



**THURBER** ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT  
REPLACEMENT OF CPR/O-TRAIN BRIDGES  
HIGHWAY 417, OTTAWA  
SITE No. 3-54**

**GWP 4245-05-00**

**5016-E-0007**

Geocres No.: 31G5-293

Report to:

**WSP**

Latitude: 45.402546  
Longitude: -75.712738

September 2018  
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**PART 1. FACTUAL INFORMATION**

**1 INTRODUCTION**

This section of the report presents the factual findings obtained from a foundation investigation completed for the proposed replacement of the Canadian Pacific Rail (CPR) / O-Train Overpasses (Site Nos. 3-54.1 and 3-54.2) located on Highway 417 in the City of Ottawa, Ontario. Thurber Engineering Limited (Thurber) carried out the current investigation as a sub-consultant to WSP under Agreement No. 4014-E-0042.

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.

**2 SITE DESCRIPTION**

The existing Highway 417 overhead structures at the CPR/O-Train tracks consists of two side-by-side structures supporting the eastbound lanes (EBL) and westbound lanes (WBL). The EBL structure is identified as Site #3-54.1 and the WBL structure is identified as Site #3-54.2.

Both structures were reportedly built between 1961 and 1962 and consist of five span concrete T-beam bridges with integral piers and conventional abutments. The abutments and piers are founded on spread footings bearing on bedrock. Both bridges are reported to have a width of 21.5 m and a length of 85.2 m (individual span lengths are 18.2 m, 18.2 m, 18.3 m, 18.3 m and 12.2 m). Concrete cantilever retaining walls are present adjacent to the structure. Beneath the bridges, the railway is located within a rock cut section with concrete crib walls in front of the middle piers. Rock faces are visible within the cut section. The top of rail elevation is approximately 55.3 m beneath the bridges. The top of the rock cut beside the rail tracks is typically in the range of elevation 59 to 60 m.

At the location of the overpasses (Linear Highway Referencing System Base Point: 49450, Offset: 0.26), Highway 417 is an urban freeway with four through lanes of traffic in each direction, plus one speed change lane in each direction. Traffic volumes on Highway 417 are understood to be 184,100 AADT (2016).

The land adjacent to the highway is generally developed with both industrial and residential properties. The slopes above the rock cut beside the railway are densely covered with

shrubs and trees. A pedestrian walking and biking pathway (Trillium Pathway) is located along the east side of the railway and crosses beneath the Highway 417 structures. A pedestrian bridge over the railway tracks is located approximately 40 m south of the Highway 417 structures and connects the Trillium Pathway to the City streets on the west side.

Select photographs showing the existing conditions in the area of the bridges are included in Appendix D for reference.

### **3 INVESTIGATION PROCEDURES**

A previous foundation investigation report for this site was available from the Ministry's Geocres library. The reference for this report is as follows:

Foundation Investigation Report for C.P.R. Overpass – Bridge No. 14,  
Queensway, Geocres 31G05-033, Site 59-F-220C, Ottawa, Ont., dated 1959.

The report was reviewed during the planning stages of the current investigation, however, it was noted that the investigation was carried out prior to the construction of the railway rock cut and the Highway 417 bridges and embankment. In addition, the exact locations of the boreholes in this document were not known. Therefore, the boreholes from the previous investigation were not incorporated into the current report.

It is noted that separate investigations were completed for a proposed retaining wall in the northwest quadrant of the site and for environmental purposes. This information is provided under separate cover.

#### **3.1 Site Investigation and Field Testing**

The site investigation and field testing program was carried out in two phases:

The first phase of the field investigation was carried out between March 28<sup>th</sup> and April 12<sup>th</sup>, 2017 and consisted of advancing nine boreholes identified as 16-01 through 16-03, 16-05 through 16-09 and 16-11.

The second phase of the field investigation was carried out between February 20<sup>th</sup> and March 7<sup>th</sup>, 2018, and consisted of advancing seven boreholes identified as 16-04, 16-10 and 18-08 through 18-12.

The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A and are summarized in Table 3-1. The site is within MTM Zone 9. The elevations were surveyed relative to site benchmarks HCP 105 and HCP 106 which have geodetic elevations of 62.659 m and 62.605 m, respectively. Northing and easting coordinates were derived from CAD files provided by WSP using measurements of offsets from site features.

**Table 3-1: Borehole Summary**

<b>Borehole No.</b>	<b>Drilled Location</b>	<b>Northing (m)</b>	<b>Easting (m)</b>	<b>Ground Surface Elevation (m)</b>	<b>Borehole Termination Depth Below Existing Ground Surface (m)</b>
16-01	East Abutment	5029507.6	366437.9	62.8	7.2
16-02	East Abutment	5029463.7	366465.5	62.5	13.7
16-03	Retaining Wall	5029487.8	366363.4	66.5	9.2
16-04	East Slide Path	5029516.9	366432.6	63.4	5.9
16-05	West Abutment	5029458.8	366420.7	63.8	6.2
16-06	Retaining Wall	5029453.8	366480.2	62.5	7.2
16-07	West Approach	5029458.7	366381.5	72.0	10.5
16-08	East Approach	5029491.6	366478.1	68.9	8.2
16-09	West Slide Path	5029527.1	366379.9	63.5	7.5
16-10	East Slide Path	5029544.4	366413.9	63.7	7.2
16-11	West Abutment	5029497.5	366400.8	63.8	12.3
18-08	West Slide Path	5029510.9	366392.1	63.7	10.1
18-09	West Abutment	5029489.7	366404.0	63.7	9.0
18-10	West Abutment	5029478.3	366410.8	63.7	9.0
18-11	West Abutment	5029468.5	366417.0	63.7	9.1
18-12	West Abutment	5029459.4	366422.0	63.4	9.1

Thurber contacted Ontario One Call in advance of the field investigation to obtain utility locates/clearances in the vicinity of the proposed boreholes. Private locate services were carried out for Boreholes located on private property.

Boreholes 16-07 and 16-08 were advanced through the highway embankment and were drilled with a truck-mounted CME 75 drill rig. All other off-road boreholes were drilled with a track-mounted CME 55LC drill rig.

The subsurface stratigraphy encountered in the boreholes was recorded in the field by Thurber personnel. Split spoon samples were collected at regular depth intervals in the boreholes via the completion of Standard Penetration Tests (SPT), following the methods described in ASTM Standard D1586. Rock was cored and collected using NQ coring equipment. All soil and rock core samples recovered from the boreholes were transported to Thurber's Ottawa geotechnical laboratory for further examination and testing.

A standpipe piezometer was installed in Borehole 16-04. The piezometer consisted of ¾" (19 mm) PVC pipe with a 1.5 m long slotted screen installed just above the bedrock surface and surrounded by filter sand. Solid pipe was used above the slotted screen and the backfill included a bentonite seal.

The boreholes were backfilled in accordance with MOEE requirements (O.Reg. 903). Boreholes 16-03, 16-07 and 16-08 were capped with 200 mm of cold patch asphalt to reinstate the traveling surface.

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix A. The coordinates and elevation of the boreholes are provided on this drawing and on the individual Record of Borehole sheets.

### **3.2 Laboratory Testing**

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples in accordance with the current MTO standards. Grain size distribution analyses and Atterberg Limit testing was also carried out on selected samples to MTO and ASTM standards. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were determined. Twenty-three rock core samples were submitted to Stantec's laboratory in Ottawa for unconfined compression (UCS) testing. Chemical analysis for determination of pH, conductivity, resistivity, soluble sulphate and chloride concentrations was carried out on two soil samples.

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

## 4 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata drawing included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations.

In general terms, the investigation advanced through the highway embankment found that the asphalt was underlain by a road base/subbase and embankment fill. Fill was also encountered from surface and underlying the topsoil and asphalt in the off-road boreholes. The fill materials were underlain by silt, sand and gravel materials and/or till overlying limestone bedrock with interbedded shale. A discontinuous layer of clay was also encountered underlying the fill materials.

### 4.1 Topsoil

A surficial layer of topsoil was encountered in Boreholes 16-01, 16-02, 16-04, 16-06, 16-09 and 16-10 with a thickness ranging from 100 to 200 mm.

### 4.2 Highway 417 Embankment Fill

Boreholes 16-07 and 17-08 were drilled through the existing Highway 417 pavement structure behind the existing bridge abutments.

#### 4.2.1 Asphalt

The thickness of the asphalt was 250 mm in both boreholes.

#### 4.2.2 Base/Subbase Fill: Gravel with Sand and Silt to Sand with Gravel and Silt

Fill material consisting of gravel with sand and silt to sand with gravel and silt was encountered below the asphalt in Boreholes 16-07 and 16-08. The thickness of the fill was 1.3 m with the base of the fill at 1.5 m depth below the existing highway surface (elev. 67.4 to 70.5 m).

The SPT tests conducted in the fill gave N-values ranging from 28 to 33 blows indicating a relative density of compact to dense.

Recorded moisture contents were 2% to 3% within the road base/subbase. The results of grain size analyses conducted on two samples of this material are summarized below and are illustrated on Figure C1 in Appendix C.

Soil Particle	Percentage (%)
Gravel	45 - 49
Sand	41 - 45
Silt and Clay	10

#### 4.2.3 Embankment Fill: Sand

A sand fill was encountered below the pavement base/subbase in Boreholes 16-07 and 16-08. The thickness of the fill was 4.3 m in both boreholes with the base of the fill at 5.8 m below the existing ground surface (elev. 63.1 to 66.2 m).

The SPT tests conducted in the fill gave N-values typically ranging from 3 to 28 blows indicating a relative density of very loose to dense. One SPT N-value of 100 blows per 250 mm penetration was recorded in Borehole 16-07 and may be indicative of a cobble or boulder.

Recorded moisture contents were 4 to 10% within the embankment fill. The results of grain size analyses conducted on two samples of the embankment fill materials are summarized below and are illustrated on Figure C2 in Appendix C.

Soil Particle	Percentage (%)
Gravel	1
Sand	95 - 96
Silt and Clay	3 - 4

### 4.3 Fill: Beyond Highway 417 Embankment

#### 4.3.1 Fill: Asphalt

Borehole 16-03 was drilled through a parking lot and encountered a 100 mm layer of asphalt at surface.

#### 4.3.2 Fill: Gravel with Sand to Silty Gravel with Sand

A gravel with sand to silty gravel with sand layer was encountered below the asphalt in Borehole 16-03, below the topsoil in Borehole 16-09 and at surface in Boreholes 18-08 and 18-09. This layer contained occasional to frequent cobbles and boulders in Boreholes 16-09, 18-08 and 18-09. The thickness of this layer ranged from 1.0 to 2.3 m with a base depth ranging from 1.2 to 2.3 m below the existing ground surface (elev. 61.4 to 64.5 m).

The SPT tests conducted in the fill gave N-values typically ranging from 6 to 72 blows indicating a relative density of loose to very dense. One SPT N-value of 100 blows per 150 mm penetration was recorded in Borehole 18-08 and may be indicative of a cobble or boulder.

Recorded moisture contents were typically 4 to 14% within the fill. The results of grain size analyses conducted on four samples of the fill materials are summarized below and are illustrated on Figure C3 in Appendix C.

Soil Particle	Percentage (%)
Gravel	42 - 63
Sand	30 - 42
Silt and Clay	7 - 18



#### 4.3.3 Fill: Silty Sand to Sand With Silt and Gravel

A silty sand to silty sand with gravel to sand with silt and gravel fill was encountered below the topsoil in Boreholes 16-01, 16-02, 16-04, 16-06 and 16-10, and from the ground surface in Boreholes 16-05, 16-11, 18-10, 18-11 and 18-12. The thickness of this layer ranged from 1.4 to 3.5 m with base depths ranging from 1.5 to 3.7 m (elev. 58.8 to 61.9 m) below the existing ground surface.

The SPT tests conducted in the fill gave N-values ranged from 4 to 47 blows indicating a relative density of loose to dense.

Recorded moisture contents were 5 to 22% within this fill unit. The results of grain size analyses conducted on eleven samples of the fill material are summarized below and are illustrated on Figures C4 and C5 in Appendix C.

Soil Particle	Percentage (%)
Gravel	1 - 41
Sand	41 - 86
Silt and Clay	8 - 24

#### 4.4 Clay

A native deposit of clay with some sand was encountered below the fill in Boreholes 16-03 and 16-08. Trace amounts of rootlets were encountered within this layer at Borehole 16-03. The thickness of this deposit ranged from 0.9 to 2.4 m with an underside depth of 2.9 to 8.2 m below existing ground surface (elev. 60.7 and 63.6 m). The SPT N-values ranged from 3 to 9 blows.

The moisture content of the samples tested ranged from 32 to 41%. The results of grain size analyses conducted on two samples of the native clay are summarized below and are illustrated on Figure C6 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0 - 3
Sand	14 - 21
Silt	42 - 51
Clay	34 - 35

Atterberg Limit testing was completed on two samples of the native clay deposit. The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limit graphs are included in Figure C11 of Appendix C. The laboratory results are summarized below and indicate that the clay is low to intermediate plasticity (CL-CI).

Parameter	Value
Liquid Limit	33 - 35
Plastic Limit	16 - 17
Plasticity Index	17 - 18

#### 4.5 Sandy Silt to Silty Sand

A deposit of sandy silt to silty sand was encountered below the fill in Boreholes 16-07, 16-09, 16-10, 18-10 and 18-11 and below the clay layer in Borehole 16-03. Trace organics and/or wood fragments were noted in Boreholes 16-07 and 16-10. The thickness of this deposit ranged from 0.4 to 4.7 m with a base depth of 2.8 to 10.5 m below the existing ground surface (elev. 60.3 to 61.5 m).

The SPT tests conducted in this deposit gave typical N-values of 8 to 39 blows indicating a relative density of loose to dense. SPT N-values recorded near the suspected bedrock surface in Boreholes 16-07 and 16-10 were 100 blows for 25 mm of penetration.

Recorded moisture contents were 9 to 42%. The results of grain size analyses conducted on five samples of the material are summarized below and are illustrated on Figure C7 in Appendix C.

Soil Particle	Percentage (%)
Gravel	1 - 12
Sand	44 - 83
Silt and Clay	15 - 55

#### 4.6 Silty Sand with Gravel to Gravel with Sand and Silt (Glacial Till)

A layer of glacial till ranging in composition from sandy silt to silty sand with gravel to gravel with sand and silt was encountered in all boreholes except 16-07, 16-8 and 16-10. The thickness of the till ranged from 0.2 to 1.4 m with a base depth ranging from 2.4 to 5.2 m below the existing ground surface (elev. 58.2 to 61.3 m). Occasional cobbles and boulders were noted in this layer.

The SPT tests conducted in the till gave N-values typically ranging from 5 to 36 blows indicating a relative density of loose to dense. SPT N-values recorded near the bedrock surface ranged from 100 blows per 50 to 275 mm penetration.

Recorded moisture contents ranged from 3 to 11%. The results of grain size analyses conducted on eight samples of the till are summarized below and are illustrated on Figures C8 and C9 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0-51
Sand	37 - 94
Silt and Clay	6 - 52

#### 4.7 Bedrock

The overburden materials were underlain by grey limestone bedrock with some interbedded shale. Bedding and fractures were both noted to be near horizontal. The bedrock depth ranged from 2.4 to 10.5 m below the existing ground surface (elev. 58.2 to 61.5 m). The depth to bedrock and bedrock surface elevation are summarized in the table below. Photographs of the bedrock core are provided in Appendix B.

