



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
NEW TREMAINE ROAD INTERCHANGE AT HIGHWAY 401
CULVERTS**

Geocres Number: 30M12-381

Report to

WSP

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for installation of ten new culverts, extension of three existing culverts, and construction of one channel structure in connection with the proposed Tremaine Road Interchange at Highway 401 in the Town of Milton, Ontario.

New Tremaine Road will be constructed on a new alignment approximately 600 m east of the existing Tremaine Road and cross Highway 401 as part of a new interchange. The interchange project will include construction of a new underpass structure carrying Tremaine Road over Highway 401, approach embankments, and access ramps connecting the new Tremaine Road and Highway 401.

The purpose of the investigation was to explore the subsurface conditions at the proposed culvert and structure locations and, based on the data obtained, to provide borehole logs, borehole location plans, stratigraphic profiles, and written descriptions of the subsurface conditions.

Thurber carried out the investigation as a sub-consultant to MMM Group Limited who are preparing the detailed interchange design for The Regional Municipality of Halton.

2 SITE DESCRIPTION

The proposed Tremaine Road interchange with Highway 401 will be located approximately 600 m east of the existing Tremaine Road underpass and about 2.0 km west of the Regional Road 25 interchange in the Town of Milton. The project limits along the new Tremaine Road alignment extend from 3rd Side Road south of Highway 401 northerly to approximately 100 m south of Campbellville Road. Highway 401 at the site is a six lane divided highway with a tall-wall median barrier.

The proposed interchange lands are generally agricultural with a faintly undulating topography. A small tributary of the Sixteen Mile Creek crosses from the northwest to the south end of the properties. Industrial buildings exist to the east, residential areas are located to the west and south, and a heritage park and conservation/ski area are located to the southwest as well.

The project site is located within the physiographic region known as the Peel Plain, characterized by a discontinuous veneer of glacio-lacustrine clay and silt underlain by glacial till consisting of clayey silt to silty clay (Halton Till). The underlying bedrock consists of the Queenston Formation, a reddish brown shale with siltstone and limestone interbeds. The site is located approximately 1.0 km northeast of the base of the Niagara Escarpment.

3 SITE INVESTIGATION AND FIELD TESTING

The initial site investigation at the culvert locations was generally carried out during the period August 28 to October 27, 2014. One borehole (C25-01) was drilled on May 2, 2014, and supplementary investigation was carried out between January 28 and April 14, 2016. The borehole designations and depths were as follows:

Table 3.1 – Borehole Designations and Depths

Culvert/Structure No.	Borehole Numbers	Borehole Depths (m)
16A and 16B	C16-01 to C16-08	9.6 to 25.6
17	C17-01 to C17-03	9.8
18 (Extensions)	C18-01 to C18-04D	3.3 to 9.8
19	C19-01 to C19-03	8.2 to 9.8
20	C20-01, C20-02	5.2
21 (Extensions)	C21-01 to C21-03	9.8
22	C22-01 to C22-03	9.8
23	C23-01, C23-02	5.2
24	C24-01, C24-02	5.0 to 5.2
25	C25-01 to C25-02	5.2 to 11.3
26 (Extensions)	C26-01, C26-02	5.2
27	C27-01, C27-02	5.2
3 rd Sideroad Channel	C3S-01 to C3S-03	9.8 to 12.8

Four boreholes at Culvert 16A and 16B (boreholes C16-01, C16-04, C16-05 and C16-08) were advanced 3.5 to 4.4 m below the shale bedrock surface by rock coring methods. At the location of Borehole C18-04, a series of four additional boreholes (boreholes C18-04A to C18-04D) were drilled along the shoulder of Highway 401 to assess the presence of a frost taper at Culvert 18.

A key plan showing the relative culvert locations is provided behind the report text. The approximate locations of the boreholes at each culvert location are shown on the Borehole Locations and Soil Strata Drawings in the respective Appendices A through M.

Prior to commencing the site investigation, clearance was obtained from utility companies having plant in the area.

Hollow stem augers and/or solid stem augers were used to advance the boreholes in the overburden. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the soil. NQ coring equipment was used to advance the boreholes into the bedrock and recover rock core samples.

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

Groundwater conditions in the open boreholes were observed throughout the drilling operations. 50 mm diameter monitoring wells and 19 mm or 25 mm diameter standpipe piezometers were installed and enclosed in filter sand to permit longer term groundwater level monitoring. The details of the wells and piezometers are shown in Table 3.2.

The boreholes in which no wells or piezometers were installed were backfilled with bentonite and cuttings to ground surface in general accordance with MOE Regulation 903.

Table 3.2 – Well/Piezometer Details

Borehole	Well/Piezometer Tip		Instrument Type	Slotted Screen Length (m)
	Depth (m)	Elevation (m)		
C16-02	8.4	206.6	50 mm Well	3.0
C16-07	9.1	206.5	50 mm Well	1.5
C17-01	8.8	208.4	50 mm Well	3.0
C17-03	8.7	208.4	19 mm Piezometer	1.5
C18-01	9.2	208.7	19 mm Piezometer	1.5
C18-02	9.2	208.7	50 mm Well	1.5
C19-01	9.1	208.5	19 mm Piezometer	1.5
C19-03	7.6	208.6	50 mm Well	1.5
C20-01	4.0	212.7	50 mm Well	1.5
C21-01	7.1	211.5	25 mm Piezometer	1.5
C21-03	8.8	208.5	50 mm Well	1.5
C22-01	9.2	210.2	50 mm Well	1.5
C22-03	9.2	209.6	25 mm Piezometer	1.5
C23-01	4.6	212.4	50 mm Well	1.5
C23-02	4.6	212.1	25 mm Piezometer	1.5
C24-02	4.4	213.8	50 mm Well	1.5
C25-01A	11.3	206.7	25 mm Piezometer	1.5
C25-02	4.7	212.9	50 mm Well	1.5
C26-01	5.2	209.0	50 mm Well	1.5

4 LABORATORY TESTING

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

Selected samples were subjected to gradation analysis and Atterberg Limits testing. The results of this testing program are shown on the Record of Borehole sheets and on the laboratory test result figures attached in Appendix A through Appendix M.

Point load tests (PLT) were performed on selected intact rock core samples. Unconfined compressive strengths (UCS) of the rock cores correlated from the PLT results are shown on the Record of Borehole sheets in Appendix A.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference should be made to the Record of Borehole sheets in Appendices A through M. Details of the encountered soil stratigraphy are presented in these appendices and on the “Borehole Locations and Soil Strata” drawings. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

5.1 Structures 16A and 16B (Boreholes C16-01 to C16-08)

The stratigraphy encountered in the boreholes drilled at Structures 16A and 16B consists of topsoil underlain by a layer of silty clay to clayey silt till overlying discontinuous layers of silt and sand and silt, which in turn overlie a relatively thick layer of clayey silt to silt till, locally interbedded with deposits of sand and silt to gravelly sand.

5.1.1 Topsoil

Topsoil was encountered in all boreholes advanced at this site. The thickness of the topsoil encountered ranged from 200 to 275 mm in the boreholes.

5.1.2 Clayey Silt to Silty Clay (Till)

A layer of brown clayey silt to silty clay till containing some sand to sandy was encountered below the topsoil in all boreholes. The thickness of the layer ranged from 1.2 to 2.7 m, with the lower boundary at 1.5 to 3.0 m depth (elevation 213.6 to 212.1).

SPT ‘N’ values of 4 to 38 blows per 0.3 m penetration were obtained in the deposit, indicating a generally firm consistency to depths of 0.6 to 1.5 m and very stiff to hard below this depth. Measured moisture contents ranged from 11 to 37%, typically 14 to 24%.

The results of grain size distribution tests carried out on the cohesive samples are shown on Figure A1 included in Appendix A and also summarized below:

Gravel (%)	0 to 6
Sand (%)	20 to 27
Silt (%)	34 to 50
Clay (%)	26 to 39

The results of three Atterberg Limits tests carried out on the clayey silt to silty clay samples are shown on Figure A6 included in Appendix A and also summarized below:

Liquid Limit	29%
Plastic Limit	17 to 18%
Plasticity Index	11 to 12%

5.1.3 Silt

A layer of silt was encountered below the clay/silt till in all boreholes except borehole C16-01. The silt contained some sand and clay. The silt layer ranged in thickness from 0.6 to 1.7 m, with a lower boundary at depths of 2.2 to 4.1 m (elevation 212.7 to 211.3).

SPT 'N' values of 17 to 37 blows per 0.3 m penetration were obtained in the silt, indicating a compact to dense relative density. Moisture contents ranged from 14 to 19%.

The results of grain size distribution tests carried out on the silt samples are shown on Figure A2 in Appendix A and are summarized below:

Gravel (%)	0
Sand (%)	6 to 10
Silt (%)	76 to 79
Clay (%)	14 to 15

5.1.4 Sand and Silt

A brown sand and silt layer was encountered below the clay till in borehole C16-01 and the silt deposit in boreholes C16-02 to C16-06. The sand and silt contains trace clay. The thickness of the sand and silt ranged from 1.1 to 2.4 m, with the lower boundary at 4.1 to 4.8 m depth (elevation 211.1 to 210.2).

SPT 'N' values recorded in the deposit ranged from 7 to 53 blows per 0.3 m penetration, and typically from 8 to 23 indicating a loose to compact relative density. Measured moisture contents ranged from 11 to 22%.

The results of three grain size distribution tests carried out on the cohesionless samples are shown on Figure A3 included in Appendix A and also summarized below:

Gravel (%)	0
Sand (%)	38 to 42
Silt (%)	53 to 56
Clay (%)	5 to 9

5.1.5 Clayey Silt to Silt, some Clay (Till)

A layer of reddish brown to mottled brown and grey clayey silt till to silt till with some clay was encountered below the sand and silt in boreholes C16-01 to C16-05 and below the clayey silt to silty clay in boreholes C16-06 to C16-08. The till contains some sand to sandy. The thickness of the layer penetrated in boreholes ranged from 4.7 to 14.8 m, with the lower boundary at 8.7 to 13.0 m depth (elevation 206.9 to 202.1). Boreholes C16-02, C16-03 and C16-06 were terminated within this layer at 9.6 to 9.7 m depth (elevation 205.6 to 205.3).

SPT 'N' values of 17 blows per 0.3 m penetration to 100 blows per 0.275 m penetration were obtained in the deposit, indicating a very stiff to hard consistency. Measured moisture contents ranged from 7 to 27%, typically about 8 to 15%.

The results of grain size distribution tests carried out on the cohesive till samples are shown on Figures A4a and A4b included in Appendix A and also summarized below:

Gravel (%)	0 to 7
Sand (%)	8 to 34
Silt (%)	42 to 77
Clay (%)	14 to 27

The results of two Atterberg Limits tests carried out on the till samples are shown on Figure A7 included in Appendix A and also summarized below:

Liquid Limit	23%
Plastic Limit	13 to 14%
Plasticity Index	9 to 10%

5.1.6 Lower Sand and Silt

A brown sand and silt layer was encountered below the cohesive till deposit in boreholes C16-07 and C16-08. The thickness of the sand and silt in borehole C16-08 was 1.5 m with the lower boundary at 11.7 m depth (elevation 203.7). Borehole C16-07 was terminated within this layer at 9.8 m depth (elevation 205.8)

SPT 'N' values recorded in the deposit ranged from 19 to 48 blows per 0.3 m penetration, indicating a compact to dense relative density. Measured moisture contents ranged from 21 to 23%.

5.1.7 Silty Gravel to Gravelly Sand

A brown heterogeneous mixture of silty gravel, some sand to gravelly sand, some silt was encountered below the cohesive till deposit in boreholes C16-04 and C16-05 and below the lower sand and silt in borehole C16-08. The thickness of the layer ranged from 1.5 to 3.0 m with the lower boundary at 12.2 to 13.7 m depth (elevation 202.6 to 201.4).

SPT 'N' values recorded in the deposit ranged from 37 to 69 blows per 0.3 m penetration, indicating a dense to very dense relative density. Measured moisture contents ranged from 6 to 20%.

The results of two grain size distribution tests carried out on the cohesionless samples are shown on Figure A5 included in Appendix A and also summarized below:

	Gravelly Sand	Silty Gravel
Gravel (%)	31	63
Sand (%)	53	16
Silt & Clay (%)	16	21

5.1.8 Sand and Silt (Till)

A reddish brown to brown sand and silt till layer was encountered below the gravelly layer in boreholes C16-04, C16-05 and C16-08. The thickness of the sand and silt till ranged from 3.0 to 4.4 m, with the lower boundary at 15.2 to 17.7 m depth (elevation 199.6 to 197.7).

SPT 'N' values recorded in the cohesionless till ranged from 68 blows per 0.3 m penetration to 100 blows for 0.15 m penetration, indicating a very dense relative density. Measured moisture contents ranged from 7 to 22%.

The results of two grain size distribution tests carried out on the cohesionless till samples are shown on Figure A6 included in Appendix A and also summarized below:

Gravel (%)	4 to 6
Sand (%)	41 to 50
Silt (%)	41 to 42
Clay (%)	3 to 13

5.1.9 Lower Clayey Silt to Silt, some Clay (Till)

A layer of reddish brown to brown clayey silt to silt till with some clay was encountered below the sand and silt till in boreholes C16-04 and C16-08 and below the upper clayey silt till in borehole C16-01. The till contains some sand to sandy. The thickness of the layer ranged from 3.1 to 6.4 m, with the lower boundary at 18.3 to 21.9 m depth (elevation 196.5 to 193.5).

SPT 'N' values of 93 blows per 0.3 m penetration to 178 blows for 0.275 m penetration were obtained in the deposit, indicating a hard consistency. Measured moisture contents ranged from 7 to 13%.

The results of two grain size distribution tests carried out on the cohesive till are shown on Figures A4a and A4b included in Appendix A and also summarized below:

Gravel (%)	1
Sand (%)	13 to 28
Silt (%)	53 to 70
Clay (%)	16 to 18

The results of Atterberg Limits testing carried out on a till sample are shown on Figure A6 included in Appendix A and also summarized below:

Liquid Limit	21%
Plastic Limit	13%
Plasticity Index	8%

5.1.10 Shale Bedrock

Shale bedrock of the Queenston Formation was encountered below the cohesive till in boreholes C16-01, C16-04 and C16-08 and below cohesionless till in borehole C16-05. The table below summarizes the depth to bedrock and the bedrock surface elevations encountered in the boreholes.

Borehole	Depth to Bedrock (m)	Bedrock Elevation (m)
C16-01	19.4	195.7
C16-04	18.3	196.5
C16-05	16.9	198.2
C16-08	21.9	193.5

The bedrock was typically highly weathered within approximately 0.5 m of bedrock surface, below which it becomes slightly weathered to fresh. The shale is generally described as reddish brown, laminated with frequent limestone interbeds typically ranging from 25 to 100 mm in thickness and occasional soil infilling.

Total Core Recovery (TCR) in the bedrock ranged typically from 83 to 100%. The Rock Quality Designation (RQD) determined from the recovered cores generally ranged from 65 to 100%, indicating fair to excellent rock quality. TCR and RQD values recorded for Run #3 in borehole C16-05 were 33% and 12%. The Fracture Index (FI) of the rock, expressed as number of fractures per 0.3 m of core, ranged from 0 to greater than 10.

The unconfined compressive strengths (UCS) of the rock, estimated from the results of point load tests, ranged between 9 and 23 MPa for shale core samples, indicating a weak rock strength, and ranged from 45 to 57 MPa for limestone core samples, indicating medium strong to strong rock strength. The point load test results are included on the borehole logs in Appendix A.

5.1.11 Water Levels

The groundwater depths and elevations observed in the boreholes upon completion of drilling and measured in the monitoring wells after the drilling are summarized in the following table.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
C16-02	Nov. 25, 2014	1.5 *	216.5	In monitoring well
	Dec. 19, 2014	Frozen	-	In monitoring well
C16-03	Sept. 11, 2014	1.8	213.4	In open borehole
C16-06	Sept. 11, 2014	5.2	210.0	In open borehole
C16-07	Nov. 25, 2014	0.1	215.5	In monitoring well
	Dec. 19, 2014	0.2 *	215.8	In monitoring well

* Water level above ground surface

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

5.2 Culvert 17 (Boreholes C17-01 to C17-03)

The subsurface stratigraphy encountered in the boreholes drilled at Culvert 17 consists of topsoil overlying a relatively thin clayey silt till layer which overlies a layer of sand and silt. The sand and silt deposit is underlain by a discontinuous silt layer which in turn overlies a clayey silt till deposit, within which all boreholes at this site were terminated.

5.2.1 Topsoil

Topsoil was encountered in all the boreholes advanced at this site. The thickness of the topsoil encountered ranged from 225 to 300 mm in the boreholes. Measured moisture contents ranged from 33 to 44%.

5.2.2 Clayey Silt (Till)

A layer of dark brown to brown clayey silt till containing some sand to sandy was encountered below the topsoil in all boreholes. The thickness of the layer ranged from 1.0 to 1.3 m with the lower boundary at 1.2 to 1.5 m depth (elevation 216.0 to 215.6).

SPT 'N' values of 3 to 21 blows per 0.3 m penetration were obtained in the clayey silt till, indicating a soft to very stiff consistency. Measured moisture contents ranged from 19 to 48% and typically from 20 to 35%.

The results of grain size distribution testing carried out on a cohesive sample are shown on Figure B1 included in Appendix B. The test results indicate that the clayey silt contains 5% gravel, 40% sand, 40% silt and 15% clay.

5.2.3 Sand and Silt

A brown sand and silt layer was encountered below the clayey silt in all boreholes. The sand and silt contains trace clay and trace to some gravel. The thickness of the sand and silt ranged from 2.7 to 4.3 m, with the lower boundary at 4.1 to 5.5 m depth (elevation 213.1 to 211.7). A layer of silty sand was encountered within the sand and silt in borehole C17-03.

SPT 'N' values recorded in the sand and silt deposit ranged from 9 to 22 blows per 0.3 m penetration, indicating a loose to compact relative density. Measured moisture contents ranged from 9 to 23%.

The results of two grain size distribution tests carried out on the cohesionless samples are shown on Figure B2 included in Appendix B and also summarized below:

Gravel (%)	0 to 11
Sand (%)	51 to 59
Silt (%)	23 to 45
Clay (%)	4 to 7

5.2.4 Silt

A discontinuous layer of reddish brown to brown silt containing some clay and trace sand was encountered below the sand and silt in boreholes C17-01 and C17-03. The thickness of the layer ranged from 1.3 to 2.1 m, with the lower boundary at 5.6 to 6.2 m depth (elevation 211.5 to 211.0). A 500 mm thick layer of silt was also encountered in borehole C17-02 at 4.3 m depth (elevation 212.9).

SPT 'N' values of 7 and 8 blows per 0.3 m penetration were obtained in the silt, indicating a loose relative density. Measured moisture contents ranged from 13 to 26%.

The results of two grain size distribution tests carried out on the silt samples are shown on Figure B3 included in Appendix B and also summarized below:

Gravel (%)	0
Sand (%)	0 to 3
Silt (%)	85 to 87
Clay (%)	12 to 13

5.2.5 Clayey Silt (Till)

A layer of brown clayey silt till was encountered below the silt in boreholes C17-01 and C17-03, and below the sand and silt in borehole C17-02. The till contains some sand to sandy and occasional shale fragments. All boreholes were terminated within this layer at 9.8 m depth (elevation 207.3 to 207.4).

SPT 'N' values of 40 to 102 blows per 0.3 m penetration were recorded in the till deposit, indicating a hard consistency. Measured moisture contents ranged from 9 to 15%.

The results of grain size distribution testing carried out on a cohesive till sample are shown on Figure B4 included in Appendix B. The test results indicate that the till contains 1% gravel, 28% sand, 52% silt and 19% clay.

5.2.6 Water Levels

The groundwater depths and elevations measured in the monitoring well and standpipe piezometer after the drilling are summarized in the following table.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
C17-01	Nov. 25, 2014	0.6	216.6	In monitoring well
	Dec. 19, 2014	0.2	217.0	In monitoring well
C17-03	Nov. 25, 2014	1.0 *	218.1	In piezometer
	Dec. 19, 2014	0.7 *	217.8	In piezometer

* Water level above ground surface

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

5.3 Culvert 18 (Boreholes C18-01 to C18-04D)

The subsurface stratigraphy encountered in the boreholes drilled at Culvert 18 consists of topsoil or highway platform fill underlain by a thin layer of clayey silt till which overlies a sand and silt layer followed by deep deposit of silt. Clayey silt till was encountered below the silt in two boreholes.

5.3.1 Pavement Structure and Fill

A 225 mm thick layer of asphalt was encountered in Boreholes C18-04 to C18-04D drilled along the paved shoulder of Highway 401.

Sand and gravel fill was encountered below the asphalt layer. SPT 'N' values of 10 to 33 blows per 0.3 m were obtained in the granular fill, indicating a compact to dense condition. Moisture contents ranged from 2 to 9%. The depth to the base of the granular material was as follows:

Borehole	Location	Lower Boundary of Granular Fill	
		Depth (m)	Elevation
C18-04A	15 m west of west side of culvert	0.7	219.8
C18-04B	5 m west of west side of culvert	> 3.7	below 216.8
C18-04	2 m east of east side of culvert	3.0	217.5
C18-04C	9 m east of east side of culvert	1.5	219.0
C18-04D	16 m east of east side of culvert	0.9	219.6

Additional fill material was encountered below the granular material in Boreholes C18-04A, C18-04C and C18-04D. The fill consisted of silty sand to sand with some silt in Borehole C18-04A, silty clay over additional sand and gravel in Borehole C18-04C, and silty clay in Borehole C18-04D. SPT 'N' values ranged from 16 to 44 blows per 0.3 m (compact to dense) in the cohesionless fill, and from 7 to 13 blows per 0.3 m in the silty clay fill. Moisture contents varied from 4 to 19%.

Borehole C18-04B was terminated in the fill at 3.7 m depth (elevation 216.8). The lower boundary of the fill was encountered at depths of 2.2 to 3.0 m depth (elevation 218.3 to 217.5) in the remaining boreholes.

5.3.2 Topsoil

Topsoil was encountered in all off-road boreholes drilled at this site. The thickness of the topsoil encountered ranged from 100 to 300 mm in the boreholes. Measured moisture contents ranged from 30 to 55%.

