

**FOUNDATION INVESTIGATION REPORT  
STRUCTURAL CULVERTS  
HIGHWAY 69 FOUR-LANING  
FROM THE SOUTH JUNCTION OF HIGHWAY 529 NORTHERLY 15 KM  
G.W.P. 5076-06-00  
SOUTH SECTION – HIGHWAY 529 TO NAISCOOT LAKE**

**Geocres Number: 41H-130**

**Report to**

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August 21, 2014  
File: 19-5161-21

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- Record of Borehole Sheets
- Laboratory Test Results
- Borehole Locations and Soil Strata Drawings

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted for the proposed structural culverts required along a section of the Highway 69 four-laning project extending from Highway 529 northerly approximately 3.8 km to north of Naiscoot Lake. Two of the culverts associated with this project are required along the proposed Naiscoot Access Road (existing Highway 69), located to the west of the proposed Highway 69.

The report is one of two reports addressing a larger section of the four-laning project extending from the south junction of Highway 529 northerly for 15 km in the Townships of Harrison and Wallbridge, Ontario. The report deals with the culverts in the south part of this section; the remaining culverts in the north part of the section are dealt with in a separate report.

The purpose of the investigation was to explore the subsurface conditions at the proposed culvert locations and, based on the data obtained, to provide record of borehole sheets, borehole location plans, stratigraphic profiles, laboratory test results, and a generalized description of the subsurface conditions at each location. This information provides a model of the anticipated geotechnical conditions influencing design and construction of the structural culverts.

Thurber carried out the investigation as a sub-consultant to MMM Group Limited (MMM) under the Ministry of Transportation Ontario (MTO) Agreement Number 5006-E-0030.

**2 SITE DESCRIPTION**

Highway 69 in the study section (Highway 529 northerly approximately 3.8 km to north of Naiscoot Lake) is currently a two lane undivided roadway. The proposed four-lane alignment will run roughly parallel to the existing alignment, with a new median centreline approximately 130 m west of the current alignment at the south project limit, before crossing to the east side and running approximately 70 m to the east. Both northbound and southbound lanes will be on new alignment

in this section. The existing Highway 69 will become Naiscoot Access Road as part of the four-laning project.

The roadway corridor typically has a rolling topography with frequent bedrock outcrops of generally low relief, separated by low-lying swamp areas, water bodies, and small streams. In general, the area is heavily wooded except in swamp areas.

The site lies within the physiographic region known as the Georgian Bay Fringe, characterized by very shallow soils and bare rock knobs and ridges. Where present, the overburden materials consist of sand, silt and clay. Recent organic deposits of peat and muck occur in abundance in bedrock hollows and valleys. The area is underlain by strongly foliated and highly to intermediately deformed rocks of Precambrian age, primarily migmatitic rocks and gneisses.

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

The site investigation and field testing for the six (6) culverts in the south section were carried out in two phases. The first phase consisted of drilling and sampling eleven boreholes located off of the existing Highway 69 between February 11 and March 8, 2011. During the first phase of drilling one Dynamic Cone Penetration Test (DCPT) was performed from surface and a second DCPT was conducted at the base of one of the boreholes. The second phase of drilling was completed during June 2012 and consisted of two boreholes drilled on Highway 69 through the existing highway embankment. During the second phase of drilling a DCPT was conducted from the base of one of the boreholes. In addition to these boreholes and DCPTs specific to the culverts, four boreholes drilled in 2009 for the swamp crossings and high fill embankments investigation (BH10-02, BH11-02, BH13-07, and BH14-08) are included in this report for a total of seventeen boreholes and three DCPTs (one from surface and two from the base of a borehole).

The boreholes drilled at each culvert are listed in Table 3.1 along with additional information regarding the culvert location. In general, one borehole was located at each of the proposed culvert inlets, outlets, and mid points. The approximate borehole locations are shown on the Borehole Locations and Soil Strata drawings included in Appendices A through D.

The boreholes were advanced to depths of 1.1 m to 19.8 m (Elev. 191.4 to 179.0 m). The DCPT performed from surface extended to a depth of 13.1 m (Elev. 178.4 m). The two DCPTs conducted from the bottom of a borehole extended to depths of 12.5 m and 27.6 m (Elev. 179.0 and 172.3 m). All of the boreholes and DCPTs were terminated upon refusal on probable bedrock, except for boreholes C330-1 and C330-2 which were extended with a DCPT to refusal and borehole C332-2 which was advanced 1.2 m into bedrock to confirm the rock fill – bedrock interface.

The borehole locations were established by Thurber relative to culvert centreline staking by MMM Group Limited. Ground elevations at the borehole locations were approximated from survey data and detailed topographic plans provided by MMM Group Limited.

**Table 3.1 – Summary of Culvert Locations and Corresponding Boreholes**

Culvert	Site Number	Location		Boreholes/DCPTs	Appendix
		Station	Road/Direction		
313 314	44-600/C1 44-600/C2	19+303 19+299	Hwy 69 NBL Hwy 69 SBL	C313-1 to 3, C314-1 & 2, BH10-02, and BH11-02	A
317 318	44-603/C1 44-603/C2	19+830 19+830	Hwy 69 NBL Hwy 69 SBL	C317-1 & 2, C318-1, BH13-07, and BH14-08	B
330	44-601/C	11+890	Naiscoot Access Rd	C330-1 & 2, C330-2D and C314-2	C
332	44-602/C	12+357	Naiscoot Access Rd	C332-1 to 3	D

Prior to commencement of drilling, utility clearances were obtained for all borehole and DCPT locations.

Where accessible, a CME-45 track-mounted drill rig equipped with hollow stem augers was used to advance the boreholes. Wash-boring methods with casing and portable tripod were employed where drilling was conducted on ice. A truck-mounted drill rig was used for boreholes drilled on the existing Highway 69 platform. Hollow stem augers, HQ casing, and NQ coring techniques were used to advance these boreholes.

Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the fill and native soils. Where firm to soft cohesive soils were encountered, in situ vane shear testing was carried out to assess the undrained shear strength of soft to firm cohesive deposits.

Where practical, groundwater conditions were observed in the open boreholes during the drilling operations. Standpipe piezometers were installed in selected boreholes to monitor groundwater levels. The standpipe piezometers consisted of 19 mm diameter PVC pipe with a 1.5 m long slotted screen enclosed in filter sand. A bentonite seal was placed above the filter sand and the remainder of the borehole was backfilled with bentonite and/or cuttings to the ground surface. Boreholes without piezometer installations were backfilled with bentonite and/or auger cuttings upon completion. The piezometers installation details are summarized in Table 3.2 and are shown on the Record of Borehole sheets in Appendices A to D.

**Table 3.2 – Piezometer Installation Details**

<b>Borehole</b>	<b>Piezometer Tip Depth/ Elevation (m)</b>	<b>Installation Details</b>
C317-2	4.3 / 188.1	Piezometer with 1.5 m slotted screen installed, sand filter from 4.3 to 2.5 m, bentonite seal from 2.5 to 2.0 m, cuttings from 2.0 to 0.6 m, bentonite from 0.6 to 0.3 m, then cuttings to surface.
C330-2	9.1 / 182.4	Piezometer with 1.5 m slotted screen installed, sand filter from 9.5 to 7.3 m and bentonite from 7.3 m to ground surface.

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

#### **4 LABORATORY TESTING**

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. The results of this testing are presented on the Record of Borehole sheets included in Appendices A to D.

Selected samples were also subjected to gradation analysis (sieve and hydrometer) and Atterberg Limits testing where appropriate. The results of the testing program are summarized on the Record of Borehole sheets and figures included in Appendices A to D.

#### **5 DESCRIPTION OF SUBSURFACE CONDITIONS**

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and the Borehole Locations and Soil Strata Drawings included in Appendices A to D of this report. A general description of the stratigraphy based on the conditions encountered in the boreholes is given in this section. However, the factual data presented in the borehole logs takes precedence over this general description and interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

The specific conditions encountered at individual sites vary. Generalized descriptions of the individual strata at each culvert site are presented below.

##### **5.1 Culverts 313 and 314 (Station 19+303 NBL and 19+299 SBL) (Appendix A)**

###### **General**

This site consists of a pond. The site stratigraphy below the pond bottom generally consists of layers of silty clay and peat overlying sand and gravel at the eastern extent of

the site and a thin layer of peat overlying silty sand to sand and gravel at the western extent of the site. Probable bedrock was encountered below these overburden deposits.

### **Ice and Water**

Ice and water were encountered at surface at all seven borehole locations. In general, the ice was approximately 0.3 m thick at the time of drilling. The depth of the ice and water ranged from 1.2 m to 1.6 m.

### **Peat**

A thin layer of peat (25 to 50 mm) was encountered at the ground surface, below the ice and water in Boreholes C313-2, C314-1 and C314-2. The thickness of surficial peat material may vary between and beyond the borehole locations.

A thicker layer of peat was also encountered below a layer of silty clay in Boreholes C313-1 to 3, and BH10-02. This layer of peat was typically fibrous and had a dark brown colour. The peat contained trace sand at some locations.

The thickness of this buried layer of peat ranged from 0.6 m to 1.5 m and the lower boundary of this layer was encountered at depths of 1.3 m to 2.5 m below the pond bottom (Elev. 190.7 to 189.3 m).

SPT ‘N’ values recorded in the peat layer ranged from 0 to 2 blows for 0.3 m penetration, indicating a very soft to soft consistency.

Moisture contents of the peat ranged from 119 to 663%.

### **Silty Clay**

Silty clay was encountered below the water or thin peat layer in five of the seven boreholes drilled along the proposed alignment of the culverts. In three of these boreholes, a second clay layer was encountered below an interlaying layer of peat. The clay layers ranged in thickness from 0.2 to 1.3 m, and the lower boundary of the lowest layers was encountered at depths of 1.6 to 5.2 m below the ice surface, 0.3 to 3.8 m below the pond bottom (Elev. 191.6 to 188.0 m).

SPT ‘N’ values recorded in the silty clay ranged from 0 to 4 blows for 0.3 m penetration, indicating a very soft to soft consistency. A SPT ‘N’ value of 50 blows for 0.125 m penetration was recorded in the silty clay in Borehole C313-2 at the silty clay-bedrock interface.

Moisture contents of the silty clay ranged from 22% to 76%.

Three samples of the silty clay underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figure A1, Appendix A.

Gravel %	0
Sand %	18 to 21
Silt %	50 to 55
Clay %	27 to 29

### **Silt and Sand**

A layer of silt and sand was encountered locally in Borehole C313-3, below the peat. The silt and sand was grey and contained trace clay.

The layer of silt and sand was 1.0 m thick with the lower boundary of this layer encountered at a depth of 2.3 m below the pond bottom (Elev. 189.7 m).

A SPT ‘N’ value of 7 blows for 0.3 m penetration was recorded in the silt and sand layer, indicating a loose relative density.

The moisture content of one sample of the silt and sand was measured to be 15%.

One sample of the silt and sand underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curve for this sample is plotted on Figure A2 of Appendix A.

Gravel %	0
Sand %	42
Silt %	54
Clay %	4

### **Sand**

A layer of sand was encountered below the silty clay in Boreholes C314-1 and BH10-02, below the silt and sand in Borehole C313-3, below the thin peat layer in Borehole C314-2, and at ground surface (below the ice and water) in Borehole BH11-02. The sand was typically grey and contained trace silt to silty, trace gravel to gravelly, and trace clay.

The thickness of the sand layer ranged from 0.5 to 1.3 m, with the lower boundary of the sand layer encountered at depths of 0.8 to 3.7 m below the pond bottom (Elev. 191.1 to 188.0 m).

SPT ‘N’ values recorded in the sand layer ranged from 3 to 17 blows for 0.3 m penetration, indicating a very loose to compact relative density. Higher ‘N’ values were also recorded in the sand layer upon refusal on probable bedrock and are not indicative of the relative density of the sand.

Natural moisture contents of the sand ranged from 14 to 43%. The higher moisture contents (> 23%) were measured in samples collected just below the pond bottom and may reflect an organic component.



One sample of the sand underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curve for this sample is plotted on Figure A3 of Appendix A.

Gravel %	5
Sand %	73
Silt %	20
Clay %	2

### **Sand and Gravel**

A layer of sand and gravel was encountered below the lower layer of silty clay in Borehole C313-1 and below the sand in Borehole C314-2. The sand and gravel was brown to grey and contained trace silt as well as occasional cobbles.

The sand and gravel layer was 4.2 m thick in Borehole C313-1, with the lower boundary of this layer encountered at a depth of 8.0 m below the pond bottom (Elev. 183.8). In Borehole C314-2, the sand and gravel layer was 0.8 m thick with the lower boundary at a depth of 2.2 m below the pond bottom (Elev. 189.4).

SPT ‘N’ values recorded in the sand and gravel generally ranged from 7 to 9 blows for 0.3 m penetration, indicating a loose relative density. ‘N’ values of greater than 50 blows for less than 0.3 m penetration were also recorded in the sand and gravel layer at refusal on probable bedrock.

Natural moisture contents of the sand and gravel ranged from 9 to 15%.

Two samples of the sand and gravel underwent laboratory grain size analysis testing. The results of these tests are summarized below and are presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figure A4 of Appendix A.

Gravel %	39 to 53
Sand %	40 to 55
Silt and Clay %	6 to 7

### **Bedrock**

The boreholes were terminated at depths ranging from 0.8 m to 8.0 m below the pond bottom (Elev. 191.1 to 183.8 m) upon refusal on probable bedrock. The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.1.

**Table 5.1 – Depth/Elevation of Probable Bedrock**

Borehole	Probable Bedrock Surface	
	Depth below Pond Bottom (m)	Elevation (m)
C313-1	8.0	183.8
C313-2	3.4	188.4
BH10-02	3.7	188.0
C313-3	2.8	189.2
C314-1	0.8	191.1
BH11-02	1.1	190.6
C314-2	2.2	189.4

### **Groundwater Conditions**

Water levels were not observed in the open boreholes as water was introduced into the boreholes during the drilling process.

The ice surface was at Elevation 193.2 m at the time of drilling. The water level in the pond will fluctuate subject to seasonal variations, rainfall patterns, and possible beaver dams.

## **5.2 Culverts 317 and 318 (Station 19+830 NBL and SBL) (Appendix B)**

### **General**

The stratigraphy at this site generally consists of peat and/or organics overlying silty clay and silty sand to sand, underlain by probable bedrock. At one borehole location (C317-1) no silty clay was encountered and at one borehole location (C317-2) no sand was encountered.

### **Peat and Organics**

A layer of fibrous peat and/or organics was encountered at surface in all five boreholes. This layer was dark brown to black and occasionally contained trace sand.

The thickness of the surficial peat/organic layer ranged from 0.1 m to 0.3 m.

A natural moisture content of 91% was measured in one sample.

The thickness of peat and organics may vary between and beyond the borehole locations.

### **Silty Clay**

A layer of silty clay was encountered below the peat in four of the boreholes; no silty clay was encountered in borehole C317-1. The silty clay was brown to grey and contained trace sand with occasional sandy zones and occasional sand seams.

The thickness of the silty clay layer ranged from 1.4 m to 4.1 with the lower boundary of the silty clay encountered at depths of 1.5 m to 4.3 m (Elev. 191.2 to 188.1 m).

SPT ‘N’ values recorded in the silty clay layer ranged from 0 to 11 blows for 0.3 m penetration, indicating a very soft to stiff consistency. Generally, the ‘N’ value was in the range of 3 to 11 blows for 0.3 m penetration (soft to stiff). The undrained shear strength of the silty clay determined by an in situ vane shear strength test in Borehole C317-2 was 50 kPa (firm to stiff).

The moisture content of samples of the silty clay ranged from 20% to 53%.

Five samples of the silty clay underwent laboratory grain size analysis testing. Four of these samples also underwent Atterberg Limits testing. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B and are presented below. These results are also plotted on Figures B1 and B3, Appendix B.

Gravel %	0
Sand %	3 to 22
Silt %	40 to 57
Clay %	24 to 56
Liquid Limit	33 to 58
Plastic Limit	16 to 22

The results of the Atterberg Limits tests indicate that the silty clay ranges from low plastic to high plastic with group symbol CL to CH.