Borehole	Depth to Bedrock (m)	Bedrock Surface Elevation (m)	Comments
16-01	3.3	59.5	Cored 3.9 m
16-02	4.3	58.2	Cored 9.4 m
16-03	5.2	61.3	Cored 4.0 m
16-04	2.9	60.5	Cored 3.0 m
16-05	2.9	60.9	Cored 3.3 m
16-06	3.4	59.1	Cored 3.8 m
16-07	10.5	61.5	Auger refusal on inferred bedrock
16-08	8.2	60.7	Auger refusal on inferred bedrock
16-09	3.0	60.5	Cored 4.5 m
16-10	3.4	60.3	Cored 3.8 m
16-11	3.5	60.3	Cored 8.8 m
18-08	2.4	61.3	Cored 7.7 m
18-09	3.1	60.6	Cored 5.9 m
18-10	3.3	60.5	Cored 5.7 m
18-11	3.3	60.4	Cored 5.8 m
18-12	3.1	60.3	Cored 6.0 m

The total core recovery ranged from 64% to 100%, the solid core recovery ranged from 56% to 100% and the Rock Quality Designation (RQD) ranged from 32% to 100%. Only 15% of the RQD values were determined to be less than 75%. Based on the RQD value the bedrock is classified as poor to excellent quality, but generally good to excellent. The results of the UCS testing on select cores of the bedrock yielded strengths ranging from 93 to 157 MPa, with an average of 124 MPa, indicating that it has an average strength classification of very strong.

#### 4.8 Groundwater

The water levels were measured in the standpipe piezometer installed in Borehole 16-04 and the results are presented in the table below along with those observed in open Boreholes 16-07, 16-09 and 16-11 after drilling:

Borehole	Groundwater Level		Date of Measurement
	Depth (mbgs)	Elevation (m)	
16-04	2.7	60.7	March 12, 2018
	2.8	60.8	March 23, 2018
16-07	9.4	62.6	March 28, 2017
16-09	2.4	61.1	April 11, 2017
16-11	2.3	61.5	April 11, 2017

These observations are considered short term and it should be noted that the groundwater level at the time of construction and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

#### 4.9 Analytical Testing

Two samples of soil were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations and resistivity. The analysis results are included in Appendix C and are summarized in the table below:

Borehole	Sample	Depth (m)	Sulphate (µg/g)	pH ( - )	Resistivity (Ohm-cm)	Chloride (µg/g)
16-4	SS4	2.3 – 2.9	64	7.90	4410	33
18-11	SS4	3.1 – 3.7	122	7.89	1480	333

## 5 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features and the anticipated foundation locations. The as-drilled locations and ground surface elevation were measured by Thurber following completion of the field program.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario supplied and operated the drilling equipment to conduct the drilling, soil sampling, in-situ testing and borehole decommissioning for all the boreholes on site. The field investigation was supervised on a full time basis by Mr. Justin Gray, E.I.T., Ms. Katya Edney, P.Eng., and Sean O'Bryan of Thurber. Overall supervision of the investigation program was provided by Mr. Fred Griffiths, P.Eng.

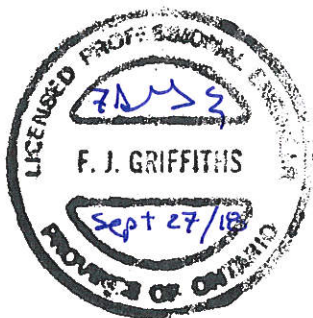
Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. UCS testing was completed by Stantec's laboratory in Ottawa, Ontario. Interpretation of the factual data and preparation of this report were carried out by Mr. Justin Gray, E.I.T. and Mr. Paul Carnaffan, P.Eng. The report was reviewed by Dr. Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.



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Senior Geotechnical Engineer



Dr. P.K. Chatterji, Ph.D., P.Eng.  
Designated Principal Contact  
Senior Geotechnical Engineer

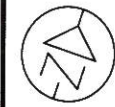
**Appendix A.**

**Borehole Location Plan and Stratigraphic Drawings**



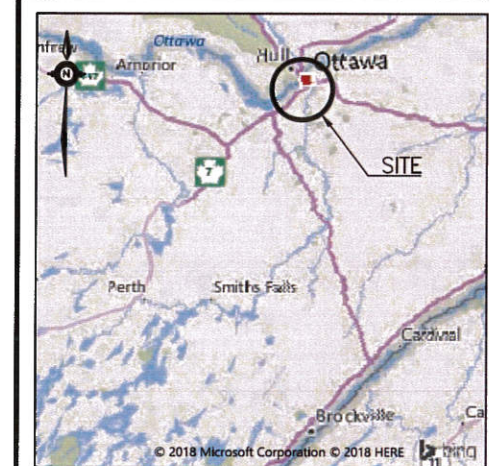
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DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
GWP No 4245-05-00



HIGHWAY 417  
CPR/O-TRAIN  
OVERPASS  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



KEYPLAN

LEGEND

- Borehole
- ⊕ Borehole and Cone
- 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

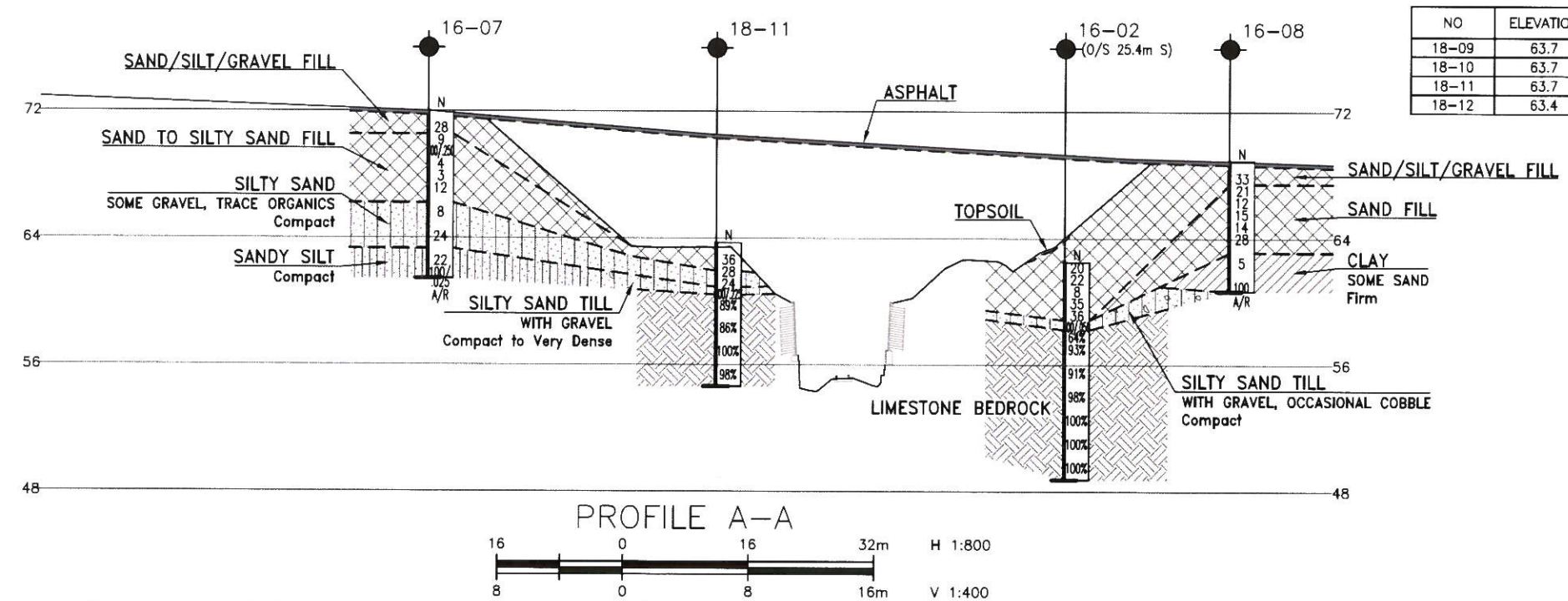
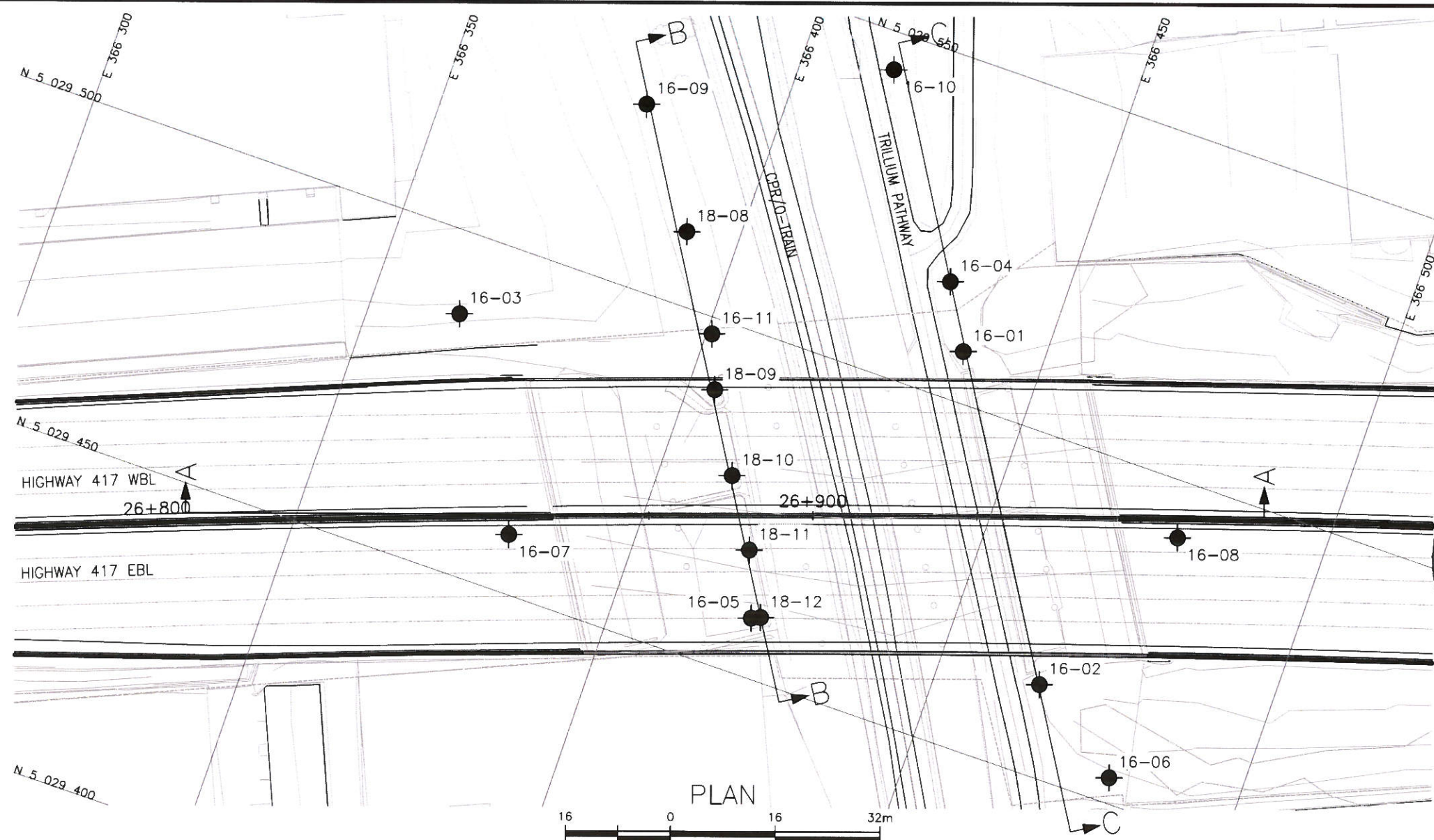
NO	ELEVATION	NORTHING	EASTING
16-01	62.8	5 029 507.6	366 437.9
16-02	62.5	5 029 463.7	366 465.5
16-03	66.5	5 029 487.8	366 363.4
16-04	63.4	5 029 516.9	366 432.6
16-05	63.8	5 029 458.8	366 420.7
16-06	62.5	5 029 453.8	366 480.2
16-07	72.0	5 029 458.7	366 381.5
16-08	68.9	5 029 491.6	366 478.1
16-09	63.5	5 029 527.1	366 379.9
16-10	63.7	5 029 544.4	366 413.9
16-11	63.8	5 029 497.5	366 400.8
18-08	63.7	5 029 510.9	366 392.1

-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. 31G5-293

DATE	BY	DESCRIPTION
DESIGN	DJP	CHK PC
DRAWN	MFA	CHK DJP
CODE	LOAD	DATE
3-54	STRUCT	SEP 2018
	DWG	1



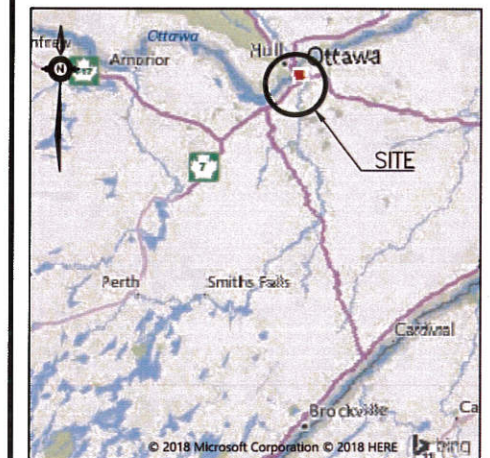


METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
GWP No 4245-05-00

HIGHWAY 417  
CPR/O-TRAIN  
OVERPASS  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



# KEYPLAN LEGEND

- Borehole
- Borehole and Cone
- 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
18-09	63.7	5 029 489.7	366 404.0
18-10	63.7	5 029 478.3	366 410.8
18-11	63.7	5 029 468.5	366 417.0
18-12	63.4	5 029 459.4	366 422.0