5.3.3 Clayey Silt (Till)

A layer of brown sandy clayey silt till was encountered below the topsoil in all boreholes except Borehole C18-04B. The thickness of the layer ranged from 0.5 to 2.0 m with the lower boundary at 0.8 to 4.1 m depth (elevation 217.1 to 215.8). Boreholes C18-04A,

C18-04C and C18-04D were terminated in the till at depths of 3.3 to 3.7 m (elevation 217.2 to 216.8).

SPT 'N' values of 3 to 15 blows per 0.3 m penetration were obtained in the clayey silt till, indicating a soft to stiff consistency. A higher 'N' value of 50 blows/0.125 m was obtained on a probable cobble at the base of Borehole C18-04A. Measured moisture contents ranged from 7 to 31%.

The results of two grain size distribution tests carried out on the cohesive samples are shown on Figure C1 included in Appendix C and also summarized below:

Gravel (%)	0
Sand (%)	26 to 29
Silt (%)	47 to 53
Clay (%)	21 to 24

5.3.4 Sand and Silt

A brown to grey sand and silt layer was encountered below the clayey silt in boreholes C18-02 to C18-04. The sand and silt contains trace to some clay. The thickness of the sand and silt ranged from 1.6 to 3.2 m, with the lower boundary at 2.4 to 7.2 m depth (elevation 215.5 to 213.2).

SPT 'N' values recorded in the sand and silt deposit ranged from 12 to 34 blows per 0.3 m penetration, indicating a compact to dense relative density. Measured moisture contents ranged from 9 to 21%.

The results of a grain size distribution test carried out on a cohesionless sample are shown on Figure C2 included in Appendix C. The test results indicate that the sand and silt contains 0% gravel, 47% sand, 41% silt and 12% clay.

5.3.5 Silt

A layer of brown to grey silt was encountered below the clayey silt in borehole C18-01 and below the sand and silt in boreholes C18-02 to C18-04. The thickness of the silt layer was 1.5 and 2.1 m in boreholes C18-03 and C18-04, with the lower boundary at depths of 5.6 and 9.3 m (elevation 211.7 and 211.2). Boreholes C18-01 and C18-02 were both terminated within the silt at 9.8 m depth (elevation 208.1).

SPT 'N' values obtained in the silt ranged from 0 to 18 blows per 0.3 m penetration, and typically from 4 to 11, indicating a loose to compact relative density. Low SPT 'N' values of 0 and 1 were likely associated with the soil disturbance during drilling. Measured moisture contents ranged from 13 to 24%, locally 31% in one sample.

The results of four grain size distribution tests carried out on the silt samples are shown on Figure C3 included in Appendix C and also summarized below:

Gravel (%)	0
Sand (%)	2 to 8
Silt (%)	81 to 89
Clay (%)	9 to 11

5.3.6 Clayey Silt (Till)

A brown to grey clayey silt till layer was encountered below the silt in boreholes C18-03 and C18-04. The till contains some sand to sandy. Boreholes C18-03 and C18-04 were terminated within this layer at 9.8 m depth (elevation 207.5 and 210.7).

SPT 'N' values recorded in the till deposit ranged from 19 to 65 blows per 0.3 m penetration, indicating a very stiff to hard consistency. Measured moisture contents ranged from 11 to 17%.

The results of a grain size distribution test carried out on a clayey silt till sample are shown on Figure C4 included in Appendix C. The test results indicate that the till contains 0% gravel, 29% sand, 47% silt and 24% clay.

5.3.7 Water Levels

The groundwater levels observed in the open borehole during drilling and measured in the monitoring well and standpipe piezometer after the drilling are summarized in the following table.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
C18-01	Sept. 8, 2014	1.2	216.7	In open borehole
	Nov. 26, 2014	0.9 *	218.8	In piezometer
	Dec. 19, 2014	0.4	217.5	In piezometer
C18-02	Nov. 26, 2014	0.7 *	218.6	In monitoring well
	Dec. 19, 2014	Frozen	-	In monitoring well

* Water level above ground surface

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

5.4 Culvert 19 (Boreholes C19-01 to C19-03)

The subsurface stratigraphy encountered in the boreholes drilled at Culvert 19 consists of topsoil underlain by a thin layer of clayey silt to silty clay till which overlies silt and/or sand and silt, then clayey silt till.

5.4.1 Topsoil

Topsoil was encountered in all the boreholes drilled at this site. Thickness of the topsoil encountered ranged from 100 to 610 mm in the boreholes. Measured moisture contents ranged from 39 to 50%.

5.4.2 Clayey Silt to Silty Clay (Till)

A layer of dark brown to brown clayey silt to silty clay till was encountered below the topsoil in all boreholes. The cohesive layer contains some sand to sandy. Thickness of the layer ranged from 1.3 to 2.0 m with the lower boundary at 1.5 to 2.2 m depth (elevation 215.5 to 214.0).

SPT 'N' values of 5 to 28 blows per 0.3 m penetration were obtained in the cohesive layer, indicating a firm to very stiff consistency. Measured moisture contents ranged from 13 to 35%.

The results of two grain size distribution tests carried out on the cohesive samples are shown on Figure D1 included in Appendix D and also summarized below:

Gravel (%)	0
Sand (%)	19 to 27
Silt (%)	45 to 59
Clay (%)	14 to 36

The results of Atterberg Limits testing carried out on a silty clay till sample are shown on Figure D5 included in Appendix D and also summarized below:

Liquid Limit	36%
Plastic Limit	19%
Plasticity Index	17%

5.4.3 Silt

A discontinuous layer of grey silt containing some clay and trace sand was encountered below the silty clay in borehole C19-01. Thickness of the layer was 2.0 m with the lower boundary at 4.1 m depth (elevation 213.5).

SPT 'N' values of 41 and 22 blows per 0.3 m penetration were obtained in the silt, indicating a compact to dense relative density. Measured moisture contents ranged from 12 to 19%.

The results of a grain size distribution test carried out on a silt sample are shown on Figure D2 included in Appendix D. The test results indicate that the silt contains 0% gravel, 3% sand, 82% silt and 15% clay.

5.4.4 Sand and Silt

A brown to grey sand and silt layer was encountered below the silt in borehole C19-01 and below the clayey silt in boreholes C19-02 and C19-03. The sand and silt contains trace clay. Thickness of the sand and silt ranged from 1.9 to 3.6 m, with the lower boundary at 3.4 to 7.7 m depth (elevation 212.7 to 209.9).

SPT 'N' values recorded in the sand and silt deposit ranged from 8 to 21 blows per 0.3 m penetration, indicating a loose to compact relative density. Measured moisture contents ranged from 16 to 26%.

The results of a grain size distribution test carried out on a cohesionless sample are shown on Figure D3 included in Appendix D. The test results indicate that the sand and silt contains 0% gravel, 35% sand, 63% silt and 2% clay.

5.4.5 Clayey Silt (Till)

A layer of brown clayey silt till was encountered below the sand and silt in all boreholes. The till was described as sandy. All boreholes were terminated within this layer at 8.2 to 9.8 m depth (elevation 208.0 to 206.3).

SPT 'N' values of 15 to 68 blows per 0.3 m penetration were recorded in the till, indicating a very stiff to hard consistency. Measured moisture contents ranged from 10 to 18%.

The results of two grain size distribution tests carried out on the till samples are shown on Figure D4 included in Appendix D and also summarized below:

Gravel (%)	0 to 3
Sand (%)	24 to 27
Silt (%)	43 to 53
Clay (%)	23 to 27

The results of Atterberg Limits testing carried out on a till sample are shown on Figure D5 included in Appendix D and also summarized below:

Liquid Limit	24%
Plastic Limit	14%
Plasticity Index	10%

5.4.6 Water Levels

The groundwater levels measured in the monitoring well and standpipe piezometer after the drilling are summarized in the following table.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
C19-01	Nov. 25, 2014	2.6	215.0	In piezometer
	Dec. 19, 2014	1.5	216.1	In piezometer
C19-03	Nov. 25, 2014	0.4 *	216.6	In monitoring well
	Dec. 19, 2014	0.5 *	216.7	In monitoring well

* Water level above ground surface

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

5.5 Culvert 20 (Boreholes C20-01 and C20-02)

The subsurface stratigraphy encountered in the boreholes drilled at Culvert 20 consists of topsoil underlain by a thin layer of clayey silt till which overlies sand and silt to silt.

5.5.1 Topsoil

Topsoil was encountered in both boreholes drilled at this site. The thickness of the topsoil encountered was about 300 mm in the boreholes.

5.5.2 Clayey Silt (Till)

A layer of brown to reddish brown clayey silt till was encountered below the topsoil in both boreholes. The till contains some sand to sandy and trace gravel. The thickness of the layer ranged from 1.3 to 2.7 m with the lower boundary at 1.6 to 3.0 m depth (elevation 215.3 to 213.7).

SPT 'N' values of 5 to 26 blows per 0.3 m penetration were obtained in the till, indicating a firm to very stiff consistency, typically very stiff below 0.6 m depth. Measured moisture contents ranged from 14 to 26%.

5.5.3 Sand and Silt to Sandy Silt

A brown to grey sand and silt to sandy silt layer was encountered below the clayey silt till in both boreholes. The sand and silt contains trace clay. Both boreholes were terminated within this layer at 5.2 m depth (elevation 211.7 to 211.5).

SPT 'N' values recorded in the sand and silt deposit ranged from 8 to 22 blows per 0.3 m penetration, indicating a loose to compact relative density. Measured moisture contents ranged from 16 to 19%.

The results of two grain size distribution tests carried out on the cohesionless samples are shown on Figure E1 included in Appendix E and also summarized below:

Gravel (%)	0
Sand (%)	21 to 40
Silt (%)	57 to 70
Clay (%)	3 to 9

5.5.4 Silt

A discontinuous layer of brown silt containing trace clay was encountered within the sand and silt layer in borehole C20-02. The thickness of the layer was 0.7 m with the lower boundary at 3.0 m depth (elevation 213.9).

An SPT 'N' value of 27 blows per 0.3 m penetration was obtained in the silt, indicating a compact relative density. Measured moisture content was about 19%.

The results of a grain size distribution test carried out on a silt sample are shown on Figure E2 included in Appendix E. The test results indicate that the silt contains 0% gravel, 0% sand, 91% silt and 9% clay.

5.5.5 Water Levels

The groundwater levels observed in the open borehole and measured in the monitoring well after the drilling are summarized in the following table.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
C20-01	Nov. 25, 2014	0.7	216.0	In monitoring well
	Dec. 19, 2014	0.5	216.2	In monitoring well
C20-02	Sept. 12, 2014	4.2	212.7	In open borehole

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

5.6 Culvert 21 (Boreholes C21-01 to C21-03)

The subsurface stratigraphy encountered in the boreholes drilled at Culvert 21 consists of topsoil underlain by a thin layer of silty clay till which overlies silt, then sand and silt, over clayey silt till.

5.6.1 Topsoil

Topsoil was encountered in all the boreholes drilled at this site. The thickness of the topsoil encountered ranged from 200 to 300 mm in the boreholes.

5.6.2 Silty Clay (Till)

A layer of dark brown to brown silty clay till was encountered below the topsoil in all boreholes. The till contains some sand to sandy. The thickness of the layer ranged from 1.2 to 2.7 m with the lower boundary at 1.4 to 3.0 m depth (elevation 216.3 to 215.0).

SPT 'N' values of 6 to 27 blows per 0.3 m penetration were recorded in the layer, indicating a firm to very stiff consistency, typically very stiff below 0.6 to 1.5 m depth. Moisture contents ranged from 16 to 31%.

The results of a grain size distribution test carried out on a silty clay till sample are shown on Figure F1 included in Appendix F. The test results indicate that the clayey silt contains 0% gravel, 32% sand, 42% silt and 26% clay.

5.6.3 Silt

A discontinuous layer of brown silt was encountered below the silty clay till in boreholes C21-02 and C21-03. The silt contains trace to some clay and sand. The layer thickness ranged between 1.8 and 2.7 m with the lower boundary at 4.1 m depth (elevation 213.6 and 213.2).

SPT 'N' values of 17 to 39 blows per 0.3 m penetration were obtained in the silt, indicating a compact to dense relative density. Measured moisture contents ranged from 16 to 19%.

The results of two grain size distribution tests carried out on the silt samples are shown on Figure F2 included in Appendix F and also summarized below:

Gravel (%)	0
Sand (%)	0 to 12
Silt (%)	81 to 82
Clay (%)	7 to 18

5.6.4 Sand and Silt

A layer of brown to grey sand and silt was encountered below the silty clay till in borehole C21-01 and below the silt in boreholes C21-02 and C21-03. The sand and silt contains trace clay. The thickness of the sand and silt ranged from 1.5 to 3.1 m, with the lower boundary at 5.6 to 7.2 m depth (elevation 213.0 to 210.1).

SPT 'N' values recorded in the sand and silt deposit ranged from 11 to 14 blows per 0.3 m penetration, indicating a compact relative density. Measured moisture contents ranged from 17 to 20%.

The results of a grain size distribution test carried out on a sand and silt sample are shown on Figure F3 included in Appendix F. The test results indicate that the sand and silt contains 0% gravel, 52% sand, 45% silt and 3% clay.

5.6.5 Clayey Silt to Silt, some Clay (Till)

A layer of brown to grey clayey silt to silt till with some clay was encountered below the sand and silt in all boreholes. The till contains trace sand to sandy. All boreholes were terminated within this layer at 9.8 m depth (elevation 208.8 to 207.5).

SPT 'N' values of 23 to 57 blows per 0.3 m penetration were recorded in the till, indicating a very stiff to hard consistency. Measured moisture contents ranged from 10 to 17%.

The results of two grain size distribution tests carried out on the till samples are shown on Figure F4 included in Appendix F and also summarized below:

Gravel (%)	0 to 3
Sand (%)	6 to 19
Silt (%)	52 to 82
Clay (%)	12 to 26

The results of Atterberg Limits testing carried out on a till sample are shown on Figure F5 included in Appendix F and also summarized below:

Liquid Limit	22%
Plastic Limit	13%
Plasticity Index	9%

5.6.6 Water Levels

The groundwater levels observed in the open borehole and measured in the monitoring well and standpipe piezometer after the drilling are summarized in the following table.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
C21-01	Nov. 26, 2014	0.6	218.0	In piezometer
	Dec. 19, 2014	Frozen	-	In piezometer
C21-02	Sept. 3, 2014	2.9	214.8	In open borehole
C21-03	Dec. 19, 2014	0.2	217.1	In monitoring well

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

5.7 Culvert 22 (Boreholes C22-01 to C22-03)

The subsurface stratigraphy encountered in the boreholes drilled at Culvert 22 consists of topsoil underlain by successive layers of silty clay till, silt, sand and silt, and silt overlying clayey silt till.

5.7.1 Topsoil

Topsoil was encountered in all boreholes drilled at this site. The thickness of the topsoil encountered ranged from 125 to 200 mm in the boreholes.

5.7.2 Silty Clay (Till)

A layer of brown silty clay till was encountered below the topsoil in all boreholes. The cohesive layer contains some sand to sandy. The layer thickness ranged from 1.2 to 1.3 m with the lower boundary at 1.4 to 1.5 m depth (elevation 218.0 to 217.3).

SPT 'N' values of 10 to 22 blows per 0.3 m penetration were recorded in the layer, indicating a stiff to very stiff consistency. Moisture contents ranged from 11 to 20%.

The results of a grain size distribution test carried out on a till sample are shown on Figure G1 included in Appendix G and also summarized below:

Gravel (%)	0
Sand (%)	19
Silt (%)	47
Clay (%)	34

The results of Atterberg Limits testing carried out on the silty clay till sample are shown on Figure G5 included in Appendix G and also summarized below:

Liquid Limit	30%
Plastic Limit	17%
Plasticity Index	13%

5.7.3 Silt

A thin layer of silt was encountered below the silty clay till in all boreholes. The silt contains some clay to clayey. The thickness of the silt layer ranged from 0.7 to 0.9 m, with a lower boundary at depths of 2.2 to 2.3 m (elevation 217.1 to 216.6).

SPT 'N' values of 17 to 26 blows per 0.3 m penetration were recorded in the silt, indicating a very stiff consistency. Moisture contents ranged from 18 to 22%.

The results of a grain size distribution analysis conducted on the silt are shown on Figure G2 in Appendix G. The results indicate that the silt contains 81% silt and 19% clay.

5.7.4 Sand and Silt

A layer of brown sand and silt was encountered below the silt in all boreholes. The sand and silt contains trace clay. The thickness of the sand and silt ranged from 1.8 to 2.2 m, with the lower boundary at 4.1 to 4.4 m depth (elevation 215.3 to 214.5).

SPT 'N' values recorded in the sand and silt deposit ranged from 10 to 21 blows per 0.3 m penetration, indicating a compact relative density. Measured moisture contents ranged from 17 to 21%.

The results of two grain size distribution tests carried out on the cohesionless samples are shown on Figure G3 included in Appendix G and also summarized below:

Gravel (%)	0
Sand (%)	38 to 53
Silt (%)	44 to 57
Clay (%)	3 to 5

5.7.5 Silt

A layer of brown silt was encountered below the sand and silt in all boreholes. The silt contains trace to some clay. The layer thickness ranged from 1.4 and 3.1 m with the lower boundary at 5.7 to 7.2 m depth (elevation 213.1 to 212.2).

SPT 'N' values of 14 to 18 blows per 0.3 m penetration were obtained in the silt, indicating a compact relative density. Measured moisture contents ranged from 16 to 22%.

The results of a grain size distribution test carried out on a silt sample are shown on Figure G2 included in Appendix G. The test results indicate that the silt contains 0% gravel, 0% sand, 87% silt and 13% clay.

5.7.6 Clayey Silt to Silt, some Clay (Till)

A layer of brown to grey clayey silt to silt till with some clay was encountered below the silt in all boreholes. The till contains some sand to sandy. All boreholes were terminated within this layer at 9.8 m depth (elevation 209.6 to 209.0).

SPT 'N' values of 20 to 82 blows per 0.3 m penetration, typically 20 to 39 blows per 0.3 m penetration, were recorded in the till, indicating a very stiff to hard consistency. Measured moisture contents ranged from 11 to 18%.

The results of two grain size distribution tests carried out on the till samples are shown on Figure G4 included in Appendix G and also summarized below:

Gravel (%)	0
Sand (%)	14 to 18
Silt (%)	62 to 69
Clay (%)	17 to 20

5.7.7 Water Levels

The groundwater levels observed in the open borehole and measured in the monitoring well and standpipe piezometer after the drilling are summarized in the following table.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
C22-01	Nov. 26, 2014	1.0	218.4	In monitoring well
	Dec. 19, 2014	0.5	218.9	In monitoring well
C22-02	Aug. 28, 2014	2.5	216.6	In open borehole
C22-03	Nov. 26, 2014	0.2	217.1	In piezometer
	Dec. 19, 2014	0.6	218.2	In piezometer

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

5.8 Culvert 23 (Boreholes C23-01 and C23-02)

The subsurface stratigraphy encountered in the boreholes drilled at Culvert 23 consists of topsoil underlain by a layer of silty clay till overlying silt.

5.8.1 Topsoil

Topsoil was encountered in both boreholes drilled at this site. The thickness of the topsoil encountered ranged between 100 and 200 mm in the boreholes.

5.8.2 Silty Clay (Till)

A layer of brown to reddish brown silty clay till was encountered below the topsoil in both boreholes. The till contains some sand to sandy and trace gravel. The layer thickness ranged between 3.4 and 4.0 m with the lower boundary at 3.6 and 4.1 m depth (elevation 213.4 and 212.6).

SPT 'N' values of 5 to 37 blows per 0.3 m penetration were obtained in the till (25 blows or greater below 0.6 m depth), indicating a firm to hard consistency. Measured moisture contents ranged from 10 to 29%, typically 10 to 15%.

The results of two grain size distribution tests carried out on the till samples are shown on Figure H1 included in Appendix H and also summarized below:

Gravel (%)	0 to 7
Sand (%)	20 to 24
Silt (%)	41 to 52
Clay (%)	28

The results of two Atterberg Limits tests carried out on the till samples are shown on Figure H3 included in Appendix H and also summarized below:

Liquid Limit	28 to 29%
Plastic Limit	17%
Plasticity Index	11 to 12%

5.8.3 Silt

A layer of grey silt containing trace to some clay and trace sand was encountered below the till in both boreholes. Both boreholes were terminated within the silt at 5.2 m depth (elevation 211.8 and 211.5).

SPT 'N' values of 30 and 32 blows per 0.3 m penetration were obtained in the silt, indicating a dense relative density. Measured moisture content was about 11%.

The results of a grain size distribution test carried out on a silt sample are shown on Figure H2 included in Appendix H. The test results indicate that the silt contains 0% gravel, 7% sand, 82% silt and 11% clay.

5.8.4 Water Levels

The groundwater levels observed in the open borehole and measured in the monitoring well and standpipe piezometer after the drilling are summarized in the following table.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
C23-01	Sept. 15, 2014	dry	-	In open borehole
	Nov. 25, 2014	0.6	216.4	In monitoring well
	Dec. 19, 2014	0.3	216.7	In monitoring well
C23-02	Nov. 25, 2014	0.6	216.1	In piezometer
	Dec. 19, 2014	0.4	216.3	In piezometer

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

5.9 Culvert 24 (Boreholes C24-01 and C24-02)

The subsurface stratigraphy encountered in boreholes C24-01 and C24-02 drilled at Culvert 24 consists of fill or topsoil underlain by a layer of silty clay till overlying sand and silt.

5.9.1 Fill

Fill consisting of clayey silt over crushed shale was encountered in borehole C24-01. The thickness of the fill was about 0.6 m. An SPT 'N' value of 13 blows per 0.3 m (stiff) was recorded in the fill. Measured water contents were about 10%.

5.9.2 Topsoil

Topsoil was encountered in borehole C24-02. The thickness of the topsoil encountered was about 100 mm. Measured water content was about 34%.

5.9.3 Silty Clay (Till)

A layer of brown silty clay till was encountered below the fill and topsoil. The till contains some sand to sandy and trace gravel. The layer thickness was 4.0 to 4.2 m with the lower boundary at 4.1 and 4.8 m depth (elevation 214.1 and 215.0).

SPT 'N' values of 4 to 32 blows per 0.3 m penetration were obtained in the till (16 blows or greater below 0.6 m depth), indicating a firm to hard consistency. Measured moisture contents ranged from 10 to 17%.