### **Silty Sand to Sand**

A layer of silty sand to sand was encountered directly below the peat/organics in Borehole C317-1 and below the silty clay layer in Boreholes BH13-07, BH14-08, and C318-1. The silty sand to sand is brown to grey and contains trace gravel, trace to some clay, and occasional cobbles.

The thickness of the sand layer ranged from 0.2 m to 1.4 m with the lower boundary of the silty sand to sand layer encountered at depths of 1.2 m to 4.8 m (Elev. 191.4 to 187.1 m).

SPT ‘N’ values recorded in the silty sand to sand ranged from 53 blows for 0.3 m penetration to 50 blows for 0.075 m penetration. However, all of the ‘N’ values were recorded at borehole refusal upon probable bedrock and are therefore not representative of the denseness of the silty sand to sand layer.

Natural moisture contents of the silty sand to sand ranged from 15 to 25%.

One sample of the silty sand to sand underwent laboratory grain size analysis testing. The results of this test are summarized below and are presented on the Record of Borehole sheets included in Appendix B. The grain size distribution curve for this sample is plotted on Figure B2 of Appendix B.

Gravel %	6
Sand %	61
Silt %	23
Clay %	10

### Bedrock

The boreholes were terminated at depths ranging from 1.2 m to 4.8 m (Elev. 191.4 to 187.1 m) upon refusal on probable bedrock. The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.2.

**Table 5.2 – Depth/Elevation of Probable Bedrock**

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
C317-1	1.2	191.4
BH13-07	1.8	190.9
C317-2	4.3	188.1
BH14-08	4.8	187.1
C318-1	2.4	190.5

### Groundwater Conditions

Water levels were observed in the open boreholes upon completion of drilling. A standpipe piezometer was installed in Borehole C317-2 to monitor water levels after completion of drilling. The water levels observed in the boreholes upon completion of drilling and subsequently measured in the piezometer are summarized in Table 5.3.

**Table 5.3 – Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
C317-1	Feb. 11, 2011	0.9	191.8	Open borehole
BH13-07	Feb. 12, 2009	0.5	192.2	Open borehole
C317-2	Feb. 22, 2011	0.0	192.4	Piezometer
	Mar. 1, 2011	0.0	192.4	Piezometer
	Mar. 13, 2011	0.0	192.4	Piezometer
	Apr. 27, 2011	0.1	192.3	Piezometer
BH14-08	Feb. 12, 2009	0.0	191.9	Open borehole
C318-1	Feb. 11, 2011	0.6	192.3	Open borehole

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

### **5.3 Culvert 330 (Station 11+890 Naiscoot Access Rd) (Appendix C)**

#### **Pavement Structure**

Pavement structure consisting of a thin layer of asphalt overlying granular fill was encountered in Borehole C330-1, which was drilled through the existing highway shoulder. The asphalt was 40 mm thick.

The granular fill underlying the asphalt consisted of dark brown sand containing some gravel. The sand fill was 1.0 m thick with the lower boundary of the sand fill encountered at Elevation 198.9 m. The moisture content of one sample of the sand fill was measured to be 2%.

#### **Rock Fill**

Rock fill was encountered below the pavement structure in Borehole C330-1. The rock fill consisted of cobble and boulder sized pieces with some gravel. Coring techniques were required to advance the borehole through the rock fill.

The rock fill was 9.2 m thick, with the lower boundary of the rock fill encountered at a depth of 10.3 m (Elev. 189.6 m).

#### **Ice and Water**

Ice and water were encountered at surface at the location of Borehole C314-2. The ice was 0.3 m thick at the time of drilling. The ground surface was encountered 1.6 m below the top of ice (Elev. 191.6 m).

#### **Peat**

A layer of peat was encountered surficially in Borehole C330-2 and at surface (below the water) in Borehole C314-2. At Borehole C330-2 the peat was 0.7 m thick and at Borehole C314-2 the peat was 50 mm thick. The thickness of peat may vary between and beyond the borehole locations.

A SPT ‘N’ value of 4 blows for 0.3 m penetration was recorded in the peat, indicating a soft consistency.

#### **Silt and Sand**

A layer of silt and sand was encountered locally in Borehole C330-2, below the peat. The silt and sand was brown and contained trace gravel and trace clay.

The silt and sand layer was 1.1 m thick, with the lower boundary of the silt and sand encountered at a depth of 1.8 m (Elev. 189.7).

SPT ‘N’ values recorded in the silt and sand layer ranged from 18 to 25 blows for 0.3 m penetration, indicating a compact relative density.

The moisture content of samples of the silt and sand ranged from 8 to 19%.

One sample of the silt and sand was selected for laboratory grain size analysis testing, the results of which are summarized below. The grain size distribution curve for this sample is plotted on Figure C1, Appendix C.

Gravel %	2
Sand %	41
Silt %	54
Clay %	3

### **Sand**

A layer of brown sand was encountered below the sand and gravel layer in Borehole C330-1 and below the silt and sand layer in Borehole C330-2. The sand was brown and contained trace to some gravel and trace to some silt and clay. A layer of grey sand containing some silt and trace gravel was encountered below the thin layer of peat in Borehole C314-2.

The sand encountered in Borehole C314-2 was 1.3 m thick with the lower boundary of the sand encountered at a depth of 3.0 m below the ice level (Elev. 190.2). The sand encountered in Boreholes C330-1 and C330-2 was not fully penetrated and the sampled boreholes were terminated at depths of 19.8 m and 11.3 m, respectively (Elev. 180.1 and 180.2).

SPT ‘N’ values recorded in the sand layer ranged from 0 to 33 blows for 0.3 m penetration, indicating a variable relative density ranging from very loose to dense. In general, the sand had a loose to compact relative density (‘N’ values of 4 to 28).

Moisture contents of samples of the sand typically ranged from 15 to 23%. A moisture content of 40% was measured in a sample of sand collected from just below the water in Borehole C314-2.

Four samples of the sand underwent laboratory grain size analysis testing. The results of these tests are summarized below and are presented on the Record of Borehole sheets included in Appendix C. The grain size distribution curves for these samples are plotted on Figure C2 of Appendix C.

Gravel %	0 to 5
Sand %	73 to 97
Silt and Clay %	3 to 22

### **Sand and Gravel**

A layer of sand and gravel was encountered below the sand layer in Borehole C314-2 and below the rock fill in Borehole C330-1. The sand and gravel was brown and contained trace to some silt.

The thickness of the sand and gravel layer in Borehole C314-2 was 0.8 m, with the lower boundary of this layer encountered at a depth of 3.8 m below the ice surface (Elev. 189.4 m). In Borehole C330-1, the sand and gravel layer was 1.6 m thick with the lower boundary encountered at a depth of 11.9 m below ground surface (Elev. 188.0 m).

SPT ‘N’ values recorded in the sand and gravel in Borehole C330-1 ranged from 3 to 7 blows for 0.3 m penetration, indicating a very loose to loose relative density. In Borehole C314-2, a SPT ‘N’ value of 61 blows for 0.275 m penetration (very dense) was recorded near refusal on probable bedrock.

The moisture content of samples of the sand and gravel ranged from 9 to 10%.

One sample of the sand and gravel underwent laboratory grain size analysis testing. The results of this test are summarized below and are presented on the Record of Borehole sheets included in Appendix C. The grain size distribution curve for this sample is plotted on Figure C3 of Appendix C.

Gravel %	53
Sand %	40
Silt and Clay %	7

### Bedrock

Borehole C314-2 was terminated upon refusal on probable bedrock. Boreholes C330-1 and C330-2 were terminated within the sand layer and a DCPT was performed from the bottom of each of these boreholes to refusal on probable bedrock. A DCPT was also conducted 3 m west of Borehole C330-2 (designated C330-2D). The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.4.

**Table 5.4 – Depth/Elevation of Probable Bedrock**

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
C314-2	2.2	189.4
C330-1	27.6	172.3
C330-2	12.5	179.0
C330-2D	13.1	178.4

### Groundwater Conditions

Water levels were not observed in the open boreholes upon completion of drilling since water was introduced into the boreholes during the drilling process. One piezometer was installed at this site, in Borehole C330-2, with a 1.5 m long screen encased with filter sand. The water levels observed in the piezometer are summarized in Table 5.5.

**Table 5.5 – Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
C330-2	Mar. 13, 2011	0.0	191.5	Piezometer
	Apr. 27, 2011	0.5	191.0	Piezometer

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

#### **5.4 Culvert 332 (Station 12+357, Naiscoot Access Rd) (Appendix D)**

##### **General**

The stratigraphy encountered at this site generally consists of peat or organics overlying deposits of silty clay and sand overlying bedrock. At the existing highway embankment, the stratigraphy consists of pavement structure overlying rock fill overlying bedrock.

##### **Pavement Structure**

Pavement structure consisting of a thin layer of asphalt overlying granular fill was encountered in Borehole C332-2, which was drilled through the existing highway shoulder. The asphalt was 50 mm thick.

The granular fill consisted of brown gravelly sand containing some silt. The sand fill was 1.1 m thick with the lower boundary of the sand fill encountered at Elevation 196.1 m. The moisture content of one sample of the sand fill was measured to be 4%.

One sample of the granular fill underwent laboratory grain size analysis testing. The results of this testing are presented on the corresponding Record of Borehole sheets included in Appendix D and are plotted on Figure D1, Appendix D. The laboratory results are summarized as follows:

Gravel %	29
Sand %	59
Silt and Clay %	12

##### **Rock Fill**

Rock fill was encountered below the pavement structure in Borehole C332-2. The rock fill consisted of cobble and boulder sized pieces with some gravel and sand. Coring techniques were required to advance the borehole through the rock fill.



The rock fill was 6.4 m thick, with the lower boundary of the rock fill encountered at a depth of 7.5 m (Elev. 189.7 m).

### **Peat and Organics**

A layer of peat 0.8 m thick was encountered at surface in Borehole C332-3 and a layer of organics (200 mm) was encountered at surface in Borehole C332-1. The thickness of peat and organics may vary between and beyond the borehole locations.

### **Silty Clay**

A layer of silty clay was encountered below the organics in Borehole C332-1, below the rock fill in Borehole C332-2, and below a layer of native sand in Borehole C332-3. The silty clay was brown and generally contained trace sand.

The thickness of the silty clay ranged from 0.1 m to 1.9 m, with the lower boundary of the silty clay encountered at depths of 2.1 m to 7.6 m (Elev. 189.8 to 189.1 m). The layer of silty clay was the thinnest in Borehole C332-2, where it was encountered below the rock fill.

SPT ‘N’ values recorded in the silty clay ranged from 5 to 9 blows for 0.3 m penetration, indicating a firm to stiff consistency. A SPT ‘N’ value of 50 blows for 0.1 m penetration was also recorded in the silty clay in Borehole C332-3 at the silty clay – bedrock interface.

The moisture content of samples of the silty clay ranged from 25% to 37%.

Two samples of the silty clay underwent laboratory grain size analysis and Atterberg Limits testing, the results of which are summarized below. The results of these tests are also summarized on the Record of Borehole sheets included in Appendix D and plotted on Figures D2 and D3, Appendix D.

Gravel %	0
Sand %	5
Silt %	42 to 48
Clay %	47 to 53
Liquid Limit	48 to 52
Plastic Limit	21

The results of the Atterberg Limits tests indicate that the silty clay is medium to high plastic with group symbol CI-CH.

### **Sand**

A layer of brown sand containing some silt to silty was encountered below the silty clay in Borehole C332-1 and below the peat in Borehole C332-3.

The thickness of the sand layer ranged from 0.1 m to 0.6 m, with the lower boundary of the sand layer encountered at depths of 1.4 m to 2.2 m (Elev. 190.2 to 189.7 m). Borehole C332-1 was terminated below the sand layer upon refusal on probable bedrock.

A SPT ‘N’ value of 4 blows for 0.3 m penetration was recorded in the sand in Borehole C332-3, indicating a very loose to loose relative density.

The moisture content of one sand sample was measured to be 19%.

### Bedrock

Boreholes C332-1 and C332-3 were terminated upon refusal on probable bedrock and Borehole C332-2 was advanced 1.2 m into the bedrock to confirm the transition from rock fill to bedrock. The depths and elevations of the probable bedrock surface at the borehole locations are summarized in Table 5.6.

**Table 5.6 – Depth/Elevation of Probable Bedrock**

Borehole	Probable Bedrock Surface	
	Depth below Ground Surface (m)	Elevation (m)
C332-1	2.2	189.7
C332-2	7.6	189.6
C332-3	2.5	189.1

### Groundwater Conditions

Water levels were observed in the open boreholes upon completion of drilling, where possible. The water levels observed during drilling are summarized in Table 5.7.

**Table 5.7 – Water Level Observations**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
C332-1	Feb. 2, 2011	0.0	191.9	Open borehole
C332-3	Feb. 2, 2011	0.1	191.5	Open borehole

The above values are short-term observations. The surface water depth and depths to groundwater will vary depending upon seasonal fluctuations, rainfall patterns and swamp outlet conditions such as presented by beaver dams. In particular, water levels may be higher after the spring snowmelt or periods of heavy rainfall.

## 6 MISCELLANEOUS

MMM Group survey personnel staked the centreline alignment of the culverts prior to drilling of the boreholes. The borehole locations were established by measuring offset distances from the centreline staking. The approximate ground surface elevations at the boreholes were interpreted from the survey data and contour plan provided by MMM Group Limited.

Eastern Ontario Diamond Drilling Ltd. of Hawkesbury, Ontario supplied and operated the drilling and sampling equipment for the field program.

Supervision of the field activities, including obtaining utility clearances, was carried out by Ms. Eckie Siu, Mr. Stephane Loranger, Mr. Jason Mei and Mr. Will Ball of Thurber.

Supervision of the field program was carried out by Ms. Lindsey Blaine, E.I.T. and Ms. Rocío Palomeque Reyna, P. Eng. Interpretation of the field data and preparation of the report was performed by Ms. Lindsey Blaine, E.I.T. and Mr. Murray Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

### Thurber Engineering Ltd.

Lindsey Blaine, E.I.T.  
Project Manager



Murray R. Anderson, P.Eng.  
Senior Geotechnical Engineer



P.K. Chatterji, P.Eng.  
Review Principal

**Appendix A**

**Culverts 313 and 314**

**Record of Borehole Sheets  
Laboratory Test Results  
Borehole Locations and Soil Strata Drawings**

## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

### 2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT <sup>(1)</sup> 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



### 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

### 5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level  
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value      Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT      Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

# UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	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	SILTS AND CLAYS W <sub>L</sub> < 50%	ML	Inorganic silts and 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. (W <sub>L</sub> < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W <sub>L</sub> < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W <sub>L</sub> > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

## EXPLANATION OF ROCK LOGGING TERMS


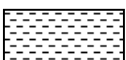

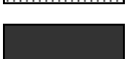

### ROCK WEATHERING CLASSIFICATION

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

### DISCONTINUITY SPACING

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

### SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

### STRENGTH CLASSIFICATION

<b>Rock Strength</b>	<b>Approximate Uniaxial Compressive Strength</b>		<b>Field Estimation of Hardness*</b>
	<b>(MPa)</b>	<b>(psi)</b>	
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

### 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 0.1m in length or larger as a % of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index:(FI)	Frequency of natural fractures per 0.3m of core run.