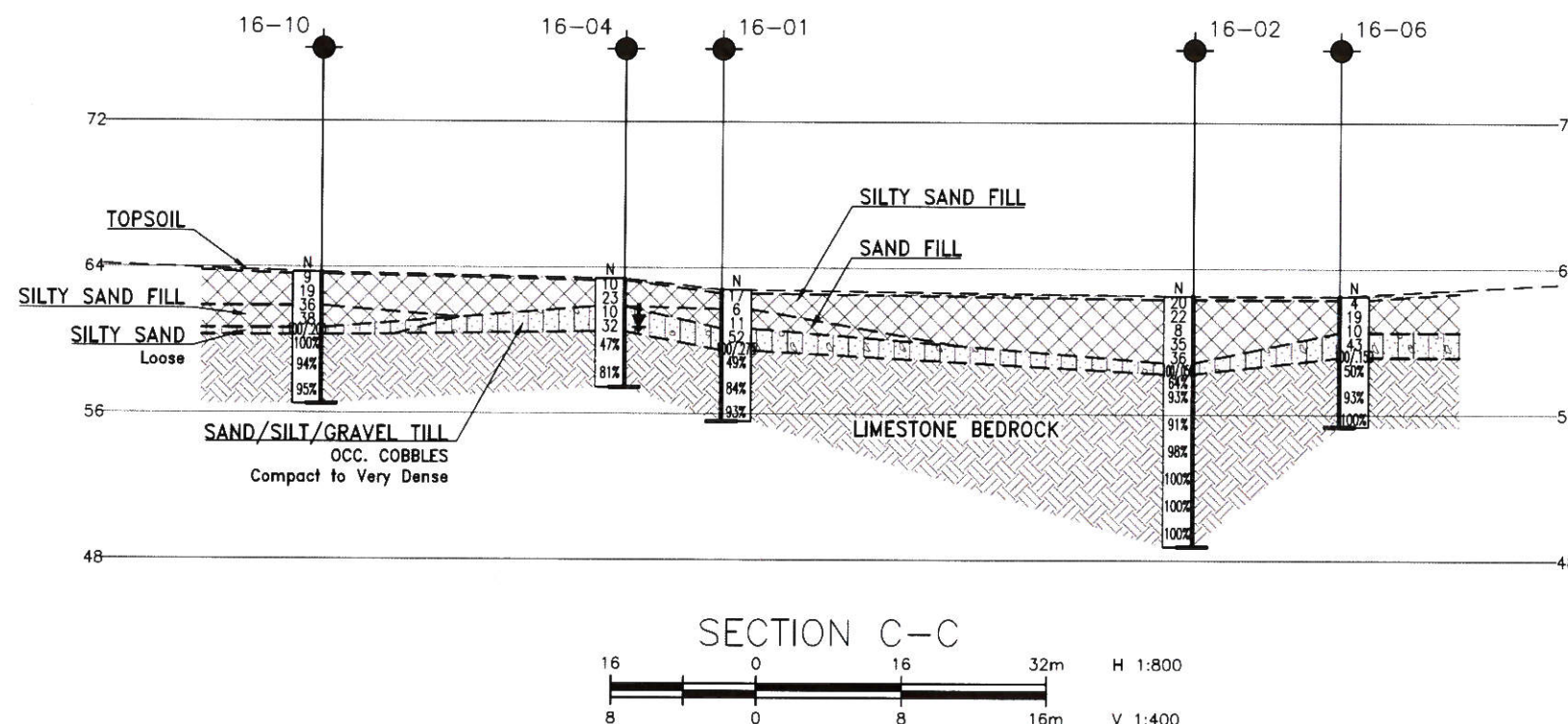
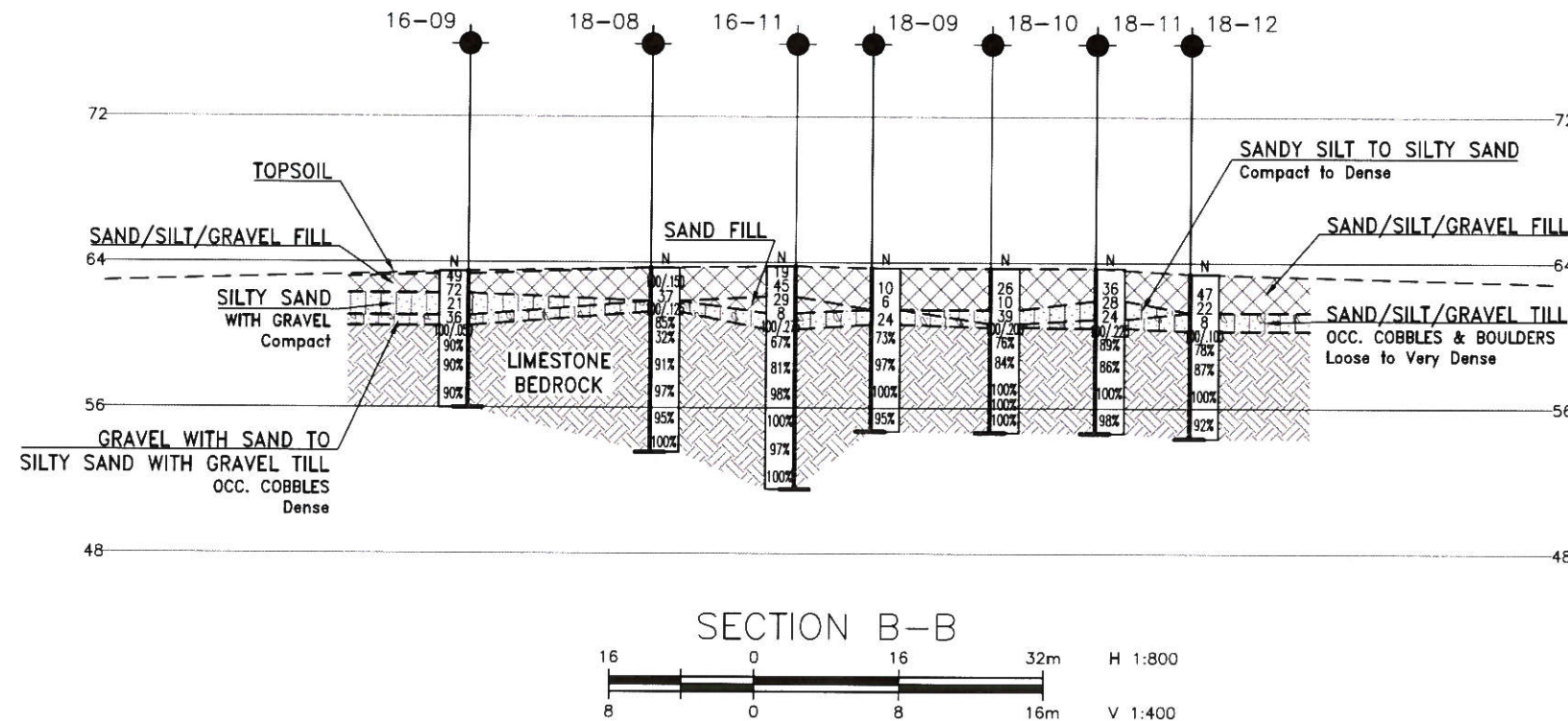
NO	ELEVATION	NORTHING	EASTING
16-01	62.8	5 029 507.6	366 437.9
16-02	62.5	5 029 463.7	366 465.5
16-03	66.5	5 029 487.8	366 363.4
16-04	63.4	5 029 516.9	366 432.6
16-05	63.8	5 029 458.8	366 420.7
16-06	62.5	5 029 453.8	366 480.2
16-07	72.0	5 029 458.7	366 381.5
16-08	68.9	5 029 491.6	366 478.1
16-09	63.5	5 029 527.1	366 379.9
16-10	63.7	5 029 544.4	366 413.9
16-11	63.8	5 029 497.5	366 400.8
18-08	63.7	5 029 510.9	366 392.1

## -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. 31G5-293

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	DJP	CHK PC	CODE
DRAWN	MFA	CHK DJP	SITE 3-54
			STRUCT
			DWG 2





**Appendix B.**

**Record of Borehole Sheets  
Rock Core Photographs**



## **SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS**

### **TERMINOLOGY DESCRIBING COMMON SOIL GENESIS**

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

### **TERMINOLOGY DESCRIBING SOIL STRUCTURE:**

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

### **RECOVERY:**

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

### **N-VALUE:**

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

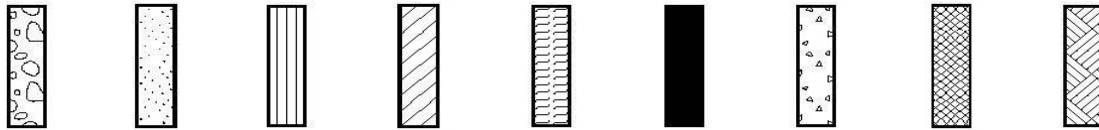
### **DYNAMIC CONE PENETRATION TEST (DCPT):**

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.



### STRATA PLOT:

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



Boulders  
Cobbles  
Gravel      Sand      Silt      Clay      Organics      Asphalt      Concrete      Fill      Bedrock

### TEXTURING CLASSIFICATION OF SOILS

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

### TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

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

### SAMPLE TYPES

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

### TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

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

### MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note -  $W_L$  = Liquid Limit



## EXPLANATION OF ROCK LOGGING TERMS

### ROCK WEATHERING CLASSIFICATION

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

### TERMS

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

### DISCONTINUITY SPACING

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

### STRENGTH CLASSIFICATION

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

## METRIC

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 16-02

1 OF 2

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 463.7 E 366 465.5 ORIGINATED BY JG  
 HWY 417 BOREHOLE TYPE HSA/NW Coring COMPILED BY JG  
 DATUM Geodetic DATE 2017.04.12 - 2017.04.12 CHECKED BY FJG

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			SHEAR STRENGTH kPa				W P      W      W L				
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE	20   40   60   80   100			20   40   60				
62.5																
0.0	TOPSOIL (180 mm)															
0.2	SAND with silt and gravel to SILTY SAND with gravel FILL Loose to dense Brown		1	SS	20		62						○			41   50   9 (SI+CL)
														○		
														○		
														○		
														○		
			2	SS	22		61						○			40   41   19 (SI+CL)
												○				
			3	SS	8		60						○			
			4	SS	35		59						○			
			5	SS	36								○			
58.8																
3.7	SILTY SAND with gravel, occasional cobble TILL Very Dense Grey		6	SS	100/ 50 mm								○			FI 0 2 1 2 2 1 0 2 2 2 0 0 0 2 0 0 0 1
			1	RUN			58									
			2	RUN			57									
			3	RUN			56									
							55									RUN #3 TCR=100% SCR=100% RQD=91% UCS=120MPa
																RUN #4 TCR=100% SCR=100% RQD=98% UCS=136MPa
			4	RUN			54									
							53									

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 16-02

2 OF 2

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 463.7 E 366 465.5 ORIGINATED BY JG  
 HWY 417 BOREHOLE TYPE HSA/NW Coring COMPILED BY JG  
 DATUM Geodetic DATE 2017.04.12 - 2017.04.12 CHECKED BY FJG

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								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
							WATER CONTENT (%)				20 40 60					
	Continued From Previous Page		5	RUN			52								1	RUN #5 TCR=100% SCR=100% RQD=100%
	LIMESTONE BEDROCK with some shale interbedding Grey Fresh Very Thinly Bedded		6	RUN			51								0	RUN #6 TCR=100% SCR=100% RQD=100% UCS=138MPa
			7	RUN			50								1	RUN #7 TCR=100% SCR=100% RQD=100%
48.8							49								1	
13.7	End of Borehole Borehole open and dry prior to coring															



# RECORD OF BOREHOLE No 16-03

1 OF 1

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 487.8 E 366 363.4 ORIGINATED BY JG  
 HWY 417 BOREHOLE TYPE HSA/NW Coring COMPILED BY JG  
 DATUM Geodetic DATE 2017.04.11 - 2017.04.11 CHECKED BY FJG

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								
								○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								
								20 40 60 80 100								
						WATER CONTENT (%)				20 40 60						
66.5																
0.0																
0.1	ASPHALT 100 mm															
	GRAVEL with sand and silt <b>FILL</b> Loose to Compact Brown		1	SS	8		66						○			
			2	SS	25								○			54 36 10 (SI+CL)
			3	SS	14		65						○			
64.5														○		
2.0	CLAY (CL) some sand, trace rootlets Soft Grey		4	SS	3		64						┌─┐ ○			3 21 42 34
63.6																
2.9	SILTY SAND (SM) Compact Brown to Grey		5	SS	18		63						○			
			6	SS	17								○			0 70 30 (SI+CL)
			7	SS	14		62						○			
61.5																
60.9	SILTY SAND with gravel TILL														FI	
5.2	LIMESTONE BEDROCK with some shale interbedding Grey Fresh Very Thinly Bedded		1	RUN			61								2	RUN #1 TCR=100% SCR=100% RQD=79%
			2	RUN			60								2	RUN #2 TCR=100% SCR=100% RQD=97% UCS=128MPa
			3	RUN			59								1	
							58								1	RUN #3 TCR=100% SCR=100% RQD=96%
57.3															0	
9.2	End of Borehole														1	

ONTMT4S 11189 - HWY 417 O-TRAIN GPJ 2012TEMPLATE(MTO).GDT 19/6/18

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
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10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 16-04

1 OF 1

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 516.9 E 366 432.6 ORIGINATED BY SOB  
 HWY 417 BOREHOLE TYPE HSA / NQ Coring COMPILED BY SOB  
 DATUM Geodetic DATE 2018.03.07 - 2018.03.07 CHECKED BY PC

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						
								WATER CONTENT (%)						
63.4														
0.0														
0.1	TOPSOIL (100 mm)		1	SS	10									
	SILTY SAND some gravel FILL Compact Brown		2	SS	23									
61.8														
1.5	GRAVEL (GP-GM), silty with sand TILL Compact to Dense Brown		3	SS	10									
			4	SS	32									
60.5														
2.9	LIMESTONE BEDROCK Slightly weathered to fresh Very thinly bedded with shale seams Strong Grey		1	RUN										
			2	RUN										
57.4														
5.9	End of Borehole Borehole open and dry prior to coring  WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m) 2018.03.12      2.7      60.7 2018.03.23      2.8      60.8													

ONTMT4S 11189 - HWY 417 O-TRAIN GPJ 2012TEMPLATE(MTO).GDT 19/6/18

# RECORD OF BOREHOLE No 16-05

1 OF 1

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 458.8 E 366 420.7 ORIGINATED BY JG  
 HWY 417 BOREHOLE TYPE HSA/NW Coring COMPILED BY JG  
 DATUM Geodetic DATE 2017.04.11 - 2017.04.11 CHECKED BY FJG

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				WATER CONTENT (%)								
63.8								20	40	60	80	100		W <sub>p</sub>	W	W <sub>L</sub>				
0.0	SILTY SAND with gravel <b>FILL</b> Loose to Compact Brown		1	SS	5															
62.4			2	SS	12															
1.4	SILTY SAND <b>FILL</b> Compact Brown																			
61.4			3	SS	26															
2.4	SILTY SAND ( <b>SM</b> ) some gravel <b>TILL</b> Loose Grey		4	SS	5															
60.9																				
2.9	LIMESTONE BEDROCK with some shale interbedding Grey Fresh Very Thinly Bedded		1	RUN																
				2	RUN															
				3	RUN															
57.6																				
6.2	End of Borehole Borehole open and dry prior to coring																			

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

# RECORD OF BOREHOLE No 16-06

1 OF 1

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 453.8 E 366 480.2 ORIGINATED BY JG  
 HWY 417 BOREHOLE TYPE HSA/NW Coring COMPILED BY JG  
 DATUM Geodetic DATE 2017.04.11 - 2017.04.11 CHECKED BY FJG

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						
								20 40 60 80 100						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			WATER CONTENT (%)				
							W P W W L							
62.5														
0.0	TOPSOIL (180 mm)													
0.2	SILTY SAND with gravel FILL Loose to Compact Brown		1	SS	4		62							33 49 18 (SI+CL)
			2	SS	19									
							61							
60.5	- trace wood/ organics		3	SS	10									
2.0	SILTY SAND (SM) with gravel, occasional cobble TILL Dense Brown													
			4	SS	43		60							38 45 17 (SI+CL)
			5	SS	100/									
59.1					150 mm									
3.4	LIMESTONE BEDROCK with some shale interbedding Grey Fresh Very Thinly Bedded		1	RUN			59							FI
														10
														10
														3
							58							1
														1
			2	RUN			57							3
														1
														1
														0
			3	RUN			56							3
55.3														
7.2	End of Borehole Borehole open and dry prior to coring													2

ONTMT4S 11189 - HWY 417 O-TRAIN GPJ 2012TEMPLATE(MTO).GDT 19/6/18

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

# RECORD OF BOREHOLE No 16-07

1 OF 2

METRIC

GWP# 4245-05-00 LOCATION Highway 417, West Approach MTM Zone 9: N 5 029 458.7 E 366 381.5 ORIGINATED BY JG  
HWY 417 BOREHOLE TYPE HSA COMPILED BY JSM  
DATUM Geodetic DATE 2017.03.28 - 2017.03.28 CHECKED BY FJG

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			SHEAR STRENGTH kPa						
72.0								<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>						
0.0	ASPHALT 250 mm							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>						
0.2	GRAVEL with sand and silt to SAND with gravel and silt FILL Compact Brown		1	AS			71							49 41 10 (SI+CL)
			2	SS	28									
70.5														
1.5	SAND FILL Compact to very loose Brown		3	SS	9		70							
	- cobble		4	SS	100 / 250 mm									
			5	SS	4		69							
			6	SS	3		68							1 96 3 (SI+CL)
			7	SS	12		67							
66.2														
5.8	SILTY SAND (SM) some gravel, trace organics Loose to compact Brown		8	SS	8		66							12 51 37 (SI+CL)
							65							
			9	SS	24		64							
63.3														
8.7	Sandy SILT (ML) Compact Brown		10	SS	22		63							1 44 55 (SI+CL)

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 16-07

2 OF 2

METRIC

GWP# 4245-05-00 LOCATION Highway 417, West Approach MTM Zone 9: N 5 029 458.7 E 366 381.5 ORIGINATED BY JG  
 HWY 417 BOREHOLE TYPE HSA COMPILED BY JSM  
 DATUM Geodetic DATE 2017.03.28 - 2017.03.28 CHECKED BY FJG