The results of a grain size distribution test carried out on a till sample are shown on Figure I1 included in Appendix I. The test results indicated that the till contains 2% gravel, 26% sand, 47% silt and 25% clay.

The results of Atterberg Limits testing carried out on a till sample are shown on Figure I3 included in Appendix I and also summarized below:

Liquid Limit	28%
Plastic Limit	17%
Plasticity Index	11%

5.9.4 Sand and Silt

A layer of brown to grey sand and silt containing trace clay was encountered below the till. The boreholes were terminated within the sand and silt at 5.0 to 5.2 m depth (elevation 214.8 and 213.0).

SPT 'N' values of 8 and 22 blows per 0.3 m penetration was obtained in the sand and silt, indicating a loose to compact relative density. Measured moisture contents were about 18 to 21%.

The results of a grain size distribution test carried out on a sand and silt sample are shown on Figure I2 included in Appendix I. The test results indicate that the sand and silt contains 0% gravel, 45% sand, 50% silt and 5% clay.

5.9.5 Water Levels

The groundwater levels measured in the monitoring well after the drilling are summarized in the following table.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
C24-02	Nov. 26, 2014	0.8 *	219.0	In monitoring well
	Dec. 19, 2014	0.6	217.6	In monitoring well

* Water level above ground surface

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

5.10 Culvert 25 (Boreholes C25-01, C25-01A and C25-02)

The subsurface stratigraphy encountered in the boreholes drilled at Culvert 25 consists of fill or topsoil underlain by a layer of clayey silt till overlying sand and silt to silt. Additional layers of clayey silt till and sand and silt were encountered in borehole C25-01A drilled to advance borehole C25-01 to greater depth.

5.10.1 Asphalt

Asphalt pavement was encountered in borehole C25-01. The thickness of the asphalt encountered was about 50 mm.

5.10.2 Sand and Gravel (Fill)

A layer of brown sand and gravel fill was encountered in borehole C25-01. The thickness of the fill encountered was about 0.4 m.

5.10.3 Topsoil

Topsoil was encountered in borehole C25-02. The thickness of the topsoil encountered was about 225 mm. Measured water content was about 28%.

5.10.4 Clayey Silt (Till)

A layer of brown to grey sandy clayey silt till was encountered below the topsoil in both boreholes. The layer thickness ranged between 3.3 and 3.9 m with the lower boundary at 3.7 and 4.1 m depth (elevation 214.3 and 213.5).

SPT ‘N’ values of 5 to 52 blows per 0.3 m penetration were obtained in the till (16 blows or greater below 0.6 m depth), indicating a firm to hard consistency. Measured moisture contents ranged from 12 to 21%.

The results of two grain size distribution tests carried out on the till samples are shown on Figure J1 included in Appendix J and also summarized below:

Gravel (%)	0 to 2
Sand (%)	24 to 28
Silt (%)	46 to 53
Clay (%)	23 to 24

The results of Atterberg Limits testing carried out on a till sample are shown on Figure J4 included in Appendix J and also summarized below:

Liquid Limit	27%
Plastic Limit	16%
Plasticity Index	11%

5.10.5 Sand and Silt

A layer of grey sand and silt containing trace clay was encountered below the till in borehole C25-01. Borehole C25-01 was terminated within the sand and silt at 5.2 m depth (elevation 212.8). In borehole C25-01A, the lower boundary of the sand and silt layer was encountered at 5.9 m depth (elevation 212.1).

SPT ‘N’ values of 16 and 30 blows per 0.3 m penetration were obtained in the sand and silt, indicating a compact to dense relative density. An ‘N’ value of “0” was obtained in borehole C25-01A due to hydraulic disturbance. Measured moisture contents ranged between 14 and 24%.

The results of a grain size distribution test carried out on a sand and silt sample are shown on Figure J2 included in Appendix J. The test results indicate that the sand and silt contains 0% gravel, 37% sand, 59% silt and 4% clay.

5.10.6 Silt

A layer of grey silt containing trace clay and trace sand was encountered below the till in borehole C25-02. Borehole C25-02 was terminated within the silt at 5.2 m depth (elevation 212.4).

SPT 'N' value of 19 blows per 0.3 m penetration was obtained in the silt, indicating a compact relative density. Measured moisture content was about 18%.

The results of a grain size distribution test carried out on a silt sample are shown on Figure J3 included in Appendix J. The test results indicate that the silt contains 0% gravel, 4% sand, 91% silt and 5% clay.

5.10.7 Lower Clayey Silt (Till)

A second layer of sandy clayey silt till was encountered below the sand and silt in borehole C25-01A. The layer thickness was 2.8 m with the lower boundary at 8.7 m depth (elevation 209.3).

SPT 'N' values of 22 and 28 blows per 0.3 m penetration were obtained in the till, indicating a very stiff consistency. Measured moisture contents ranged from 10 to 12%.

The results of a grain size distribution test carried out on the lower till are included on Figure J1 in Appendix J and summarized below:

Gravel (%)	0
Sand (%)	24
Silt (%)	49
Clay (%)	27

The results of Atterberg Limits testing carried out on the till are shown on Figure J4 included in Appendix J and also summarized below:

Liquid Limit	21%
Plastic Limit	13%
Plasticity Index	8%

5.10.8 Lower Sand and Silt

A lower layer of sand and silt was encountered below the lower till in borehole C25-01A. Borehole C25-01A was terminated within the sand and silt at 11.3 m depth (elevation 206.7).

SPT 'N' values of 11 and 3 blows per 0.3 m penetration was obtained in the sand and silt, indicating a compact to very loose condition, possibly as a result of hydraulic disturbance. Moisture contents of 19 and 12% were measured.

5.10.9 Water Levels

The groundwater levels observed in the open borehole and measured in the monitoring well after the drilling are summarized in the following table. A piezometer installed in Borehole C25-01A was destroyed prior to reading.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
C25-01	May 2, 2014	3.5	214.5	In open borehole
C25-02	Oct. 27, 2014	4.6	213.0	In open borehole
	Nov. 26, 2014	0.2 *	217.8	In monitoring well
	Dec. 19, 2014	0.5 *	218.1	In monitoring well

* Water level above ground surface

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

5.11 Culvert 26 (Boreholes C26-01 and C26-02)

The subsurface stratigraphy encountered in the boreholes drilled at Culvert 26 consists of topsoil underlain by a layer of clayey silt till locally overlying silt.

5.11.1 Topsoil

Topsoil was encountered in both boreholes drilled at this site. The thickness of the topsoil encountered ranged between 50 and 75 mm.

5.11.2 Clayey Silt (Till)

A layer of brown to grey sandy clayey silt till was encountered below the topsoil in both boreholes. The layer thickness was about 4.0 m in borehole C26-01 with the lower boundary at 4.1 m depth (elevation 210.1). Borehole C26-02 was terminated within the till at 5.2 m depth (elevation 209.0).

SPT 'N' values of 6 to 69 blows per 0.3 m penetration were obtained in the till (17 blows or greater below 0.6 m depth), indicating a firm to hard consistency. Measured moisture contents ranged from 8 to 35%, typically 8 to 16%.

The results of three grain size distribution tests carried out on the till samples are shown on Figure K1 included in Appendix K and also summarized below:

Gravel (%)	3 to 6
Sand (%)	25 to 32
Silt (%)	42 to 46
Clay (%)	18 to 27

The results of two Atterberg Limits tests carried out on the till sample are shown on Figure K3 included in Appendix K and also summarized below:

Liquid Limit	25 to 28%
Plastic Limit	15 to 19%
Plasticity Index	9 to 10%

5.11.3 Silt

A layer of grey silt containing trace clay and trace sand was encountered below the till in borehole C26-01. Borehole C26-01 was terminated within the silt at 5.2 m depth (elevation 209.0).

An SPT 'N' value of 32 blows per 0.3 m penetration was obtained in the silt, indicating a dense relative density. Measured moisture content was about 18%.

The results of a grain size distribution test carried out on a silt sample are shown on Figure K2 included in Appendix K. The test results indicate that the silt contains 0% gravel, 9% sand, 84% silt and 7% clay.

5.11.4 Water Levels

The groundwater levels observed in the open borehole and measured in the monitoring well after the drilling are summarized in the following table.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
C26-01	Oct. 27, 2014	5.0	209.2	In open borehole
	Nov. 26, 2014	0.9 *	215.1	In monitoring well
	Dec. 19, 2014	Frozen	-	In monitoring well

* Water level above ground surface

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

5.12 Culvert 27 (Boreholes C27-01 and C27-02)

The subsurface stratigraphy encountered in the boreholes drilled at Culvert 27 consists of topsoil underlain by a layer of silty clay till overlying sand and silt.

5.12.1 Topsoil

Topsoil was encountered in both boreholes drilled at this site. The thickness of the topsoil encountered ranged between 150 and 300 mm.

5.12.2 Silty Clay (Till)

A layer of brown to reddish brown silty clay till was encountered below the topsoil in both boreholes. The till contains some sand to sandy. The layer thickness ranged between 2.7 and 2.8 m with the lower boundary at 3.0 m depth (elevation 214.0 and 213.3).

SPT 'N' values of 5 to 48 blows per 0.3 m penetration were obtained in the till (20 blows or greater below 0.6 m depth), indicating a firm to hard consistency. Measured moisture contents ranged from 11 to 25%, typically 11 to 16%.

The results of two grain size distribution tests carried out on the till samples are shown on Figure L1 included in Appendix L and also summarized below:

Gravel (%)	0
Sand (%)	18 to 23
Silt (%)	48 to 50
Clay (%)	29 to 32

5.12.3 Sand and Silt

A layer of grey sand and silt containing trace clay was encountered below the till in both boreholes. Both boreholes were terminated within the sand and silt at 5.2 m depth (elevation 211.8 and 211.1).

SPT 'N' values of 19 to 31 blows per 0.3 m penetration were obtained in the sand and silt, indicating a compact to dense relative density. Measured moisture contents ranged from 17 to 18%.

The results of a grain size distribution test carried out on a sand and silt sample are shown on Figure L2 included in Appendix L. The test results indicate that the sand and silt contains 0% gravel, 41% sand, 55% silt and 4% clay.

5.12.4 Water Levels

The sand and silt layer was described as wet. Based on the soil description, moisture content profile, and groundwater levels measured in monitoring wells installed at the adjacent grade separation structure and Culvert 16, the stabilized groundwater level is expected to be at approximate Elev. 216.0.

The water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

5.13 3rd Side Road Channel Structure (Boreholes C3S-01 to C3S-03)

The subsurface stratigraphy encountered in the boreholes drilled at 3rd Side Road Channel Structure consists of topsoil or fill underlain by silty clay till clayey silt till interrupted by a relatively thin silt layer.

5.13.1 Fill

A 500 mm thick layer of sand and gravel fill was encountered in borehole C3S-03 drilled on 3rd Side Road.

5.13.2 Topsoil

Topsoil of about 300 mm in thickness was encountered in boreholes C3S-01 and C3S-02.

5.13.3 Silty Clay (Till)

A layer of brown to light brown sandy silty clay till was encountered below the topsoil in both boreholes. The clay till layer was 2.0 to 3.1 m thick with a lower boundary at 2.3 to 3.4 m depth (elevation 210.2 and 209.4) in Boreholes C3S-01 and C3S-02. Borehole C3S-03 was terminated in the till at 12.8 m depth (elevation 200.4).

SPT 'N' values obtained in the till ranged from 3 to 47 blows per 0.3 m penetration, and 17 to 49 below 0.6 m depth, indicating a very stiff to hard consistency. Measured moisture contents ranged from 9 to 30%, and typically 9 to 14%.

The results of grain size distribution tests carried out on till samples are shown on Figure M1 included in Appendix M and also summarized below:

Gravel (%)	0 to 4
Sand (%)	16 to 24
Silt (%)	43 to 48
Clay (%)	28 to 33

The results of two Atterberg Limits tests carried out on the till sample are shown on Figure M3 included in Appendix M and also summarized below:

Liquid Limit	26 to 31%
Plastic Limit	16 to 19%
Plasticity Index	10 to 12%

5.13.4 Silt

A relatively thin layer of brown to grey silt containing trace to some clay was encountered within the till deposits in boreholes C3S-01 and C3S-02 at 2.3 and 3.4 m depth, with the lower boundary at 3.5 and 4.6 m depth (elevation 209.0 and 208.2).

SPT 'N' values of 11 to 28 blows per 0.3 m penetration were obtained in the silt, indicating a compact relative density. Measured moisture contents ranged from 10 to 21%.

The results of a grain size distribution test carried out on a silt sample are shown on Figure M2 included in Appendix M. The test results indicate that the silt contains 0% gravel, 0% sand, 88% silt and 12% clay.

5.13.5 Clayey Silt (Till)

Clayey silt till was encountered below the silt layer. The till contains some sand to sandy. Boreholes C3S-01 and C3S-02 were terminated within the till at 9.8 m depth (elevation 202.7 and 203.0).

SPT 'N' values obtained in the till ranged from 28 to 62 blows per 0.3 m penetration, indicating a very stiff to hard consistency. Moisture contents of 9 to 22%, typically around 10% was measured.

The results of two grain size distribution analyses conducted on the till are presented on Figure M1 in Appendix M and are summarized below:

Gravel (%)	2 to 6
Sand (%)	22 to 24
Silt (%)	45 to 53
Clay (%)	23 to 25

5.13.6 Water Levels

The groundwater levels measured in the monitoring well after the drilling are summarized in the following table.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
C3S-01	Dec. 19, 2014	Frozen	-	In monitoring well
	Oct. 12, 2016	Damaged	-	
C3S-02	Nov. 26, 2014	0.8	212.0	In monitoring well
	Dec. 19, 2014	0.3 *	213.1	In monitoring well

* Water level above ground surface

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

6 MISCELLANEOUS

MMM Group Limited staked out boreholes and determined the co-ordinates and ground elevations at borehole locations prior to the site investigation.

DBW Drilling of North York, Ontario, Walker Drilling of Utopia, Ontario, and Determination Drilling of Hamilton, Ontario, supplied and operated the drilling and sampling equipment for the field program.

Full time supervision of the field activities, including obtaining utility clearances, was carried out by various field technicians provided by Thurber Engineering. Overall supervision of the field program was performed by Mr. Matthew Whalen and Keli Shi, P.Eng. of Thurber.

Interpretation of the field data and preparation of the report was performed by Mr. Keli Shi, P.Eng. The report was reviewed by Mr. Murray Anderson, P.Eng., and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Review Principal



**FOUNDATION INVESTIGATION AND DESIGN REPORT
NEW TREMAINE ROAD INTERCHANGE AT HIGHWAY 401
CULVERTS**

Geocres Number: 30M12-381

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical recommendations for design of the culverts and channel structure.

Construction of the new Tremaine Road interchange at Highway 401 will include installation of ten new culverts under various interchange ramps, extension of three existing culverts under Highway 401, and construction of a new channel structure at 3rd Side Road.

Based on the General Arrangement drawings and profile drawings provided by MMM Group, the structure designations, locations and approximate invert levels are summarized in Table 7.1. Details regarding the proposed structure and culvert design, where available, are also provided.

Table 7.1 – Proposed Structure and Culvert Details

Structure No.	Facility	Structure Type	Culvert Size (m)		Proposed Invert Elevation (m)
			Span x Height	Length	
16A	Tremaine Road	Rigid frame open footing	14.6 x 6.0±	40.4	213.8 to 213.5
16B	S-E Ramp		14.6 x 5.5±	10.5	213.2 to 213.1
17	W-N/S Ramp	Open footing	5.0 x 2.0	31.0	216.5 to 216.3
18 (Extension)	N-W Ramp	Open footing	3.0 x 1.5	31.0	217.3 to 217.2
	401 EBL		3.0 x 1.5	13.2	216.7 to 216.6
19	W-N/S Ramp	Closed box	1.8 x 1.2	56.9	214.9 to 214.6
20	N-E Ramp	Undefined	-		215.3
21 (Extension)	S-W SCL	Undefined	-		-
	401 EBL		-		-
22	N-W Ramp	Closed box	1.8 x 1.2	52.4	218.2 to 218.0
23	S-E Ramp	Pipe	-		215.5
24	S-W Ramp	Undefined	-		217.7
25	E-N/S Ramp	Undefined	-		215.6
26 (Extension)	E-N/S SCL	Pipe	-		214.0
	S-E Ramp	Pipe	-		212.7
27	Carpool Access	Undefined	-		-
C3S	3 rd Side Road	Box Girder Deck Bridge	9.1 x 1.5±	15.5 (span)	210.5±

The discussion and recommendations presented in this report are based on the information provided by MMM Group Limited and on the factual data obtained in the course of the investigation.

8 FOUNDATION DESIGN

Proposed Structures 16A, 16B and C3S are relatively large span structures, and initial consideration was given to supporting the structures using the following foundation types:

- Spread footings on native soil or engineered fill
- Driven steel H-piles
- Drilled shafts (Caissons)

Preliminary General Arrangement drawings for Culverts 17, 18, 19 and 22 indicate that these structures will be either open footing or closed box concrete culverts. GA drawings were not available for the remaining culverts, and it is assumed that these culverts will comprise either small concrete boxes or CSPs.

A comparison of the technical advantages and disadvantages of the different foundation schemes and culvert types is presented in Appendix N.

Foundation recommendations specific to each structure or culvert site are presented below, followed by general recommendations at all sites.

8.1 Structures 16A (Tremaine Road) and 16B (S-E Ramp)

In general, the subsurface conditions encountered at this site consist of very stiff to hard silty clay to clayey silt till underlain by discontinuous layers of loose to dense silt to sand and silt, which overlie a relatively thick layer of very stiff to hard clayey silt to silt till. The till is interbedded with compact to very dense sand and silt to gravelly sand deposits. Shale bedrock was encountered below the till at depths of 16.9 to 21.9 m.

Groundwater levels observed during drilling were 1.8 to 5.2 m below the ground surface. Groundwater levels measured in the monitoring wells with screens installed in the lower till deposit were 0.2 to 1.5 m above the ground surface, at elevation 215.8 to 216.5.

8.1.1 Spread footings on Native Soil or Engineered Fill

Based on the subsurface conditions encountered at this site, consideration may be given to supporting the proposed culverts on spread footings. However, footings are not the recommended foundation option in view of the loose/wet zones encountered at the anticipated founding levels, as well as the high groundwater level at the site.

Based on the preliminary GA drawings, the design founding level is expected to be near elevation 212.0. The subgrade soil at this level generally comprises cohesionless silt to

sand and silt. The silt/sand is compact under Structure 16B and the east half of Structure 16A, and loose along the west half of Structure 16A.

In general, spread footings founded on the native compact silts and sands should be designed using the following resistance values, assuming a minimum 2 m wide footing subjected to vertical concentric loading:

Factored Geotechnical Resistance at ULS = 350 kPa

Geotechnical Reaction at SLS = 225 kPa

At the west end of Structure 16A, it is recommended that the loose silt/sand be subexcavated down to the surface of the underlying clayey silt till (elevation 210.3 to 210.5) and be replaced with granular engineered fill back up to the design founding level. The engineered fill should consist of OPSS Granular 'A' placed in 150 mm lifts and compacted to 100% of its SPMDD at $\pm 2\%$ of optimum moisture content. The fill should extend laterally at least 1.0 m beyond the edge of footing. The resistance values provided above for the native soil are considered applicable for the engineered fill.

Depending upon the performance of the dewatering scheme and the groundwater conditions at the time of construction, areas of the silt subgrade may exhibit dilatancy and a "rolling" or "spongy" condition upon exposure in the excavation. A contingency should be included in the contract for subexcavation and replacement of unstable material with a minimum 1.0 m thickness of engineered granular fill below the footing base.

The geotechnical resistance at SLS is based on an estimated settlement not exceeding 25 mm. This settlement should be essentially complete by the end of construction.

The resistance values are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with the CHBDC Clause 6.7.3 and Clause 6.7.4.

The lateral resistance developed along the base of concrete footings founded on the silt to silt and sand may be computed using an ultimate friction coefficient of 0.35. The lateral resistance of the footings founded on engineered fill may be computed using an unfactored friction coefficient of 0.6.

The bases of the foundation excavations should be inspected by a geotechnical engineer to confirm that the exposed surface conforms to the design requirements, has been adequately prepared to receive concrete, and consists of native silt/sand or clayey silt till.

Founding surfaces should be protected from disturbance during construction. The exposed surface should be protected from deterioration by placing a minimum 75 mm thick working mat of concrete of the same class as the footing immediately following approval of the founding surface.

8.1.2 Steel H-Pile Foundations

The soil conditions at the site are considered to be suitable for the use of driven H-piles.

8.1.2.1 Axial Resistance

It is recommended that H-piles be driven to refusal in the very dense/hard till deposits or on shale bedrock. The axial geotechnical resistances recommended for steel HP310x110 piles driven into the till/shale are as follows:

Factored Geotechnical Resistance at ULS = 1,600 kN

Geotechnical Reaction at SLS (up to 10 mm settlement) = 1,400 kN

A pile tip elevation at elevation 198.5 is recommended for estimating purposes. The actual pile tip elevations will be controlled as described in Section 8.1.2.3 Pile Installation.

8.1.2.2 Pile Tips

Pile tip protection is recommended for driven H-piles to prevent pile damage when setting the piles on bedrock or if cobbles or potentially boulders are encountered in the till. The tips of all driven H-piles must be fitted with pile tip protection from an approved manufacturer such as Titus Steel (Standard H-point) or approved equivalent.

8.1.2.3 Pile Installation

Pile installation should be in accordance with OPSS 903.

Pile driving must be controlled by the Hiley Formula and an ultimate pile resistance should be specified by the designer in accordance with Clause 3.3.2 (b) Construction Stage of the Structural Manual. The appropriate pile driving note is “Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance of “R” kN per pile”. “R” must have a value of two times the design load at ULS calculated by the structural engineer.

The possibility exists that piles will achieve the specified resistance at different elevations, and that some piles may meet refusal on a large boulder in the till. Driving must be terminated before the pile is damaged by overdriving.

To facilitate pile installation, embankment fill through which piles may be driven must not contain oversize material, i.e. no particles exceeding 75 mm in size.

8.1.2.4 Downdrag

Downdrag on the piles is not an issue at this site.

