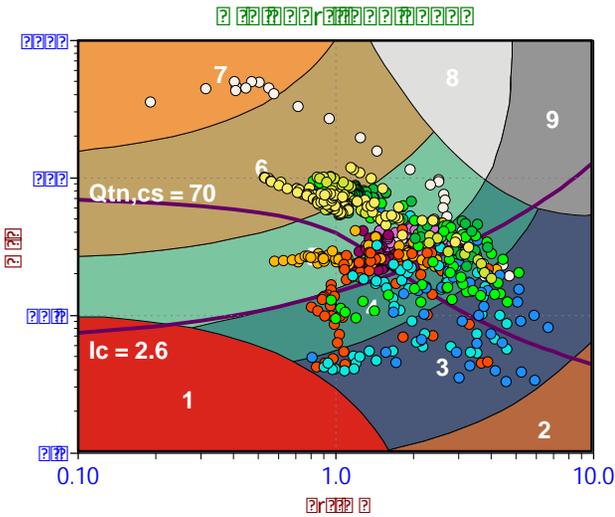
- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

### Legend

- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

### Legend

- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand



### Depth Ranges

- >0.0 to 1.5 m
- >1.5 to 3.0 m
- >3.0 to 4.5 m
- >4.5 to 6.0 m
- >6.0 to 7.5 m
- >7.5 to 9.0 m
- >9.0 to 10.5 m
- >10.5 to 12.0 m
- >12.0 to 13.5 m
- >13.5 to 15.0 m
- >15.0 m

### Legend

- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

### Legend

- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

### Legend

- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

## Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots



Job No: 19-05076  
Client: Thurber Engineering Ltd.  
Project: Highway 17 and O'Brien Road  
Start Date: 29-Nov-2019  
End Date: 29-Nov-2019