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			SHEAR STRENGTH kPa									
	Continued From Previous Page																
61.5	Sandy SILT (ML) Compact Brown		11	SS	100												
10.5	End of Borehole Auger refusal on inferred bedrock Water level measured in open hole at 9.4 m BGS When pulling out augers, hole caved at 4.6 m BGS				25mm												

ONTMT4S 11189 - HWY 417 O-TRAIN GPJ 2012TEMPLATE(MTO).GDT 19/6/18

# RECORD OF BOREHOLE No 16-08

1 OF 1

METRIC

GWP# 4245-05-00 LOCATION Highway 417, East Approach MTM Zone 9: N 5 029 491.6 E 366 478.1 ORIGINATED BY JG  
HWY 417 BOREHOLE TYPE HSA COMPILED BY JSM  
DATUM Geodetic DATE 2017.03.29 - 2017.03.29 CHECKED BY FJG

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			SHEAR STRENGTH kPa				W P      W      W L					GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
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ONTMT4S 11189 - HWY 417 O-TRAIN GPJ 2012TEMPLATE(MTO),GDT 19/6/18

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 16-09

1 OF 1

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 527.1 E 366 379.9 ORIGINATED BY JG  
 HWY 417 BOREHOLE TYPE HSA/NW Coring COMPILED BY JG  
 DATUM Geodetic DATE 2017.04.10 - 2017.04.11 CHECKED BY FJG

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			SHEAR STRENGTH kPa												
63.5								20	40	60	80	100								
0.0	TOPSOIL (150 mm)																			
0.2	GRAVEL with sand and silt, frequent cobbles <b>FILL</b> Dense to Very Dense Grey		1	SS	49		63													
62.3			2	SS	72															
1.2	<b>SILTY SAND</b> with gravel Compact Brown						62													
			3	SS	21															
61.1																				
2.4	<b>GRAVEL (GM)</b> with sand and silt to <b>SILTY SAND</b> with gravel, occasional cobble, <b>TILL</b> Dense Grey		4	SS	36		61													
60.5			5	SS	100/															
3.0	<b>LIMESTONE BEDROCK</b> with some shale interbedding Grey Slightly Weathered to Fresh Very Thinly Bedded				50 mm															
			1	RUN			60													
			2	RUN			59													
							58													
			3	RUN			57													
56.0																				
7.5	End of Borehole Borehole open and dry prior to coring Overnight water level in open borehole at 2.4 m																			

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# RECORD OF BOREHOLE No 16-10

1 OF 1

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 544.4 E 366 413.9 ORIGINATED BY SOB  
 HWY 417 BOREHOLE TYPE HSA / NQ Coring COMPILED BY SOB  
 DATUM Geodetic DATE 2018.03.07 - 2018.03.07 CHECKED BY PC

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					
								20 40 60 80 100					
								20 40 60 80 100					
63.7													
0.0	TOPSOIL (100 mm)												
0.1	SILTY SAND with gravel Loose to Dense Dark Brown FILL		1	SS	9								20 59 21 (SI+CL)
			2	SS	19								37 49 14 (SI+CL)
61.9			3	SS	36								
1.8	SAND with silt and gravel Dense Brown FILL		4	SS	38								
60.7													
3.0	SILTY SAND with organics/wood fragments Loose Dark Brown		5	SS	100/ 200mm								
60.3													
3.4	LIMESTONE BEDROCK Slightly weathered to fresh Very thinly bedded with shale seams Strong Grey		1	RUN									RUN #1 TCR=100% SCR=100% RQD=100%
			2	RUN									RUN #2 TCR=100% SCR=98% RQD=94% UCS=101MPa
			3	RUN									RUN #3 TCR=100% SCR=100% RQD=95%
56.5													
7.2	End of Borehole Borehole open and dry prior to coring												

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

# RECORD OF BOREHOLE No 16-11

1 OF 2

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 497.5 E 366 400.8 ORIGINATED BY JG  
 HWY 417 BOREHOLE TYPE HSA/NW Coring COMPILED BY JG  
 DATUM Geodetic DATE 2017.04.10 - 2017.04.10 CHECKED BY FJG

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							
								20 40 60 80 100							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
WATER CONTENT (%)				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W <sub>p</sub> W W <sub>L</sub>											
63.8															
0.0	SILTY SAND with gravel, occasional cobble <b>FILL</b> Compact to Dense Brown to Black		1	SS	19										
	- trace wood			2	SS	45									
62.1															
1.7	SAND with silt <b>FILL</b> Compact to Loose Brown		3	SS	29										
61.2															
2.6	<b>Sandy SILT (ML)</b> some gravel to <b>SILTY SAND</b> with gravel, occasional cobble, <b>TILL</b> Loose to Very Dense Grey		4	SS	8										
				5	SS	100/ 275 mm									
60.3															
3.5	<b>LIMESTONE BEDROCK</b> with some shale interbedding Grey Fresh Very Thinly Bedded		1	RUN											
				2	RUN										
				3	RUN										
				4	RUN										
						</									

Continued Next Page

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

## METRIC



[illegible]

# RECORD OF BOREHOLE No 18-08

1 OF 2

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 510.9 E 366 392.1 ORIGINATED BY KE  
 HWY 417 BOREHOLE TYPE HSA / NQ Coring COMPILED BY CM  
 DATUM Geodetic DATE 2018.02.26 - 2018.02.26 CHECKED BY PC

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				W P      W      W L						
63.7								20	40	60	80	100						
0.0	GRAVEL, silty with sand <b>FILL</b> Frequent cobbles and boulders, trace wood Very dense to dense Grey-black to brown		1	SS	100/ 150mm		63											
61.9			2	SS	37		62											42 40 18 (SI+CL)
1.8	<b>SAND (SP-SM)</b> with silt <b>TILL</b> Occasional cobbles Dense to very dense Brown		3	SS	100/ 125mm		61											0 94 6 (SI+CL)
61.3			1	RUN			60											RUN #1 TCR=100% SCR=92% RQD=85% UCS=113MPa
2.4	<b>LIMESTONE BEDROCK</b> Slightly Weathered to Fresh Occasional Shale Seams Very Strong Grey		2	RUN			59											RUN #2 TCR=100% SCR=56% RQD=32%
			3	RUN			58											RUN #3 TCR=100% SCR=100% RQD=91%
			4	RUN			57											RUN #4 TCR=100% SCR=98% RQD=97% UCS=101MPa
			5	RUN			56											RUN #5 TCR=100% SCR=100% RQD=95%
			6	RUN			55											RUN #6 TCR=100% SCR=100% RQD=100%
							54											

Continued Next Page


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

# RECORD OF BOREHOLE No 18-08

2 OF 2

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 510.9 E 366 392.1 ORIGINATED BY KE  
 HWY 417 BOREHOLE TYPE HSA / NQ Coring COMPILED BY CM  
 DATUM Geodetic DATE 2018.02.26 - 2018.02.26 CHECKED BY PC

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									
53.6	Continued From Previous Page																
10.1	End of Borehole																

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# RECORD OF BOREHOLE No 18-09

1 OF 1

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 489.7 E 366 404.0 ORIGINATED BY KE  
 HWY 417 BOREHOLE TYPE NW Casing / NQ Coring COMPILED BY SOB  
 DATUM Geodetic DATE 2018.03.01 - 2018.03.04 CHECKED BY PC

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			SHEAR STRENGTH kPa				WATER CONTENT (%)									
63.7								20	40	60	80	100									
0.0	GRAVEL with silt and sand <b>FILL</b> Occasional cobbles and boulders Loose to compact Brown																				
			1	SS	10		63														48   42   10 (SI+CL)
			2	SS	6		62														
61.4																					
2.3	<b>SILTY SAND (SM)</b> with gravel <b>TILL</b> Occasional cobbles and boulders Compact Grey		3	SS	24		61														
60.6																					
3.1	<b>LIMESTONE BEDROCK</b> Slightly Weathered to Fresh With Shale Partings Very Strong Grey		1	RUN			60														RUN #1 TCR=100% SCR=93% RQD=73%
			2	RUN			59														RUN #2 TCR=98% SCR=97% RQD=97% UCS=150MPa
			3	RUN			57														RUN #3 TCR=100% SCR=100% RQD=100% UCS=123MPa
			4	RUN			56														RUN #4 TCR=100% SCR=100% RQD=95%
54.7							55														
9.0	End of Borehole																				

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

# RECORD OF BOREHOLE No 18-10

1 OF 1

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 478.3 E 366 410.8 ORIGINATED BY KE  
 HWY 417 BOREHOLE TYPE NW Casing / NQ Coring COMPILED BY SOB  
 DATUM Geodetic DATE 2018.03.01 - 2018.03.01 CHECKED BY PC

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				W P      W      W L																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE				WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
63.7								20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

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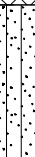


(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 18-11

1 OF 1

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 468.5 E 366 417.0 ORIGINATED BY KE  
 HWY 417 BOREHOLE TYPE NW Casing / NQ Coring COMPILED BY SOB  
 DATUM Geodetic DATE 2018.02.27 - 2018.02.28 CHECKED BY PC

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			SHEAR STRENGTH kPa				WATER CONTENT (%)					
								○ UNCONFINED      + FIELD VANE	20	40	60	80	100	W P      W      W L			
								● QUICK TRIAXIAL      × LAB VANE	20	40	60	80	100				
63.7																	
0.0	SILTY SAND some gravel <b>FILL</b> Occasional cobbles and boulders Dense Grey		1	SS	36												
61.9																	
1.8	<b>SILTY SAND (SM)</b> Compact Brown to Grey		2	SS	28												
			3	SS	24												
60.9																	
2.8	<b>SILTY SAND (SM)</b> with gravel <b>TILL</b> Compact to Very Dense Grey		4	SS100/225mm													
60.4																	
3.3	<b>LIMESTONE BEDROCK</b> Fresh With Shale Laminations Very Strong Grey		1	RUN													
			2	RUN													
			3	RUN													
			4	RUN													

ONTMT4S 11189 - HWY 417 O-TRAIN GPJ 2012TEMPLATE(MTO).GDT 19/6/18

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 18-12

1 OF 1

METRIC

GWP# 4245-05-00 LOCATION O-Train Bridge, MTM z9: N 5 029 459.4 E 366 422.0 ORIGINATED BY JG / KE  
 HWY 417 BOREHOLE TYPE HSA / NQ Coring COMPILED BY CM  
 DATUM Geodetic DATE 2018.02.20 - 2018.02.22 CHECKED BY PC

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			SHEAR STRENGTH kPa						
63.4								20 40 60 80 100						
0.0	SILTY SAND with gravel <b>FILL</b> frequent Cobbles Very Dense Brown						63							
62.8														
0.6	SILTY SAND, some gravel <b>FILL</b> Compact to Dense Brown		1	SS	47		62							12 64 24 (SI+CL)
			2	SS	22									
61.3							61							20 41 39 (SI+CL)
2.1	SILTY SAND (SM) with gravel <b>TILL</b> Loose to Very Dense Grey		3	SS	8									
60.3			4	SS	100/100mm									
3.1	LIMESTONE BEDROCK Slightly Weathered to Fresh Occasional Shale Seams Strong to Very Strong Grey		1	RUN			60							RUN #1 TCR=100% SCR=98% RQD=78% UCS=107MPa
							59							RUN #2 TCR=100% SCR=100% RQD=87%
			2	RUN			58							RUN #3 TCR=100% SCR=100% RQD=100%
							57							RUN #4 TCR=98% SCR=98% RQD=92% UCS=93MPa
			3	RUN			56							
							55							
			4	RUN										
54.4														
9.1	End of Borehole													

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

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15  
10

(%) STRAIN AT FAILURE

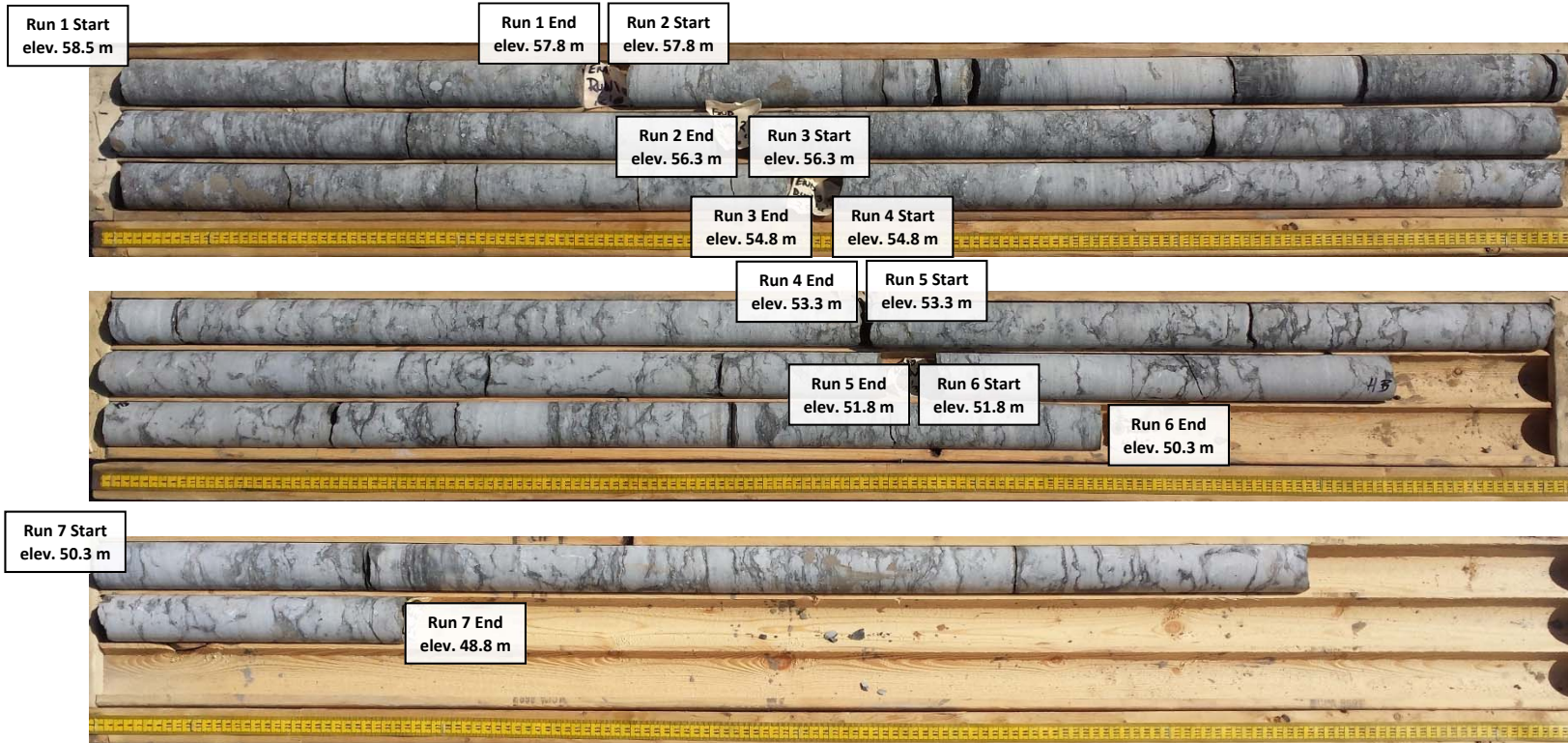
**Borehole 16-1**  
**Run 1 to 3 (of 3)**  
**Elevation 59.5 m to 55.6 m**



## Borehole 16-2

Run 1 to 7 (of 7)

Elevation 58.5 m to 48.8 m



**THURBER** ENGINEERING LTD.

Foundation Investigation  
Replacement of CPR/O-Train Bridges,  
Highway 417 Ottawa, Ontario