# RECORD OF BOREHOLE No C313-1

1 OF 2

METRIC

GWP# 5076-06-00 LOCATION N 5 055 317.8 E 235 075.4 ORIGINATED BY ES  
HWY 69 BOREHOLE TYPE Wash Boring COMPILED BY AN  
DATUM Geodetic DATE 2011.02.26 - 2011.02.26 CHECKED BY RPR

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				
								20 40 60 80 100	PLASTIC LIMIT w <sub>P</sub>	NATURAL MOISTURE CONTENT w		
193.2	Pond Surface											
0.0	ICE: (300mm)											
192.9												
0.3	WATER											
191.8												
1.4	Silty <b>CLAY</b> , trace sand Very Soft Grey		1	SS	0							
190.7												
2.5	<b>PEAT</b> , fibrous Very Soft Dark Brown Wet		2	SS	1							
189.3												
3.9	Silty <b>CLAY</b> , some sand to sandy Soft to Firm Grey		4	SS	2							
188.0												
5.2	<b>SAND</b> and <b>GRAVEL</b> , trace silt Loose Grey Wet		6	SS	7							
			7	SS	9							
			8	SS	7							
	occasional cobbles		9	SS	7							

ONTMT4S 6121(CULVERTS).GPJ 2012TEMPLATE(MTO).GDT 8/20/14

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No C313-1

2 OF 2

METRIC

GWP# 5076-06-00 LOCATION N 5 055 317.8 E 235 075.4 ORIGINATED BY ES  
 HWY 69 BOREHOLE TYPE Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2011.02.26 - 2011.02.26 CHECKED BY RPR

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			20 40 60 80 100	W P W W L	20 40 60				
	Continued From Previous Page BACKFILLED WITH HOLEPLUG AND CUTTINGS TO SURFACE.													






ONTMT4S 6121(CULVERTS).GPJ 2012TEMPLATE(MTO).GDT 8/20/14

# RECORD OF BOREHOLE No C313-2

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION N 5 055 311.2 E 235 056.3 ORIGINATED BY ES  
 HWY 69 BOREHOLE TYPE Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2011.02.26 - 2011.02.26 CHECKED BY RPR

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 (%)							
								20   40   60   80   100				w <sub>P</sub> w                      w <sub>L</sub>							
						○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      x LAB VANE													
193.2	Pond Surface																		
0.0	ICE: (300mm)																		
192.9							193												
0.3	WATER																		
191.8							192												
191.4	PEAT: (25mm)																		
1.5	Silty CLAY, trace sand Very Soft Grey		1	SS	0		191												
190.6			2	SS	2											23			
2.6	PEAT, trace sand Very Soft Dark Brown Wet						190									46			
189.5			3	SS	1														
3.7	Silty CLAY, some sand Very Soft Grey Wet		4	SS	2		189										0   19   54   27		
188.4			5	SS	50/														
4.8	END OF BOREHOLE AT 4.8m UPON REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG AND CUTTINGS TO SURFACE.				0.125														

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

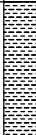





20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No C313-3

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION N 5 055 304.7 E 235 037.1 ORIGINATED BY ES  
 HWY 69 BOREHOLE TYPE Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2011.02.25 - 2011.02.25 CHECKED BY RPR

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						
193.2	Pond Surface													
0.0	ICE: (300mm)													
192.9							193							
0.3	WATER													
192.0							192							
1.2	Silty <b>CLAY</b> , some sand Soft Grey		1	SS	2									
191.4														
191.8	<b>SAND</b>													
1.9	<b>PEAT</b> , trace sand Very Soft Dark Brown Wet		2	SS	2		191							
190.7														
2.5	<b>SILT</b> and <b>SAND</b> , trace clay Loose Grey Wet		3	SS	7		190							
189.7														
3.5	<b>SAND</b> , some gravel to gravelly Compact Grey Wet		4	SS	17									
189.2														
4.0	END OF BOREHOLE AT 4.0m UPON REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG AND CUTTINGS TO SURFACE.													




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# RECORD OF BOREHOLE No C314-1

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION N 5 055 298.7 E 235 019.2 ORIGINATED BY ES  
 HWY 69 BOREHOLE TYPE Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2011.02.25 - 2011.02.25 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT  W P	NATURAL MOISTURE CONTENT  W	LIQUID LIMIT  W L	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    x LAB VANE								
193.2	Pond Surface															
0.0	ICE: (300mm)															
192.9																
0.3	WATER															
191.9																
191.8	PEAT: (50mm)															
191.6	Silty CLAY, trace sand, occasional roots and rootlets		1	SS	4											
1.6	Soft Grey															
191.1			2	SS	50/											
2.1	SAND, fine grained Loose Grey Wet				0.025											
END OF BOREHOLE AT 2.1m UPON REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.																

ONTMT4S 6121(CULVERTS).GPJ 2012TEMPLATE(MTO).GDT 8/20/14

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



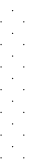
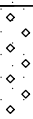
20  
15  
10  
5  
0  
5  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No C314-2

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION N 5 055 291.4 E 234 998.4 ORIGINATED BY ES  
 HWY 69 BOREHOLE TYPE Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2011.02.25 - 2011.02.25 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  <b>γ</b>  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> W      W <sub>L</sub>	WATER CONTENT (%)				
193.2	Pond Surface													
0.0	ICE: (300mm)						193							
192.9														
0.3	WATER													
191.6														
191.8	PEAT: (50mm)													
1.7	SAND, some silt, trace gravel Loose to Compact Grey Wet		1	SS	7		191							
			2	SS	16									5   73   20   2
190.2														
3.0	SAND and GRAVEL, trace silt Very Dense Brown Wet		3	SS	61/ 0.275		190							53   40   7 (SI+CL)
189.4														
3.8	END OF BOREHOLE AT 3.8m UPON REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG AND CUTTINGS TO SURFACE.													

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

# RECORD OF BOREHOLE No BH10-02

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION Harrison Twp., Station 19+301 C/L, NBL ORIGINATED BY WB  
 HWY 69 BOREHOLE TYPE Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2009.03.01 - 2009.03.01 CHECKED BY RPR

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			WATER CONTENT (%)				
193.2	Pond Surface							20 40 60 80 100							
0.0	ICE and WATER: (1500mm)							20 40 60 80 100							
191.7															
1.5	Silty <b>CLAY</b> , some sand, some peat Very Soft Grey		1	SS	0										
191.0															
2.2	<b>PEAT</b> , fibrous Very Soft Brown Wet		2	SS	0										
			3	SS	0										
189.5															
3.7	Silty <b>CLAY</b> , some sand Very Soft Grey		4	SS	0										
188.7															
4.5	<b>SAND</b> , trace gravel, trace silt Loose Grey Wet		5	SS	5										
188.0			6	SS	50/ .000										
5.2	END OF BOREHOLE (SAMPLER BOUNCING) AT 5.2m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG AND AUGER CUTTINGS UPON COMPLETION.														

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
15  
10  
5  
0  
10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100  
 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH11-02

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION Harrison Twp., Station 19+301 C/L, SBL ORIGINATED BY WB  
 HWY 69 BOREHOLE TYPE Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2009.03.04 - 2009.03.04 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT  W P	NATURAL MOISTURE CONTENT  W	LIQUID LIMIT  W L	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								
193.2	Pond Surface							20	40	60	80	100				
0.0	ICE and WATER: (1500mm)						193									
							192									
191.7																
1.5	Silty SAND, occasional peat and roots Very Loose Brown Wet		1	SS	3		191									
190.6			2	SS	115/ .175											
2.6	END OF BOREHOLE (SAMPLER BOUNCING) AT 2.6m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG AND AUGER CUTTINGS UPON COMPLETION.															

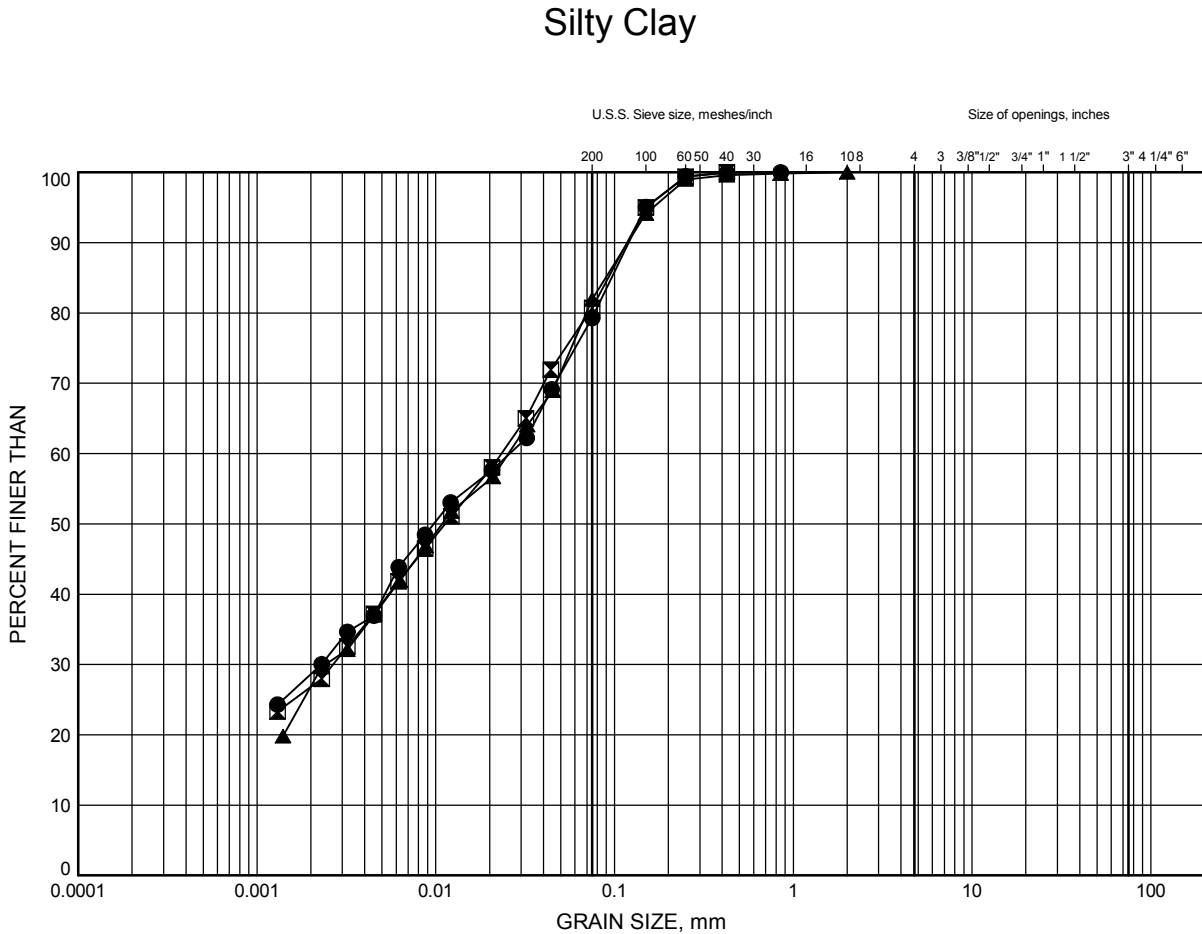
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# Hwy 69 Four-Laning North of Hwy 529 GRAIN SIZE DISTRIBUTION

FIGURE A1



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C313-1	4.78	188.42
⊠	C313-2	4.04	189.16
▲	BH10-02	4.11	189.09