8.1.2.5 Lateral Pile Resistance

The geotechnical lateral resistance of a pile in cohesionless soil may be calculated using a coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = n_h z / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 3 \gamma' z K_p \quad (\text{kPa})$$

Where	z	=	depth of embedment along pile (m)
	D	=	pile width or diameter (m)
	n_h	=	coefficient related to soil density (kN/m^3)
	γ'	=	effective unit weight (kN/m^3)
	K_p	=	coefficient of passive lateral earth pressure

The geotechnical lateral resistance acting on a pile in cohesive soils may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = 67 S_u / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 9 S_u \quad (\text{kPa})$$

Where	S_u	=	undrained shear strength (kPa)
	D	=	pile width or diameter in metres

The above equations and recommended parameters in Table 8.1 below may be used to analyse the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis must not exceed the ultimate lateral resistance.

Table 8.1 – Soil Parameters for Lateral Pile Design

Structure No.	Soil Unit	Elevation (m)		γ' (kN/m^3)	n_h (kN/m^3)	K_p	S_u (kPa)
		Top	Bottom				
16A	Clay/Silt Till	214.0	213.3	10	-	3.2	130
	Silt	213.3	212.5	10	3,500	3.2	-
	Sand & Silt	212.5	210.3	10	2,500	3.1	-
	Clayey Silt Till	210.3	204.2	11	-	3.2	150
	Silty Gravel	204.2	202.0	12	6,000	3.7	-
	Sand & Silt Till	202.0	198.0	12	10,000	4.2	-
16B	Clay/Silt Till	214.0	213.2	10	-	-	130
	Silt/Sand & Silt	213.2	211.1	10	3,500	3.2	-
	Clayey Silt Till	211.1	204.8	11	-	-	150
	Sand & Silt/ Silty Gravel	204.8	202.0	12	6,000	3.7	-
	Sand & Silt Till	202.0	198.0	12	10,000	4.2	-

The spring constant, K_s , for analysis may be obtained by the expression, $K_s = k_s L D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m^3), D is the pile width (m) and L is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance, P_{ult} , may be obtained from the expression, $P_{ult} = p_{ult} L D$. This represents the ultimate load at which geotechnical failure of the pile occurs and will not support any additional load at greater displacement.

According to the CHBDC Clause C6.8.7.1 and Table C6.4, geotechnical lateral resistances for steel HP310 x 110 piles embedded in stiff to very stiff cohesive soils should be limited to 160 kN and 65 kN under ULS (factored) and SLS (up to 10 mm of lateral movement) conditions, respectively.

The coefficient of subgrade reaction and ultimate lateral resistance may have to be reduced, based on the pile spacing. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in Table 8.2. Intermediate values may be obtained by linear interpolation.

Table 8.2 – Subgrade Reaction Reduction Factors for Pile Spacing

Condition	Pile Spacing (Centre to Centre)	Reduction Factor
Pile group oriented <i>perpendicular</i> to direction of loading	4D	1.0
	1D	0.5
Pile group oriented <i>parallel</i> to direction of loading	8D	1.0
	6D	0.7
	4D	0.4
	3D	0.25

Consideration may be given to the use of battered piles if lateral pile capacities higher than the available geotechnical lateral resistances are required.

8.1.3 Drilled Shafts (Caissons)

Caisson installation at this site would extend through cohesionless soils below the groundwater table and require the use of a permanent liner to support the caisson sidewall. Sealing of the caisson liner into the underlying till or bedrock to prevent inflow of water and boiling of cohesionless soils at the caisson base may be problematic. The use of caissons is therefore not recommended and design recommendations have not been developed.

8.1.4 Recommended Foundation

From a geotechnical perspective and based on the subsurface conditions, driven steel H-piles driven to refusal in the underlying very dense/hard till or shale bedrock are the preferred foundation option for this site.

8.2 Culvert 17 (W-N/S Ramp)

The subsurface conditions encountered at the location of proposed Culvert 17 consist of a relatively thin layer of firm to very stiff clayey silt till overlying a loose to compact sand and silt layer and a further discontinuous layer of loose silt, which in turn overlies hard clayey silt till. Groundwater levels measured in the monitoring well and piezometer with the screens installed in the lower till deposit were 0.2 m below to 0.7 m above the ground surface, or elevation 217.0 to 217.8 m.

Construction of an open footing culvert supported on the native soils or installation of a box culvert is considered feasible at this site. Foundation design recommendations for both types are presented below.

8.2.1 Open Footing Culvert

Based on the preliminary General Arrangement drawing, the anticipated founding level for spread footings supporting the culvert is elevation 214.8 to 215.0 m. Assuming a minimum 1.2 m wide footing subjected to vertical concentric loading, footings for an open footing culvert and associated wing walls founded on the compact sand and silt at this level may be designed using the following resistance values:

Factored Geotechnical Resistance at ULS	=	300 kPa
Geotechnical Resistance at SLS	=	150 kPa

The geotechnical resistance at SLS is based on an estimated settlement not exceeding 25 mm. This settlement should be essentially complete by the end of construction.

We understand that a higher SLS resistance of 200 kPa is required to support the culvert loads at this site, assuming a footing width of 3.1 m. To achieve the increased resistance, it is recommended that the footings be constructed on a 1.5 m thick pad of granular engineered fill. The engineered fill should consist of OPSS Granular 'A' placed in 150 mm lifts and compacted to 100% of its SPMDD at $\pm 2\%$ of optimum moisture content. The fill should extend laterally at least 0.5 m plus the thickness of fill beyond the edge of footing. The revised resistance values for footings on granular engineered fill are as follows:

Factored Geotechnical Resistance at ULS	=	440 kPa
Geotechnical Resistance at SLS	=	200 kPa

The resistance values are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with the CHBDC Clause 6.7.3 and Clause 6.7.4.

The lateral resistance developed along the base of concrete footings founded on the silt to sand and silt may be computed using an ultimate friction coefficient of 0.40. The lateral resistance of the footings founded on engineered fill may be computed using an unfactored friction coefficient of 0.6.

The bases of the foundation excavations should be inspected by a geotechnical engineer to confirm that the exposed surface conforms to the design requirements, has been adequately prepared to receive concrete, and consists of compact native silt and sand.

Founding surfaces should be protected from disturbance during construction. The exposed surface should be protected from deterioration by placing a minimum 75 mm thick working mat of concrete of the same class as the footing immediately following approval of the founding surface.

8.2.2 Box Culvert

Based on the stream bed elevations shown on the GA drawing, the base level for a box culvert is expected to be elevation 215.7 to 215.9 m. At this level, the subgrade is expected to consist of very stiff clayey silt till and compact sand and silt. In general, placement of a box culvert at the anticipated level is considered feasible.

For assessment of the culvert design, a factored geotechnical resistance at ULS of 300 kPa and a geotechnical reaction at SLS (25 mm settlement) of 150 kPa are recommended for the compact sand and silt at the anticipated base level.

All surface vegetation, topsoil, organic deposits, disturbed material or otherwise loose/soft soils must be stripped from the culvert area prior to culvert installation. Inspection and approval of the subgrade by geotechnical personnel is recommended prior to placement of bedding material.

Bedding and backfill to the culvert should be in accordance with OPSD 803.010. A minimum 300 mm thickness of Granular A bedding material is recommended below the culvert. The bedding thickness may need to be increased where subexcavation is required to remove deleterious materials below the design excavation level or a less competent subgrade is encountered.

8.3 Culvert 18 (Extension and Partial Replacement)

The subsurface conditions encountered at the location of proposed Culvert 18 consist of a thin layer of soft to stiff clayey silt till overlying compact to dense sand and silt and/or very loose to compact silt. Granular fill was encountered over the till below the existing highway shoulder. Groundwater levels measured in the piezometers installed at the site varied from 0.9 m above to 0.4 m below the ground surface (elevation 218.8 to 217.5).

The existing culvert is a 3.05x1.52 m concrete box culvert with a base near Elev. 217.0. Extensions to both ends and replacement of the north end of the existing culvert are planned. The new sections of culvert may consist of an open footing design supported on the native soils or a box culvert. Foundation design recommendations for both types are presented below.

8.3.1 Open Footing Culvert

Based on the preliminary General Arrangement drawing, the anticipated founding level for spread footings supporting the culvert is elevation 216.0 at the inlet and elevation 215.4 at the outlet. Assuming a minimum 1.2 m wide footing subjected to vertical concentric loading, footings for an open footing culvert founded on the stiff clayey silt till and compact sand and silt at this level may be designed using the following resistance values:

- Inlet (N-W Ramp)

Factored Geotechnical Resistance at ULS	=	225 kPa
Geotechnical Resistance at SLS	=	100 kPa

- Outlet (Hwy 401 EBL)

Factored Geotechnical Resistance at ULS	=	300 kPa
Geotechnical Resistance at SLS	=	175 kPa

The geotechnical resistance at SLS is based on an estimated settlement not exceeding 25 mm. This settlement should be essentially complete by the end of construction. The potential for differential settlement between the existing culvert and extension should be considered in the design of the connection.

We understand that a footing width of 1.5 m is proposed at the inlet, employing a higher SLS resistance of 175 kPa, similar to the outlet footing design. To achieve the increased resistance, it is recommended that the footings be constructed on a minimum 1.2 m thick pad of granular engineered fill. The engineered fill should consist of OPSS Granular 'A' placed in 150 mm lifts and compacted to 100% of its SPMDD at $\pm 2\%$ of optimum moisture content. The fill should extend laterally at least 0.5 m plus the thickness of fill beyond the edge of footing. The revised resistance values for footings on granular engineered fill are as follows:

Factored Geotechnical Resistance at ULS	=	300 kPa
Geotechnical Resistance at SLS	=	175 kPa

The resistance values are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with the CHBDC Clause 6.7.3 and Clause 6.7.4.

The lateral resistance developed along the base of concrete footings founded on the clayey silt till or sand and silt may be computed using an ultimate friction coefficient of 0.40. The lateral resistance of the footings founded on engineered fill may be computed using an unfactored friction coefficient of 0.6.

The bases of the foundation excavations should be inspected by a geotechnical engineer to confirm that the exposed surface conforms to the design requirements, has been adequately prepared to receive concrete, and consists of compact native silt and sand.

Founding surfaces should be protected from disturbance during construction. The exposed surface should be protected from deterioration by placing a minimum 75 mm thick working mat of concrete of the same class as the footing immediately following approval of the founding surface.

8.3.2 Box Culvert

Based on the stream bed elevations shown on the GA drawing, the approximate base level for a box culvert is expected to be elevation 216.9 at the inlet and elevation to 216.4 at the outlet. At these levels, the subgrade is expected to consist of stiff clayey silt till and compact sand and silt at the inlet, and compact sand and silt at the outlet. In general, placement of a box culvert at the anticipated level is considered feasible.

For assessment of the culvert design, the following geotechnical resistance values are recommended for the stiff clayey silt till and compact sand and silt at the anticipated base level:

- Inlet (N-W Ramp)

Factored Geotechnical Resistance at ULS	=	225 kPa
Geotechnical Resistance at SLS	=	100 kPa
- Outlet (Hwy 401 EBL)

Factored Geotechnical Resistance at ULS	=	300 kPa
Geotechnical Resistance at SLS	=	175 kPa

The geotechnical resistance at SLS is based on an estimated settlement not exceeding 25 mm. This settlement should be essentially complete by the end of construction. The potential for differential settlement between the existing culvert and extension should be considered in the design of the connection.

All surface vegetation, topsoil, organic deposits, disturbed material or otherwise loose/soft soils must be stripped from the culvert area prior to culvert installation. Inspection and approval of the subgrade by geotechnical personnel is recommended prior to placement of bedding material.

Bedding and backfill to the culvert should be in accordance with OPSD 803.010. A minimum 300 mm thickness of Granular A bedding material is recommended below the culvert. The bedding thickness may need to be increased where subexcavation is required to remove deleterious materials below the design excavation level or a less competent subgrade is encountered.

8.4 Culvert 19 (W-N/S Ramp)

The subsurface conditions encountered at the location of proposed Culvert 19 consist of a layer of firm to very stiff silty clay to clayey silt till overlying generally compact to dense sand and silt to silt, which in turn overlies very stiff to hard clayey silt till. Groundwater levels measured in the monitoring well and piezometer with the screens installed in the lower till deposit were 2.6 m below to 0.5 m above the ground surface, or elevation 215.0 to 216.7 m.

Installation of a box culvert is considered feasible at this site. Construction of an open footing culvert supported on the native soils may also be considered. Foundation design recommendations for both types are presented below.

8.4.1 Box Culvert

Based on the preliminary GA drawing, the invert level for a box culvert will be at elevation 214.9 to 214.6 m and the base level is expected to be at elevation 214.6 to 214.3 m. At this level, the subgrade is expected to consist of stiff clayey silt till and compact sand and silt to silt. In general, placement of a box culvert at the anticipated level is considered feasible.

For assessment of the culvert design, a factored geotechnical resistance at ULS of 300 kPa and a geotechnical reaction at SLS (25 mm settlement) of 150 kPa are recommended for the stiff clayey silt till and compact sand and silt at the anticipated base level.

All surface vegetation, topsoil, organic deposits, disturbed material or otherwise loose/soft soils must be stripped from the culvert area prior to culvert installation. Inspection and approval of the subgrade by geotechnical personnel is recommended prior to placement of bedding material.

Bedding and backfill to the culvert should be in accordance with OPSD 803.010. A minimum 300 mm thickness of Granular A bedding material is recommended below the culvert. The bedding thickness may need to be increased where subexcavation is required to remove deleterious materials below the design excavation level or a less competent subgrade is encountered.

8.4.2 Open Footing Culvert

Based on the preliminary General Arrangement drawing, the anticipated founding level for spread footings supporting the culvert is elevation 213.7 to 213.4 m. Assuming a minimum 1.2 m wide footing subjected to vertical concentric loading, footings for an open footing culvert founded on the compact sand and silt at this level may be designed using the following resistance values:

Factored Geotechnical Resistance at ULS = 300 kPa

Geotechnical Resistance at SLS = 150 kPa

The geotechnical resistance at SLS is based on an estimated settlement not exceeding 25 mm. This settlement should be essentially complete by the end of construction.

The resistance values are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with the CHBDC Clause 6.7.3 and Clause 6.7.4.

The lateral resistance developed along the base of concrete footings founded on the sand and silt may be computed using an ultimate friction coefficient of 0.40.

The bases of the foundation excavations should be inspected by a geotechnical engineer to confirm that the exposed surface conforms to the design requirements, has been adequately prepared to receive concrete, and consists of compact native sand and silt.

Founding surfaces should be protected from disturbance during construction. The exposed surface should be protected from deterioration by placing a minimum 75 mm thick working mat of concrete of the same class as the footing immediately following approval of the founding surface.

8.5 Culvert 22 (N-W Ramp)

The subsurface conditions encountered at the location of proposed Culvert 22 consist of a layer of stiff to very stiff silty clay to clayey silt till overlying successive layers of very stiff clayey silt, compact sand and silt, and compact silt. The silt is underlain by very stiff to hard clayey silt till. Groundwater levels measured in the monitoring well and piezometer with the screens installed in the lower till deposit were 0.5 to 1.0 m below the ground surface, or elevation 218.9 to 218.1 m.

Installation of a box culvert is considered feasible at this site. Construction of an open footing culvert supported on the native soils may also be considered. Foundation design recommendations for both types are presented below.

8.5.1 Box Culvert

Based on the preliminary GA drawing, the invert level for a box culvert will be at elevation 218.2 to 218.0 m and the base level is expected to be at elevation 217.9 to 217.7 m. At this level, the subgrade is expected to consist of stiff to very stiff silty clay till and clayey silt. In general, placement of a box culvert at the anticipated level is considered feasible.

For assessment of the culvert design, a factored geotechnical resistance at ULS of 300 kPa and a geotechnical reaction at SLS (25 mm settlement) of 150 kPa are recommended for the stiff to very stiff silty clay till and clayey silt at the anticipated base level.

All surface vegetation, topsoil, organic deposits, disturbed material or otherwise loose/soft soils must be stripped from the culvert area prior to culvert installation. Inspection and approval of the subgrade by geotechnical personnel is recommended prior to placement of bedding material.

Bedding and backfill to the culvert should be in accordance with OPSD 803.010. A minimum 300 mm thickness of Granular A bedding material is recommended below the culvert. The bedding thickness may need to be increased where subexcavation is required to remove deleterious materials below the design excavation level or a less competent subgrade is encountered.

8.5.2 Open Footing Culvert

Based on the preliminary General Arrangement drawing, the anticipated founding level for spread footings supporting the culvert is elevation 217.0 to 216.8 m. Assuming a minimum 1.2 m wide footing subjected to vertical concentric loading, footings for an open footing culvert founded on the compact sand and silt or very stiff clayey silt at this level may be designed using the following resistance values:

Factored Geotechnical Resistance at ULS	=	250 kPa
Geotechnical Resistance at SLS	=	125 kPa

The geotechnical resistance at SLS is based on an estimated settlement not exceeding 25 mm. This settlement should be essentially complete by the end of construction.

The resistance values are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with the CHBDC Clause 6.7.3 and Clause 6.7.4.

The lateral resistance developed along the base of concrete footings founded on the sand and silt or clayey silt may be computed using an ultimate friction coefficient of 0.35.

The bases of the foundation excavations should be inspected by a geotechnical engineer to confirm that the exposed surface conforms to the design requirements, has been adequately prepared to receive concrete, and consists of compact native sand and silt.

Founding surfaces should be protected from disturbance during construction. The exposed surface should be protected from deterioration by placing a minimum 75 mm thick working mat of concrete of the same class as the footing immediately following approval of the founding surface.

8.6 Culverts 20, 21, 23, 24, 25, 26 and 27

GA drawings were not available for Culverts 20, 21, and 23 to 27. It is assumed that these culverts will comprise CSPs or minor non-structural box culverts.

The anticipated invert levels of the minor culverts interpreted from the profile design drawings, and the anticipated subgrade conditions at the invert levels, are summarized in Table 8.3.

Table 8.3 – Anticipated Subgrade Conditions at Minor Culverts

Culvert No.	Facility	Anticipated Invert Elevation (m)	Anticipated Subgrade Conditions
20	N-E Ramp	215.3	Very stiff clayey silt till to compact sandy silt
21 (Extension)	S-W SCL	217.5	Stiff to very stiff silty clay till
	401 EBL	217.0	Stiff silty clay till
23	S-E Ramp	215.5	Very stiff silty clay till
24	S-W Ramp	217.7	Very stiff silty clay till
25	E-N/S Ramp	215.6	Very stiff to hard clayey silt till
26 (Extension)	E-N/S SCL	214.0	Very stiff clayey silt till
	S-E Ramp	212.7	Very stiff clayey silt till
27	Carpool Access	Undefined	Very stiff silty clay till

In general, the subgrade conditions at the culvert locations are considered suitable for support of the culverts.

Following excavation to the design base level of the culvert, any remaining fill, topsoil, peat, streambed deposits or soft soils within the culvert footprint should be subexcavated.

The exposed surface must be inspected to confirm that the subgrade is uniformly competent. Any fill placed below the culvert to re-establish the founding level should consist of compacted Granular A or B Type II material. This work should be carried out in accordance with OPSS 902.

Bedding and backfill to the culvert should be in accordance with OPSD 803.010. A minimum 300 mm thickness of Granular A bedding material is recommended below the culvert. The bedding thickness may need to be increased where subexcavation is required to remove deleterious materials below the design excavation level or a less competent subgrade is encountered. The bedding material should be placed as soon as practical following inspection and approval of the final subgrade as protection from disturbance during construction.

In view of the relatively competent subgrade conditions and the low embankment heights, differential settlement between the existing culverts and the extensions at non-structural Culverts 21 and 26 should not be a concern.

8.7 3rd Side Road Channel Structure

In general, the subsurface conditions encountered at this site consist of very stiff to hard silty clay till underlain by a discontinuous layer of compact silt which overlies a relatively thick deposit of hard clayey silt till. Groundwater levels measured in the monitoring wells with screens installed in the lower till deposit ranged from 0.8 m below to 0.3 m above the ground surface, or elevation 212.0 to 213.1 m.

Based on the subsurface conditions encountered at this site, supporting the proposed bridge structure on spread footings founded on the native soils is considered feasible from a geotechnical perspective.

The preliminary GA drawing indicates that the founding elevations for spread footings will be at approximate elevation 209 m at both abutments. Assuming a minimum 2 m wide footing subjected to vertical concentric loading, footings founded on the hard clayey silt till or compact silt at this level may be designed using the following resistance values:

Factored Geotechnical Resistance at ULS	=	450 kPa
Geotechnical Resistance at SLS	=	300 kPa

The geotechnical resistance at SLS is based on an estimated settlement not exceeding 25 mm. This settlement should be essentially complete by the end of construction.

The resistance values are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with the CHBDC Clause 6.7.3 and Clause 6.7.4.

The lateral resistance developed along the base of concrete footings founded on the silt or clayey silt till may be computed using an ultimate friction coefficient of 0.40.

The bases of the foundation excavations should be inspected by a geotechnical engineer to confirm that the exposed surface conforms to the design requirements, has been adequately prepared to receive concrete, and consists of compact native silt or hard clayey silt till.

Depending upon the performance of the dewatering scheme and the groundwater conditions at the time of construction, areas of the silt subgrade may exhibit dilatancy and a “rolling” or “spongy” condition upon exposure in the excavation. A contingency should be included in the contract for subexcavation of the silt down to the till surface and replacement with engineered granular fill.

Founding surfaces should be protected from disturbance during construction. The exposed surface should be protected from deterioration by placing a minimum 75 mm thick working mat of concrete of the same class as the footing immediately following approval of the founding surface.

9 FROST COVER

The depth of frost penetration at this site is 1.2 m. The base of footings or pile caps must be provided with a minimum of 1.2 m of earth cover as protection against frost action.

10 STRUCTURE BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the abutment or culvert should consist of free-draining granular material conforming to OPS Granular A or B Type II specifications. The granular material should be placed to the extents shown in OPSD 803.010.

Backfill should be placed and compacted in simultaneous equal lifts on both sides of the structure, and the top of backfill elevation should be within 400 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used adjacent to the abutment walls, and on the roof of the culvert. Compaction should be carried out in accordance with OPSS 501.