GWP 4245-05-00

Project No.: 11189

**Borehole 16-3**  
**Run 1 to 3 (of 3)**  
**Elevation 61.3 m to 57.3 m**



**Borehole 16-4**  
**Run 1 to 2 (of 2)**  
**Elevation 60.5 m to 57.4 m**





**Borehole 16-5**  
**Run 1 to 3 (of 3)**  
**Elevation 60.9.0 m to 57.6 m**



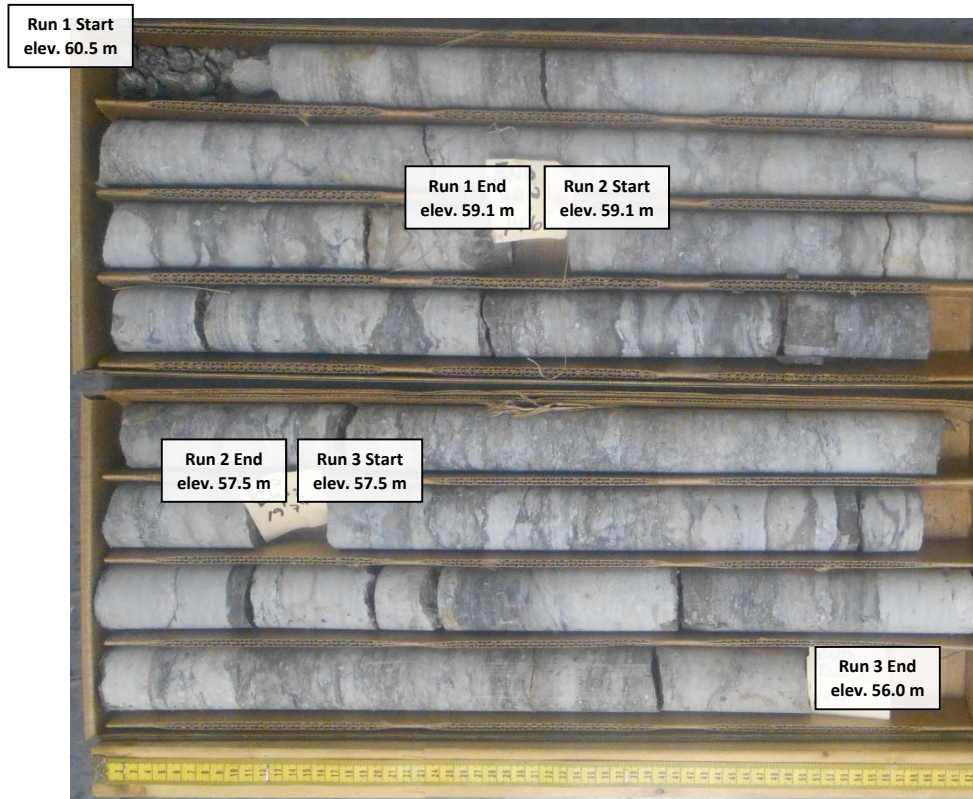
**Borehole 16-6**  
**Run 1 to 3 (of 3)**  
**Elevation 59.1 m to 55.3 m**



**16-9**

**Run 1 to 3 (of 3)**

**Elevation 60.5 m to 56.0 m**





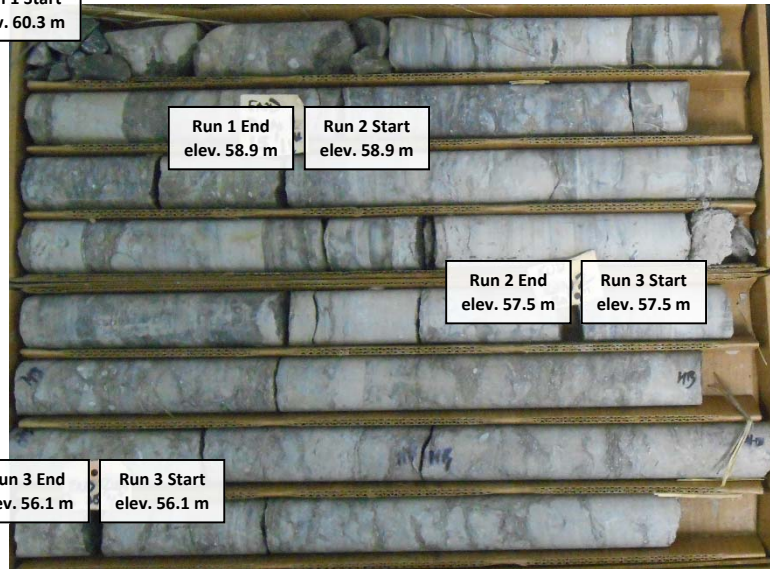
**Borehole 16-10**  
**Run 1 to 3 (of 3)**  
**Elevation 60.3 m to 56.5 m**



## 16-11

Run 1 to 6 (of 6)  
Elevation 60.3 m to 51.5 m

Run 1 Start  
elev. 60.3 m



Run 1 End  
elev. 58.9 m

Run 2 Start  
elev. 58.9 m

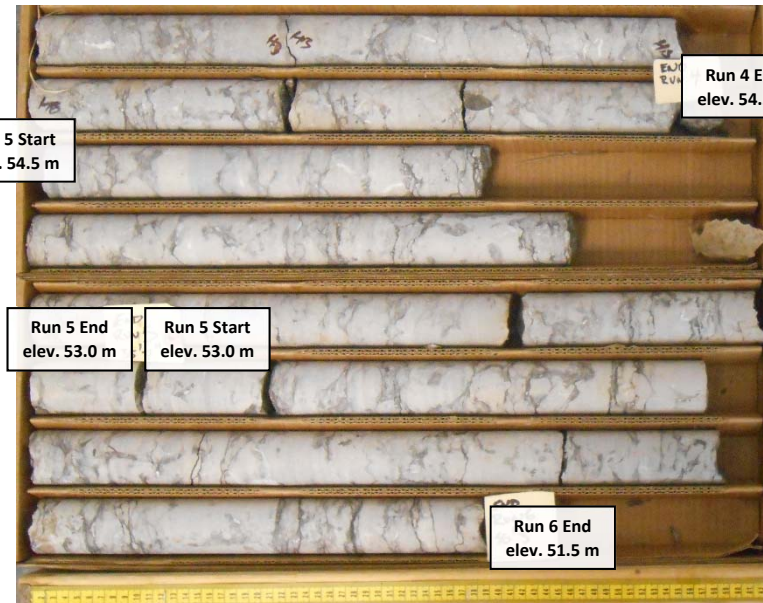
Run 2 End  
elev. 57.5 m

Run 3 Start  
elev. 57.5 m

Run 3 End  
elev. 56.1 m

Run 3 Start  
elev. 56.1 m

Run 5 Start  
elev. 54.5 m



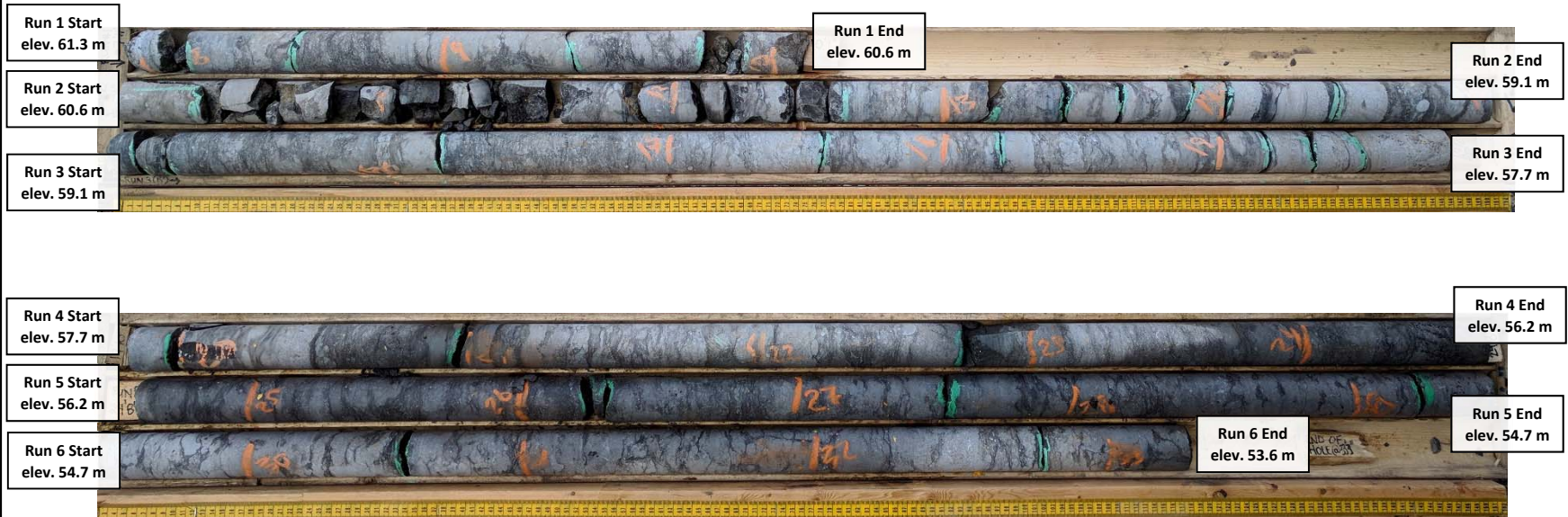
Run 4 End  
elev. 54.5 m

Run 5 End  
elev. 53.0 m

Run 5 Start  
elev. 53.0 m

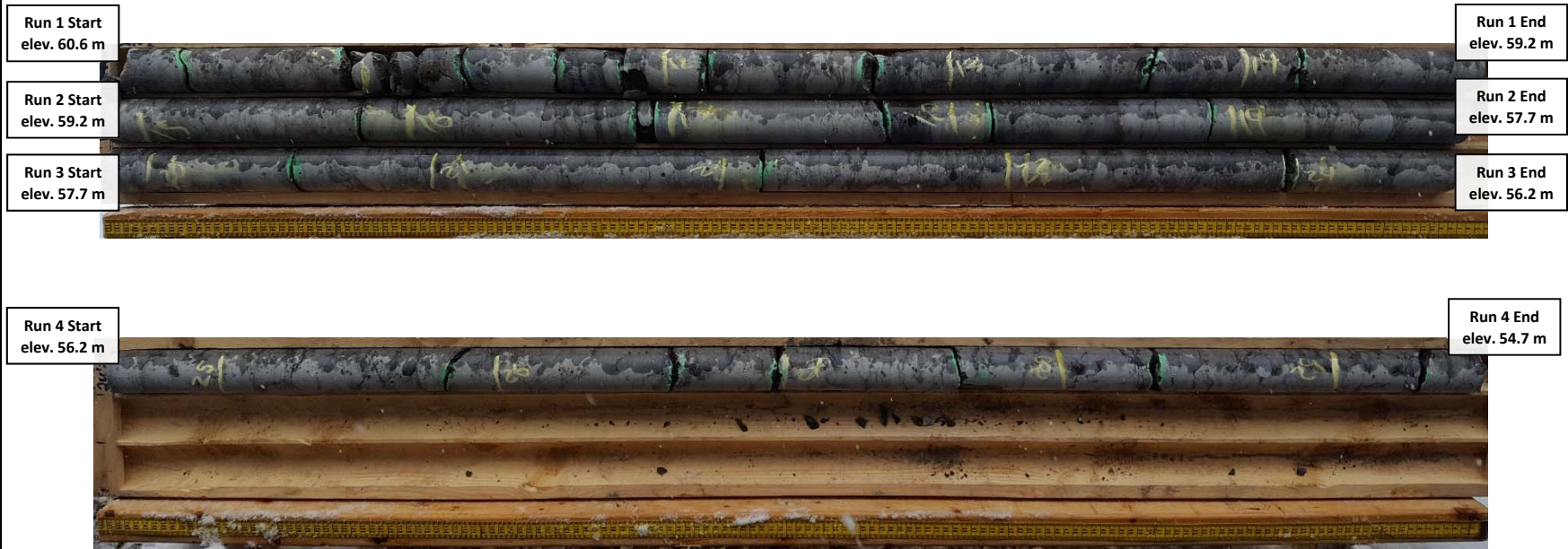
Run 6 End  
elev. 51.5 m

**Borehole 18-08**  
**Run 1 to 6 (of 6)**  
**Elevation 61.3 m to 53.6 m**

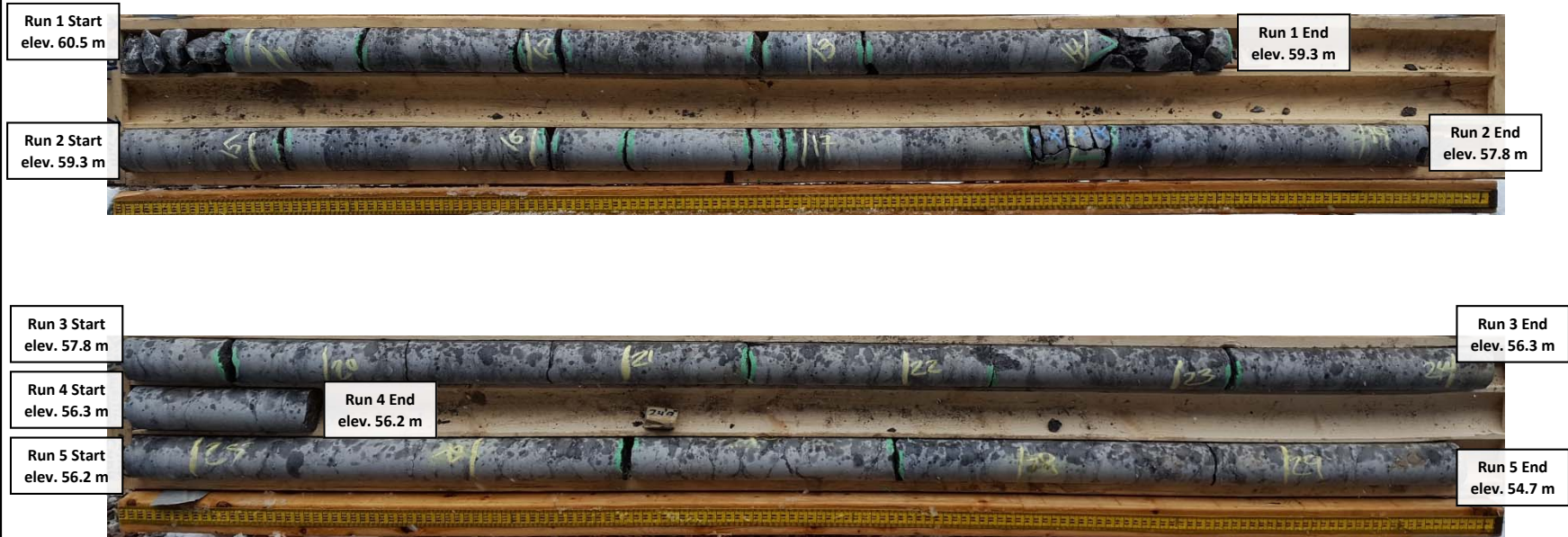




**Borehole 18-09**  
**Run 1 to 4 (of 4)**  
**Elevation 60.6 m to 54.7 m**



**Borehole 18-10**  
**Run 1 to 5 (of 5)**  
**Elevation 60.5 m to 54.7 m**



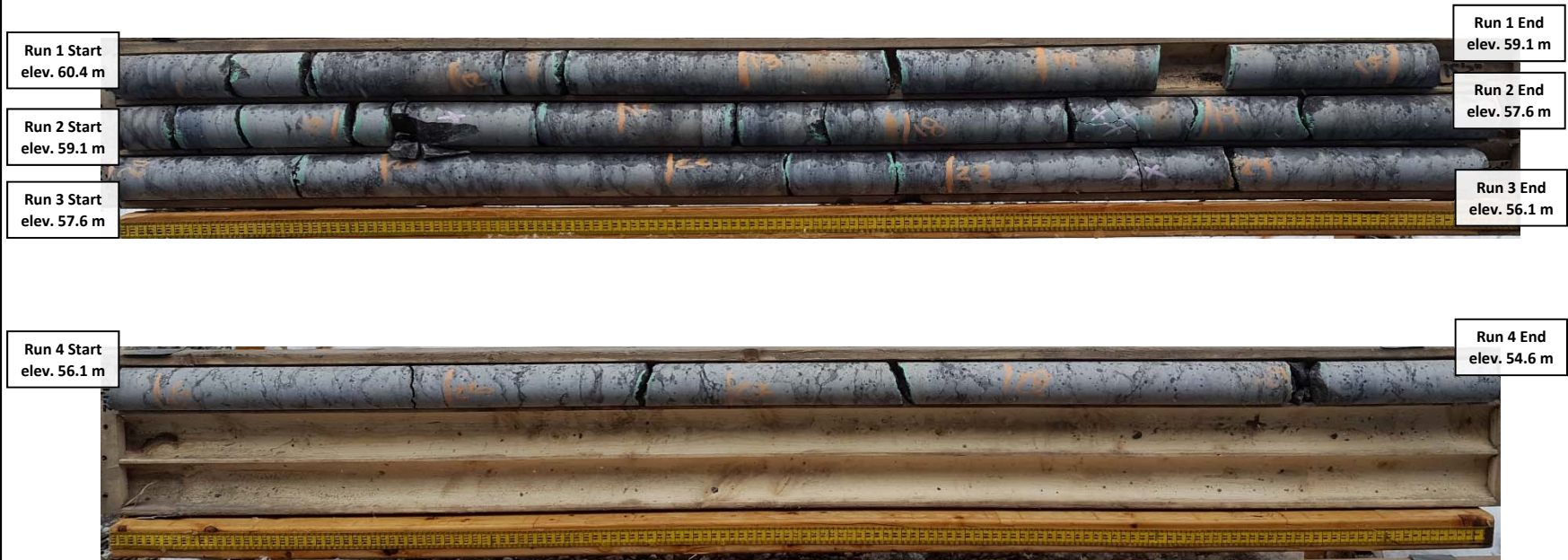
**THURBER** ENGINEERING LTD.