**CPT<sub>u</sub> PORE PRESSURE DISSIPATION SUMMARY**

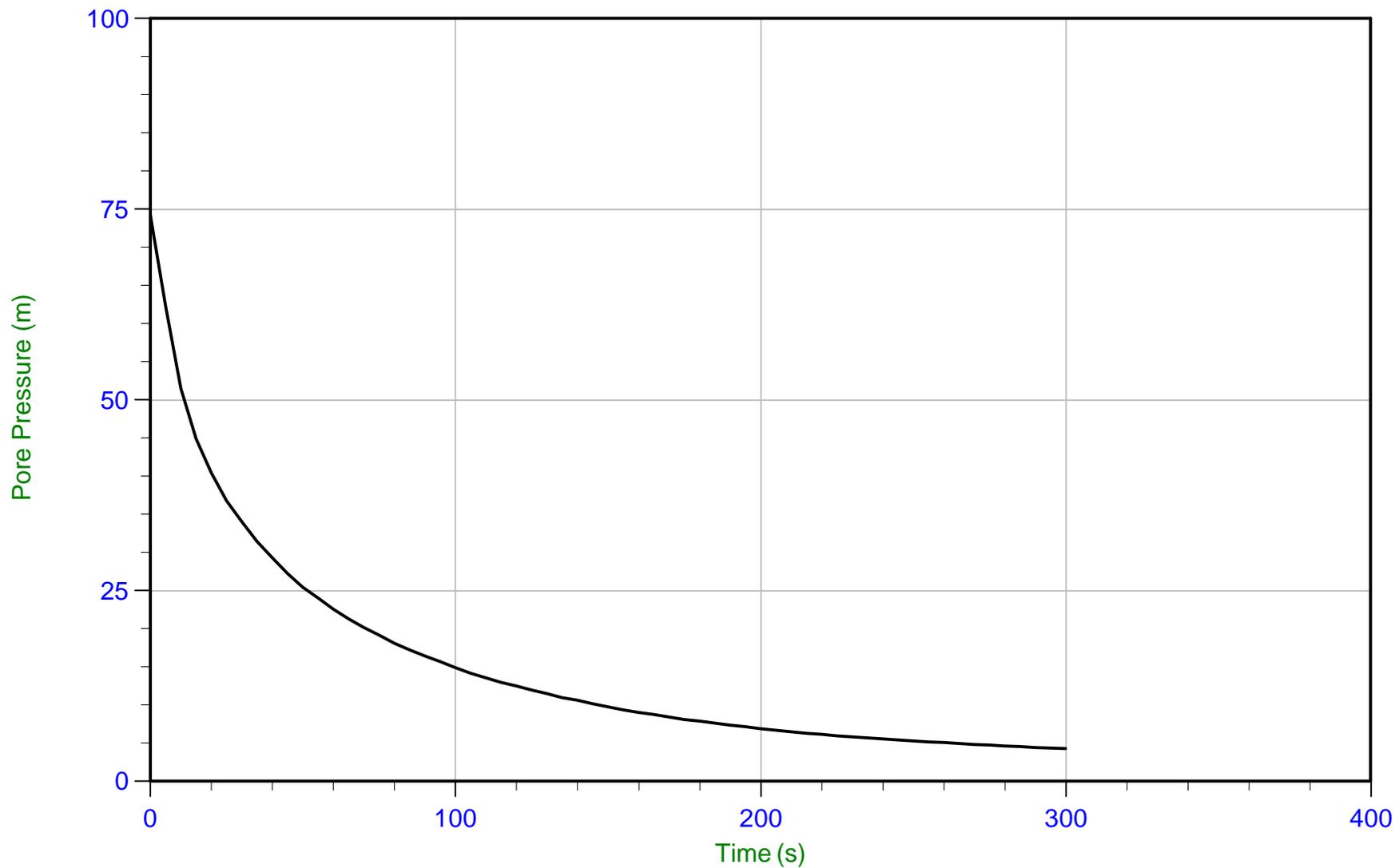
Sounding ID	File Name	Cone Area (cm <sup>2</sup> )	Duration (s)	Test Depth (m)	Estimated Equilibrium Pore Pressure U <sub>eq</sub> (m)	Calculated Phreatic Surface (m)
OBR19-10	19-05076_SP10	10	300	6.000	Not Achieved	
OBR19-10	19-05076_SP10	10	1700	14.950	0.0	
OBR19-11	19-05076_SP11	10	300	5.000	Not Achieved	
OBR19-11	19-05076_SP11	10	300	10.000	Not Achieved	
OBR19-11	19-05076_SP11	10	300	15.000	0.0	
OBR19-11	19-05076_SP11	10	300	17.975	0.0	