Date August 2014  
GWP# 5076-06-00



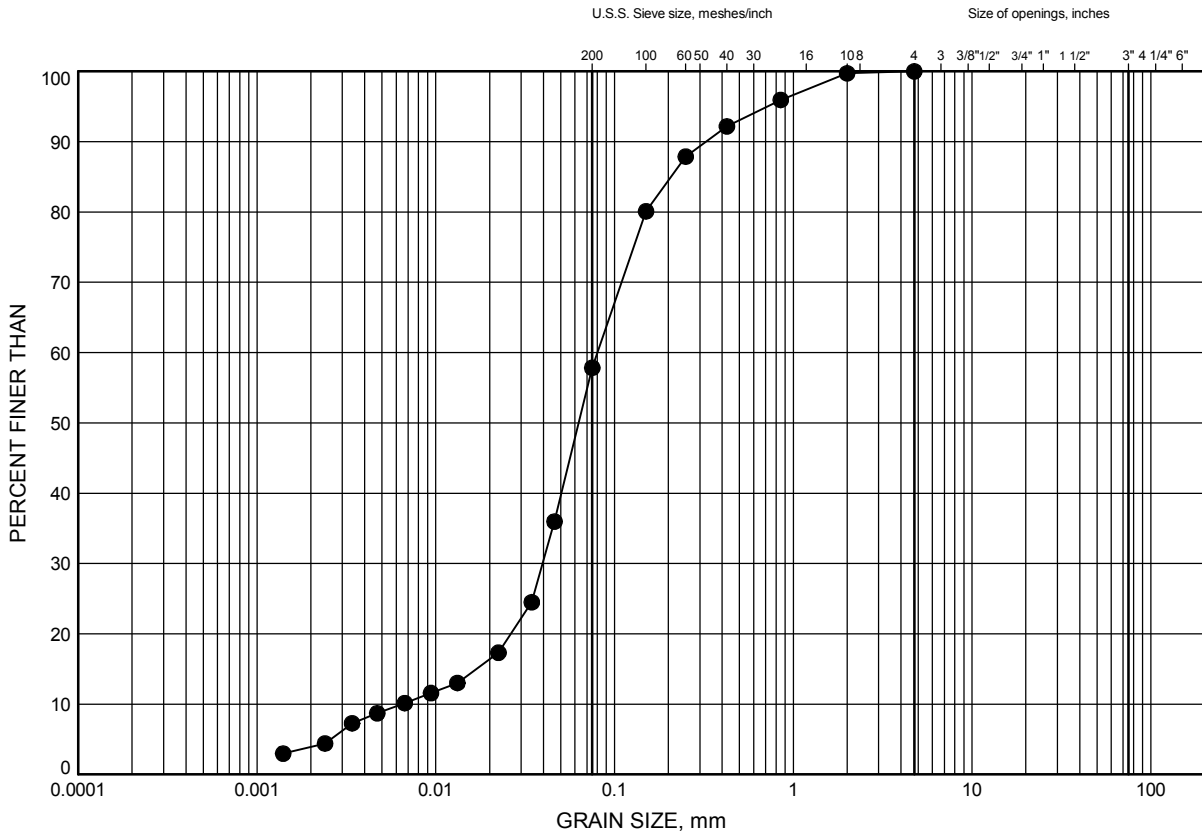
Prep'd MFA  
Chkd. MRA



# Hwy 69 Four-Laning North of Hwy 529 GRAIN SIZE DISTRIBUTION

FIGURE A2

## Silt and Sand



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C313-3	3.05	190.15

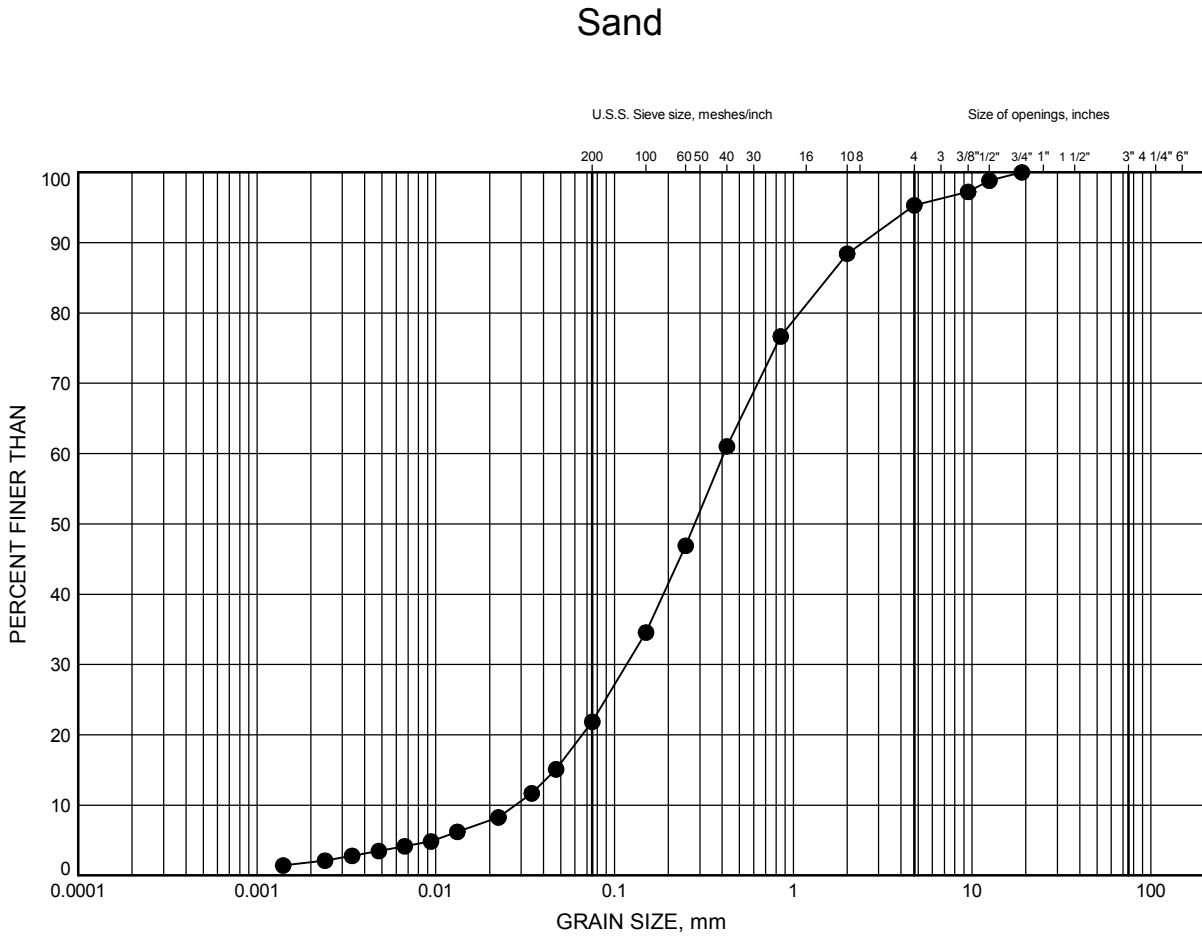
Date August 2014  
GWP# 5076-06-00



Prep'd MFA  
Chkd. MRA

# Hwy 69 Four-Laning North of Hwy 529 GRAIN SIZE DISTRIBUTION

FIGURE A3



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C314-2	2.69	190.51

Date August 2014  
GWP# 5076-06-00

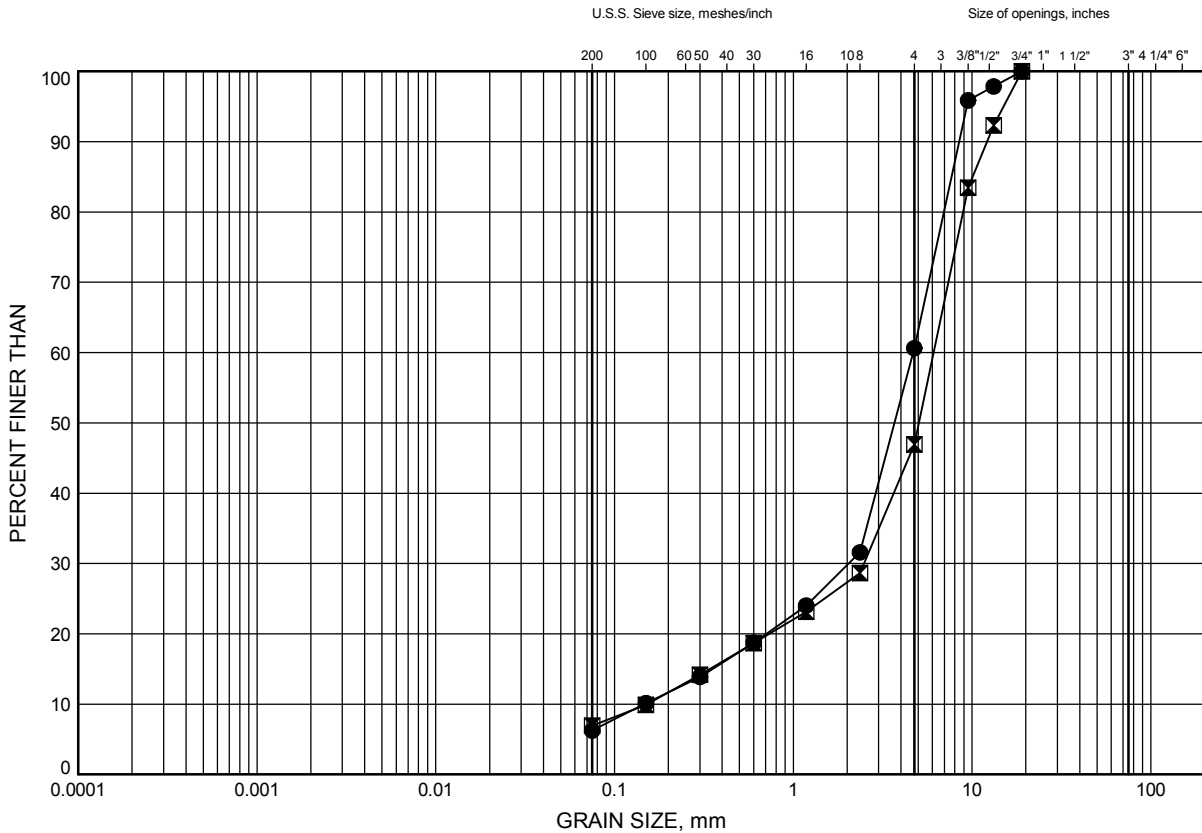


Prep'd MFA  
Chkd. MRA

# Hwy 69 Four-Laning North of Hwy 529 GRAIN SIZE DISTRIBUTION

FIGURE A4

## Sand and Gravel



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C313-1	9.22	183.98
⊠	C314-2	3.36	189.84

Date August 2014  
GWP# 5076-06-00



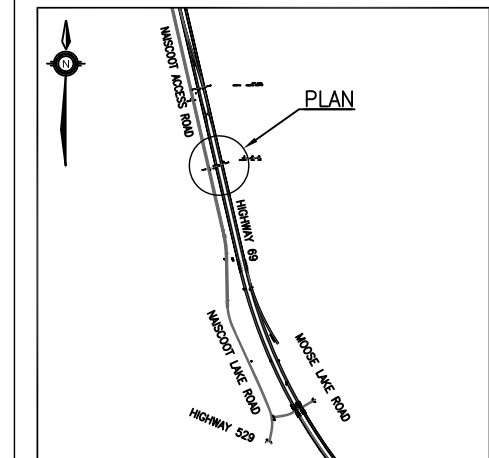
Prep'd MFA  
Chkd. MRA

A circular professional seal for a Licensed Professional Engineer in the Province of Ontario. The outer ring contains the text "LICENSED PROFESSIONAL ENGINEER" at the top and "PROVINCE OF ONTARIO" at the bottom. In the center, the name "M. R. ANDERSON" is printed. Above the name is a stylized signature "MRA". Below the name is the date "Aug 21/14". The seal is stamped in black ink on a white background.

A circular professional seal for a Licensed Professional Engineer in the Province of Ontario. The outer ring contains the text "LICENSED PROFESSIONAL ENGINEER" at the top and "PROVINCE OF ONTARIO" at the bottom. Inside the ring, the name "P. K. CHATTERJI" is printed. Above the name is a handwritten signature "P. K. Chatterji". Below the name is a date stamp "Aug 21 / 14".








**THURBER** ENGINEERING LTD



## KEYPLAN

## LEGEND

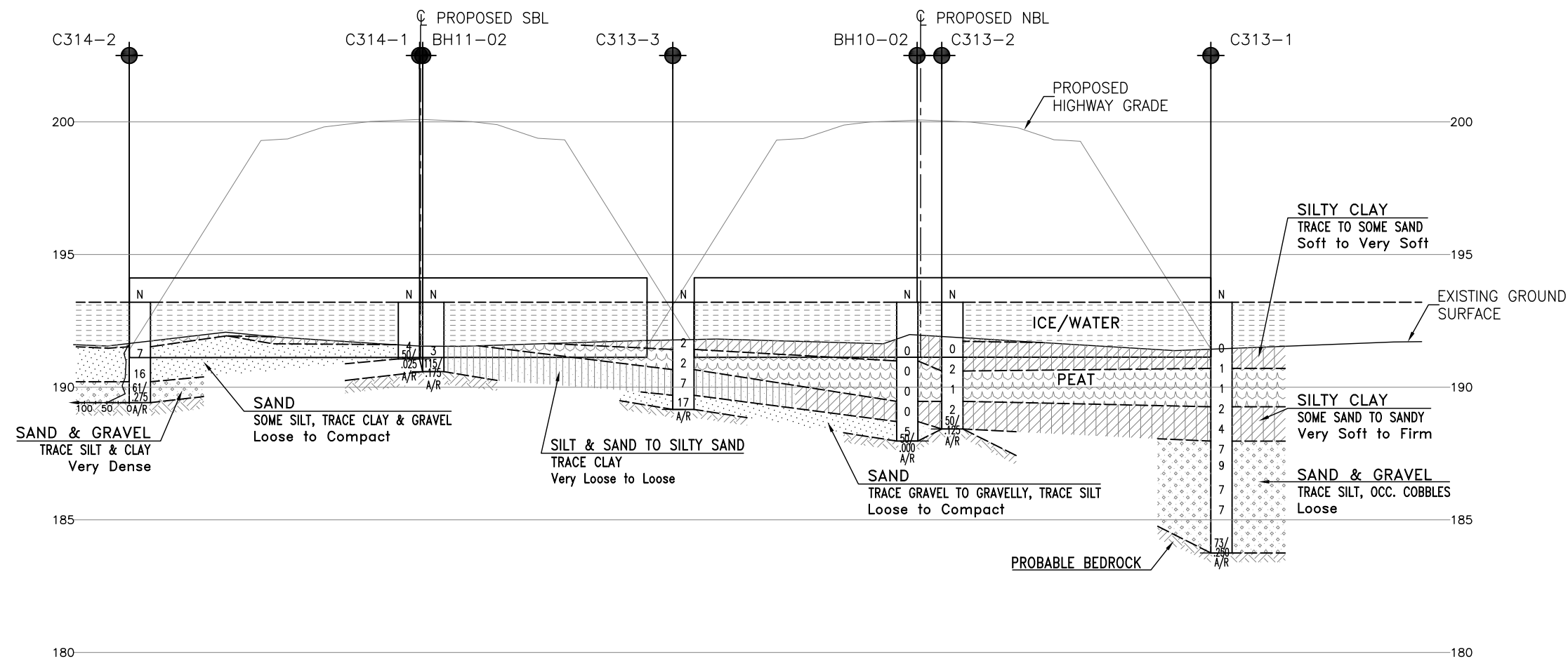
	Culvert Report Borehole / Cone
	Other Borehole / Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level During Drilling
	Water Level in
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
BH10-01	193.2	5 055 294.3	235 058.6
BH10-02	193.2	5 055 308.9	235 055.2
BH10-03L	193.2	5 055 317.6	235 037.5
BH11-01	193.2	5 055 290.7	235 020.9
BH11-02	193.2	5 055 300.4	235 018.7
BH11-03L	193.2	5 055 309.1	235 000.9
C313-1	193.2	5 055 317.8	235 075.4
C313-2	193.2	5 055 311.2	235 056.3
C313-3	193.2	5 055 304.7	235 037.1
C314-1	193.2	5 055 298.7	235 019.2
C314-2	193.2	5 055 291.4	234 998.4
D10-01R	193.2	5 055 324.5	235 067.3
D11-01R	193.2	5 055 316.1	235 030.8

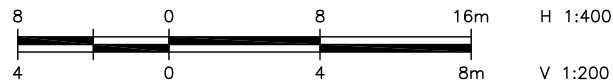
-NOTES-

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

**GEOCRES No. 41H-130**



## CULVERT 313 AND 314



REVISIONS									
	DATE	BY					DESCRIPTION		
DESIGN	LRB	CHK	MRA	CODE			LOAD	DATE	AUG. 20
DRAWN	MFA	CHK	LRB	SITE	44-600/C1&C2	STRUCT		DWG	1

**Appendix B**

**Culverts 317 and 318**

**Record of Borehole Sheets**

**Laboratory Test Results**



**Borehole Locations and Soil Strata Drawings**

# RECORD OF BOREHOLE No C317-1

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION N 5 055 827.6 E 234 950.3 ORIGINATED BY SLL  
 HWY 69 BOREHOLE TYPE Hollow Stem Augers (CME 45) COMPILED BY AN  
 DATUM Geodetic DATE 2011.02.11 - 2011.02.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT  W P	NATURAL MOISTURE CONTENT  W	LIQUID LIMIT  W L	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									
192.7	Ground Surface																
0.0	PEAT																
0.2	SAND, trace to some silt, trace gravel, occasional cobbles Brown Moist to Wet																
191.4			1	SS	59/ 0.200		192										
1.2	END OF BOREHOLE AT 1.2m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 0.9m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.																

ONTMT4S 6121(CULVERTS).GPJ 2012TEMPLATE(MTO).GDT 8/20/14

# RECORD OF BOREHOLE No C317-2

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION N 5 055 819.8 E 234 916.4 ORIGINATED BY SLL  
 HWY 69 BOREHOLE TYPE Hollow Stem Augers (CME 45) COMPILED BY AN  
 DATUM Geodetic DATE 2011.02.11 - 2011.02.11 CHECKED BY RPR

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						
192.4	Ground Surface													
0.0	PEAT Black Wet													
0.2	Silty <b>CLAY</b> , sandy to trace sand Soft to Stiff Brown		1	SS	3									0 22 54 24
	Sand seams		2	SS	9									
		3	SS	3									0 9 49 42	
	Very Soft	4	SS	0										
188.1														
4.3	END OF BOREHOLE AT 4.3m UPON AUGER REFUSAL ON PROBABLE BEDROCK. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE        DEPTH (m)    ELEV. (m) Feb 22/11    0.0        192.4 Mar 01/11    0.0        192.4 Mar 13/11    0.0        192.4 Apr 27/11    0.1        192.3													

ONTMT4S 6121(CULVERTS).GPJ 2012TEMPLATE(MTO).GDT 8/20/14

# RECORD OF BOREHOLE No C318-1

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION N 5 055 811.7 E 234 881.7 ORIGINATED BY SLL  
 HWY 69 BOREHOLE TYPE Hollow Stem Augers (CME 45) COMPILED BY AN  
 DATUM Geodetic DATE 2011.02.11 - 2011.02.11 CHECKED BY RPR

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						
192.9	Ground Surface							20	40	60	80	100		
0.0	PEAT Black							20	40	60	80	100		
0.2	Silty CLAY, trace sand Stiff Brown		1	SS	9		192							
			2	SS	8		191							
190.7														
190.6	SAND, trace silt and gravel Brown Wet		3	SS	50/									
2.4	END OF BOREHOLE AT 2.4m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 0.6m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.				0.075									

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

20  
15  
10  
(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No BH13-07

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION Harrison Twp., Station 19+826 C/L, NBL ORIGINATED BY JM  
 HWY 69 BOREHOLE TYPE Hollow Stem Augers COMPILED BY LG  
 DATUM Geodetic DATE 2009.02.12 - 2009.02.12 CHECKED BY RPR

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								
192.7	Ground Surface							20 40 60 80 100								
0.0 0.1	<b>PEAT:</b> (100mm) Dark Brown Moist  Silty <b>CLAY</b> , trace sand Soft to Stiff Grey		1	SS	2		192									
			2	SS	11			20 40 60 80 100								
191.2																
1.5 190.9 1.8	Silty <b>SAND</b> , some clay, trace gravel Grey to Brown Moist  END OF BOREHOLE AT 1.8m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 0.5m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH AUGER CUTTINGS UPON COMPLETION.		3	SS	53	191										

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

# RECORD OF BOREHOLE No BH14-08

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION Harrison Twp., Station 19+826 C/L, SBL ORIGINATED BY JM  
 HWY 69 BOREHOLE TYPE Hollow Stem Augers COMPILED BY LG  
 DATUM Geodetic DATE 2009.02.12 - 2009.02.12 CHECKED BY RPR