**Foundation Investigation  
Replacement of CPR/O-Train Bridges,  
Highway 417 Ottawa, Ontario**

**GWP 4245-05-00**

**Project No.: 11189**

**Borehole 18-11**  
**Run 1 to 4 (of 4)**  
**Elevation 60.4 m to 54.6 m**





**Borehole 18-12**  
**Run 1 to 4 (of 4)**  
**Elevation 60.3 m to 54.4 m**

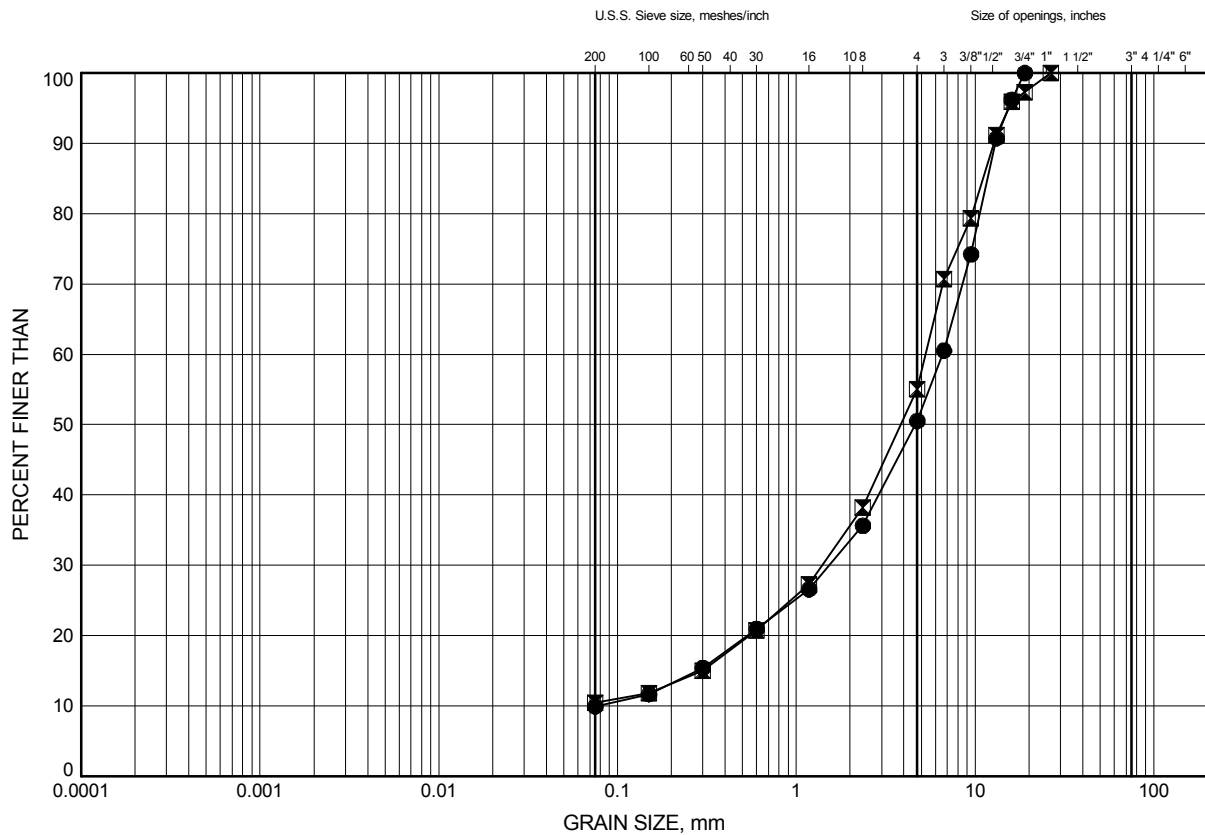


**Appendix C.**  
**Laboratory Test Results**



## GRAIN SIZE DISTRIBUTION

FILL: Road Base



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-07	0.46	71.54
⊠	16-08	0.46	68.44

Date June 2018

GWP# 4245-05-00

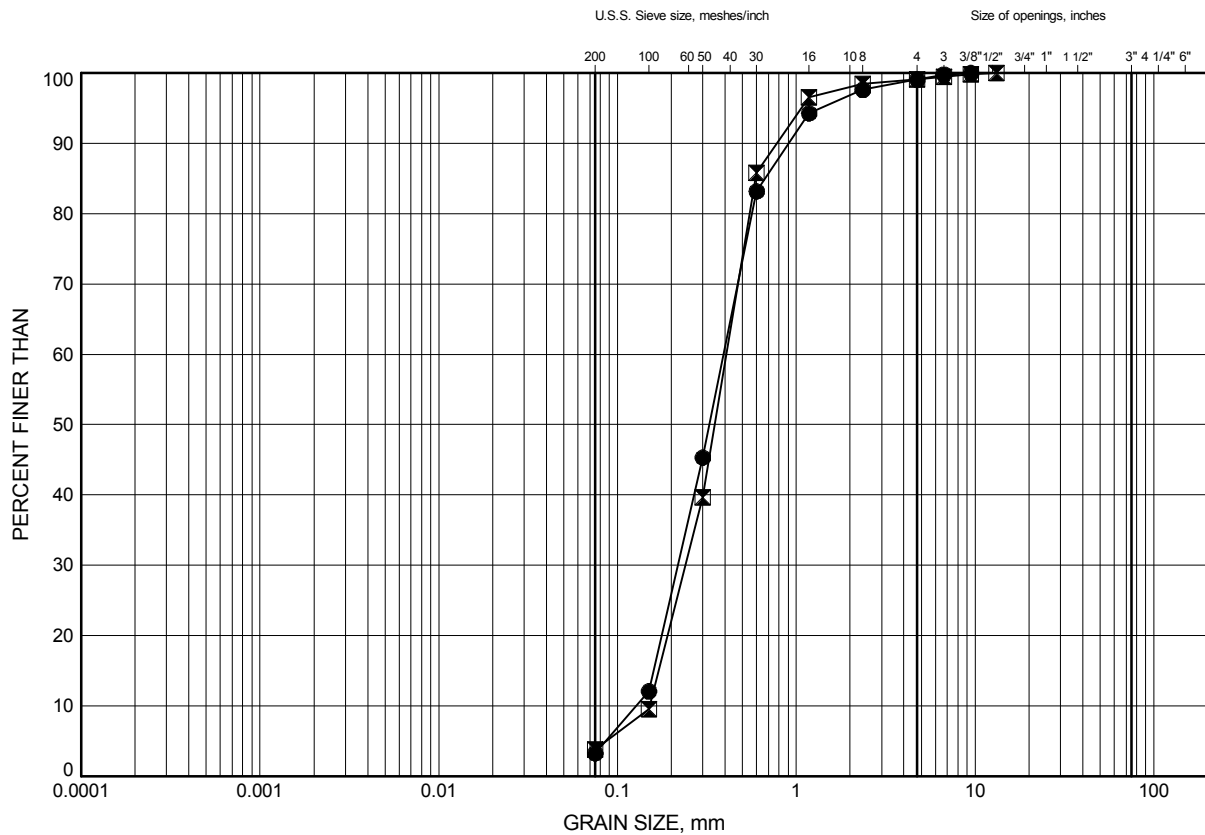


Prep'd JG

Chkd. PC

## GRAIN SIZE DISTRIBUTION

FILL: Embankment



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-07	4.11	67.89
⊠	16-08	2.59	66.31

Date June 2018

GWP# 4245-05-00

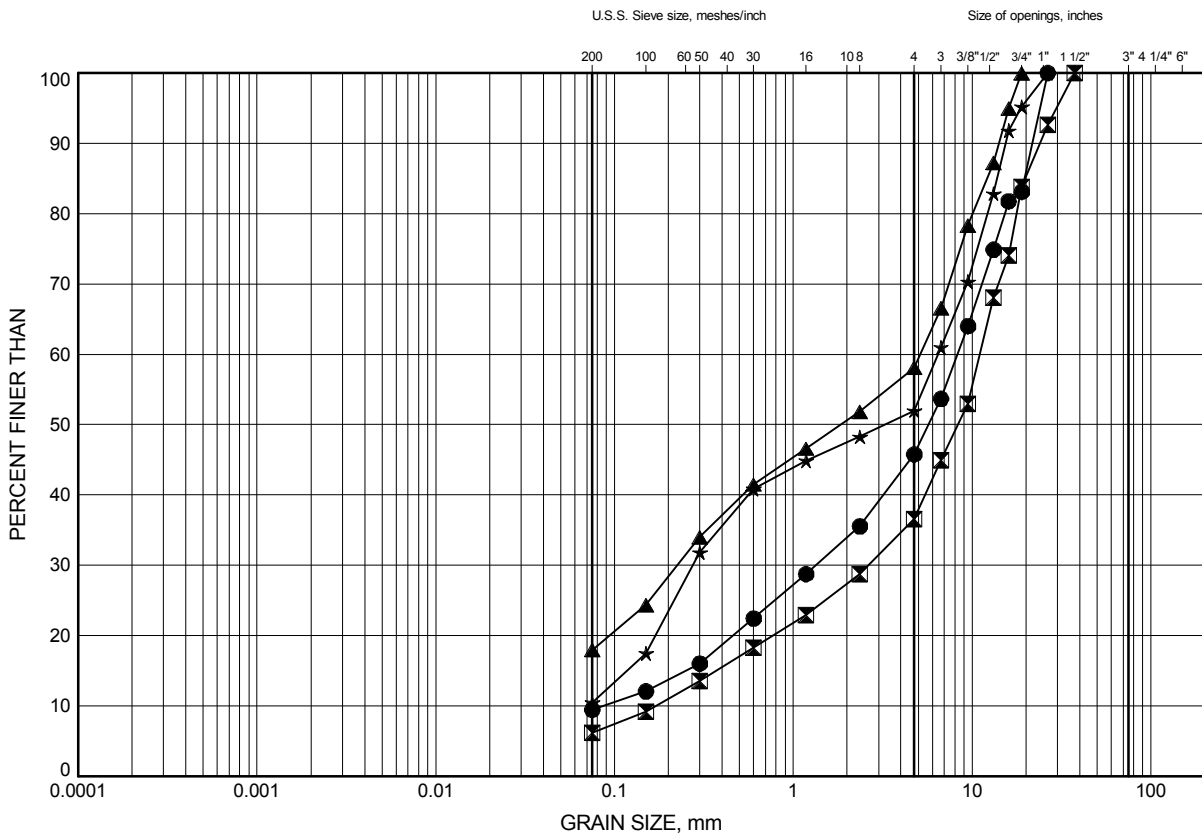


Prep'd JG

Chkd. PC

## GRAIN SIZE DISTRIBUTION

FILL: Gravel



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-03	1.07	65.43
☒	16-09	1.07	62.43
▲	18-08	1.68	62.06
★	18-09	1.07	62.59

Date June 2018

GWP# 4245-05-00

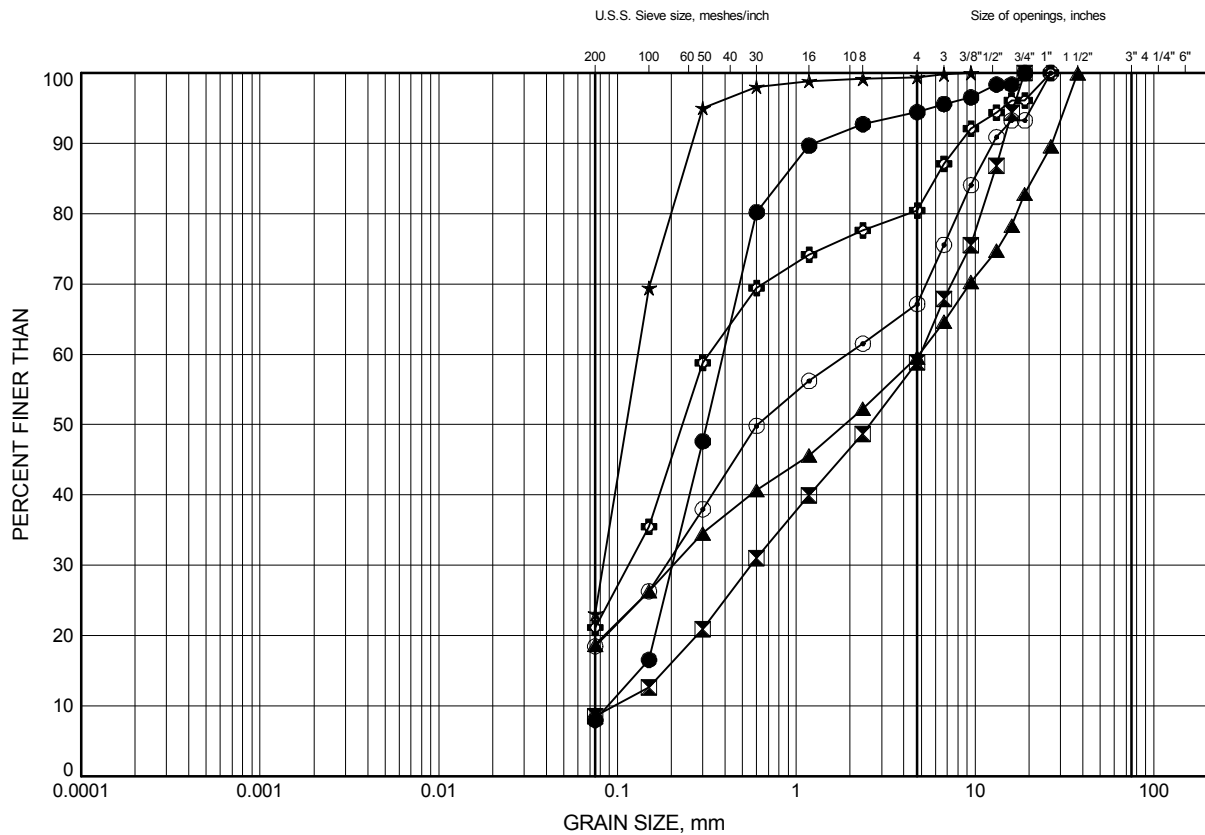


Prep'd JG

Chkd. PC

## GRAIN SIZE DISTRIBUTION

FILL: Sand



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	1.83	60.97
⊠	16-02	1.07	61.43
▲	16-02	2.59	59.91
★	16-05	1.83	61.97
⊙	16-06	0.30	62.20
⊕	16-10	0.30	63.40