# Thurber

Job No: 19-05076  
Date: 11/29/2019 09:33  
Site: O'Brien Road

Sounding: OBR19-10  
Cone: 377:T1000F10U500 Area=10 cm<sup>2</sup>



### Trace Summary:

Filename: 19-05076\_SP10.PPF  
Depth: 6.000 m / 19.685 ft  
Duration: 300.0 s

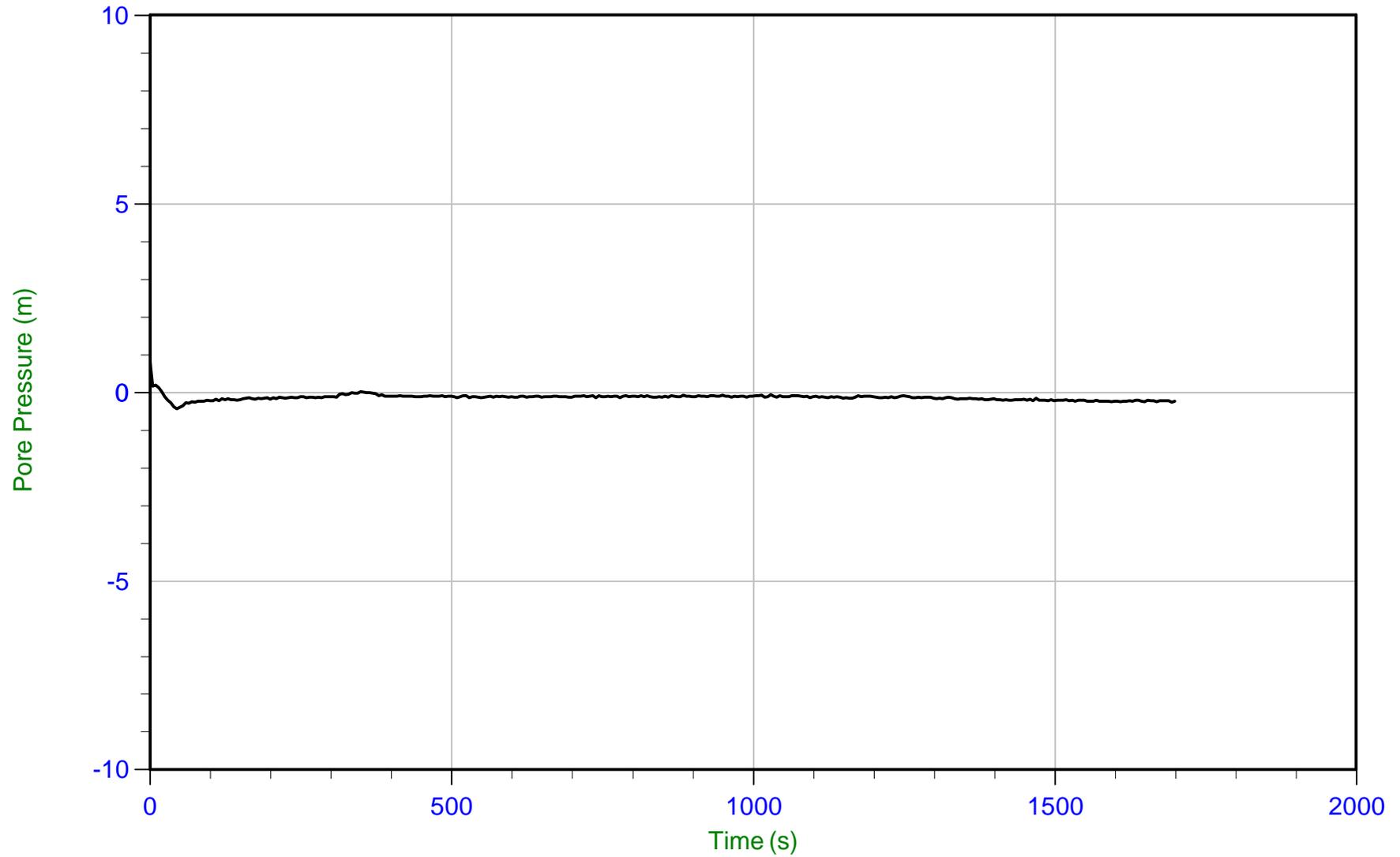
u Min: 4.3 m  
u Max: 74.2 m  
u Final: 4.3 m



Thurber

Job No: 19-05076  
Date: 11/29/2019 09:33  
Site: O'Brien Road

Sounding: OBR19-10  
Cone: 377:T1000F10U500 Area=10 cm<sup>2</sup>



Trace Summary:

Filename: 19-05076\_SP10.PPF  
Depth: 14.950 m / 49.048 ft  
Duration: 1700.0 s

u Min: -0.4 m  
u Max: 0.8 m  
u Final: -0.2 m

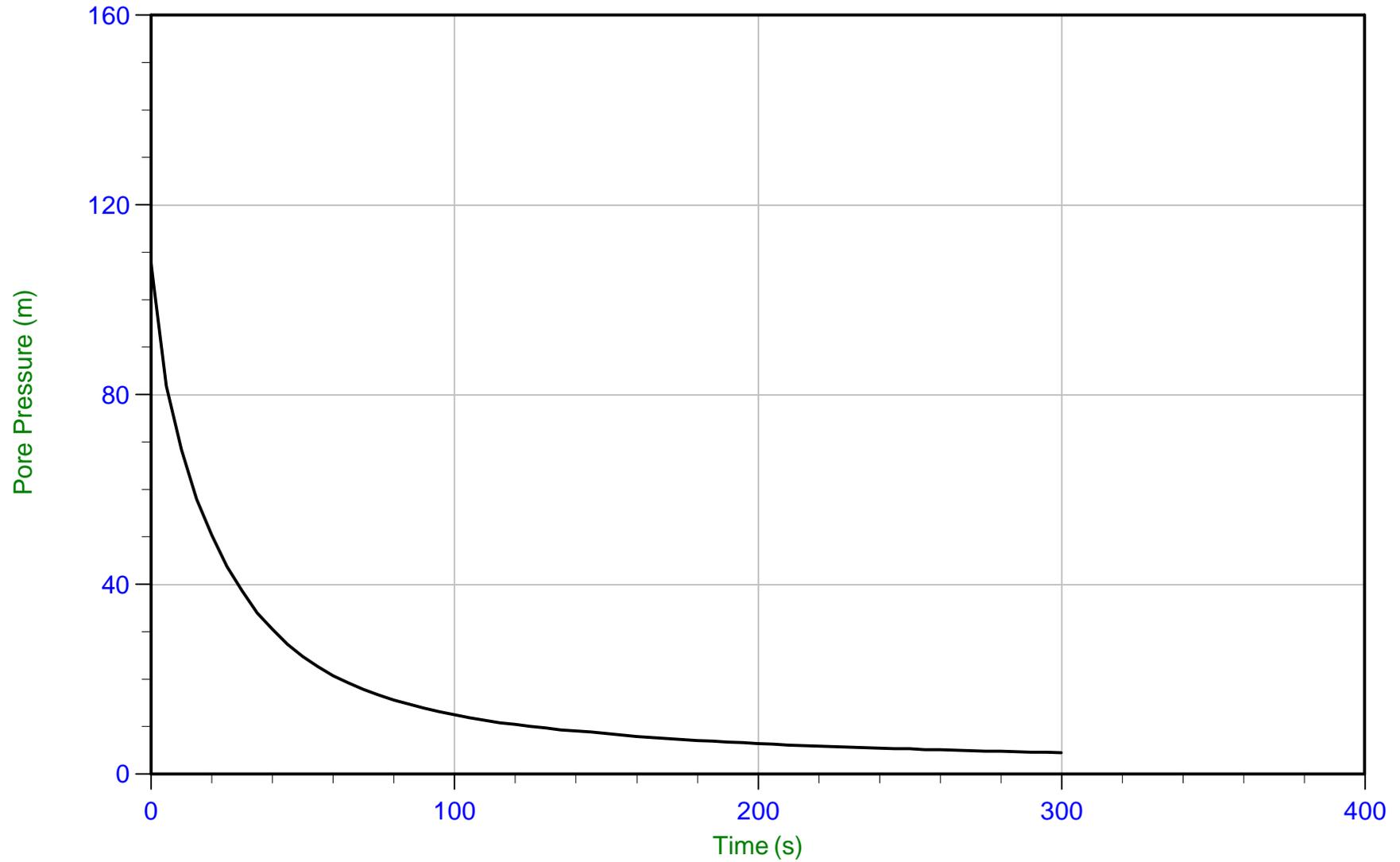
WT: 14.950 m / 49.048 ft  