Earth pressures acting on the structure may be assumed to impose a triangular distribution governed by the characteristics of the backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p = K (\gamma h + q)$$

Where:

p	= horizontal earth pressure on the wall at depth h (kPa)
K	= earth pressure coefficient (see table below)
γ	= unit weight of retained soil (see table below)
h	= depth below top of fill where pressure is computed (m)
q	= value of any surcharge (kPa)

The earth pressure coefficients are dependent on the material used as backfill. Recommended unfactored values are shown in Table 10.1. The at-rest coefficients should be employed for restrained walls. Active pressures should be used for any wingwalls or unrestrained walls.

Table 10.1 – Lateral Earth Pressure Coefficients

Loading Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.39*	0.31	0.47*
At-rest (Restrained Wall)	0.43	-	0.47	-
Passive	3.7	-	3.3	-

* For wing walls.

The parameters in the table correspond to full mobilization of active and passive earth pressures, and require certain relative movements between the wall and adjacent soil to produce these conditions. The values to be used in design can be assessed from Figure C6.16 of the Commentary to the CHBDC.

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or 1.7 m for Granular A or Granular B Type II.

The design of the abutment walls must incorporate measures such as weep holes to permit drainage of the backfill and avoid the potential build-up of hydrostatic pressures behind the walls.

11 RETAINED SOIL SYSTEMS (RSS)

Retained soil systems (RSS) are proposed for the wing walls at Structures 16A and 16B, and for Culvert 18. Foundation recommendations for the RSS walls are presented below.

11.1 Structure 16A and 16B

The general arrangement drawings provided by MMM Group Limited indicate that the wing walls for Structures 16A and 16B will consist of RSS walls. The walls will be triangularly shaped with a maximum exposed height of approximately 10.0 m, an average height of approximately 5.0 m, and a base level near elevation 213.0, i.e. approximately 2.0 to 2.5 m below the existing ground surface.

In general, RSS walls used in conjunction with the new abutments must be “High Performance” and “High Appearance”. The contract drawings should include information on the longitudinal alignment of the wall in plan, the top and base elevations of the wall in profile, cross-sectional space constraints and an NSSP for the RSS wall.

To provide an acceptable foundation performance, the RSS mass must be founded on competent soils or engineered fill. The foundation of the entire RSS mass must be considered, i.e. from the face of the wall to the furthest extent of the reinforcement.

The borehole information indicates that the soil conditions at the wall base levels will generally comprise very stiff to hard silty clay to clayey silt till, and compact to dense silt. Walls founded on the above materials should be designed for a Factored Geotechnical Resistance at ULS of 375 kPa and a Geotechnical Reaction at SLS of 250 kPa.

The geotechnical resistance values are estimated for a horizontal ground surface in front of the wall and may have to be reduced for ground surface sloping down in front of the wall.

The geotechnical resistances provided above are for concentric, vertical loading. The effects of load inclination and eccentricity need to be taken into account according to the CHBDC 2006 Section 6.7. The resistance values assume that the RSS wall reinforcement will extend a distance behind the wall face of approximately 70% of the wall height.

A minimum 500 mm thick layer of bedding material conforming to OPSS Granular “A” requirements should be provided under the RSS mass to provide a uniform subgrade condition. Engineered fill placed under the RSS mass to achieve the design founding level should consist of OPSS Granular “A” compacted to 100% of its SPMDD at a moisture content within 2% of optimum. The engineered fill pad must extend at least 500 mm beyond the limits of the RSS mass and levelling strip. Any topsoil and soft/loose fill or native material should be stripped from the footprint of the RSS. All disturbed and new embankment fill must be compacted in accordance with OPSS 501.

In view of the soil conditions at this site, the estimated foundation settlement beneath RSS walls is expected to be in the order of 40 to 50 mm and will be essentially complete at the end of construction

The RSS wall must also be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall on native silty clay to clayey silt till and engineered fill may be estimated using ultimate friction coefficients of 0.4 and 0.6, respectively. The global stability of the RSS walls must be confirmed when the actual geometry of the RSS, the founding level, the characteristics of the fill material used in the RSS mass, and other details of the proprietary design are established. The internal stability of the RSS wall should be analysed by the supplier/designer of the proprietary product selected for this site.

11.2 Culvert 18

The general arrangement drawings provided by MMM Group Limited indicate that the RSS wing walls will be provided at both extensions to Culvert 18. The walls will have maximum exposed heights of approximately 2.0 m and lengths of up to 8.5 m. The base level will be near elevation 217.0 at the inlet and 216.4 at the outlet.

In general, RSS walls used in conjunction with the new abutments must be “High Performance” and “High Appearance”. The contract drawings should include information on the longitudinal alignment of the wall in plan, the top and base elevations of the wall in profile, cross-sectional space constraints and an NSSP for the RSS wall.

To provide an acceptable foundation performance, the RSS mass must be founded on competent soils or engineered fill. The foundation of the entire RSS mass must be considered, i.e. from the face of the wall to the furthest extent of the reinforcement.

The borehole information indicates that the soil conditions at the wall base levels will generally comprise compact sand and silt. Walls founded on the compact native soil should be designed using the following resistance values:

- Inlet (N-W Ramp)

Factored Geotechnical Resistance at ULS	=	225 kPa
Geotechnical Resistance at SLS	=	100 kPa
- Outlet (Hwy 401 EBL)

Factored Geotechnical Resistance at ULS	=	300 kPa
Geotechnical Resistance at SLS	=	175 kPa

The geotechnical resistance at SLS is based on an estimated settlement not exceeding 25 mm. This settlement should be essentially complete by the end of construction.

The geotechnical resistance values are estimated for a horizontal ground surface in front of the wall and may have to be reduced for ground surface sloping down in front of the wall.

The geotechnical resistances provided above are for concentric, vertical loading. The effects of load inclination and eccentricity need to be taken into account according to the CHBDC 2006 Section 6.7. The resistance values assume that the RSS wall reinforcement will extend a distance behind the wall face of approximately 70% of the wall height.

A minimum 300 mm thick layer of bedding material conforming to OPSS Granular “A” requirements should be provided under the RSS mass to provide a uniform subgrade condition. Engineered fill placed under the RSS mass to achieve the design founding level should consist of OPSS Granular “A” compacted to 100% of its SPMDD at a moisture content within 2% of optimum. The engineered fill pad must extend at least 500 mm beyond the limits of the RSS mass and levelling strip. Any topsoil and soft/loose fill or native material should be stripped from the footprint of the RSS. All disturbed and new embankment fill must be compacted in accordance with OPSS 501.

In view of the soil conditions at this site, the estimated foundation settlement beneath RSS walls is expected to be less than 25 mm and will be essentially complete at the end of construction

The RSS wall must also be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall on native sand/silt and engineered

fill may be estimated using ultimate friction coefficients of 0.4 and 0.6, respectively. The global stability of the RSS walls must be confirmed when the actual geometry of the RSS, the founding level, the characteristics of the fill material used in the RSS mass, and other details of the proprietary design are established. The internal stability of the RSS wall should be analysed by the supplier/designer of the proprietary product selected for this site.

12 APPROACH EMBANKMENTS

Construction of the approach embankments should be carried out in accordance with OPSS.PROV 206. Materials used to construct the embankments should comprise granular materials or Select Subgrade Material (SSM) in compliance with OPSS.PROV 1010, earth borrow as per OPSS 212 (excluding high plastic clay), or on-site inorganic materials subject to geotechnical approval.

Mid-height berms comprising 2 m wide benches must be incorporated along the length of embankments with heights exceeding 8 m in earth fill. Where new embankment fill is placed against existing embankment slopes or on a sloping ground surface, the existing earth or fill slope must be benched in accordance with OPSD 208.010.

Stability analyses were carried out for selected approach embankments during concurrent preparation of the Foundation Investigation and Design Report for the High Fill Embankments. Estimates of the foundation settlement to be anticipated under the new embankment fill were also provided. Reference should be made to the High Fill Embankments report for comments regarding embankment stability and settlement.

Earth fill embankment slopes must be provided with erosion protection in accordance with OPSS.PROV 804. Design and implementation of the erosion protection works should include consideration of the surficial stability under heavy, prolonged rainfall and spring thaw conditions. Vegetation must be sufficiently established before the onset of winter. Use of granular sheeting may also be considered.

To minimize the erosion potential, surface water should be directed away from the embankment slopes and conveyed down the slope in appropriately designed drainage channels or storm sewers. Consideration should also be given to adopting flatter slope inclinations in sections of high uninterrupted slopes to increase infiltration and reduce flow velocities.

13 EROSION CONTROL

Erosion protection should be provided at the culvert inlet and outlet areas as applicable. Design of the erosion protection measures must consider hydrologic and hydraulic concerns and should be carried out by specialists experienced in this field.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in accordance with OPSS 572.

It is recommended that a clay seal or a concrete cut-off wall be used to minimize the potential for erosion near the inlet area. The clay seal should extend above the high water level, have a minimum thickness of 0.5 m, and extend laterally the width of the granular backfill material. The material requirements should be in accordance with OPSS 1205.

14 SEISMIC CONSIDERATIONS

The following seismic parameters should be used for design in accordance with the CHBDC for a design earthquake with 475-year return period:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.05
- Acceleration Related Seismic Zone 1
- Zonal Acceleration Ratio 0.05
- Peak Ground Acceleration 0.04 g

The soil profile type at this site has been classified as Type I. Therefore, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient “S” (ground motion amplification factor) of 1.0 should be used in seismic design.

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 14.1 may be used:

Table 14.1 – Lateral Earth Pressure Coefficient for Earthquake Loading

Loading Condition	Earth Pressure Coefficient (K_E) for Earthquake Loading			
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (K_{AE})*	0.29	0.42	0.32	0.51
At-rest (K_{OE})**	0.46	-	0.51	-
Passive (K_{PE})*	3.5	-	3.1	-

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

** After Woods (1973).

Based on review of the SPT data, seismically-induced liquefaction of foundation soils is not anticipated under the design earthquake.

15 EXCAVATION AND GROUNDWATER CONTROL

All excavation must be carried out in accordance with OPSS 902 and the Occupational Health and Safety Act (OHSA). For the purposes of assessing excavation slope requirements in compliance with the OHSA, the upper clay/silt till, silt and sands and silts above the water table are classified as Type 3 soil. Below the water table, the cohesionless soils are classified as Type 4 soil. Flatter side slopes may be required locally subject to conditions encountered during construction.

Excavation for foundation construction and culvert installation must be carried out in a manner that minimizes sloughing of the sidewalls and disturbance of the subgrade on which the foundations or culvert base will be placed. At many of the culvert locations, excavation is expected to extend through the upper cohesive till layer and into the underlying cohesionless sand and silt deposits below the groundwater level. Groundwater levels measured in monitoring wells and piezometers were locally above the ground surface, indicating potential artesian conditions. Preconstruction dewatering is therefore recommended to temporarily lower the groundwater level below the base of the excavation and minimize the potential for instability in the sands and silts. Unwatering must remain operational and effective until the culvert is installed and backfilled.

Depending upon the performance of the dewatering scheme and the groundwater conditions at the time of construction, areas of the silt subgrade may exhibit dilatancy and a “rolling” or “spongy” condition upon exposure in the excavation. A contingency should be included in the contract for subexcavation and replacement of unstable material with a minimum 1.0 m thickness of engineered granular fill below the footing base.

Temporary shoring may be required during culvert installation and excavation for footing construction. Based on available subsurface information, a shoring system consisting of sheet piles or steel H-piles with timber lagging may be considered. Temporary shoring should be designed by a licensed Professional Engineer experienced in design of shoring with consideration of adjacent traffic loads and any sloping retained surfaces.

Selection of the equipment and methodology to excavate and prepare the subgrade is the responsibility of the Contractor. The design of the shoring and dewatering system that may be required is also the responsibility of the Contractor and the Contract Documents must alert him to this responsibility.

Roadway protection will be required for extension of culverts under the existing highway embankment. Roadway protection should be provided in accordance with OPSS 539 and designed for Performance Level 2. The design of roadway protection is the responsibility of the Contractor and all shoring should be designed by a Professional Engineer experienced in such designs.

Temporary stream diversion measures such as impervious dykes should be provided to divert surface water runoff and stream flow away from the culvert excavations at all times during construction. The contract documents should specify that an appropriate dewatering operation shall be provided to maintain a stable and reasonably dry excavation.

If the anticipated dewatering rates range between 50,000 and 400,000 L/day, the water taking must be registered on the Ministry of the Environment, Conservation and Parks (MECP) Environmental Activity and Sector Registry (EASR). A Permit to Take Water (PTTW) may be required if pumping rates are expected to exceed 400,000 L/day. A hydrogeological assessment to determine the need for EASR registration or PTTW application was completed by others.

16 TEMPORARY SOIL ANCHORS - CULVERT 18

We understand that temporary stabilization of an approximate 20 m length of existing Culvert 18 at the inlet is planned. The stabilization works will include installation of soil anchors through the sidewalls of the culvert.

Based on the borehole information, the anchors are expected to extend into compact sand and silt and loose silt. The bond strength of anchors developed in these deposits is expected to be relatively low due to the low relative density as well as the shallow depth of cover above the anchors. For preliminary assessment of anchor length, an allowable bond strength of 30 kPa is recommended between the anchor grout and surrounding sand/silt. Bar anchors should have a minimum unbonded length of 3.0 m. A soil cover of at least 4.5 m depth is recommended above the midpoint of the anchorage length.

The above recommendations are provided to estimate the anchor capacity for design purposes only. It is necessary that selected anchors be performance tested and all remaining production anchors on site be proof tested to confirm their carrying capacities. Anchor testing and other relevant anchor installation details should be in accordance with applicable guidelines such as those recommended in OPSS 942 “Construction Specification for Prestressed Soil and Rock Anchors” and the Post-Tensioning Institute (1996) “Recommendations for Prestressed Rock and Soil Anchors”.

The anchors will be installed within cohesionless soils below the groundwater level. Installation measures that maintain the hole open and preclude loss of ground must be employed to minimize the potential for settlement of the highway pavement above the anchor zone. The method of installation is the responsibility of the Contractor, however it is anticipated that use of temporary casing and drilling fluid to balance hydrostatic pressures will be required. In view of the potential for soil disturbance, settlement monitoring of the pavement surface should be implemented during and for several weeks following anchor installation.

17 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- Excavation for foundation construction and culvert installation is expected to encounter cohesionless silts and sands below the groundwater level. Flattened side slopes, dewatering and/or shoring will be required to maintaining a stable and reasonably dry excavation for culvert installation.

- Loose, organic, wet or otherwise deleterious materials may be encountered to greater depths than identified at the borehole locations. Subexcavation of such materials and replacement with compacted granular material will be required to provide a uniform competent subgrade on which to place the culverts.
- Care must be exercised during excavation to avoid disturbing the founding subgrade. The exposed subgrade should be protected from physical disturbance, and the granular bedding and/or a mud slab must be placed on the approved subgrade expeditiously following excavation.
- Steel H-piles driven for Structures 16A and 16B may encounter refusal at varying depths on cobbles, boulders, or hard/very dense till above the bedrock surface. If the pile tip elevations vary by more than 3 m from the predicted values, the design team should be notified and permitted to review the possible implications.

The successful performance of the culverts will depend largely upon good workmanship and quality control during construction. Subgrade examination and field density testing should be carried out by qualified geotechnical personnel during construction to confirm that foundation recommendations are correctly implemented and material specifications are met.

18 CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Mr. Keli Shi, P.Eng. The report was reviewed by Mr. Murray Anderson, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Keli Shi, P.Eng.
Geotechnical Engineer



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







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





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 In Open Borehole
	Water Level In Well/Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

[illegible]

- 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.

REV	REVISIONS					
	DATE	BY	DESCRIPTION			
DRAWN	KS	CHK	MRA	CODE	LOAD	DATE OCT 2019
	AN	CHK	KS	SITE	STRUCT	DWG 1

FILENAME: H:\Draughting\19\5161\155\teed1155-BoreholePlan&Profile(Culverts)-2019-2.dwg
PLOTDATE: 10/23/2019 9:46 AM

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 ⁽¹⁾ '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 _L < 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 _L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W _L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W _L > 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


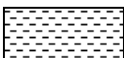



ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
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 structure are preserved.

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
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

Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
	(MPa)	(psi)	
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.

Appendix A

Structures 16A and 16B

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

RECORD OF BOREHOLE No C16-01

1 OF 3

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 409.7 E 586 680.4 ORIGINATED BY ADH
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/Tricone/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.09.23 - 2014.09.26 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
						WATER CONTENT (%) 20 40 60								
215.1	GROUND SURFACE													
0.0 214.8	TOPSOIL: (250mm)													
0.3	Silty CLAY , sandy to some sand, trace organic matter Firm to Very Stiff Brown Moist (TILL) Occasional cobbles		1	SS	4		215							
			2	SS	17		214							0 27 34 39
			3	SS	17									
			4	SS	17									
212.1														
3.0	SAND and SILT , trace clay Loose Brown Wet		5	SS	7		212							
							211							
210.5														
4.6	Clayey SILT , sandy to some sand, trace gravel, occasional cobbles and boulders Very Stiff to Hard Grey Moist (TILL)		6	SS	19									
							210							
							209							5 29 45 21
			7	SS	25									
							208							
			8	SS	80									
							207							
							206							
	Silt seam		9	SS	100									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C16-01

2 OF 3

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 409.7 E 586 680.4 ORIGINATED BY ADH
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/Tricone/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.09.23 - 2014.09.26 CHECKED BY KS

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				GR	SA	SI	CL				
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE													
	Continued From Previous Page							20	40	60	80	100	20	40	60							
			10	SS	107								○						0	13	60	27
			11	SS	79								○									
202.1																						
13.0	SILT, some clay, some sand, trace gravel, occasional limestone fragments Hard Reddish Brown Moist (TILL)		12	SS	139								○									
			13	SS	145								○									
			14	SS	139/ 0.275								○						1	13	70	16
			15	SS	121/ 0.250								○									
195.7																						
19.4	SHALE, highly weathered, laminated, reddish brown: (Queenston Formation)		16	SS	120/ 0.250								○									

Continued Next Page

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

RECORD OF BOREHOLE No C16-01

3 OF 3

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 409.7 E 586 680.4 ORIGINATED BY ADH
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/Tricone/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.09.23 - 2014.09.26 CHECKED BY KS

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				
								20 40 60 80 100	W _P W W _L						
	Continued From Previous Page				0.050										
192.2 22.9	Slightly weathered, laminated, with frequent limestone interbeds, reddish brown		1	RUN		195							9	RUN #1 TCR=100% SCR=80% RQD=82% RUN #2 TCR=100% SCR=90% RQD=85% UCS=9.1MPa (Shale) RUN #3 TCR=100% SCR=100% RQD=100% UCS=57.2MPa (Limestone)	
													1		
	Limestone interbeds (25mm to 75mm) at 19.8m, 20.1m, 20.3m and 20.8m												0		
	Vertical joint (200mm) at 22.0m												0		
	Limestone interbeds (25mm to 50mm) at 21.0m, 21.9m, 22.1m and 22.5m		2	RUN		194							0		
	Limestone interbed (240mm) at 22.5m												1		
													4		
						193							0		
													10		
			3	RUN									0		
	END OF BOREHOLE AT 22.9m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.												0		

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

RECORD OF BOREHOLE No C16-02

1 OF 2

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 400.8 E 586 685.4 ORIGINATED BY ES
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.10 - 2014.09.10 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
215.0	GROUND SURFACE							20 40 60 80 100					
0.0	TOPSOIL: (225mm)							20 40 60 80 100					
0.2	Clayey SILT , some sand, trace gravel, trace roots and organics Firm to Very Stiff Dark Brown Moist (TILL) Sandy silt seam from 0.6m to 0.9m		1	SS	6		214	20 40 60 80 100					* Water level 1.5m above ground surface
			2	SS	5			20 40 60 80 100					
213.3								20 40 60 80 100					
1.7	SILT , some sand and clay Compact Brown Moist		3	SS	17		213	20 40 60 80 100					
212.7								20 40 60 80 100					
2.3	SAND and SILT , trace clay Compact to Loose Brown Moist to Wet		4	SS	20		212	20 40 60 80 100					
			5	SS	9			20 40 60 80 100					0 38 53 9
							211	20 40 60 80 100					
210.3								20 40 60 80 100					
4.7	Clayey SILT , sandy to some sand, trace gravel, occasional limestone fragments Very Stiff to Hard Reddish Brown Moist to Wet (TILL)		6	SS	17		210	20 40 60 80 100					
							209	20 40 60 80 100					
			7	SS	32			20 40 60 80 100					4 27 42 27
							208	20 40 60 80 100					
			8	SS	100/ 0.275		207	20 40 60 80 100					
							206	20 40 60 80 100					
			9	SS	75			20 40 60 80 100					
205.3								20 40 60 80 100					
9.7	END OF BOREHOLE AT 9.7m. Well installation consists of 50mm							20 40 60 80 100					

Continued Next Page

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

RECORD OF BOREHOLE No C16-02

2 OF 2

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 400.8 E 586 685.4 ORIGINATED BY ES
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.10 - 2014.09.10 CHECKED BY KS

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 ³	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 _p	W	W _L			
	Continued From Previous Page																
	diameter Schedule 40 PVC pipe with a 3.0m slotted screen.																
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 25/ 14 1.5* 216.5 Dec 19/ 14 Frozen																
	* Above ground surface																

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO).GDT 2/18/15

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

ONTMT4S 19-5161-155 (FOUNDATION).GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C16-03

2 OF 2

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 419.0 E 586 698.1 ORIGINATED BY DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.11 - 2014.09.11 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	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		
	Continued From Previous Page																
	BOREHOLE OPEN TO 2.4m AND WATER LEVEL AT 1.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C16-04

1 OF 3

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 419.3 E 586 720.9 ORIGINATED BY ADH
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.09.29 - 2014.10.02 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
214.8	GROUND SURFACE												
0.0	TOPSOIL: (250mm)												
214.5													
0.3	Clayey SILT , some sand, trace organics Firm to Very Stiff Brown Moist (TILL)		1	SS	4								
			2	SS	20								
213.3													
1.5	SILT , some sand and clay Compact Grey Moist		3	SS	27								
212.6													
2.2	SAND and SILT , trace clay Compact to Very Dense Brown Moist to Wet		4	SS	53								
				5	SS	23							
210.2													
4.6	Clayey SILT , some sand to sandy, trace gravel Hard to Very Stiff Brown Moist (TILL)		6	SS	50								
				7	SS	27							
				8	SS	19							