Date June 2018

GWP# 4245-05-00

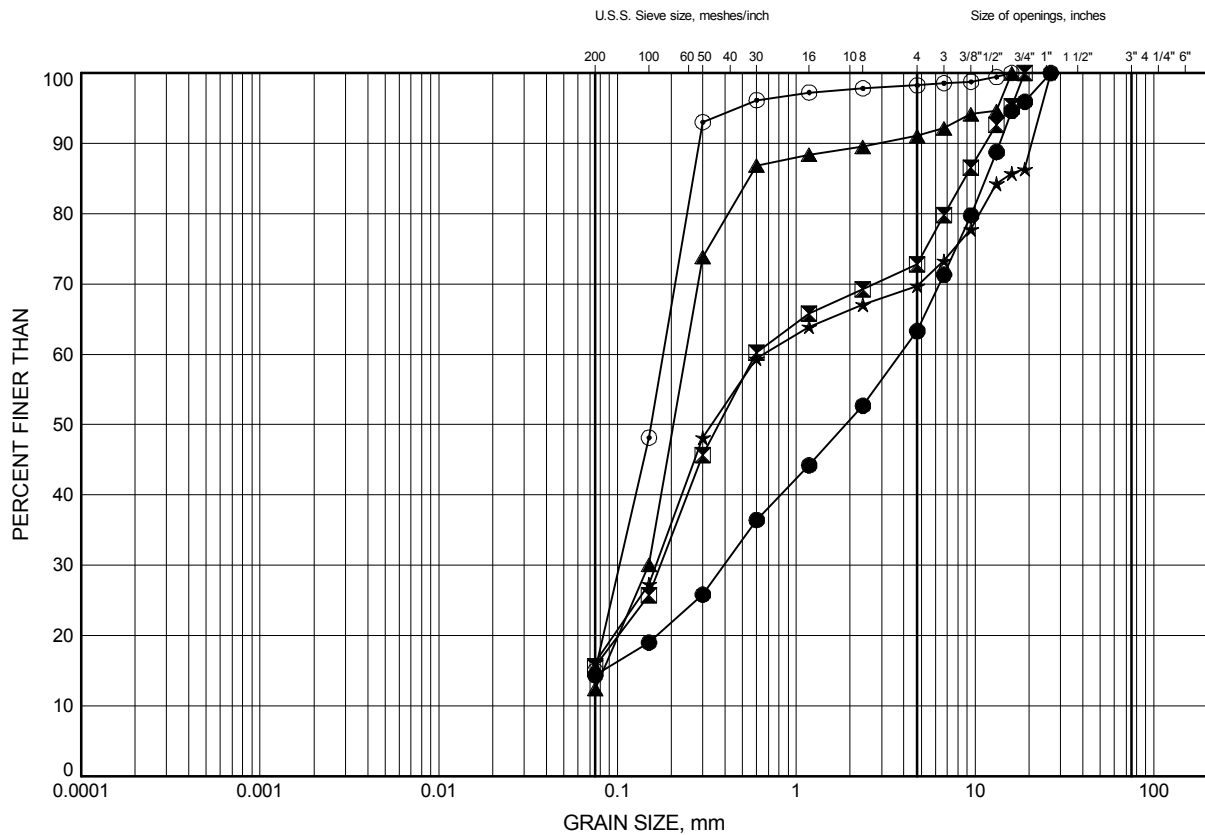


Prep'd JG

Chkd. PC

## GRAIN SIZE DISTRIBUTION

FILL: Sand



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-10	1.22	62.48
⊠	16-11	1.07	62.73
▲	16-11	1.91	61.89
★	18-10	1.07	62.65
⊙	18-11	1.98	61.72

Date June 2018

GWP# 4245-05-00

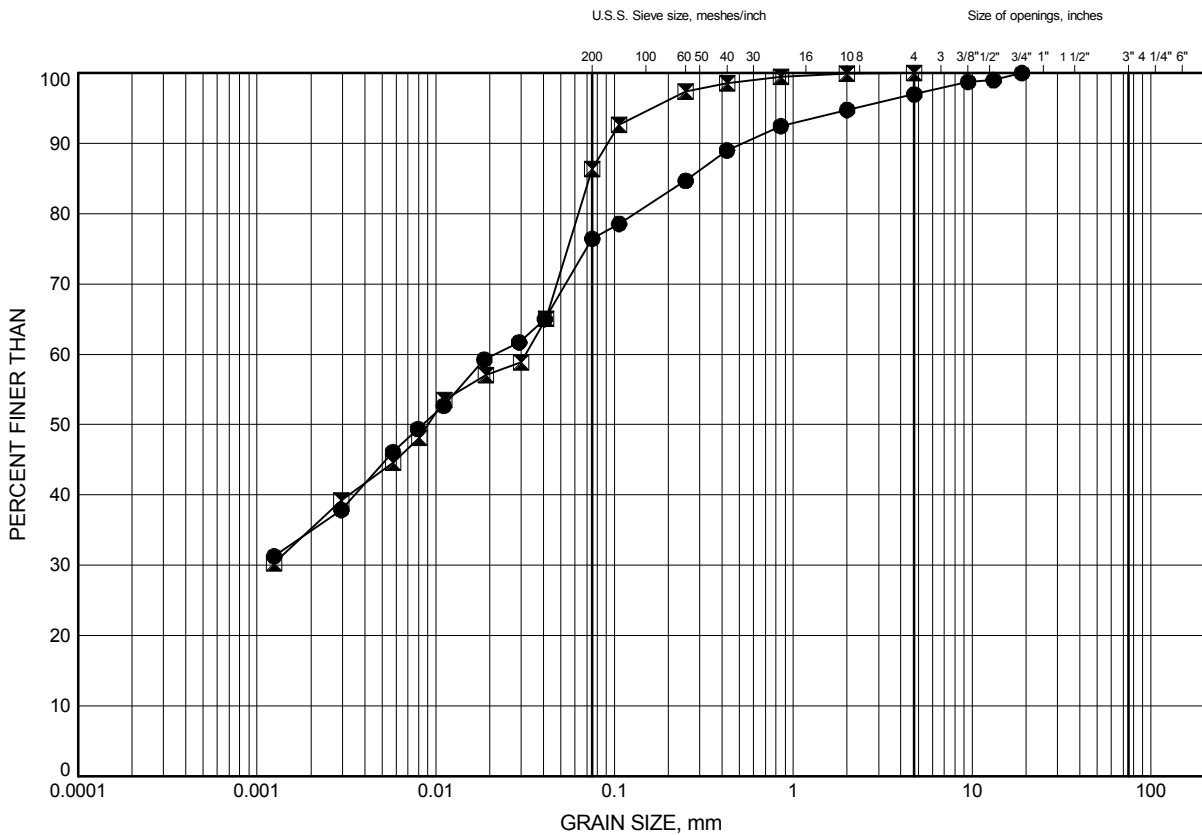


Prep'd JG

Chkd. PC

## GRAIN SIZE DISTRIBUTION

## CLAY



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-03	2.59	63.91
⊠	16-08	6.40	62.50

Date June 2018

GWP# 4245-05-00

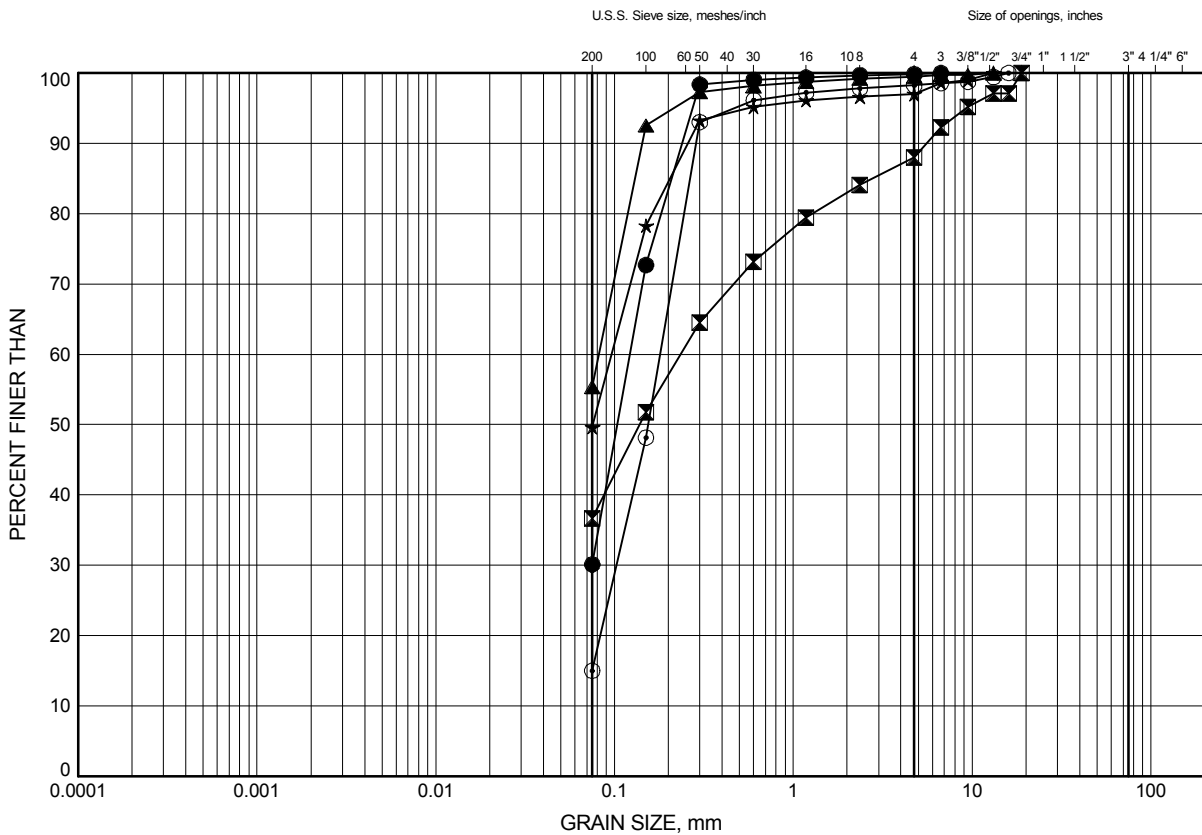


Prep'd JG

Chkd. PC

## GRAIN SIZE DISTRIBUTION

## SANDY SILT TO SILTY SAND



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-03	4.11	62.39
⊠	16-07	6.40	65.60
▲	16-07	9.45	62.55
★	18-10	2.59	61.13
◉	18-11	1.98	61.72

Date June 2018

GWP# 4245-05-00

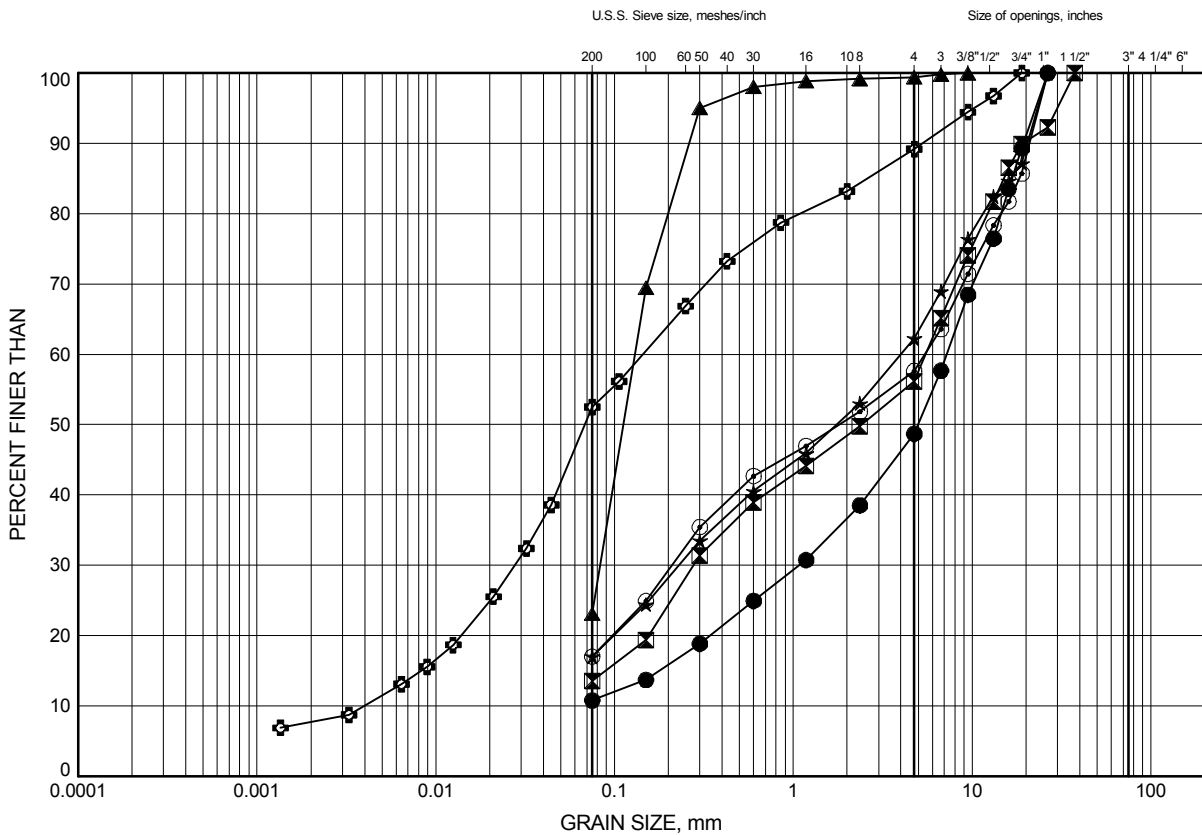


Prep'd JG

Chkd. PC

## GRAIN SIZE DISTRIBUTION

## GLACIAL TILL



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	2.59	60.21
⊠	16-04	1.83	61.53
▲	16-05	1.83	61.97
★	16-06	2.59	59.91
⊙	16-09	2.59	60.91
⊕	16-11	2.74	61.06

Date June 2018

GWP# 4245-05-00



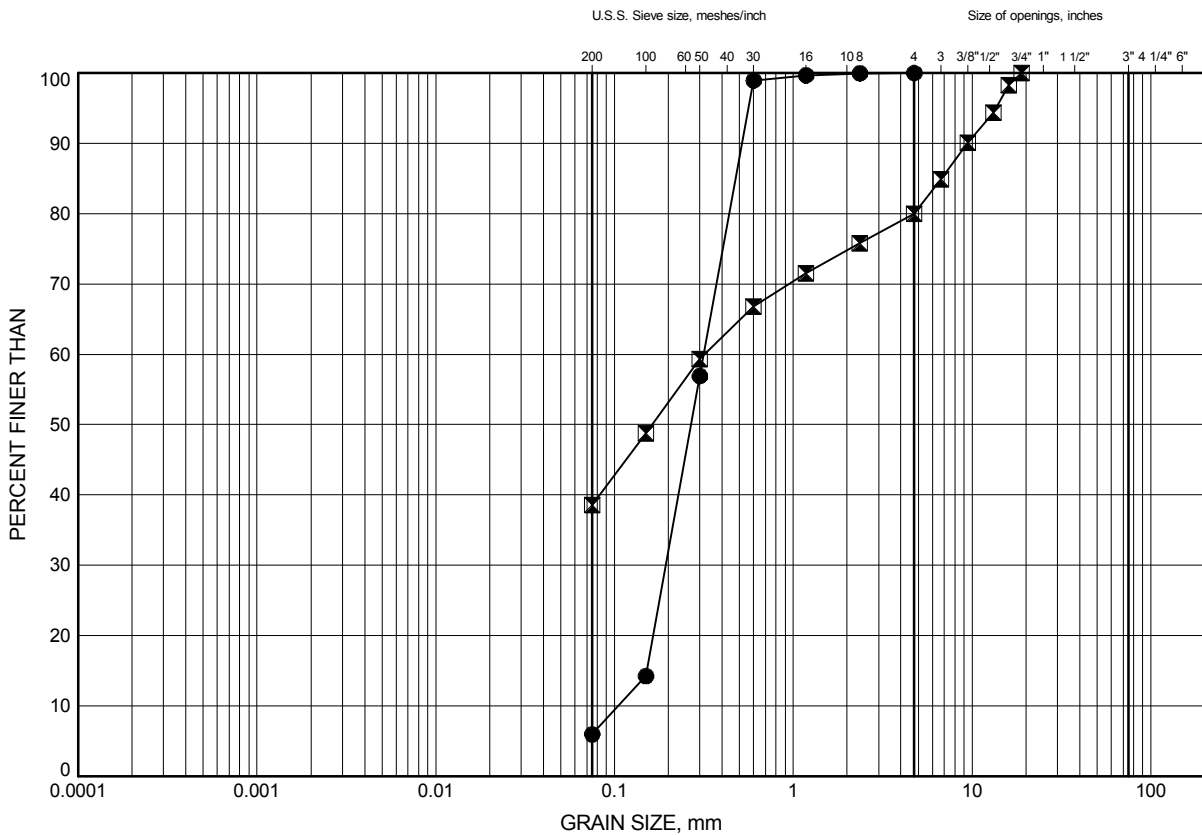
Prep'd JG

Chkd. PC



## GRAIN SIZE DISTRIBUTION

## GLACIAL TILL



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-08	1.98	61.76
⊠	18-12	2.59	60.85