Ueq: 0.0 m



# Thurber

Job No: 19-05076  
Date: 11/29/2019 11:35  
Site: O'Brien Road

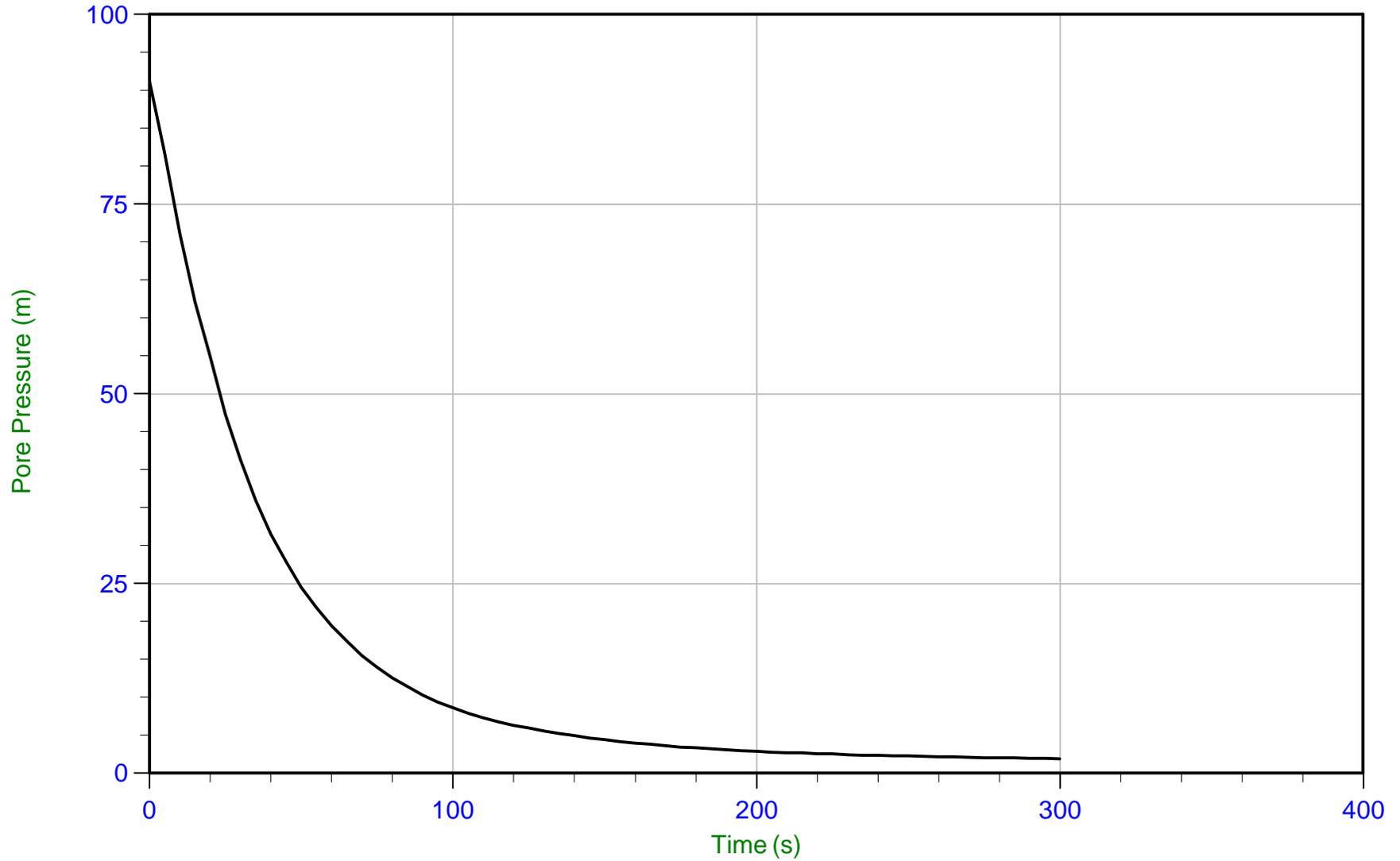
Sounding: OBR19-11  
Cone: 377:T1000F10U500 Area=10 cm<sup>2</sup>