Continued Next Page

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

RECORD OF BOREHOLE No C16-04

2 OF 3

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 419.3 E 586 720.9 ORIGINATED BY ADH
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.09.29 - 2014.10.02 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								20 40 60 80 100											
Continued From Previous Page							<div><div></div></div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>20 40 60 80 100</div>				<div><div>PLASTIC LIMIT</div><div>NATURAL MOISTURE CONTENT</div><div>LIQUID LIMIT</div></div> <div>W_P W W_L</div> <div>WATER CONTENT (%)</div> <div>20 40 60</div>								
204.1							204												
10.7	Silty GRAVEL , some sand, occasional cobbles Dense Brown Wet		10	SS	37		203												
202.6							202												
12.2	SAND and SILT , trace clay, trace gravel Very Dense Reddish Brown Wet (TILL)		11	SS	99/ 0.275		201												
			12	SS	89		200												
199.6							199												
15.2	Clayey SILT , some sand, trace gravel, occasional cobbles, occasional limestone fragments Hard Reddish Brown Moist (TILL)		13	SS	178/ 0.275		198												
			14	SS	124		197												
196.5																			
18.3	SHALE , highly weathered, reddish brown Slightly weathered, laminated, reddish brown: (Queenston Formation) Limestone interbed (25mm to 50mm) at 18.7m, 18.9m, 19.0m, 19.2m, 19.5m, 19.6m 125mm at 18.4m		15	SS	100/ 0.075		196												
			1	RUN			195												

Continued Next Page

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

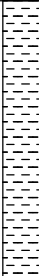
ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO) GDT 2/18/15

RECORD OF BOREHOLE No C16-04

3 OF 3

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 419.3 E 586 720.9 ORIGINATED BY ADH
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.09.29 - 2014.10.02 CHECKED BY KS

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 γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page						20	40	60	80	100						
	Highly weathered zone from 18.3m to 18.6m and 19.6m to 19.8m		2	RUN													
	Fresh Limestone interbed (25mm to 40mm) at 20.1m, 20.4m, 20.9m																
	Limestone interbed (40mm) at 21.1m		3	RUN													
193.0																	
21.8	END OF BOREHOLE AT 21.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																

RECORD OF BOREHOLE No C16-05

1 OF 3

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 437.8 E 586 733.3 ORIGINATED BY ADH/DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.10.02 - 2014.10.03 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			
								20 40 60 80 100	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		
215.1	GROUND SURFACE										
0.0	TOPSOIL: (200mm)										
0.2	Silty CLAY , some sand, trace gravel, trace organics Firm to Very Stiff Brown Moist (TILL)		1	SS	6		215				
			2	SS	19		214				6 20 48 26
213.6											
1.5	SILT , some sand and clay Compact to Dense Brown to Grey Moist		3	SS	28		213				
			4	SS	37						
212.1											
3.0	SAND and SILT , trace clay Compact Brown Moist to Wet		5	SS	23		212				
							211				
210.5											
4.6	SILT , clayey to some clay, some sand to sandy, occasional cobbles, occasional limestone fragments Very Stiff Brown Moist (TILL)		6	SS	24		210				
							209				
			7	SS	24						
							208				
			8	SS	25		207				
							206				
			9	SS	17						0 8 77 15

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity


20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C16-05

2 OF 3

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 437.8 E 586 733.3 ORIGINATED BY ADH/DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.10.02 - 2014.10.03 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								20 40 60 80 100				
Continued From Previous Page												
								○ UNCONFINED + FIELD VANE				
								● QUICK TRIAXIAL x LAB VANE				
								WATER CONTENT (%)				
								20 40 60				
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				
								w _p w w _L				
204.4							205					
10.7	Silty GRAVEL , some sand, occasional cobbles Very Dense Brown Wet		10	SS	69		204					
							203					
			11	SS	66		202					
201.4							201					
13.7	SAND and SILT , some clay, trace gravel, occasional cobbles and limestone fragments Very Dense Brown Wet to Moist (TILL)		12	SS	50/ 0.150		200					
							199					
			13	SS	91		198					
198.2							197					
16.9	SHALE , highly weathered		14	SS	100/ 0.150		196					
	Slightly weathered, laminated, reddish brown: (Queenston Formation)		1	RUN								
	Limestone interbed (25mm to 50mm) at 17.7m, 17.8m, 18.1m											
	Highly broken zone (100mm) at 18.2m		2	RUN								
	Sub-vertical fracture (25mm) at 18.6m 150mm at 18.4m 75mm at 18.6m											
	Limestone interbed (25mm) at 18.7m, 18.8m		3	RUN								
	Highly broken zone from 19.1m to 20.0m											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity


20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C16-05

3 OF 3

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 437.8 E 586 733.3 ORIGINATED BY ADH/DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.10.02 - 2014.10.03 CHECKED BY KS

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 γ kN/m ³	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	20	40	60
								○ UNCONFINED	+	FIELD VANE						● QUICK TRIAXIAL	×	LAB VANE		
	Continued From Previous Page						195													
	Limestone interbed (25mm) at 20.5m, 20.8m, 21.2m																			
	Slightly weathered		4	RUN																
	Vertical fracture (75mm) at 20.8m						194													
193.8																				
21.3	END OF BOREHOLE AT 21.3m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																			

RECORD OF BOREHOLE No C16-06

1 OF 2

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 438.9 E 586 757.5 ORIGINATED BY DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.11 - 2014.09.11 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100							
215.2	GROUND SURFACE														
0.0 214.9	TOPSOIL: (250mm)														
0.3	Clayey SILT , some sand Firm to Very Stiff Brown Moist (TILL)		1	SS	5										
			2	SS	8										
			3	SS	27										
213.2															
2.0	SILT , some sand and clay Dense Brown to Grey Moist														
			4	SS	32										
212.2															
3.0	SAND and SILT , trace clay Compact Brown Moist														
			5	SS	24										
211.1															
4.1	SILT , clayey to some clay, sandy to some sand, trace gravel, occasional sand pockets Very Stiff to Hard Brown Moist (TILL)														
			6	SS	28										

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C16-06

2 OF 2

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 438.9 E 586 757.5 ORIGINATED BY DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.11 - 2014.09.11 CHECKED BY KS

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L				
	Continued From Previous Page													
	BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.													

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C16-07

1 OF 2

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 458.7 E 586 772.5 ORIGINATED BY DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.12 - 2014.09.12 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
215.6	GROUND SURFACE							20 40 60 80 100					
0.0	TOPSOIL: (250mm)							20 40 60 80 100					
215.3								20 40 60 80 100					
0.3	Clayey SILT , some sand, trace gravel Firm to Hard Reddish Brown to Grey Moist (TILL)		1	SS	4		215						
			2	SS	30								
			3	SS	38		214						
213.3													
2.3	SILT , some sand and clay Compact to Dense Grey Moist		4	SS	34		213						
			5	SS	19		212						
211.6													
4.0	SILT , clayey to some clay, some sand, trace gravel, occasional sand pockets and gravel seams Compact to Very Dense Brown Moist (TILL)		6	SS	25		211						
			7	SS	40		210						
			8	SS	98/ 0.275		209						
							208						
206.9							207						
8.7	SAND and SILT Compact Brown Wet		9	SS	19		206						
205.8													
9.8	END OF BOREHOLE AT 9.8m.												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C16-07

2 OF 2

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 458.7 E 586 772.5 ORIGINATED BY DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.12 - 2014.09.12 CHECKED BY KS

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 ³	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 _p	W	W _L			
	Continued From Previous Page BOREHOLE OPEN TO 9.8m AND WATER LEVEL AT 9.1m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 25/ 14 0.1 215.5 Dec 19/ 14 0.2* 215.8 * Above ground surface																

RECORD OF BOREHOLE No C16-08

1 OF 3

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 448.2 E 586 774.3 ORIGINATED BY DJP/ADH
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/Tricone/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.09.18 - 2014.09.22 CHECKED BY KS

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 ³	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				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					WATER CONTENT (%)								
215.4	GROUND SURFACE						20	40	60	80	100										
0.0	TOPSOIL: (225mm)						20	40	60	80	100										
0.2	Silty CLAY , some sand to sandy Firm to Hard Brown Moist (TILL)		1	SS	6																
			2	SS	28																
			3	SS	24																
212.9																					
2.5	SILT, some sand and clay Compact to Dense Brown and Grey Moist		4	SS	36																
			5	SS	21																
211.3																					
4.1	SILT, clayey to some clay, sandy to some sand, trace gravel Very Stiff to Hard Brown Moist (TILL)																				
			6	SS	19																
			7	SS	31																
			8	SS	81																
			9	SS	78/ 0.275																

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C16-08

2 OF 3

METRIC

W.P. _____ LOCATION C16A/B Culvert N 4 819 448.2 E 586 774.3 ORIGINATED BY DJP/ADH
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/Tricone/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.09.18 - 2014.09.22 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
Continued From Previous Page								20 40 60 80 100						
205.2							205							
10.2	SAND and SILT Dense Brown Wet		10	SS	48		204							
203.7														
11.7	Gravelly SAND , some silt, occasional cobbles Very Dense Brown Wet		11	SS	64		203							
202.1														
13.3	SAND and SILT , trace clay, trace gravel Very Dense Brown Wet (TILL)		12	SS	100/ 0.200		202							
							201							
							200							
			13	SS	68									
							199							
			14	SS	72/ 0.275									
							198							
197.7														
17.7	SILT , some clay to clayey, trace to some sand, trace gravel, occasional cobbles and limestone fragments Hard Brown to Reddish Brown Moist (TILL)		15	SS	50/ 0.100		197							
							196							

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C16-08

3 OF 3

METRIC

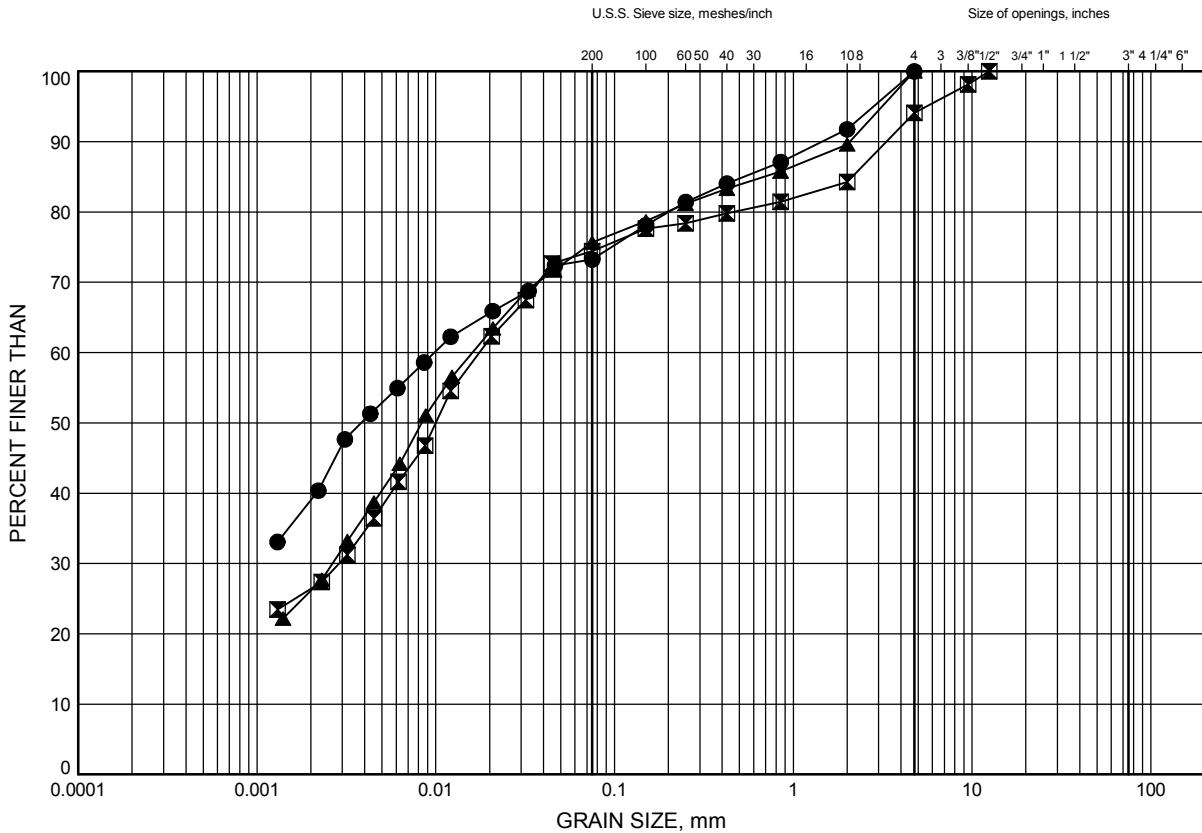
W.P. _____ LOCATION C16A/B Culvert N 4 819 448.2 E 586 774.3 ORIGINATED BY DJP/ADH
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/Tricone/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.09.18 - 2014.09.22 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
								20 40 60 80 100				w P w w L					
	Continued From Previous Page																
193.5			16	SS	93		195										
21.9	SHALE , highly weathered, reddish brown Silty sand infills from 21.9m to 22.5m Moderately weathered, laminated: (Queenston Formation) Limestone interbed (25mm to 100mm) at 22.5m, 22.8m, 23.0m and 23.2m Limestone interbed at 23.9m Limestone interbed (25mm to 75mm) at 24.6m and 25.5m		17	SS	50/ 0.100		193										
			1	RUN			192										
			2	RUN			191										
			3	RUN			190										
189.8																	
25.6	END OF BOREHOLE AT 25.6m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND SOIL CUTTINGS TO SURFACE.																

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO).GDT 2/18/15

GRAIN SIZE DISTRIBUTION

SILTY CLAY (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C16-01	1.07	214.03
⊠	C16-05	1.07	214.03
▲	C16-08	1.83	213.57

Date February 2015

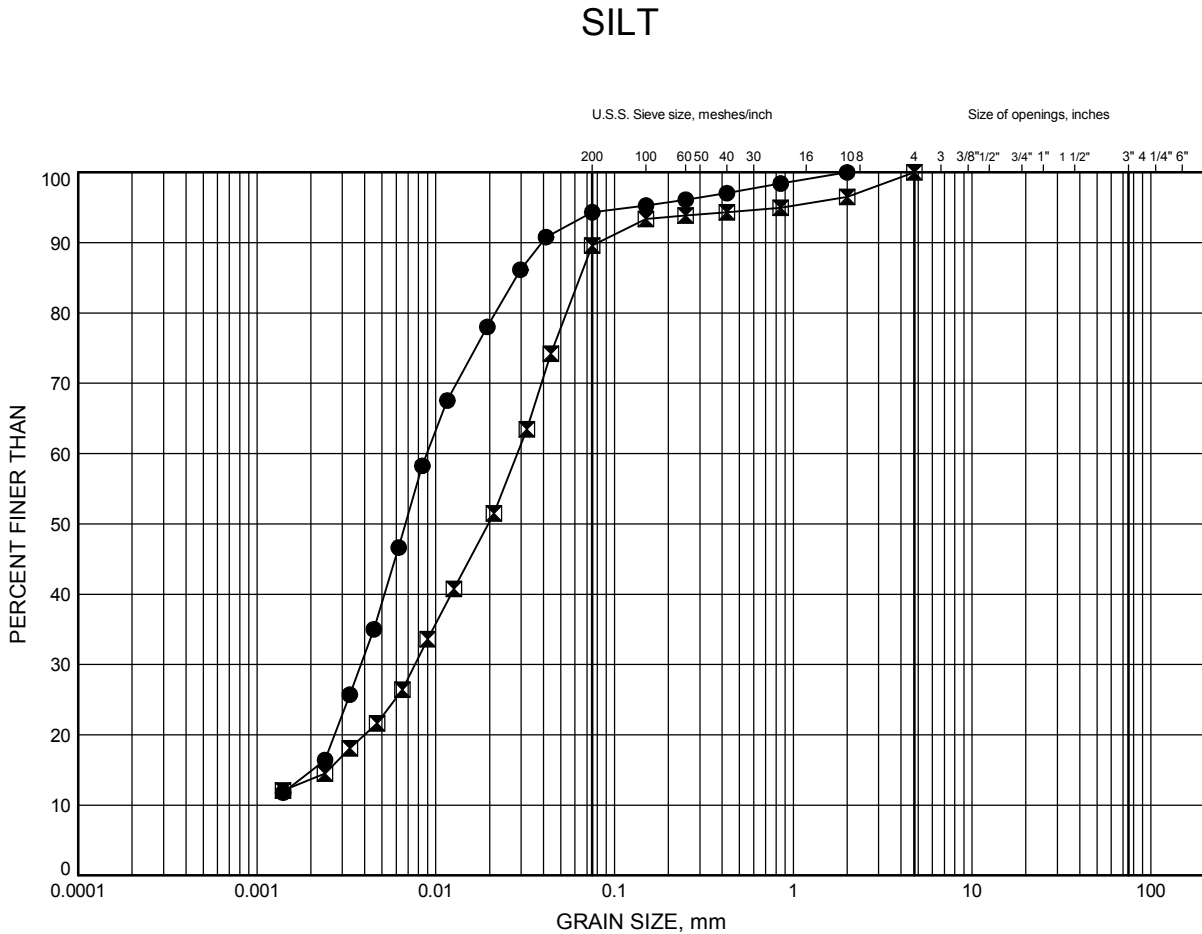
W.P.



Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C16-03	2.11	213.09
⊠	C16-06	2.59	212.61

Date February 2015

W.P. _____

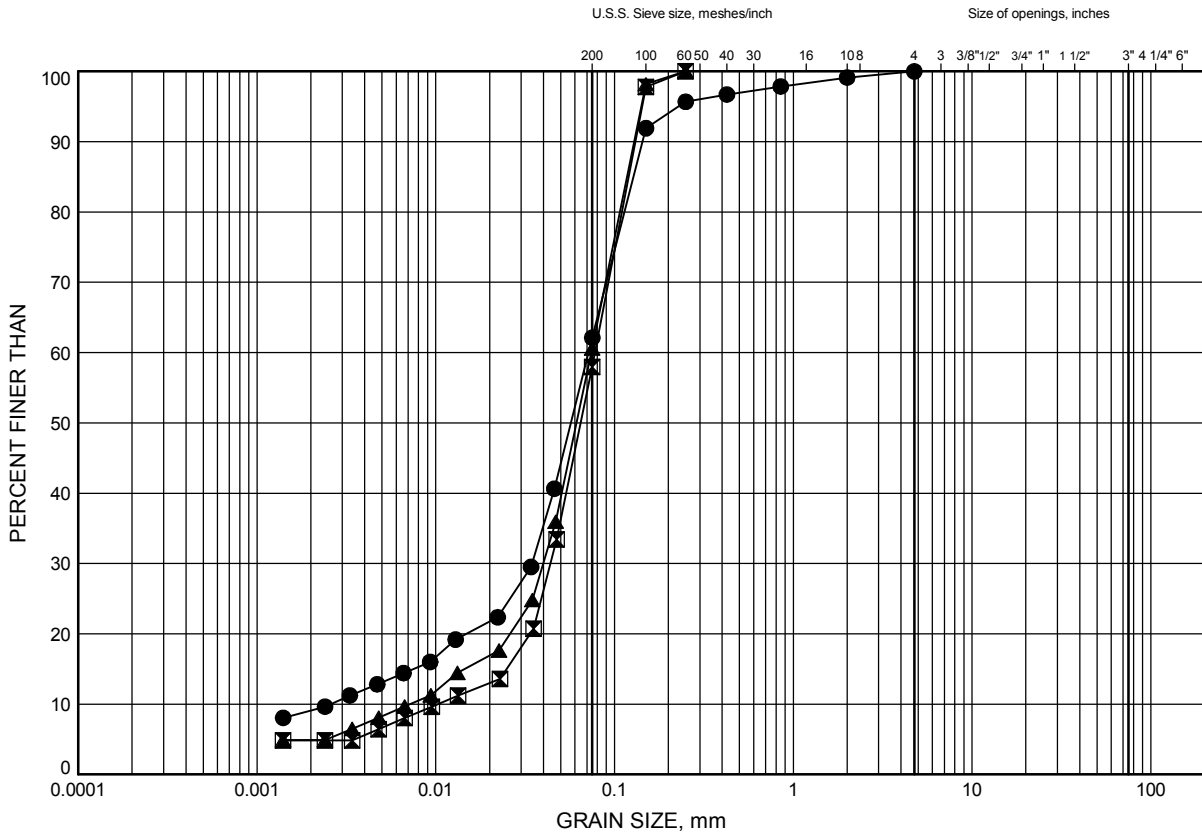


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C16-02	3.35	211.65
⊠	C16-03	4.66	210.54
▲	C16-04	3.35	211.45

Date February 2015

W.P.