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						
								20 40 60 80 100						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
191.9	Ground Surface													
0.0	PEAT, fibrous, trace sand													
191.6	Very Soft		1	SS	1									
0.3	Dark Brown													
	Wet (300mm)													
	Silty CLAY, trace sand		2	SS	4		191						0 8 57 35	
	Very Soft to Soft													
	Brown to Grey		3	SS	4		190							
			4	SS	2		189							
188.5			5	SS	6		188						6 61 23 10	
3.4	Silty SAND, trace clay													
	Loose													
	Grey													
	Moist													
	Occasional cobbles		6	SS	50/									
187.1														
4.8	END OF BOREHOLE AT 4.8m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT SURFACE UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH HOLEPLUG AND AUGER CUTTINGS UPON COMPLETION.				.100									

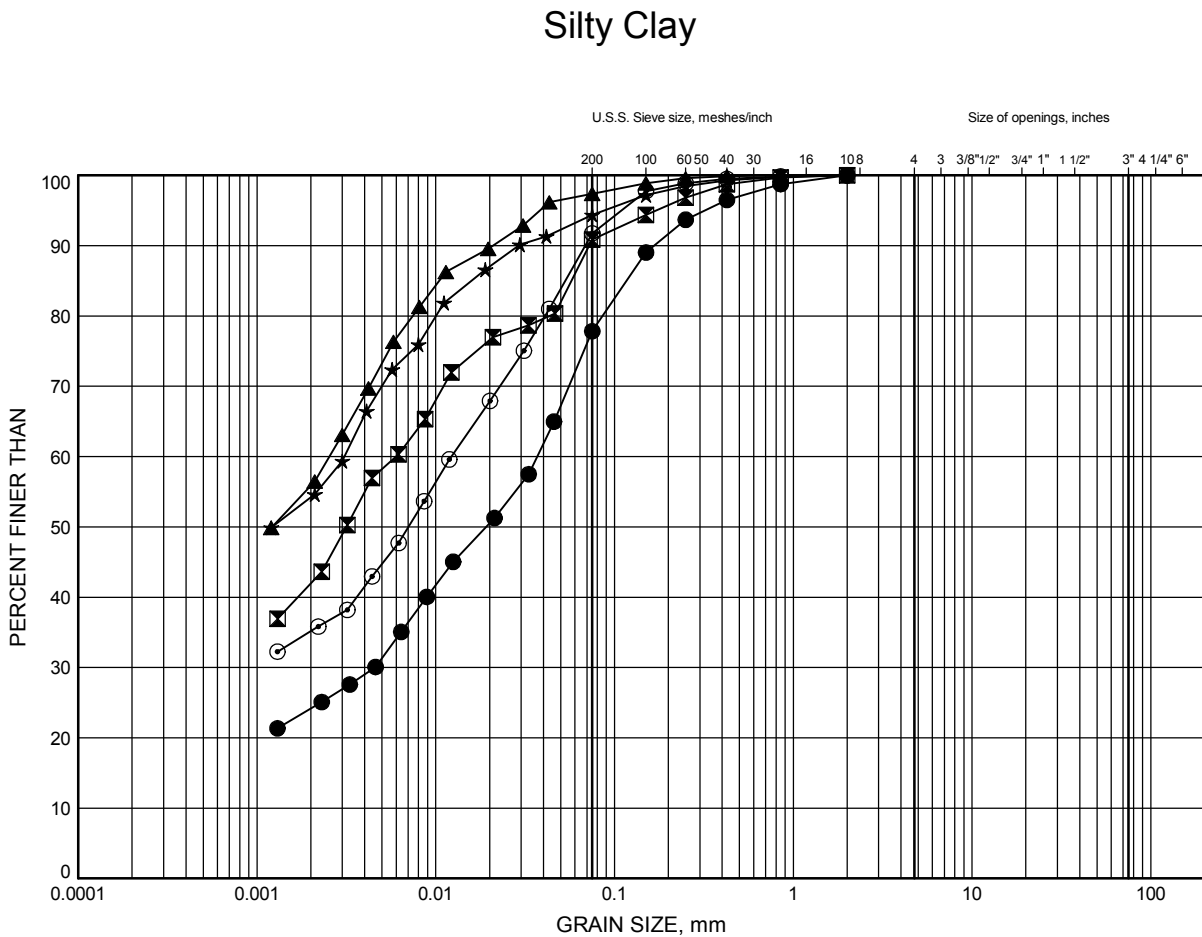
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# Hwy 69 Four-Laning North of Hwy 529 GRAIN SIZE DISTRIBUTION

FIGURE B1



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C317-2	1.07	191.33
◻	C317-2	2.59	189.81
▲	C318-1	1.83	191.04
★	BH13-07	1.07	191.63
⊙	BH14-08	1.07	190.83

Date August 2014

GWP# 5076-06-00



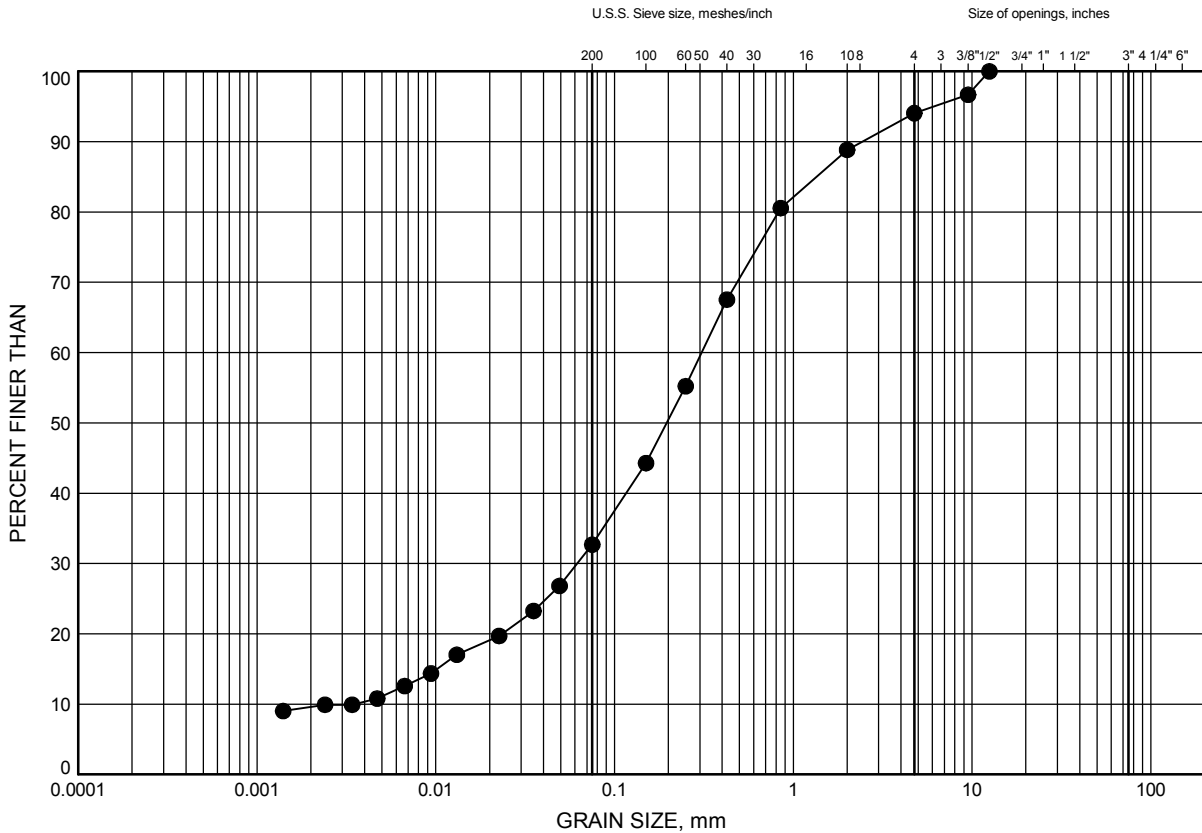
Prep'd MFA

Chkd. MRA

Hwy 69 Four-Laning North of Hwy 529  
**GRAIN SIZE DISTRIBUTION**

FIGURE B2

**Silty Sand**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BH14-08	3.51	188.39

Date August 2014  
 GWP# 5076-06-00



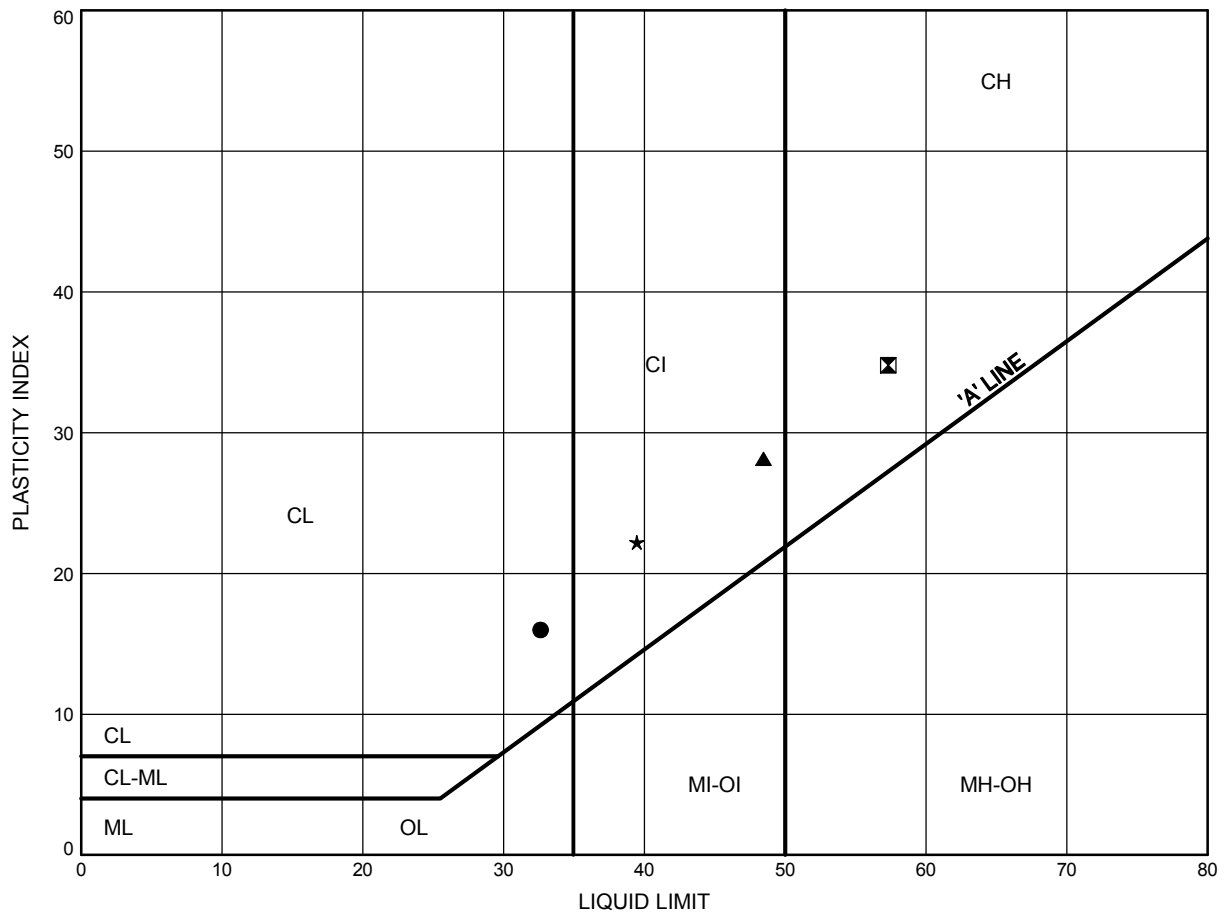
Prep'd MFA  
 Chkd. MRA

Hwy 69 Four-Laning North of Hwy 529

# ATTERBERG LIMITS TEST RESULTS

FIGURE B3

Silty Clay



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C317-2	1.07	191.33
⊠	C318-1	1.83	191.04
▲	BH13-07	1.07	191.63
★	BH14-08	1.07	190.83

Date August 2014  
GWP# 5076-06-00

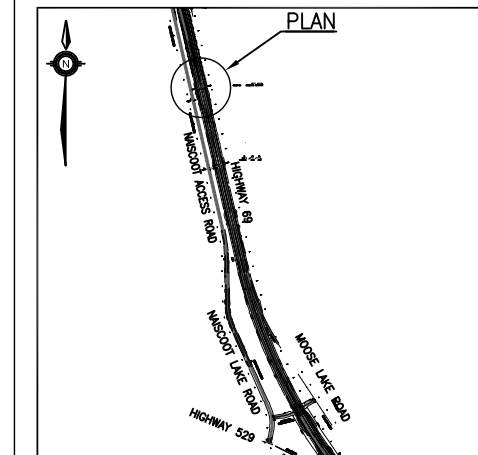


Prep'd MFA  
Chkd. MRA

A circular professional seal for a Licensed Professional Engineer in the Province of Ontario. The outer ring contains the text "LICENSED PROFESSIONAL ENGINEER" at the top and "PROVINCE OF ONTARIO" at the bottom. In the center, the name "M. R. ANDERSON" is printed. Below the name is a semi-circular stamp containing the handwritten date "Aug 21/14". Above the name is a stylized graphic of a bridge or arch structure.

A circular professional seal for a Licensed Professional Engineer in the Province of Ontario. The outer ring contains the text "LICENSED PROFESSIONAL ENGINEER" at the top and "PROVINCE OF ONTARIO" at the bottom. In the center, the name "P. K. CHATTERJI" is printed. Above the name is a handwritten signature, and below the name is a handwritten date "Aug 21 / 14".

HIGHWAY 69 FOUR-LANING  
SOUTH SECTION  
CULVERT 317 AND 318  
BOREHOLE LOCATIONS AND SOIL STRATA



## KEYPLAN

## LEGEND

- |      |                                       |
|------|---------------------------------------|
|      | Culvert Report Borehole / Cone        |
|      | Other Borehole / Cone                 |
| N    | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60° Cone, 475J/blow)     |
| PH   | Pressure, Hydraulic                   |
|      | Water Level During Drilling           |
|      | Water Level in                        |
|      | Piezometer                            |
| 90%  | Rock Quality Designation (RQD)        |
| A/R  | Auger Refusal                         |

NO	ELEVATION	NORTHING	EASTING
BH13-06L	192.0	5 055 805.3	234 927.0
BH13-07	192.7	5 055 820.3	234 936.4
BH13-08R	192.8	5 055 832.8	234 946.2
BH13-09	193.0	5 055 839.8	234 931.9
BH14-07L	191.9	5 055 796.7	234 890.2
BH14-08	191.9	5 055 811.8	234 899.9
BH14-09R	192.1	5 055 826.7	234 908.8
BH14-10	192.6	5 055 836.2	234 894.2
C317-1	192.7	5 055 827.6	234 950.3
C317-2	192.4	5 055 819.8	234 916.4
C318-1	192.9	5 055 811.7	234 881.7
D13-03R	193.3	5 055 811.0	234 951.5
D13-04L	192.1	5 055 827.2	234 922.1