### Trace Summary:

Filename: 19-05076\_SP11.PPF  
Depth: 5.000 m / 16.404 ft  
Duration: 300.0 s

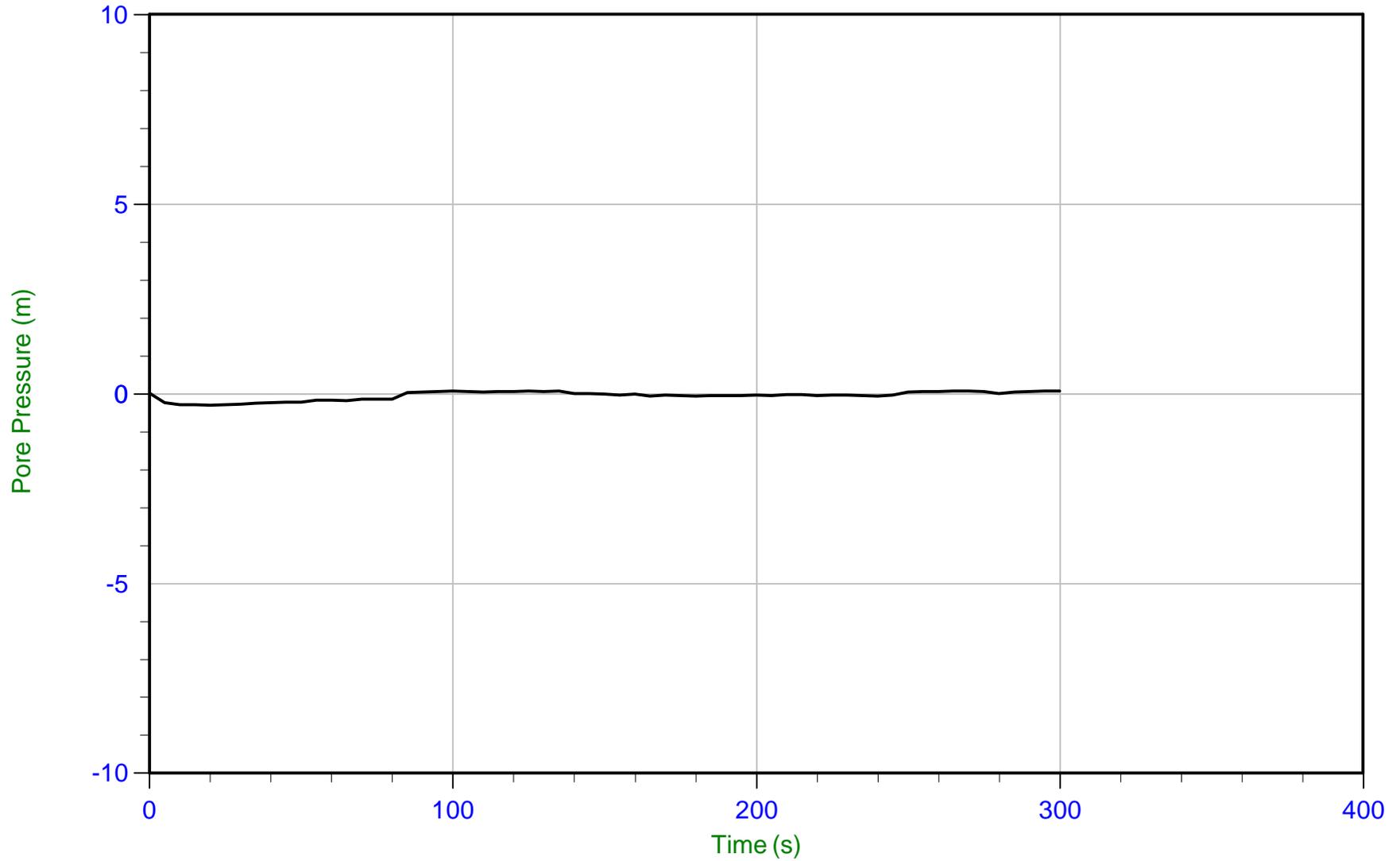
u Min: 4.5 m  
u Max: 107.6 m  
u Final: 4.5 m



Trace Summary:

Filename: 19-05076\_SP11.PPF  
Depth: 10.000 m / 32.808 ft  
Duration: 300.0 s

u Min: 1.9 m  
u Max: 91.2 m  
u Final: 1.9 m

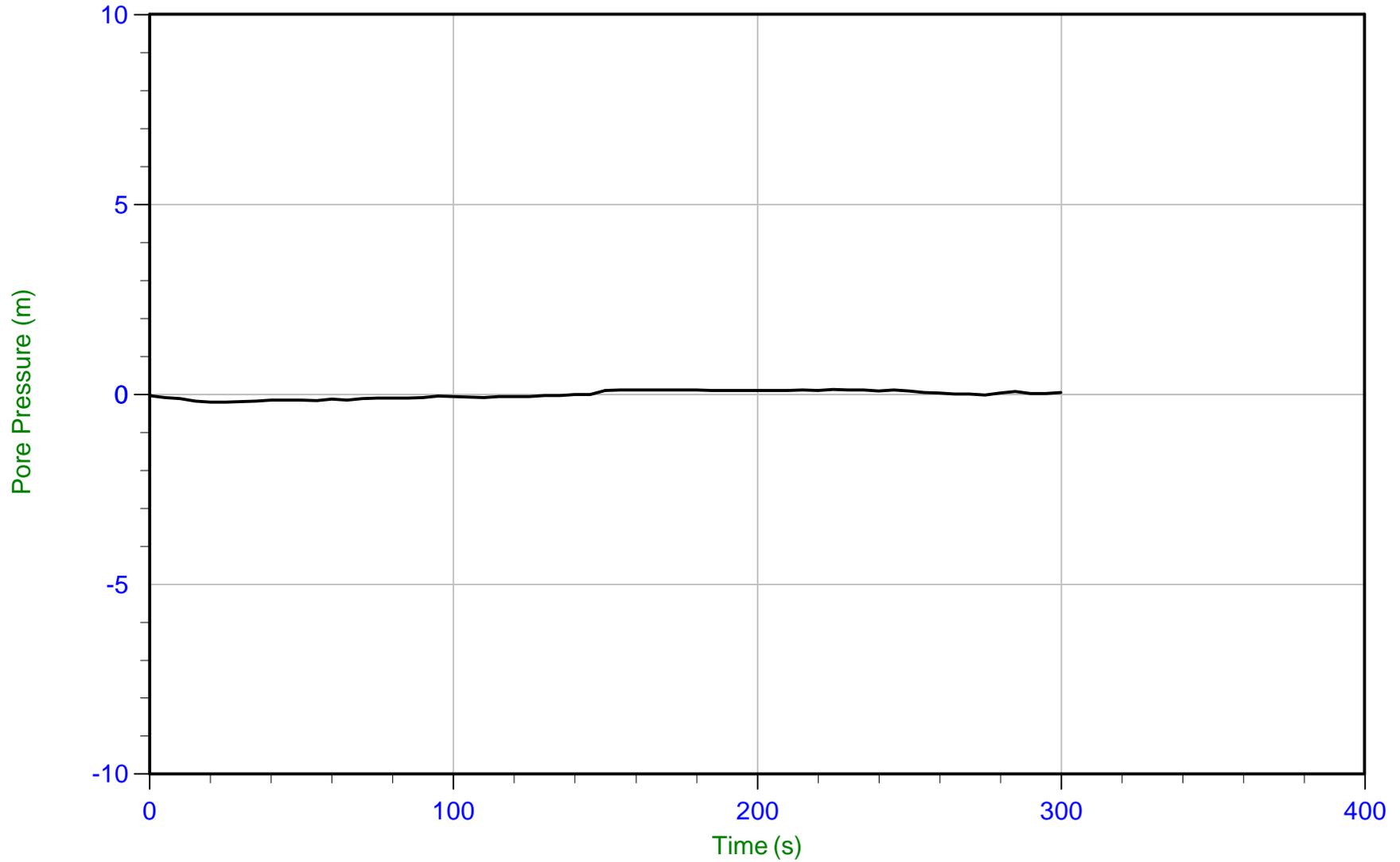


Trace Summary:

Filename: 19-05076\_SP11.PPF  
Depth: 15.000 m / 49.212 ft  
Duration: 300.0 s

u Min: -0.3 m  
u Max: 0.1 m  
u Final: 0.1 m

WT: 15.000 m / 49.212 ft  
Ueq: 0.0 m



Trace Summary:

Filename: 19-05076\_SP11.PPF  
Depth: 17.975 m / 58.972 ft  
Duration: 300.0 s

u Min: -0.2 m  
u Max: 0.1 m  
u Final: 0.0 m

WT: 17.975 m / 58.972 ft  
Ueq: 0.0 m