Date June 2018

GWP# 4245-05-00



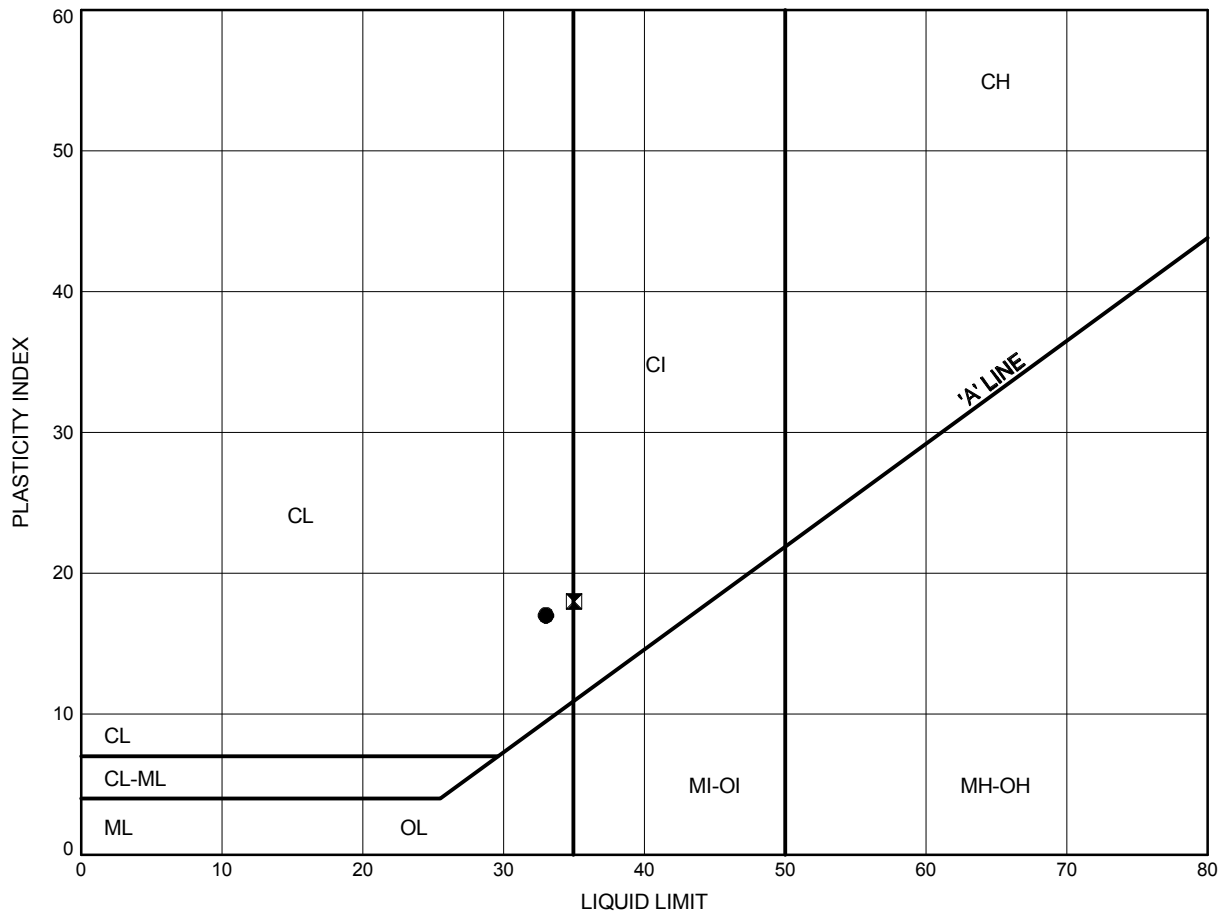
Prep'd JG

Chkd. PC

Replacement of CPR/O-Train Bridges, Highway 417 Ottawa

# ATTERBERG LIMITS TEST RESULTS

FIGURE C10



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-03	2.59	63.91
⊠	16-08	6.40	62.50

Date June 2018  
GWP# 4245-05-00



Prep'd JG  
Chkd. PC



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

**Stantec**

April 25, 2017  
File: 122410864

**Attention: Thurber Engineering Ltd., File #11189**

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

The table below summarizes twelve rock core unconfined compressive strength results.

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
BH16-1 Run-3	23'	123.4	No well-formed cones, vertical cracks throughout
BH16-3 Run-2	25'3"	128.1	No well-formed cones on either end
Bh16-5 Run-2	17'5"	141.2	No well-formed cones, vertical cracks throughout
BH16-6 Run-2	20'3"	142.7	Well-formed cone on bottom, vertical cracks through top
Bh16-2 Run-2	18'3"	127.9	Two well-formed cones on either end
BH16-2 Run-3	24'2"	119.6	Two well-formed cones on either end
BH16-2 Run-4	35'	136.3	Well-formed cone on bottom, vertical cracks through top
BH16-2 Run-6	39'1"	137.5	No well-formed cones, vertical cracks throughout
BH16-11 Run-2	17'	156.6	Two well-formed cones on either end
BH16-11 Run-3	23'3"	131.7	Two well-formed cones on either end
BH16-11 Run-5	31'2"	139.5	Two well-formed cones on either end
BH16-11 Run-6	38'9"	106.5	No well-formed cones, long vertical cracks throughout

Sincerely,

**Stantec Consulting Ltd**

Brian Prevost  
Laboratory Supervisor  
Tel: 613-738-6075  
[brian.prevost@stantec.com](mailto:brian.prevost@stantec.com)



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

**Stantec**

March 7, 2018  
File: 122410864

**Attention: Thurber Engineering Ltd., File #11189**

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

The table below summarizes three (8) rock core unconfined compressive strength results.

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
18-8	8'5"-9'5"	112.5	One large diagonal crack through centre of core
18-8	20'-21'	101.4	Two well formed cones on either end
18-12	11'3"-12'1"	106.9	One large straight crack down centre of core
18-12	24'4"-25'2"	93	Well formed cone on one bottom, cracks through rest
<del>18-3</del>	<del>20' 20'0"</del>	<del>120.2</del>	<del>Long vertical cracks throughout core</del>
<del>18-5</del>	<del>11' 15'</del>	<del>96.4</del>	<del>Two well formed cones on either end</del>
<del>18-4</del>	<del>10' 10'0"</del>	<del>98.8</del>	<del>Two well formed cones on either end</del>
<del>18-2</del>	<del>30'4"-31'3"</del>	<del>93.3</del>	<del>Well formed cone on bottom, vertical cracks through rest</del>

Sincerely,

**Stantec Consulting Ltd**

*Brian Prevost*

Brian Prevost  
Laboratory Supervisor  
Tel: 613-738-6075  
[brian.prevost@stantec.com](mailto:brian.prevost@stantec.com)



**Stantec**

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

March 20, 2018  
File: 122410864

**Attention: Thurber Engineering Ltd., File #11189**

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

The table below summarizes seven (7) rock core unconfined compressive strength results.

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
16-10	15'10"	101.1	Two well-formed cones on either end
18-9	14'6"	150.3	Well-formed cone on bottom, vertical cracks through top
18-9	24'3"	123.0	Two well-formed cones on either end
18-10	14'10"	118.0	No well-formed cones, vertical cracks throughout
18-10	24'6"	116.3	Two well-formed cones on either end
18-11	14'7"	108.7	Two well-formed cones on either end
18-11	20'3"	139.0	No well-formed cones, vertical cracks throughout

Sincerely,

**Stantec Consulting Ltd**

*Brian Prevost*

Brian Prevost  
Laboratory Supervisor  
Tel: 613-738-6075  
[brian.prevost@stantec.com](mailto:brian.prevost@stantec.com)

## Certificate of Analysis

**Thurber Engineering Ltd.**

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

Client PO: 11189  
Project: OTrain Bridge  
Custody: 39592

Report Date: 21-Jun-2018  
Order Date: 8-Mar-2018

Revised Report

**Order #: 1810380**

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

Paracel ID	Client ID
1810380-01	16-4, SS4, 7'6"-9'6"
1810380-02	18-11, SS4, 10'-10'9"

Approved By:



Mark Foto, M.Sc.  
Lab Supervisor

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 11189

Report Date: 21-Jun-2018

Order Date: 8-Mar-2018

Project Description: OTrain Bridge

## Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	9-Mar-18	10-Mar-18
Conductivity	MOE E3138 - probe @25 °C, water ext	9-Mar-18	9-Mar-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	11-Mar-18	12-Mar-18
Resistivity	EPA 120.1 - probe, water extraction	9-Mar-18	9-Mar-18
Solids, %	Gravimetric, calculation	13-Mar-18	13-Mar-18



Certificate of Analysis  
**Client: Thurber Engineering Ltd.**  
**Client PO: 11189**

Report Date: 21-Jun-2018

Order Date: 8-Mar-2018

**Project Description: OTrain Bridge**

<b>Client ID:</b>	16-4, SS4, 7'6"-9'6"	18-11, SS4, 10'-10'9"	-	-
<b>Sample Date:</b>	03/07/2018 00:00	02/27/2018 00:00	-	-
<b>Sample ID:</b>	1810380-01	1810380-02	-	-
<b>MDL/Units</b>	Soil	Soil	-	-

#### Physical Characteristics

% Solids	0.1 % by Wt.	88.7	91.8	-	-
----------	--------------	------	------	---	---

#### General Inorganics

Conductivity	5 uS/cm	227	675	-	-
pH	0.05 pH Units	7.90	7.89	-	-
Resistivity	0.10 Ohm.m	44.1	14.8	-	-

#### Anions

Chloride	5 ug/g dry	33	333	-	-
Sulphate	5 ug/g dry	64	122	-	-

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 11189

Report Date: 21-Jun-2018

Order Date: 8-Mar-2018

Project Description: OTrain Bridge

### 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: 11189

Report Date: 21-Jun-2018

Order Date: 8-Mar-2018

Project Description: OTrain Bridge

### Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	30.7	5	ug/g dry	32.9			6.8	20	
Sulphate	58.9	5	ug/g dry	64.0			8.3	20	
<b>General Inorganics</b>									
Conductivity	163	5	uS/cm	165			1.3	6.2	
pH	7.00	0.05	pH Units	7.02			0.3	10	
Resistivity	61.3	0.10	Ohm.m	60.5			1.3	20	
<b>Physical Characteristics</b>									
% Solids	82.6	0.1	% by Wt.	82.7			0.2	25	

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 11189

Report Date: 21-Jun-2018

Order Date: 8-Mar-2018

Project Description: OTrain Bridge

**Method Quality Control: Spike**

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
<b>Anions</b>									
Chloride	127	5	ug/g	32.9	93.7	78-113			
Sulphate	160	5	ug/g	64.0	96.5	78-111			

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO: 11189

Report Date: 21-Jun-2018

Order Date: 8-Mar-2018

Project Description: OTrain Bridge

**Qualifier Notes:**

***Login Qualifiers :***

Container(s) - Bottle and COC sample ID don't match -  
*Applies to samples: 18-11, SS4, 10'-10'9"*

**Sample Data Revisions**

None

**Work Order Revisions / Comments:**

Revision 1 - this report includes an updated client Sample ID.

**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.

Paracel ID: 1810380



RELIABLE

Office  
9 St. Laurent Blvd.  
Ontario K1G 4J8  
749-1947  
e: paracel@paracellabs.com

Chain of Custody  
(Lab Use Only)

No 39592

Page 1 of 1

Client Name: <u>Thurber Engineering Ltd.</u>	Project Reference: <u>OTrain Bridge</u>	Turnaround Time: <input type="checkbox"/> 1 Day <input type="checkbox"/> 3 Day <input type="checkbox"/> 2 Day <input checked="" type="checkbox"/> Regular Date Required: _____
Contact Name: <u>Justin Gray</u>	Quote # _____	
Address: <u>2460 Lancaster Rd Ottawa.</u>	PO # <u>11189</u>	
Telephone: <u>613-247-2121</u>	Email Address: <u>jgray@thurber.ca</u>	

Criteria: ☐ O. Reg. 153/04 (As Amended) Table \_\_ ☐ RSC Filing ☐ O. Reg. 558/00 ☐ PWQO ☐ CCME ☐ SUB (Storm) ☐ SUB (Sanitary) Municipality: \_\_\_\_\_ ☐ Other: \_\_\_\_\_

Matrix Type: S (Soil Sed.) GW (Ground Water) SW (Surface Water) SS (Storm Sanitary Sewer) P (Paint) A (Air) O (Other)

Required Analyses

Parcel Order Number:			Matrix	Air Volume	# of Containers	Sample Taken		pH	conductivity	resistivity	sulphates chlorides								
Sample ID/Location Name						Date	Time												
1	16-4, SS4, 7'6"-9'6"			S		1	Mar 7/2018	✓	✓	✓	✓								
2	16-10, SS4, 10'-10'9"			S		1	Feb 27/2018	✓	✓	✓	✓								
3	↳ Boreholes 18-11																		
4																			
5																			
6																			
7																			
8																			
9																			
10																			

Comments:			Method of Delivery: <u>Walkin</u>		
Relinquished By (Sign): <u>[Signature]</u>	Received by Driver/Depot:	Received at Lab: <u>[Signature]</u>	Verified By: <u>Rachel Subject</u>		
Relinquished By (Print): <u>Justin Gray</u>	Date/Time:	Date/Time: <u>March 8, 2018</u>	Date/Time: <u>Mar 8/18</u>		
Date/Time: <u>March 8, 2018</u>	Temperature: _____ °C	Temperature: <u>22.4</u> °C	pH Verified <input checked="" type="checkbox"/> By: <u>N/A</u> <u>3:14</u>		

Chain of Custody (Blank) - Rev 0.4 Feb 2016

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



REPLACEMENT OF CPR/O-TRAIN BRIDGES  
HIGHWAY 417, OTTAWA



**Photo 1. Looking south under the 417 (along the Trillium Pathway) (2017-02-02) .**



**Photo 2. Looking east at bridge abutment (near 16-03) (2017-02-02).**

REPLACEMENT OF CPR/O-TRAIN BRIDGES  
HIGHWAY 417, OTTAWA

v



**Photo 3. Looking north under Highway 417 (near 16-05) (2017-02-02).**



**Photo 4. Looking west from east abutment (near 16-11) (2017-02-02).**



REPLACEMENT OF CPR/O-TRAIN BRIDGES  
HIGHWAY 417, OTTAWA



**Photo 5. Looking north from pedestrian bridge (2017-01-27).**



**Photo 6. Looking west showing exposed rock in railway cut (2017-02-02).**