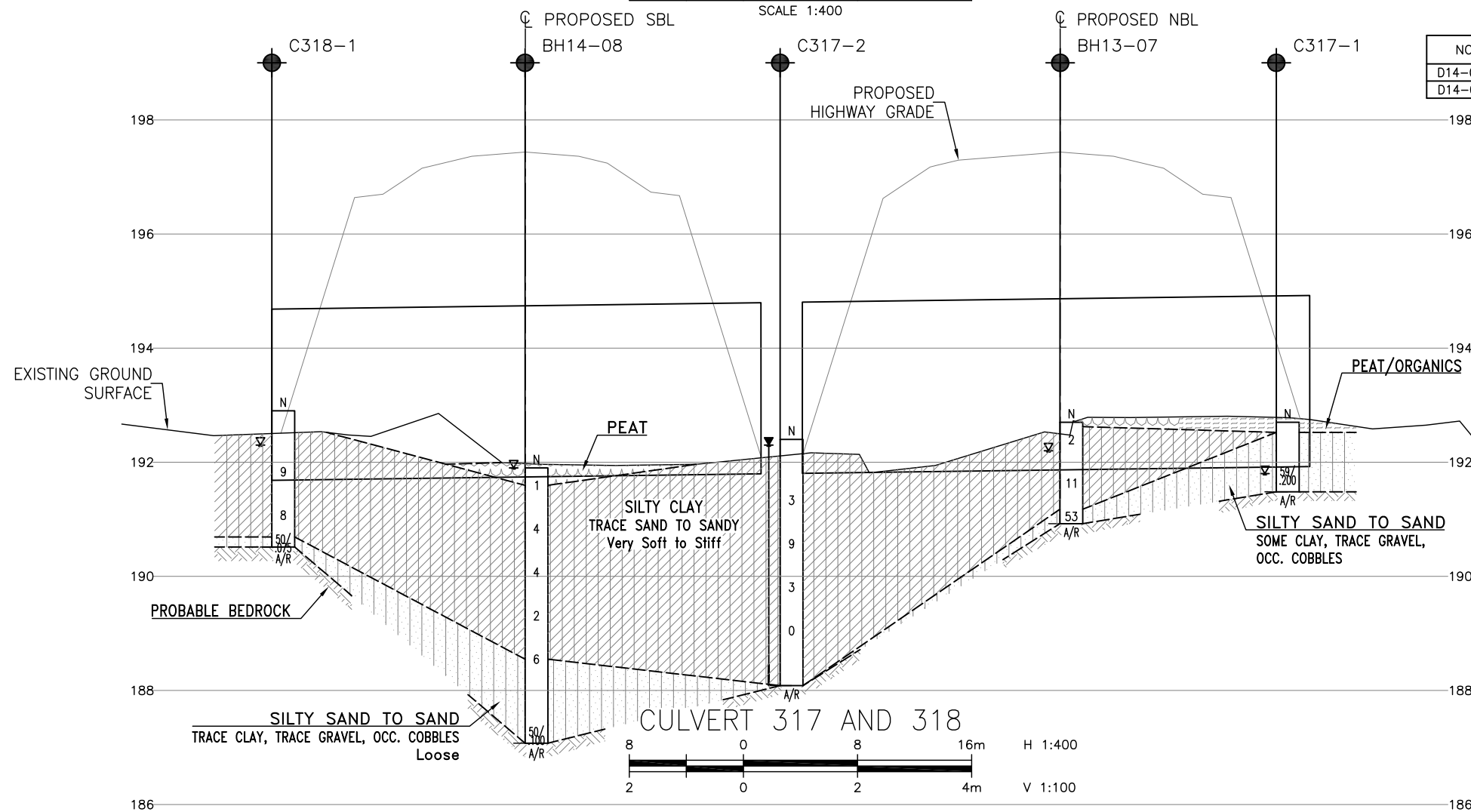
-NOTES-

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

**GEOCRES No. 41H-130**

REVISIONS											
	DATE	BY	DESCRIPTION								
DESIGN	LRB	CHK	MRA	CODE	LOAD	DATE				AUG. 2014	
DRAWN	MFA	CHK	LRB	SITE 44-603/C1&C2		STRUCT	DWG	1			

FILENAME: H:\Drafting\19\5161\21\ted6121-Plan&Sections(Culverts).dwg  
DATE: 8/22/2014 0:45 AM



**Appendix C**

**Culvert 330**

**Record of Borehole Sheets  
Laboratory Test Results  
Borehole Locations and Soil Strata Drawings**

# RECORD OF BOREHOLE No C330-1

1 OF 3

METRIC

GWP# 5076-06-00 LOCATION N 5 055 288.6 E 234 971.2 ORIGINATED BY ES/GM  
 HWY 69 BOREHOLE TYPE Hollow Stem Augers/HQ/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2012.06.12 - 2012.06.12 CHECKED BY LRB

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	WATER CONTENT (%)					
199.9	Road Surface													
0.0	ASPHALT: (40mm)		1	GS										
198.9	SAND, some gravel Dark Brown Damp (FILL)													
1.0	ROCK FILL		1	RUN										
			2	RUN										
			3	RUN										
			4	RUN										
			5	RUN										

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No C330-1

2 OF 3

METRIC

GWP# 5076-06-00 LOCATION N 5 055 288.6 E 234 971.2 ORIGINATED BY ES/GM  
 HWY 69 BOREHOLE TYPE Hollow Stem Augers/HQ/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2012.06.12 - 2012.06.12 CHECKED BY LRB

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													
189.6	Trace peat													
10.3	SAND and GRAVEL, some silt, trace rootlets Loose to Very Loose Brown Wet		1	SS	7		189							
			2	SS	3									
188.0							188							
11.9	SAND, trace gravel, some silt Dense to Compact Brown Wet		3	SS	0									
			4	SS	23		187							
			5	SS	33									
							186							
			6	SS	23		185							
	Occasional cobbles						184							
			7	SS	15									
							183							
			8	SS	11		182							
							181							
			9	SS	10									
180.1														
19.8	Start DCPT at 19.8m						180							

Continued Next Page

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

RECORD OF BOREHOLE No C330-1

3 OF 3

METRIC

GWP# 5076-06-00 LOCATION N 5 055 288.6 E 234 971.2 ORIGINATED BY ES/GM  
HWY 69 BOREHOLE TYPE Hollow Stem Augers/HQ/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2012.06.12 - 2012.06.12 CHECKED BY LRB

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 $\gamma$ 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 (%)					
	Continued From Previous Page							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60					
172.3							179							
							178							
							177							
							176							
							175							
							174							
							173							
27.6	END OF BOREHOLE AT 27.6m UPON REFUSAL ON PROBABLE BEDROCK OR BOULDER. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

ONTMT4S 6121(CULVERTS).GPJ 2012TEMPLATE(MTO).GDT 8/20/14

# RECORD OF BOREHOLE No C330-2

1 OF 2

METRIC

GWP# 5076-06-00 LOCATION N 5 055 278.7 E 234 945.0 ORIGINATED BY ES  
 HWY 69 BOREHOLE TYPE Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2011.03.03 - 2011.03.08 CHECKED BY RPR

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					
191.5	Ground Surface							20 40 60 80 100					
0.0	PEAT Soft Dark Brown		1	SS	4		191						
190.8	SILT and SAND, trace gravel, trace clay Compact Brown Wet		2	SS	18								2 41 53 4
0.7			3	SS	25		190						
189.7													
1.8	SAND, trace to some gravel, trace to some silt and clay Loose to Very Loose Brown Wet          Compact		4	SS	5		189						
			5	SS	4								
			6	SS	2		188						
			7	SS	4		187						
			8	SS	3		186						1 86 13 (SI+CL)
			9	SS	2		185						
			10	SS	5		184						
		11	SS	28		183							
		12	SS	28		182						0 97 3 (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 C330-2

2 OF 2

METRIC

GWP# 5076-06-00 LOCATION N 5 055 278.7 E 234 945.0 ORIGINATED BY ES  
 HWY 69 BOREHOLE TYPE Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2011.03.03 - 2011.03.08 CHECKED BY RPR

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							20 40 60 80 100							
								○ UNCONFINED + FIELD VANE							
								● QUICK TRIAXIAL × LAB VANE							
								20 40 60 80 100							
								20 40 60							

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

## METRIC

[illegible]

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

RECORD OF BOREHOLE No C330-2D

2 OF 2

METRIC

GWP# 5076-06-00 LOCATION N 5 055 278.0 E 234 942.0 ORIGINATED BY ES  
HWY 69 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN  
DATUM Geodetic DATE 2011.03.08 - 2011.03.08 CHECKED BY LRB

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 $\gamma$ 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 (%)					
	Continued From Previous Page						181							
							180							
							179							
178.4														
13.1	END OF BOREHOLE AT 13.1m.													

ONTMT4S 6121(CULVERTS).GPJ 2012TEMPLATE(MTO).GDT 8/20/14

# RECORD OF BOREHOLE No C314-2

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION N 5 055 291.4 E 234 998.4 ORIGINATED BY ES  
 HWY 69 BOREHOLE TYPE Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2011.02.25 - 2011.02.25 CHECKED BY RPR

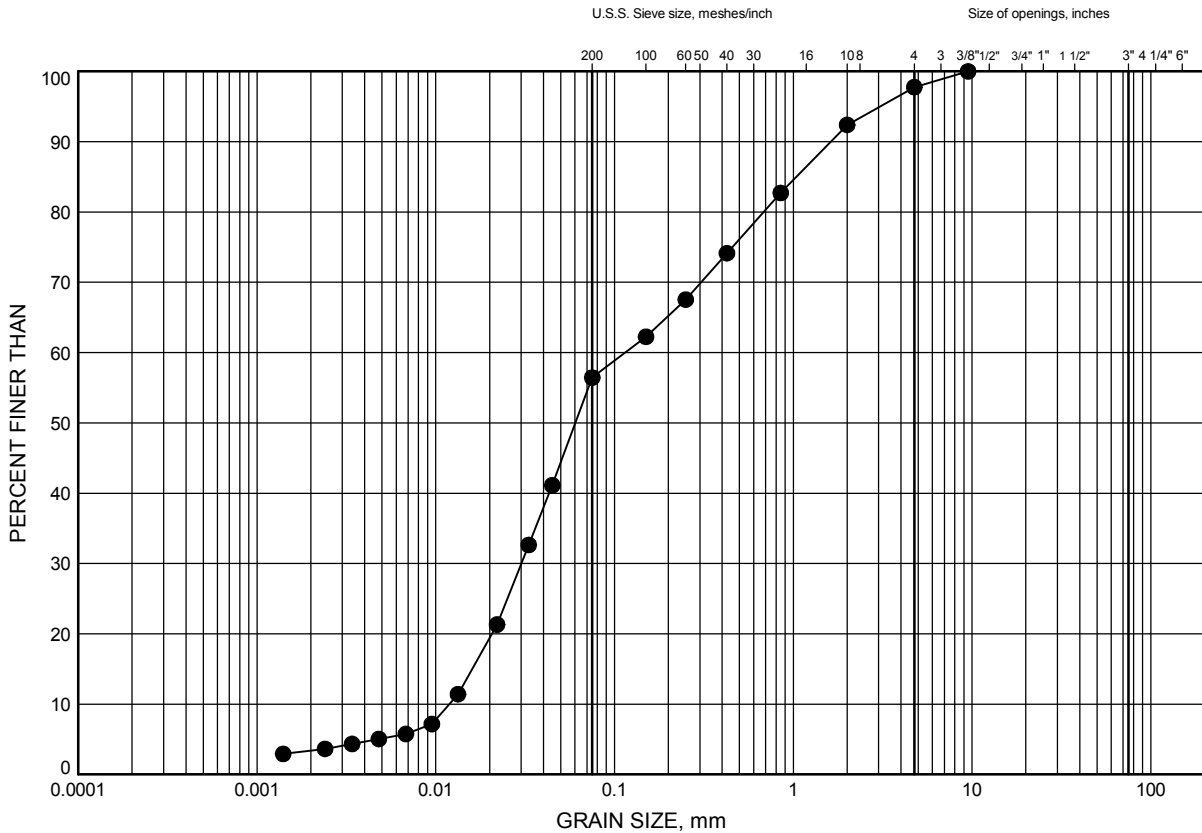
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				
193.2	Pond Surface							20 40 60 80 100							
0.0	ICE: (300mm)														
192.9							193								
0.3	WATER														
191.6							192								
191.8	PEAT: (50mm)														
1.7	SAND, some silt, trace gravel Loose to Compact Grey Wet		1	SS	7		191								
			2	SS	16									5 73 20 2	
190.2							190								
3.0	SAND and GRAVEL, trace silt Very Dense Brown Wet		3	SS	61/ 0.275									53 40 7 (SI+CL)	
189.4															
3.8	END OF BOREHOLE AT 3.8m UPON REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG AND CUTTINGS TO SURFACE.														

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

# Hwy 69 Four-Laning North of Hwy 529 GRAIN SIZE DISTRIBUTION

FIGURE C1

## Silt and Sand



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C330-2	0.91	190.59

Date August 2014  
GWP# 5076-06-00

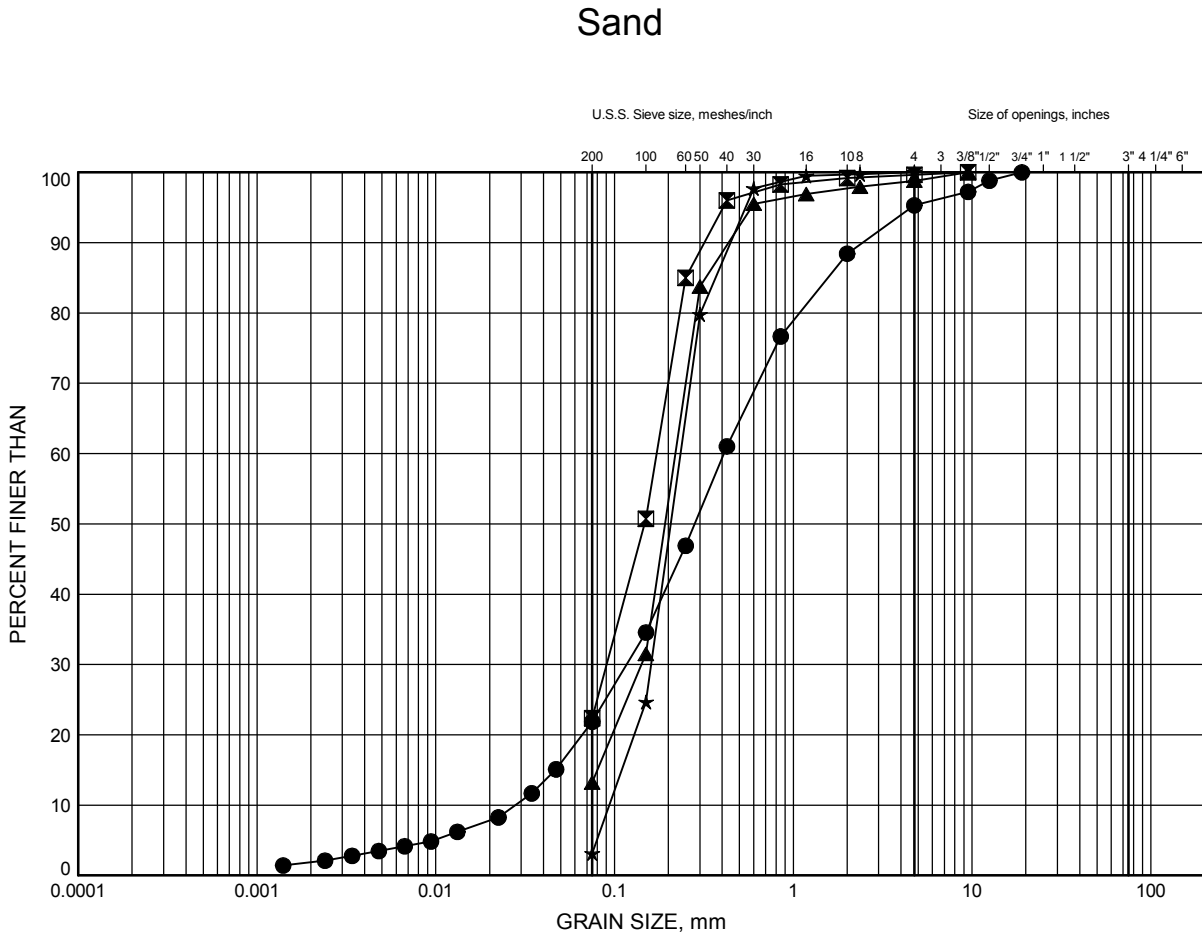


Prep'd MFA  
Chkd. MRA



# Hwy 69 Four-Laning North of Hwy 529 GRAIN SIZE DISTRIBUTION

FIGURE C2



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C314-2	2.69	190.51
⊠	C330-1	19.51	180.39
▲	C330-2	4.88	186.62
★	C330-2	9.45	182.05