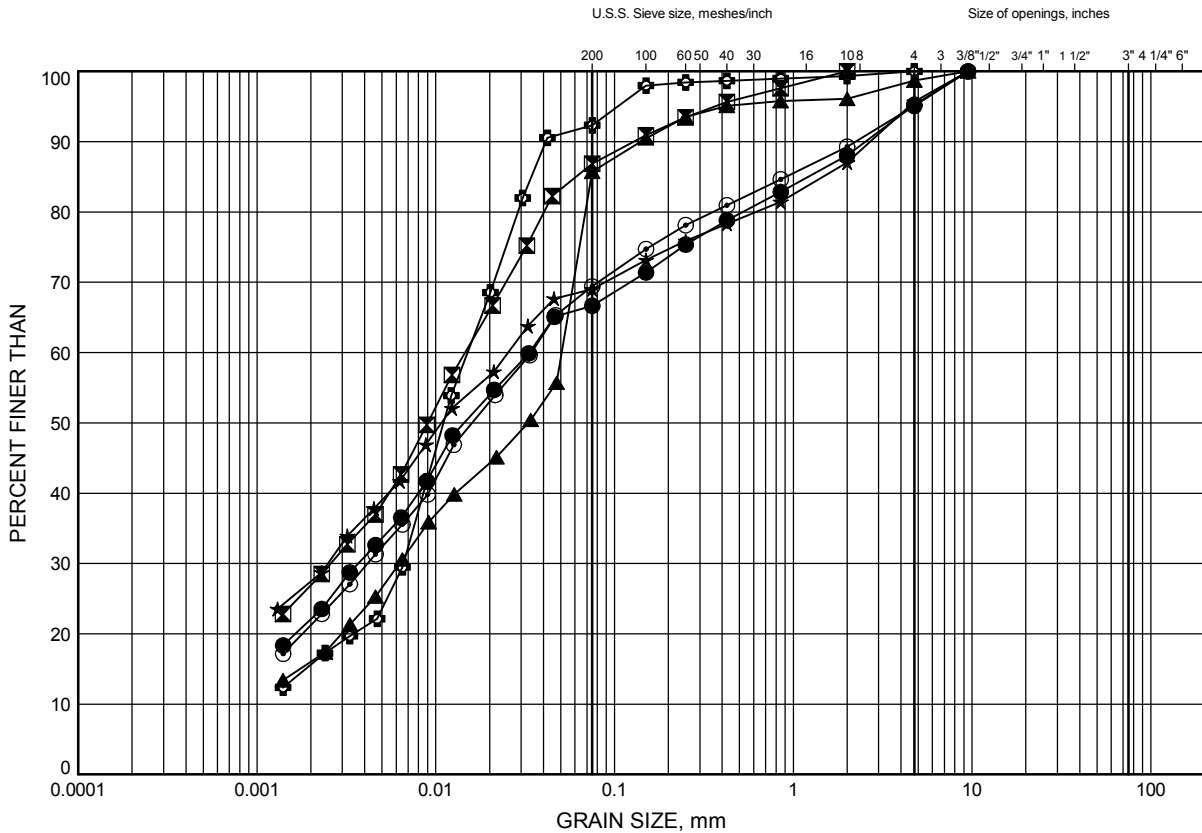


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

CLAYEY SILT to SILT, Some Clay (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C16-01	6.25	208.85
⊠	C16-01	10.52	204.58
▲	C16-01	16.59	198.51
★	C16-02	6.40	208.60
⊙	C16-04	6.40	208.40
⊕	C16-05	9.45	205.65

Date February 2015

W.P. _____

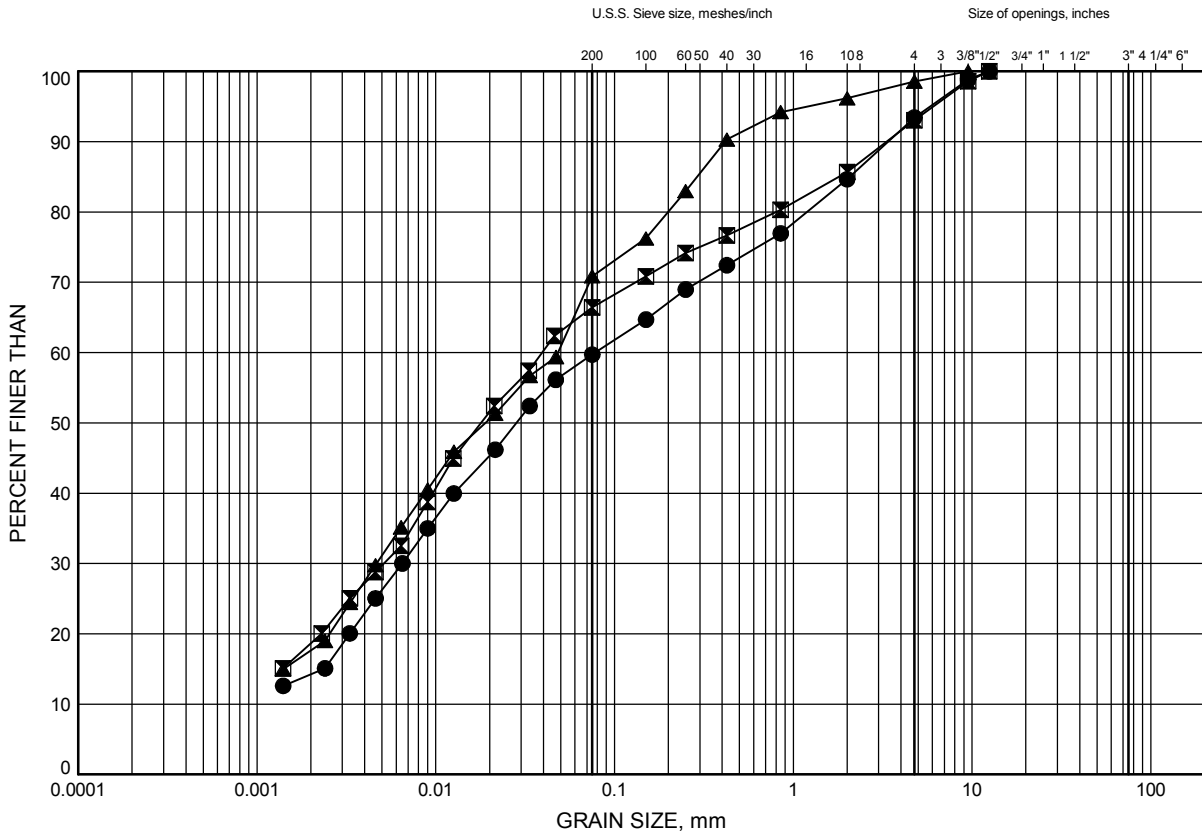


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

CLAYEY SILT to SILT, Some Clay (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C16-06	6.40	208.80
⊠	C16-08	6.40	209.00
▲	C16-08	19.96	195.44

Date February 2015

W.P.

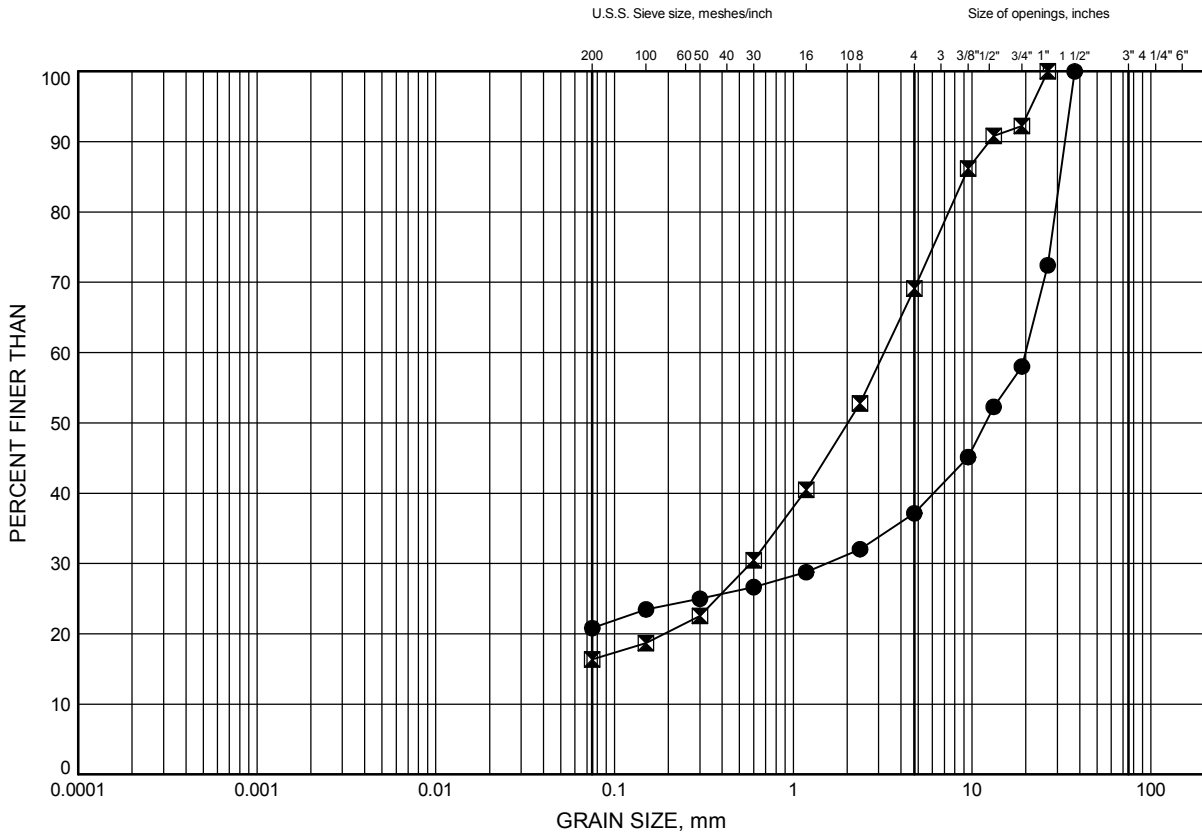


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

SILTY GRAVEL to GRAVELLY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C16-04	10.97	203.83
⊠	C16-08	12.50	202.90

Date February 2015

W.P. _____

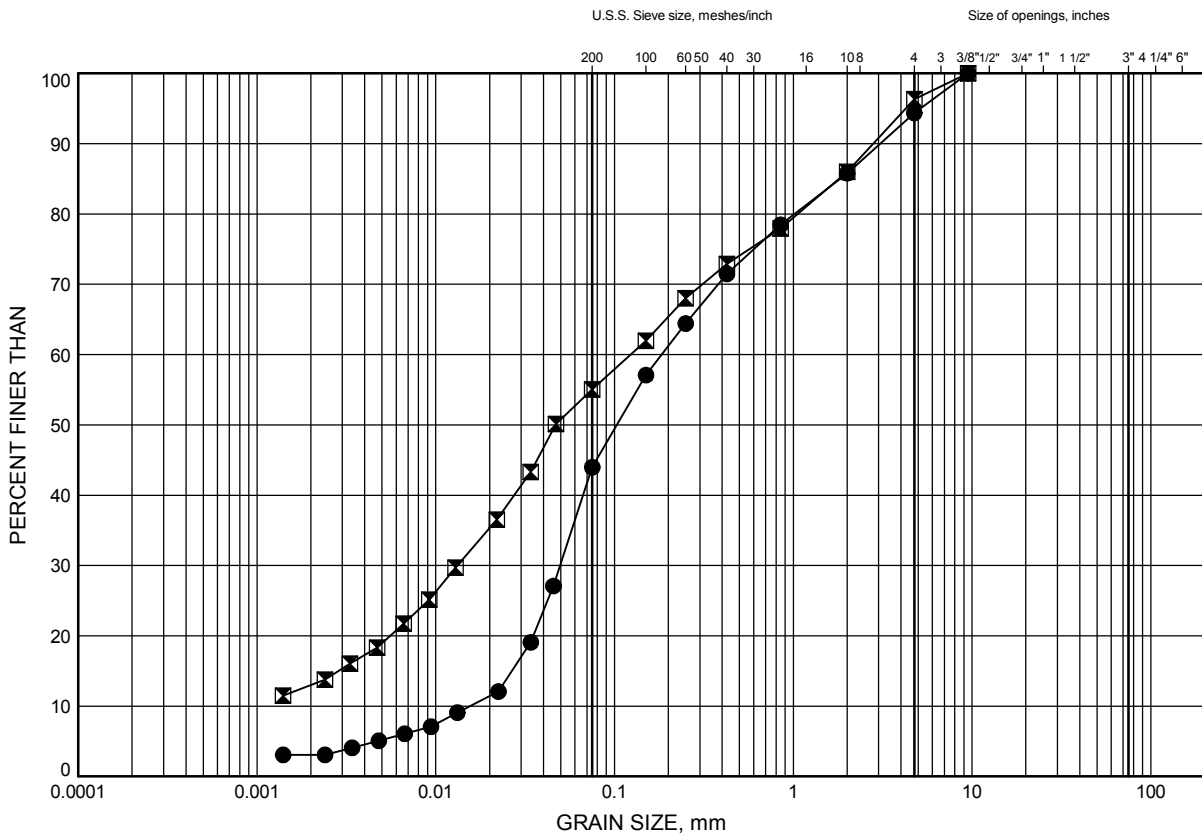


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Chkd. KS

GRAIN SIZE DISTRIBUTION

SAND & SILT (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C16-04	14.02	200.78
⊠	C16-05	15.51	199.59

Date February 2015

W.P.



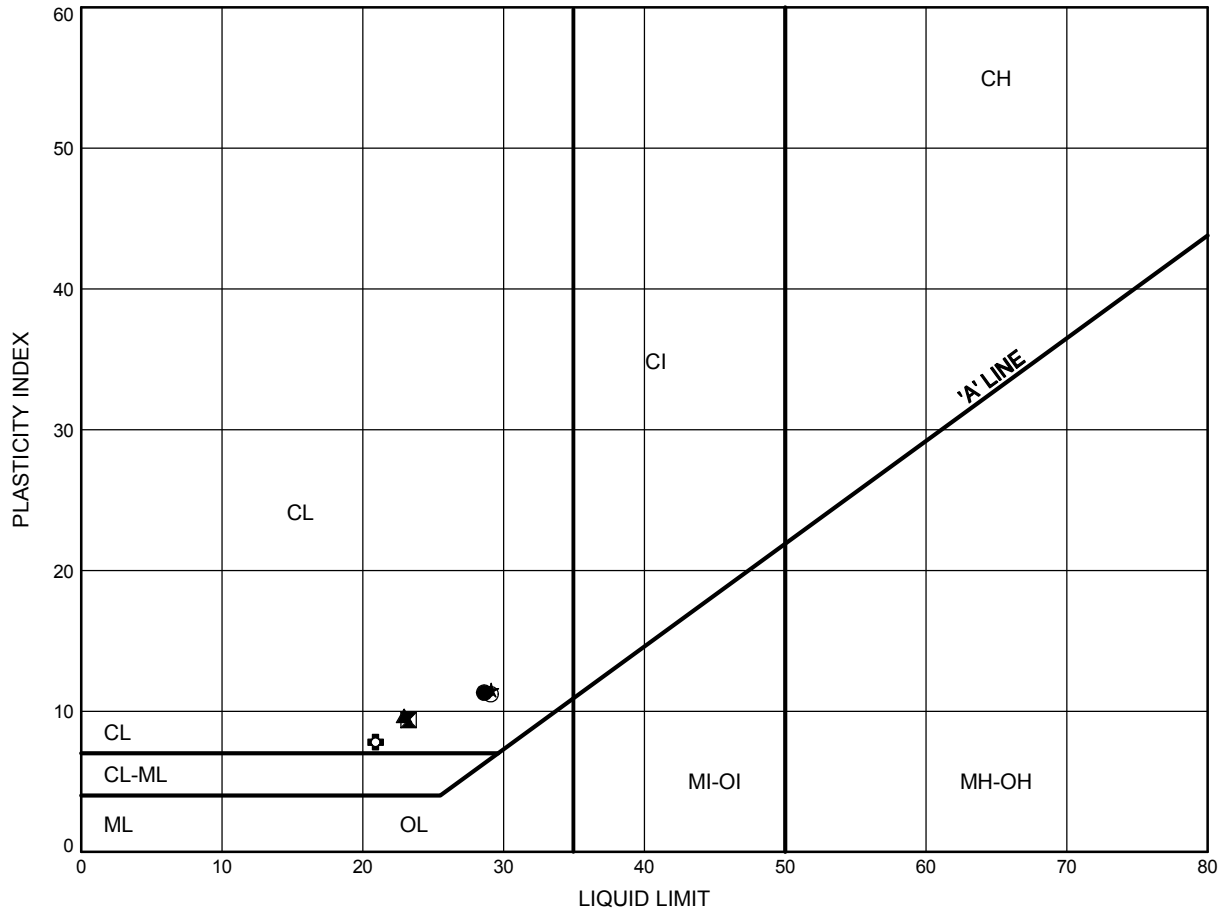
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Chkd. KS

New Tremaine Road I/C at Hwy 401 - Culvert C16A & C16B
ATTERBERG LIMITS TEST RESULTS

FIGURE A7

CLAYEY SILT to SILTY CLAY



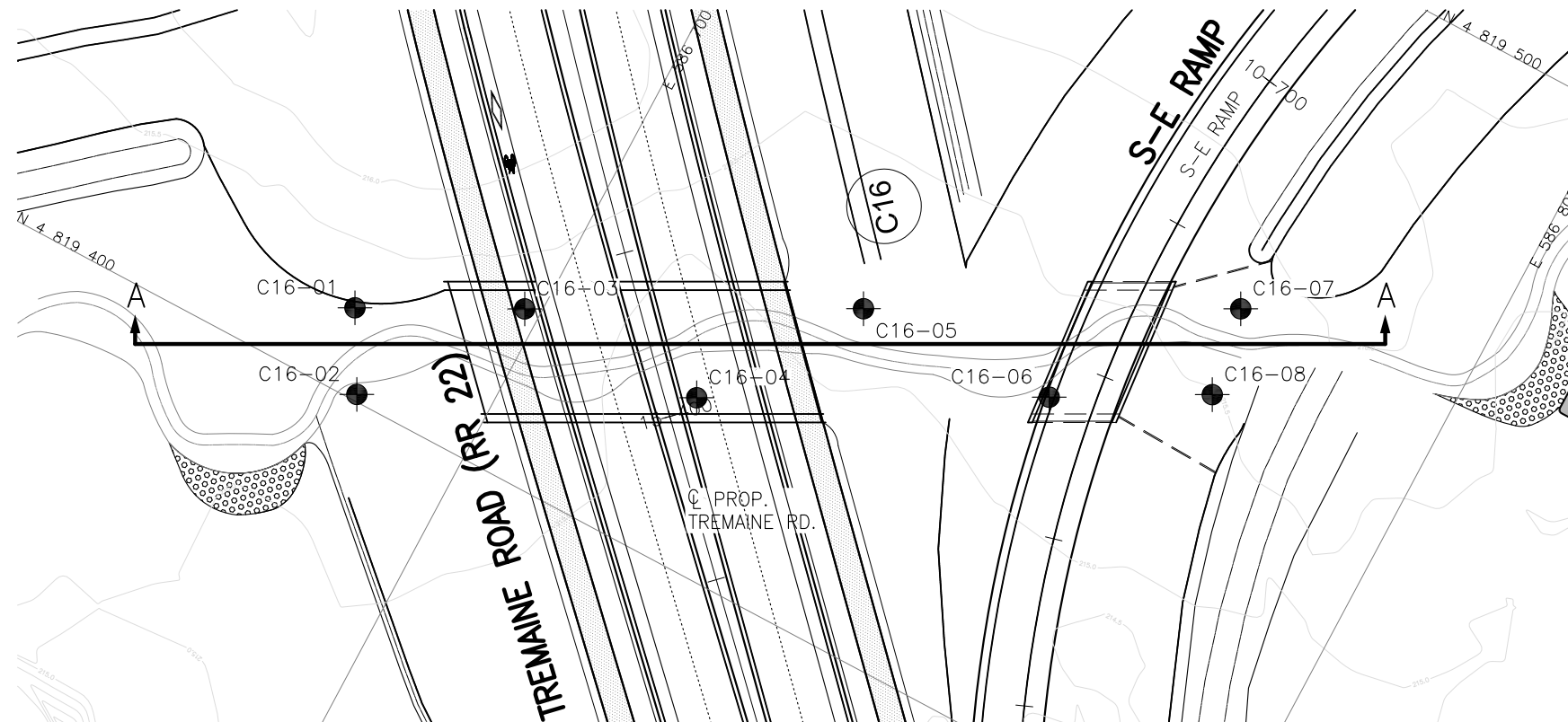
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C16-01	1.07	214.03
⊠	C16-01	6.25	208.85
▲	C16-02	6.40	208.60
★	C16-05	1.07	214.03
⊙	C16-08	1.83	213.57
⊕	C16-08	19.96	195.44

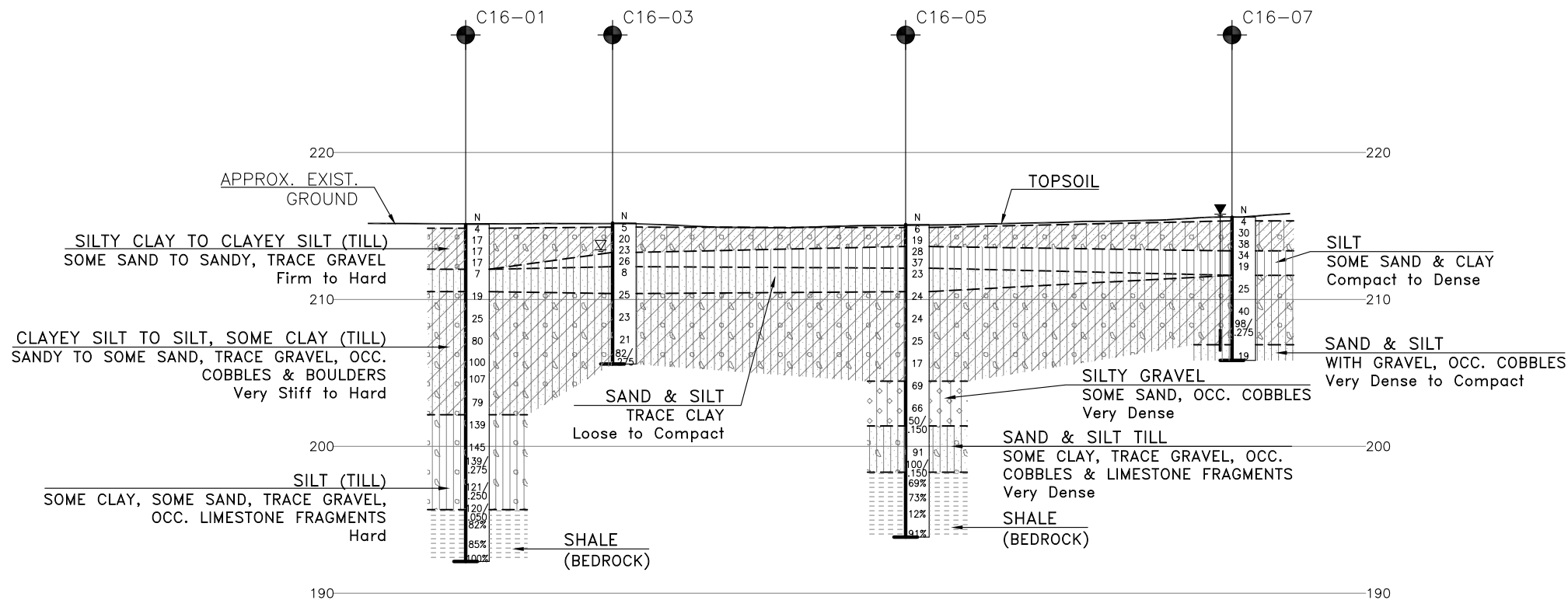
Date February 2015
 W.P.