Date August 2014  
GWP# 5076-06-00

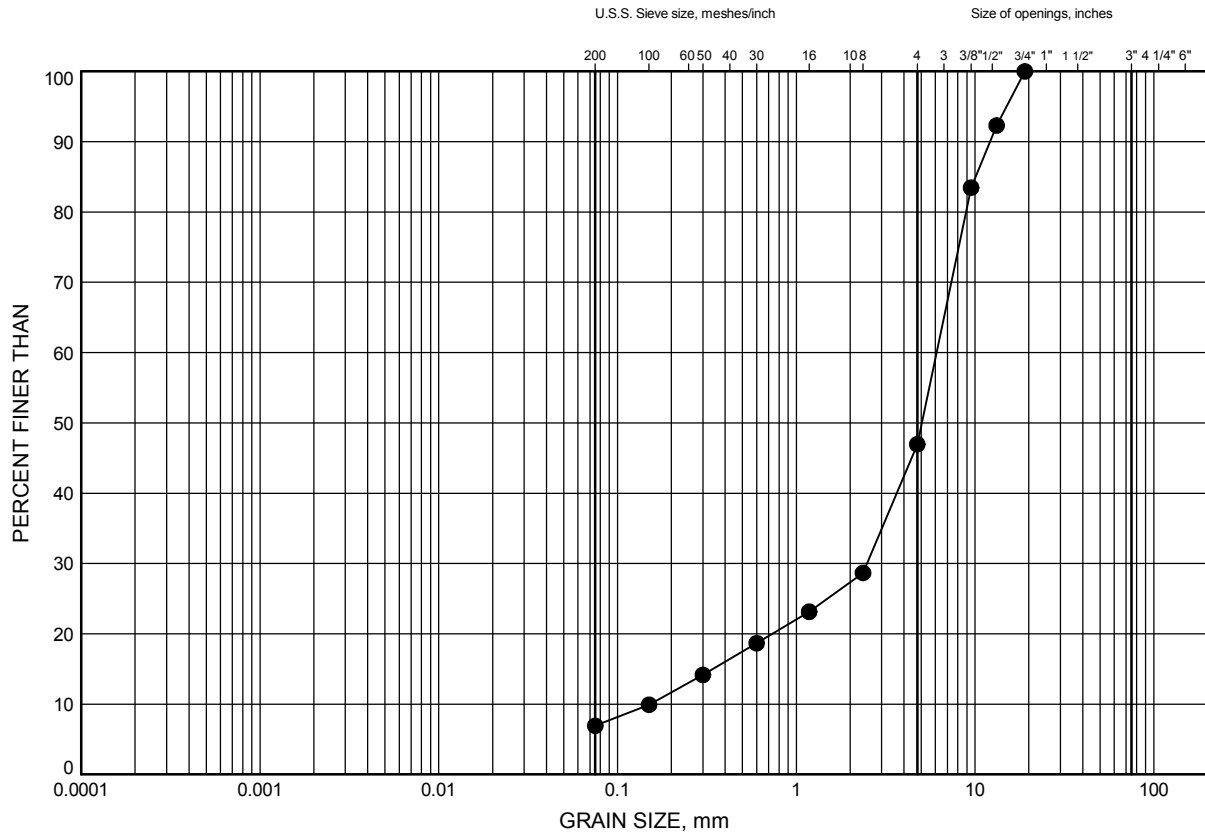


Prep'd MFA  
Chkd. MRA

Hwy 69 Four-Laning North of Hwy 529  
**GRAIN SIZE DISTRIBUTION**

FIGURE C3

**Sand and Gravel**



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

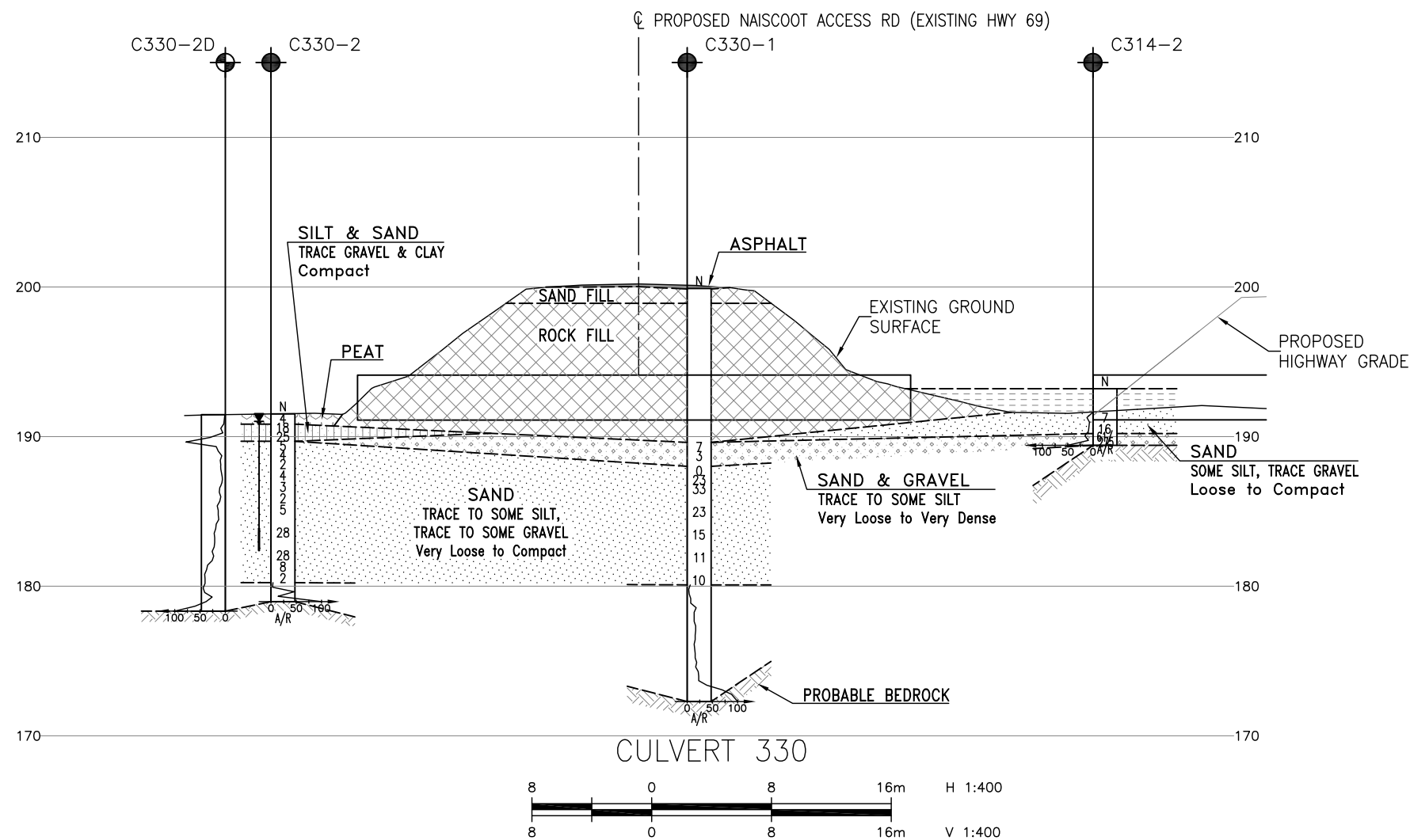
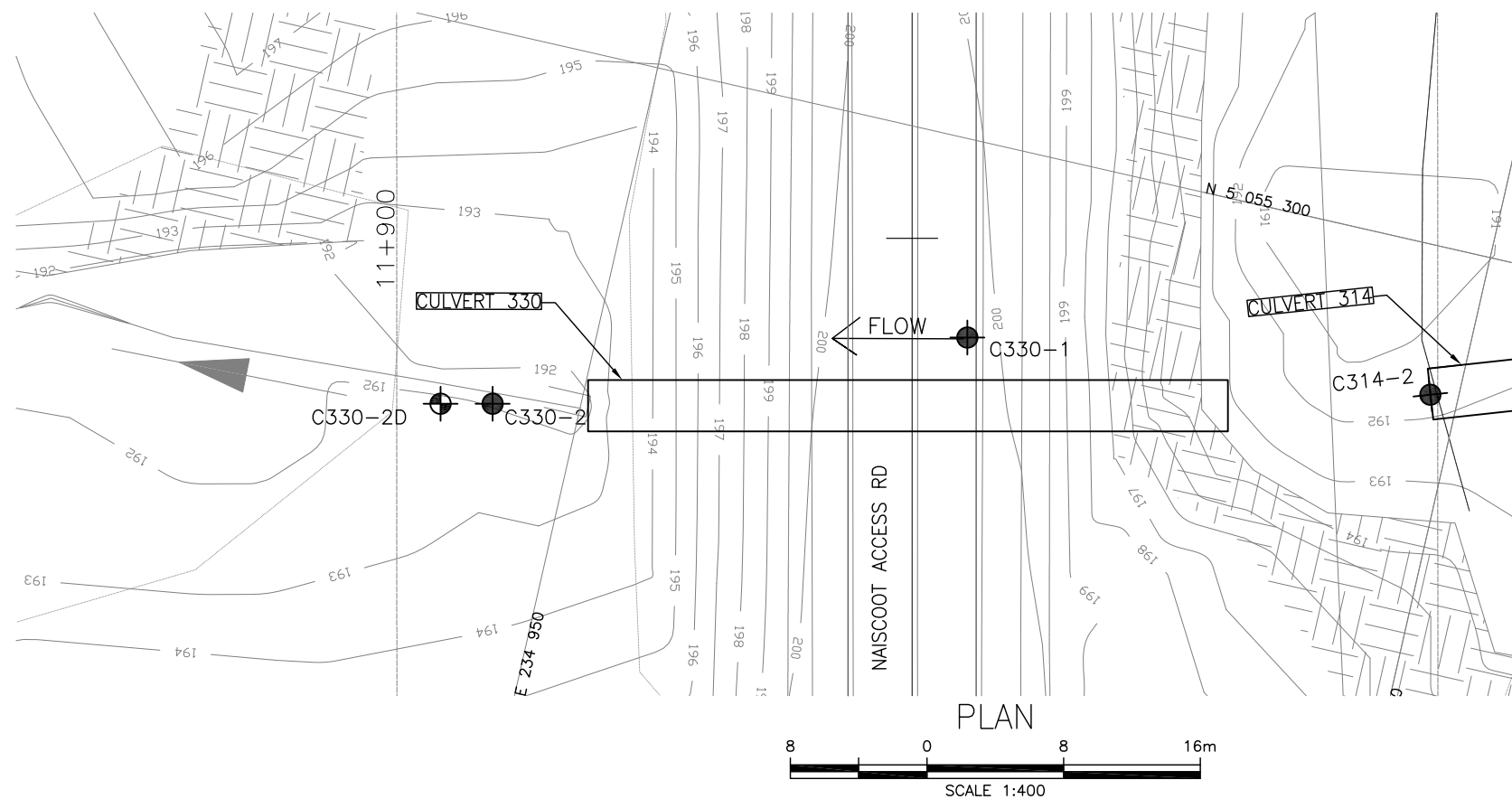
**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C314-2	3.36	189.84

Date August 2014  
 GWP# 5076-06-00



Prep'd MFA  
 Chkd. MRA

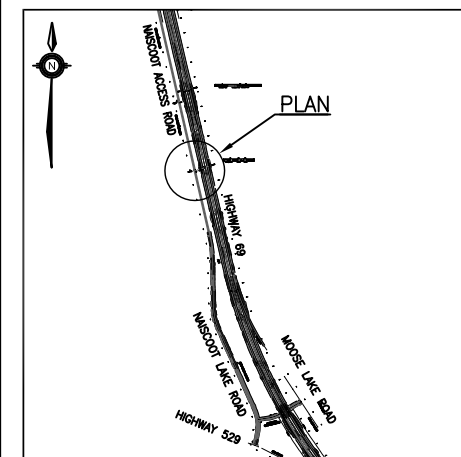


METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN







CONT No  
WP No 5134-12-03

HIGHWAY 69 FOUR-LANING  
SOUTH SECTION  
CULVERT 330  
BOREHOLE LOCATIONS AND SOIL STRATA



## KEYPLAN

## LEGEND

	Culvert Report Borehole / Cone
	Other Borehole / Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level During Drilling
	Water Level in
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

[illegible]

-NOTES-

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

GEOCRES No. 41H-130

REVISIONS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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**Appendix D**

**Culvert 332**

**Record of Borehole Sheets  
Laboratory Test Results  
Borehole Locations and Soil Strata Drawings**

# RECORD OF BOREHOLE No C332-1

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION N 5 055 735.4 E 234 849.5 ORIGINATED BY SLL  
 HWY 69 BOREHOLE TYPE Hollow Stem Augers (CME 45) COMPILED BY AN  
 DATUM Geodetic DATE 2011.02.11 - 2011.02.11 CHECKED BY RPR

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						
191.9	Ground Surface													
0.0	ORGANICS, roots and rootlets													
0.2	Silty CLAY, trace sand Firm Brown		1	SS	7		191							
			2	SS	9		190							
189.8														
188.7	SAND, some silt to silty Brown Wet													
2.2	END OF BOREHOLE AT 2.2m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT SURFACE UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.													

# RECORD OF BOREHOLE No C332-2

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION N 5 055 740.6 E 234 870.1 ORIGINATED BY ES  
 HWY 69 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2012.06.13 - 2012.06.13 CHECKED BY LRB

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					
								WATER CONTENT (%)					
197.2	Ground Surface												
0.0	ASPHALT: (50mm)												
	Gravelly SAND, some silt Brown Damp (FILL)		1	GS									29 59 12 (SI+CL)
196.1													
1.1	ROCK FILL												
			1	RUN									
			2	RUN									
			3	RUN									
			4	RUN									
189.7													
189.6	Silty CLAY, some gravel Firm Brown Moist												
7.6	BEDROCK, granite, grey/pink Vertical fracture from 8.4m to 8.7m		5	RUN									RUN #5 TCR=100% SCR=100% RQD=72%
188.4													
8.8	END OF BOREHOLE AT 8.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 6.4m, CUTTINGS TO 1.2m, BENTONITE HOLEPLUG TO 0.1m, THEN ASPHALT TO SURFACE.												

ONTMT4S 6121(CULVERTS).GPJ 2012TEMPLATE(MTO).GDT 8/20/14

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

20  
15  
10







(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No C332-3

1 OF 1

METRIC

GWP# 5076-06-00 LOCATION N 5 055 743.5 E 234 881.5 ORIGINATED BY SLL  
 HWY 69 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.02.11 - 2011.02.11 CHECKED BY RPR

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  $\gamma$  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										
191.6	Ground Surface																	
0.0	PEAT, roots and rootlets						191											
190.8	SAND, some silt Loose Brown		1	SS	4		190											
190.2																		
1.4	Silty CLAY, trace sand, occasional rootlets Firm Brown		2	SS	5										0	5	42	53
189.1			3	SS	50/													
2.5	END OF BOREHOLE AT 2.5m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 0.1m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.				0.100													

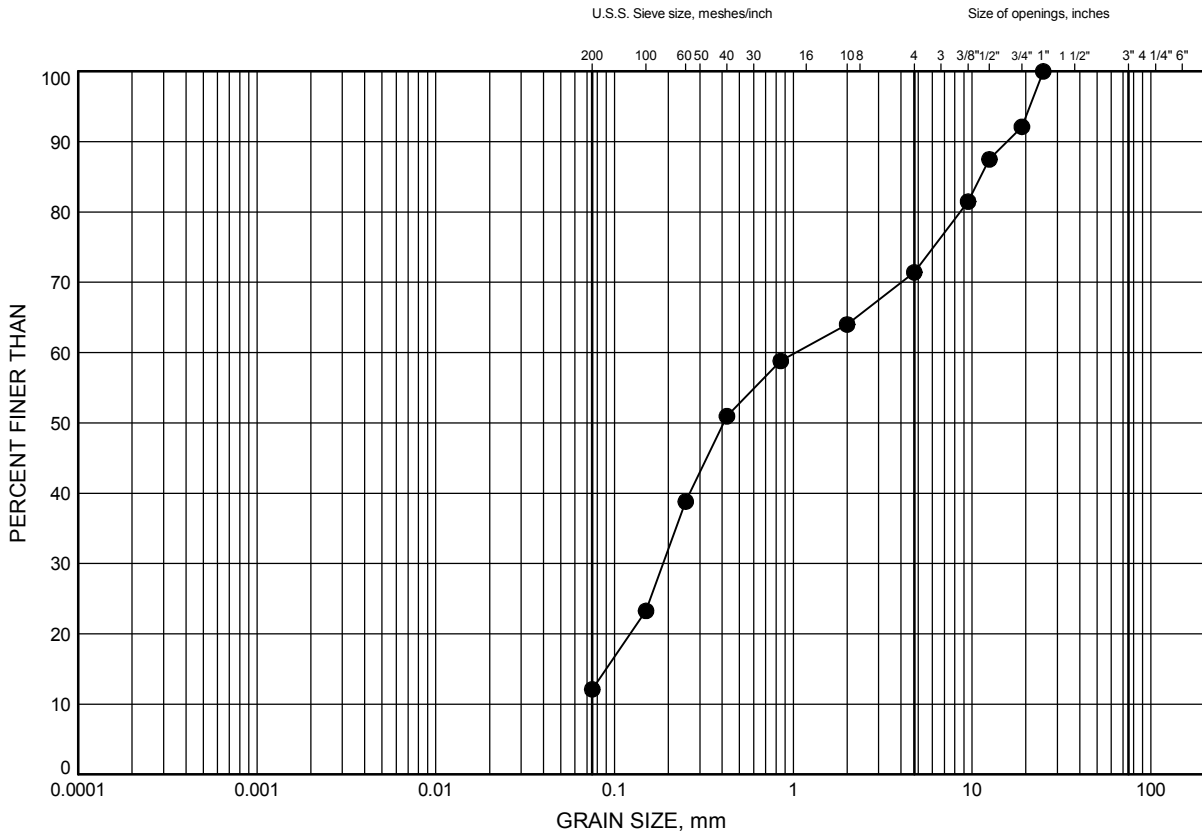
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
5  
0  
5  
10  
(%) STRAIN AT FAILURE

Hwy 69 Four-Laning North of Hwy 529  
**GRAIN SIZE DISTRIBUTION**

FIGURE D1

**Gravelly Sand Fill**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C332-2	0.50	196.70

Date August 2014  
 GWP# 5076-06-00

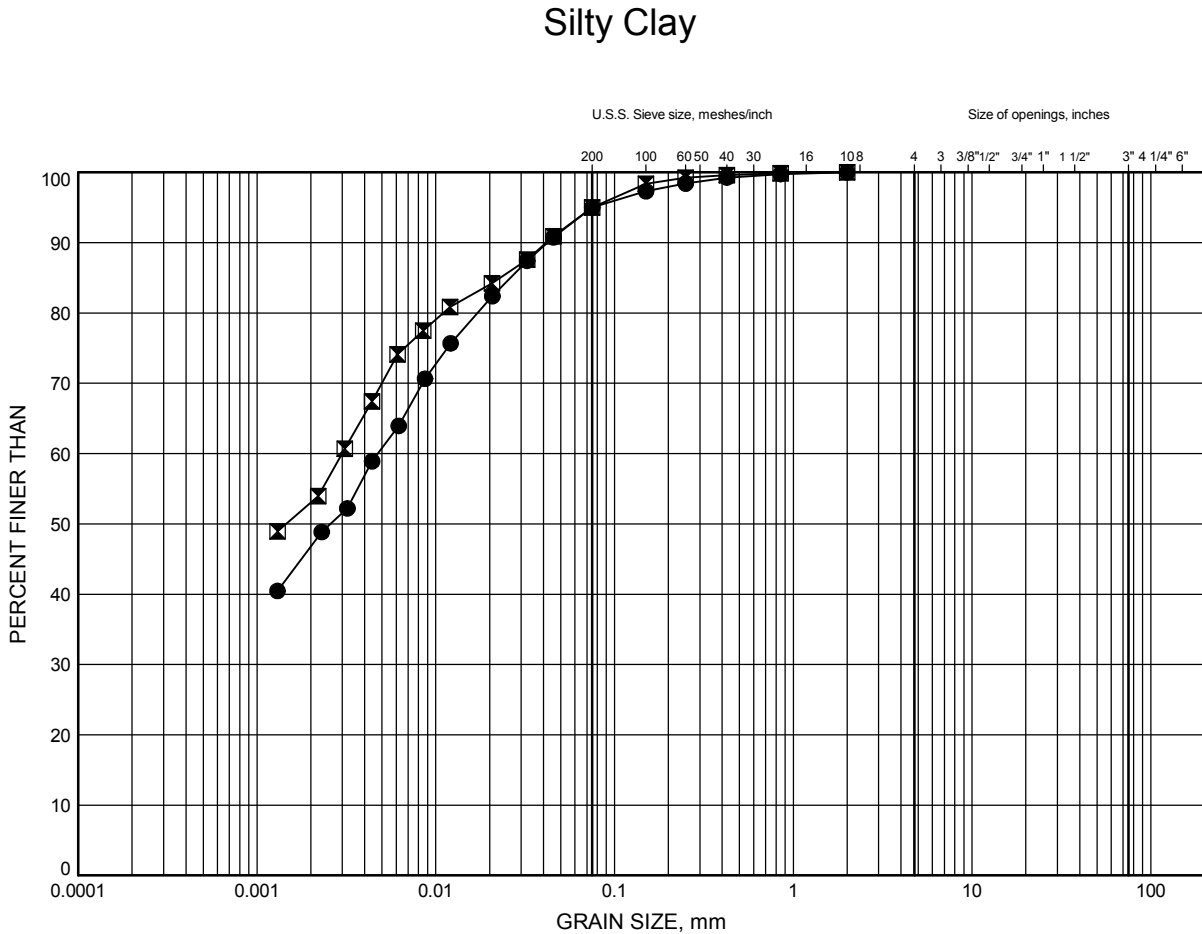


Prep'd MFA  
 Chkd. MRA



# Hwy 69 Four-Laning North of Hwy 529 GRAIN SIZE DISTRIBUTION

FIGURE D2



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C332-1	1.83	190.07
⊠	C332-3	1.83	189.77

Date August 2014  
GWP# 5076-06-00

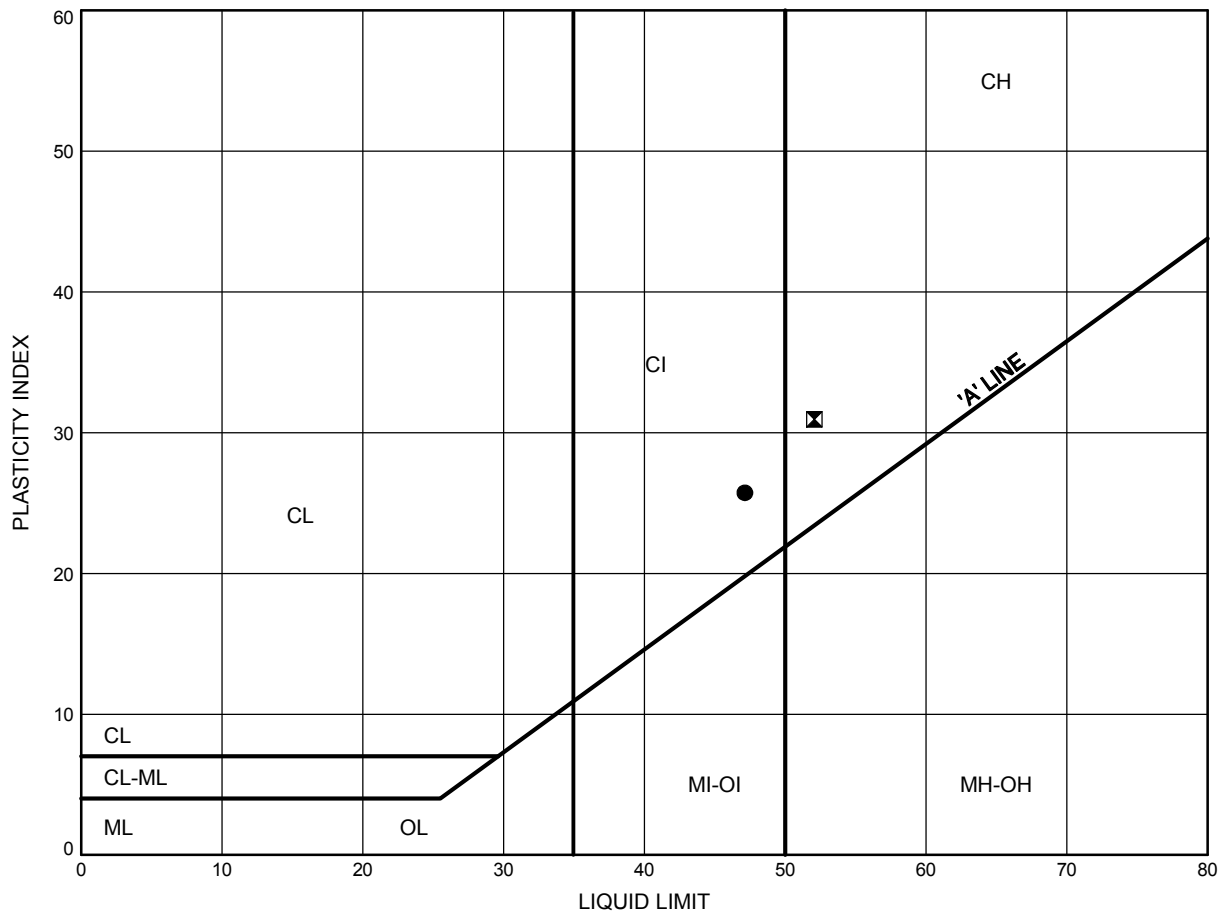


Prep'd MFA  
Chkd. MRA

Hwy 69 Four-Laning North of Hwy 529  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE D3

Silty Clay



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C332-1	1.83	190.07
⊠	C332-3	1.83	189.77


Date August 2014  
 GWP# 5076-06-00



Prep'd MFA  
 Chkd. MRA

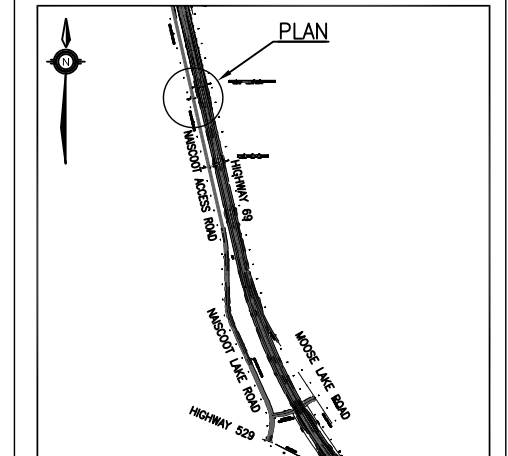
A circular professional seal for a Licensed Professional Engineer in the Province of Ontario. The outer ring contains the text "LICENSED PROFESSIONAL ENGINEER" at the top and "PROVINCE OF ONTARIO" at the bottom. In the center, the name "M. R. ANDERSON" is printed. Below the name is a handwritten signature "Aug 21/14". Above the name is a stylized graphic of a bridge or arch. The seal is stamped in black ink on a light-colored background.

A circular professional seal for a Licensed Professional Engineer in the Province of Ontario. The outer ring contains the text "LICENSED PROFESSIONAL ENGINEER" at the top and "PROVINCE OF ONTARIO" at the bottom. Inside the ring, the name "P. K. CHATTERJI" is printed. Below the name, the date "Aug 21 / 14" is handwritten. Above the name, there is a handwritten signature that appears to be "P. K. Chatterji".

	
	SHEET







**THURBER** ENGINEERING LTD.



## KEYPLAN

### LEGEND

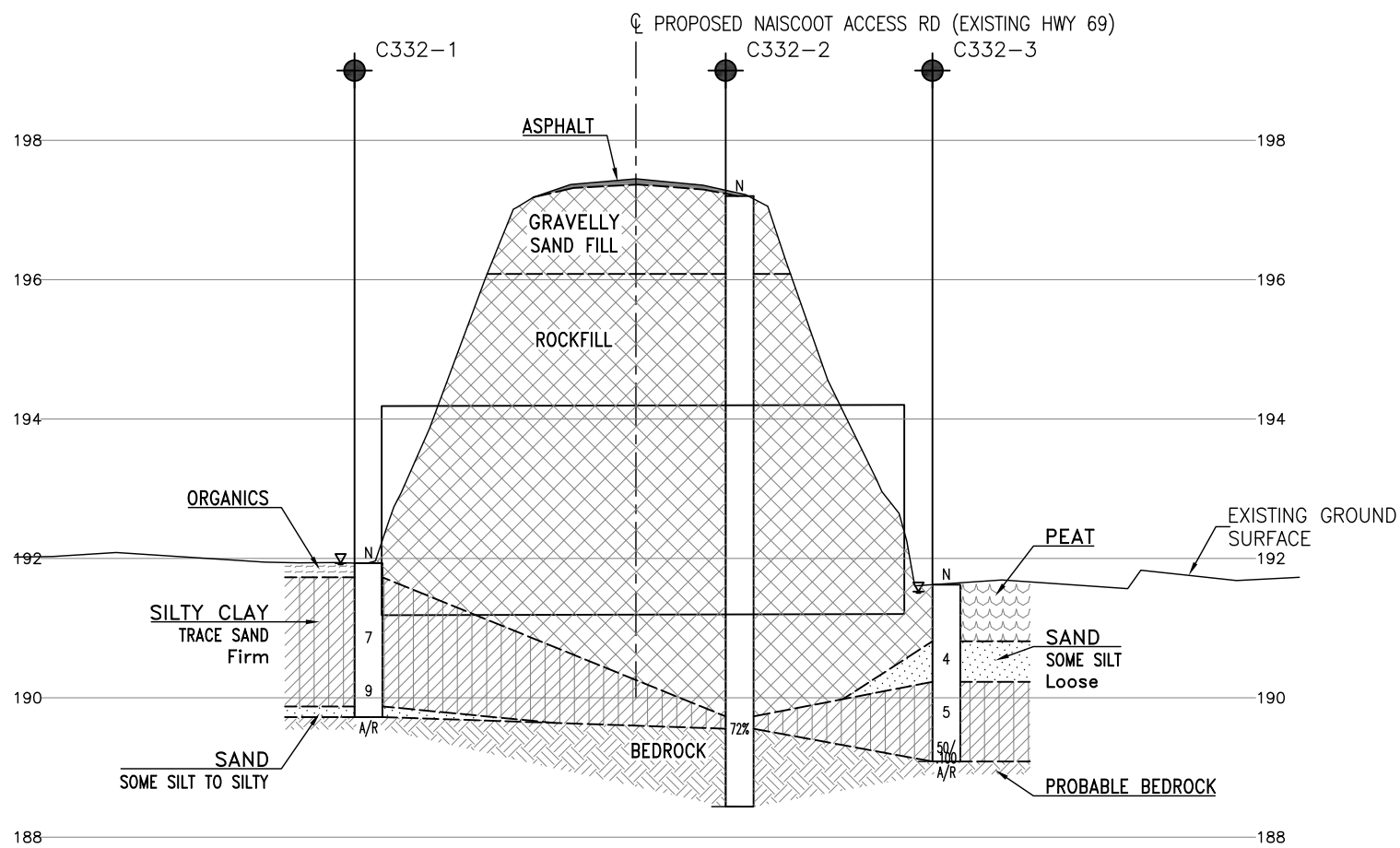
	Culvert Report Borehole / Cone
	Other Borehole / Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level During Drilling
	Water Level in Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

[illegible]

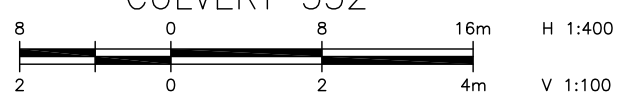
-NOTES-

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

**GEOCRES No. 41H-130**



CULVERT 332

[illegible]