Prep'd AN
 Chkd. KS



PLAN



PROFILE ALONG A-A

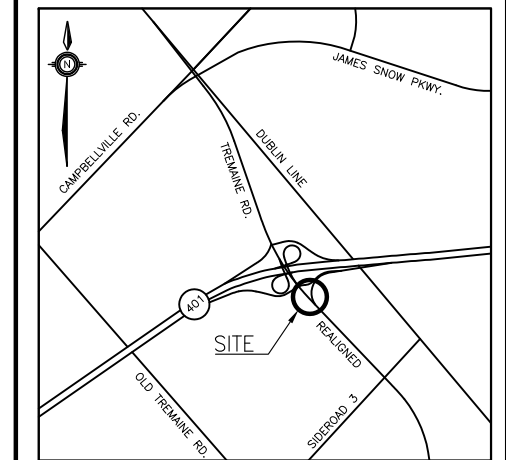


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No
WP No

NEW TREMAINE ROAD
INTERCHANGE AT HWY 401
STRUCTURES C16A & C16B
BOREHOLE LOCATIONS AND SOIL STRATA



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 In Open Borehole
	Water Level In Well/Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

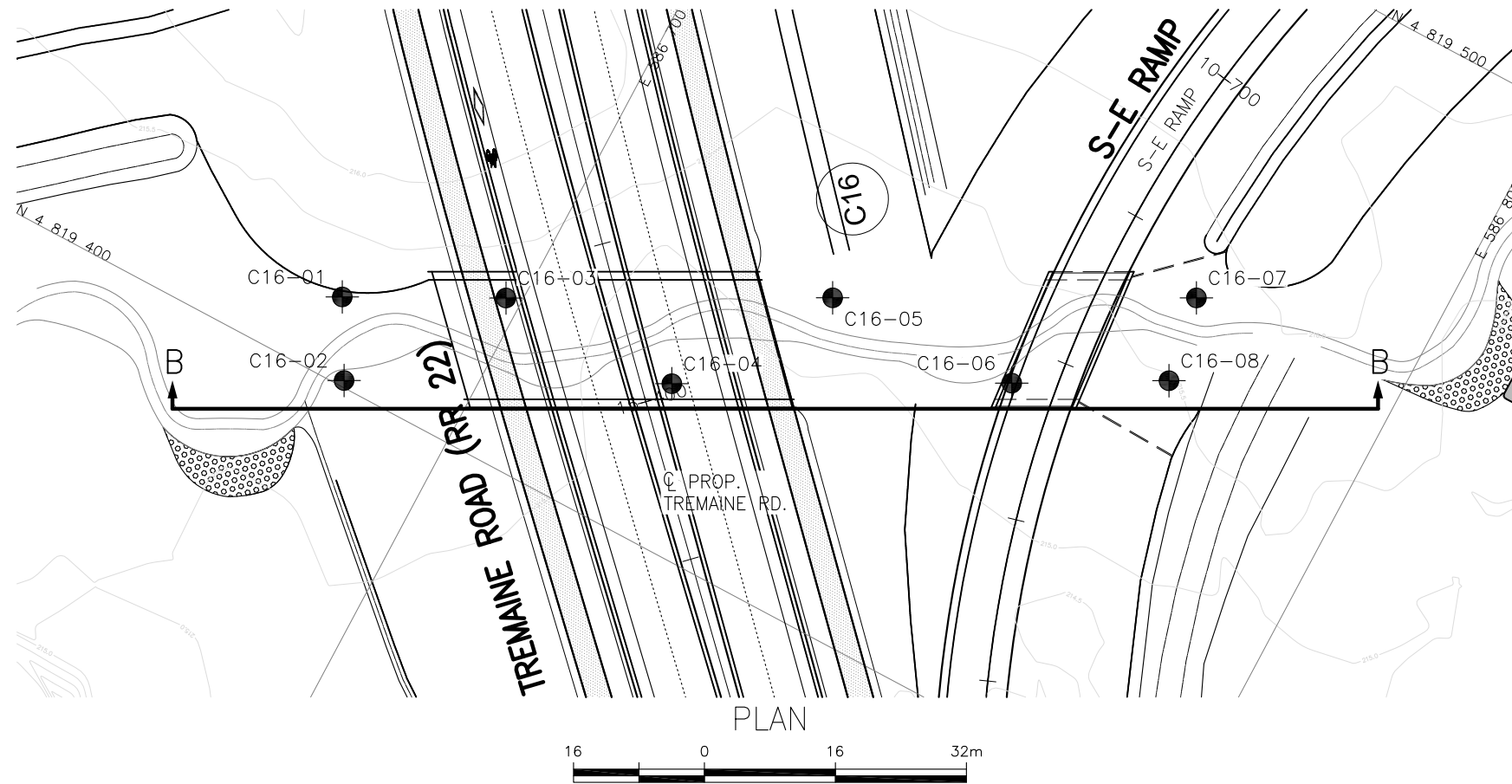
NO	ELEVATION	NORTHING	EASTING
C16-01	215.1	4 819 409.7	586 680.4
C16-02	215.0	4 819 400.8	586 685.4
C16-03	215.2	4 819 419.0	586 698.1
C16-04	214.8	4 819 419.3	586 720.9
C16-05	215.1	4 819 437.8	586 733.3
C16-06	215.2	4 819 438.9	586 757.5
C16-07	215.6	4 819 458.7	586 772.5
C16-08	215.4	4 819 448.2	586 774.3

NOTES

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

GEOCRES No. 30M12-381

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	KS	CHK MRA	CODE
DRAWN	AN	CHK KS	SITE
			LOAD
			STRUCT
			DWG 1
			DATE OCT 2019



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

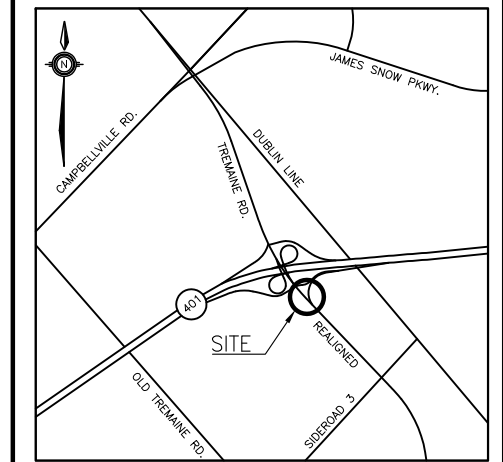


CONT No
WP No

NEW TREMAINE ROAD
INTERCHANGE AT HWY 401
STRUCTURES C16A & C16B
BOREHOLE LOCATIONS AND SOIL STRATA

WSP

SHEET



KEYPLAN

LEGEND

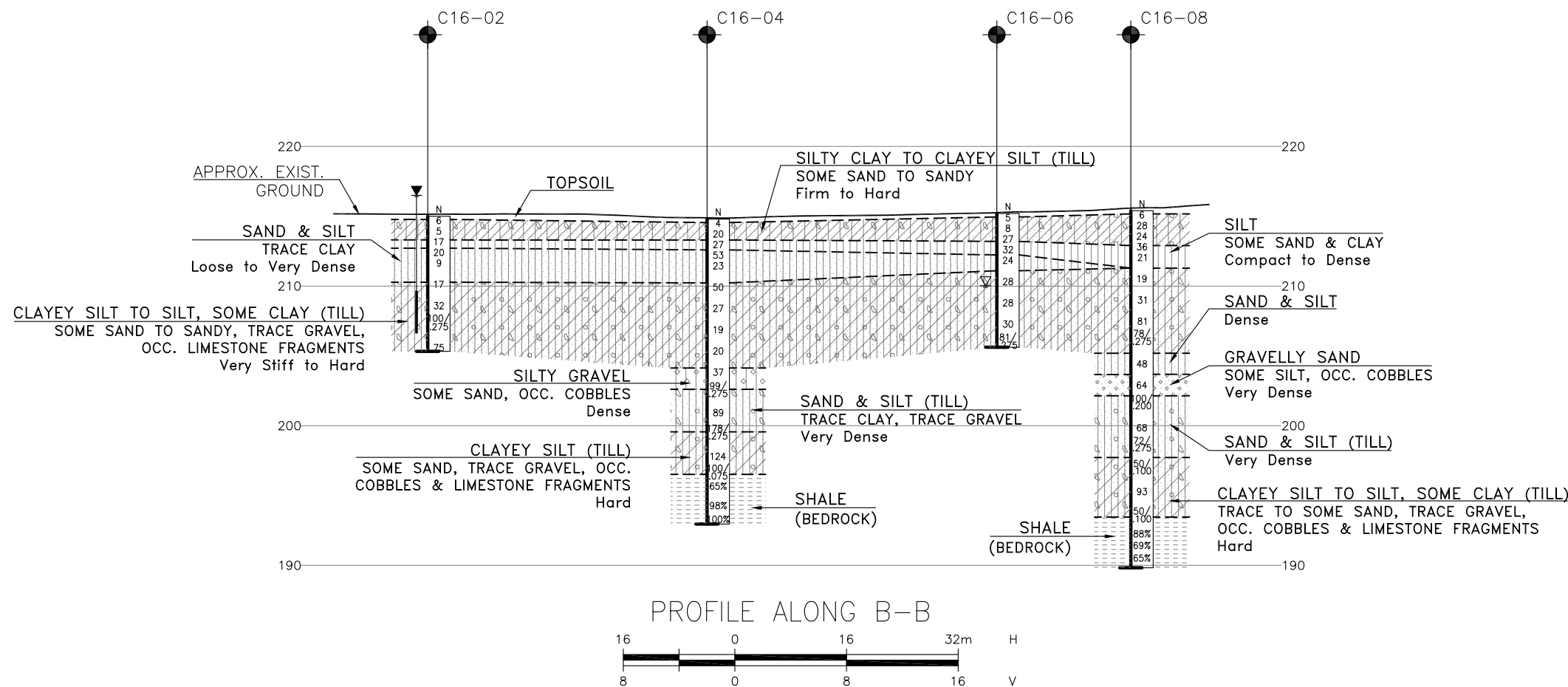
- Borehole
- Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level In Open Borehole
- Water Level In Well/Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
C16-01	215.1	4 819 409.7	586 680.4
C16-02	215.0	4 819 400.8	586 685.4
C16-03	215.2	4 819 419.0	586 698.1
C16-04	214.8	4 819 419.3	586 720.9
C16-05	215.1	4 819 437.8	586 733.3
C16-06	215.2	4 819 438.9	586 757.5
C16-07	215.6	4 819 458.7	586 772.5
C16-08	215.4	4 819 448.2	586 774.3

NOTES-

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

GEOCRES No. 30M12-381



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	KS	CHK MRA	CODE
DRAWN	AN	CHK KS	SITE
			LOAD
			STRUCT
			DATE
			DWG

Appendix B

Culvert 17

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

RECORD OF BOREHOLE No C17-01

1 OF 2

METRIC

W.P. _____ LOCATION C17 Culvert N 4 819 416.9 E 586 337.9 ORIGINATED BY MNW
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.09 - 2014.09.09 CHECKED BY KS

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
217.2	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL: (300mm)						217										
216.9			1	SS	3												
0.3	Clayey SILT , some sand, trace gravel, with organics Soft to Firm Dark Brown to Brown Moist to Wet (TILL)																
			2	SS	6												
215.8							216										
1.4	SAND and SILT , trace clay Compact Brown Wet		3	SS	12												
			4	SS	14												
							215										
			5	SS	16												
							214										
213.1							213										
4.1	SILT , some clay, trace sand Loose Brown Wet		6	SS	8												
							212										
211.0							211										
6.2	Clayey SILT , sandy to some sand, trace gravel Hard Brown Moist (TILL)		7	SS	40												
			8	SS	34												
							210										
							209										
			9	SS	102		208										
207.4																	
9.8	END OF BOREHOLE AT 9.8m.																

Continued Next Page

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

RECORD OF BOREHOLE No C17-01

2 OF 2

METRIC

W.P. _____ LOCATION C17 Culvert N 4 819 416.9 E 586 337.9 ORIGINATED BY MNW
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.09 - 2014.09.09 CHECKED BY KS

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W P	W	W L	WATER CONTENT (%)		
	Continued From Previous Page													
	Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 25/ 14 0.6 216.6 Dec 19/ 14 0.2 217.0													

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C17-02

1 OF 2

METRIC

W.P. _____ LOCATION C17 Culvert N 4 819 406.6 E 586 347.8 ORIGINATED BY MNW
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.08 - 2014.09.08 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
217.2	GROUND SURFACE													
0.0	TOPSOIL: (225mm)													
0.2	Clayey SILT , sandy, trace gravel, occasional sand pockets, with organic staining Firm to Very Stiff Brown Moist (TILL)		1	SS	7		217							
216.0			2	SS	21		216							5 40 40 15
1.2	SAND and SILT , trace to some clay, trace gravel Loose to Compact Brown Wet		3	SS	21		215							
			4	SS	15		214							
			5	SS	9		213							
			6	SS	22		212							
211.7	Silt layer from 4.3m to 4.8m						211							
5.5	Clayey SILT , sandy, trace gravel, occasional silt pockets Hard Brown Moist (TILL)		7	SS	49		210							
			8	SS	45		209							1 28 52 19
			9	SS	52		208							
207.4	END OF BOREHOLE AT 9.8m.													
9.8														

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C17-02

2 OF 2

METRIC

W.P. _____ LOCATION C17 Culvert N 4 819 406.6 E 586 347.8 ORIGINATED BY MNW
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.08 - 2014.09.08 CHECKED BY KS

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 ³	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 _p	W	W _L				
	Continued From Previous Page BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																	

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C17-03

1 OF 2

METRIC

W.P. _____ LOCATION C17 Culvert N 4 819 393.8 E 586 358.6 ORIGINATED BY MNW
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.11 - 2014.09.11 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
217.1	GROUND SURFACE							20 40 60 80 100						
0.0	TOPSOIL: (225mm)						217	20 40 60 80 100						
0.2	Clayey SILT , some sand to sandy, trace gravel, with oxide staining Firm to Very Stiff Brown Moist (TILL)		1	SS	5		217	20 40 60 80 100					11 59 23 7	
			2	SS	21		216	20 40 60 80 100						
215.6								20 40 60 80 100						
1.5	SAND and SILT , trace to some gravel, trace clay Compact Brown Wet With zone of silty sand, some gravel		3	SS	20		215	20 40 60 80 100						
			4	SS	19		214	20 40 60 80 100						
			5	SS	10		213	20 40 60 80 100						
							212	20 40 60 80 100						
212.8								20 40 60 80 100						0 0 87 13
4.3	SILT , some clay Loose Brown to Reddish Brown Wet		6	SS	7		212	20 40 60 80 100						
							211	20 40 60 80 100						
211.5								20 40 60 80 100						
5.6	Clayey SILT , some sand, trace gravel, occasional shale fragments Hard Brown Moist (TILL)		7	SS	68		211	20 40 60 80 100						
							210	20 40 60 80 100						
			8	SS	48		209	20 40 60 80 100						
							208	20 40 60 80 100						
207.3			9	SS	52			20 40 60 80 100						
9.8	END OF BOREHOLE AT 9.8m.							20 40 60 80 100						

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C17-03

2 OF 2

METRIC

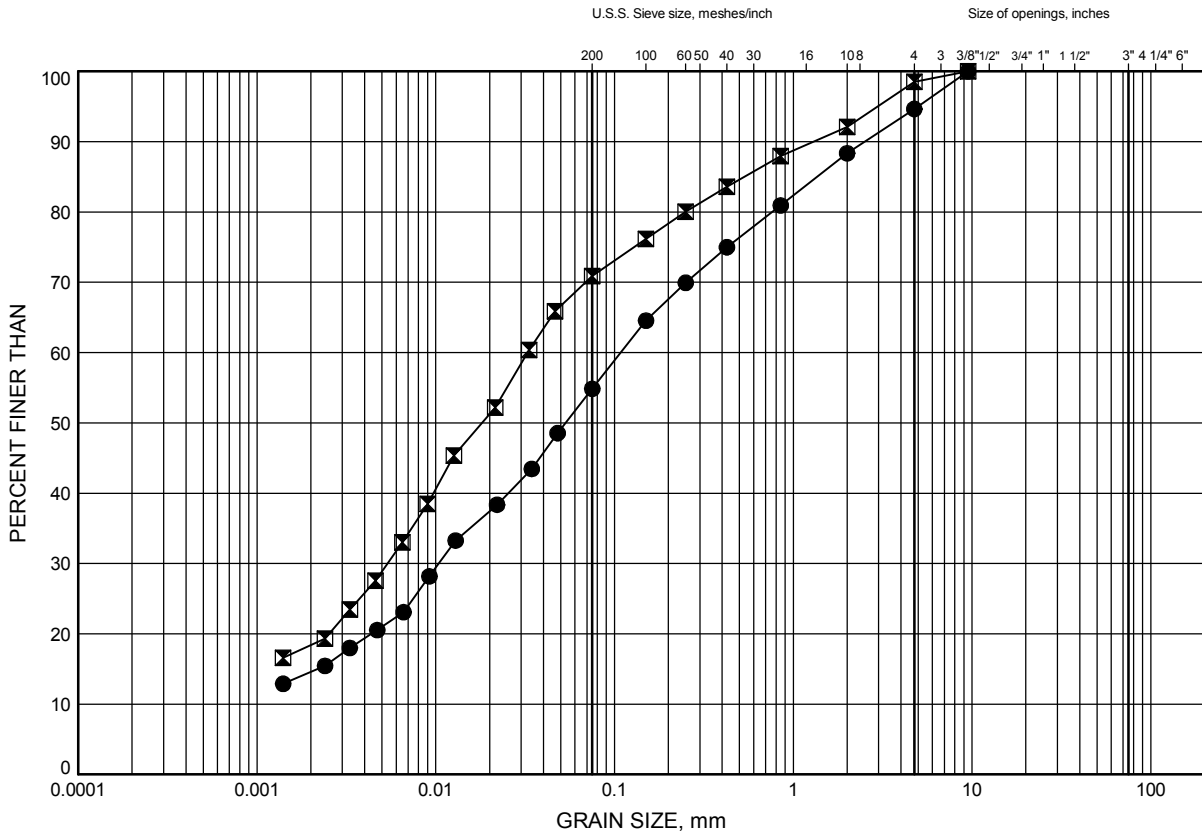
W.P. _____ LOCATION C17 Culvert N 4 819 393.8 E 586 358.6 ORIGINATED BY MNW
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.11 - 2014.09.11 CHECKED BY KS

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 γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
	Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 25/ 14 1.0* 218.1 Dec 19/ 14 0.7* 217.8 * Above ground surface													

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO).GDT 2/18/15

GRAIN SIZE DISTRIBUTION

SANDY, CLAYEY SILT (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C17-02	1.14	216.06
⊠	C17-02	8.08	209.12

Date February 2015

W.P.

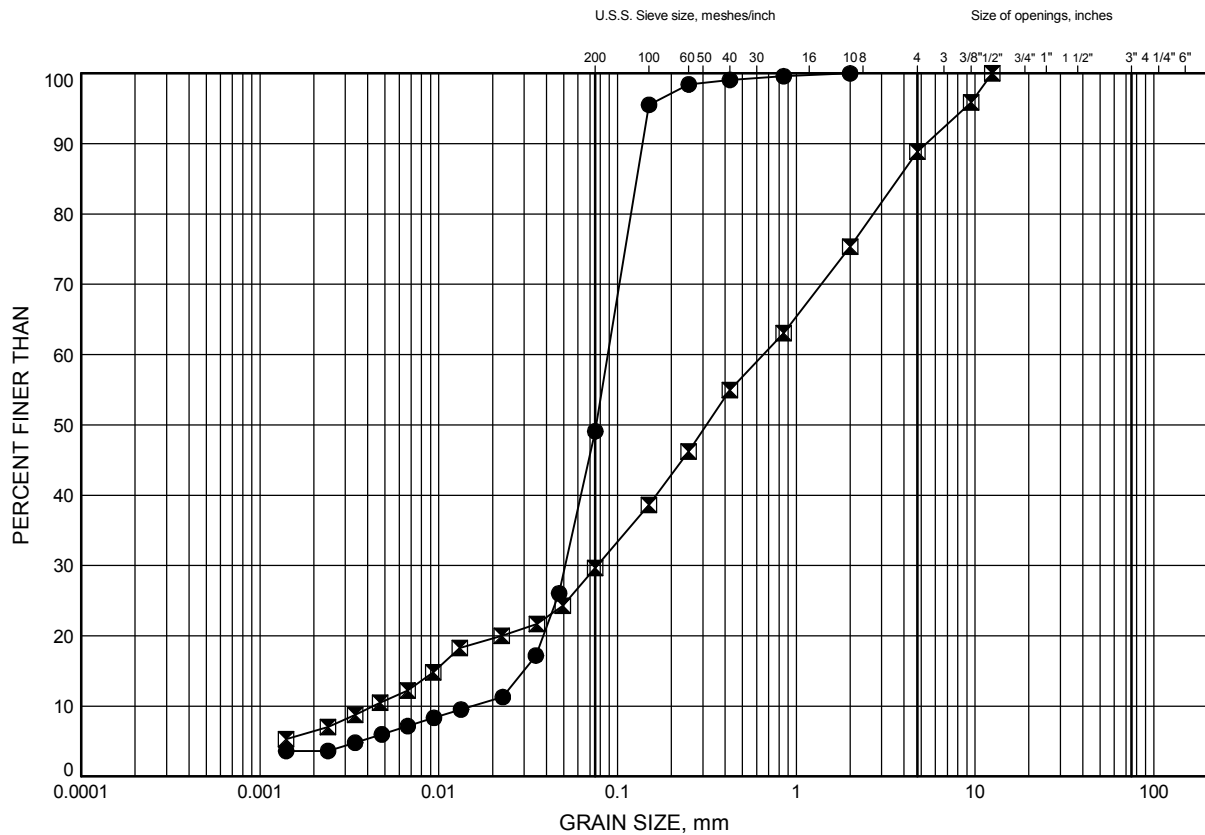


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

SAND & 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)
●	C17-01	2.59	214.61
⊠	C17-03	2.47	214.63

Date February 2015

W.P.

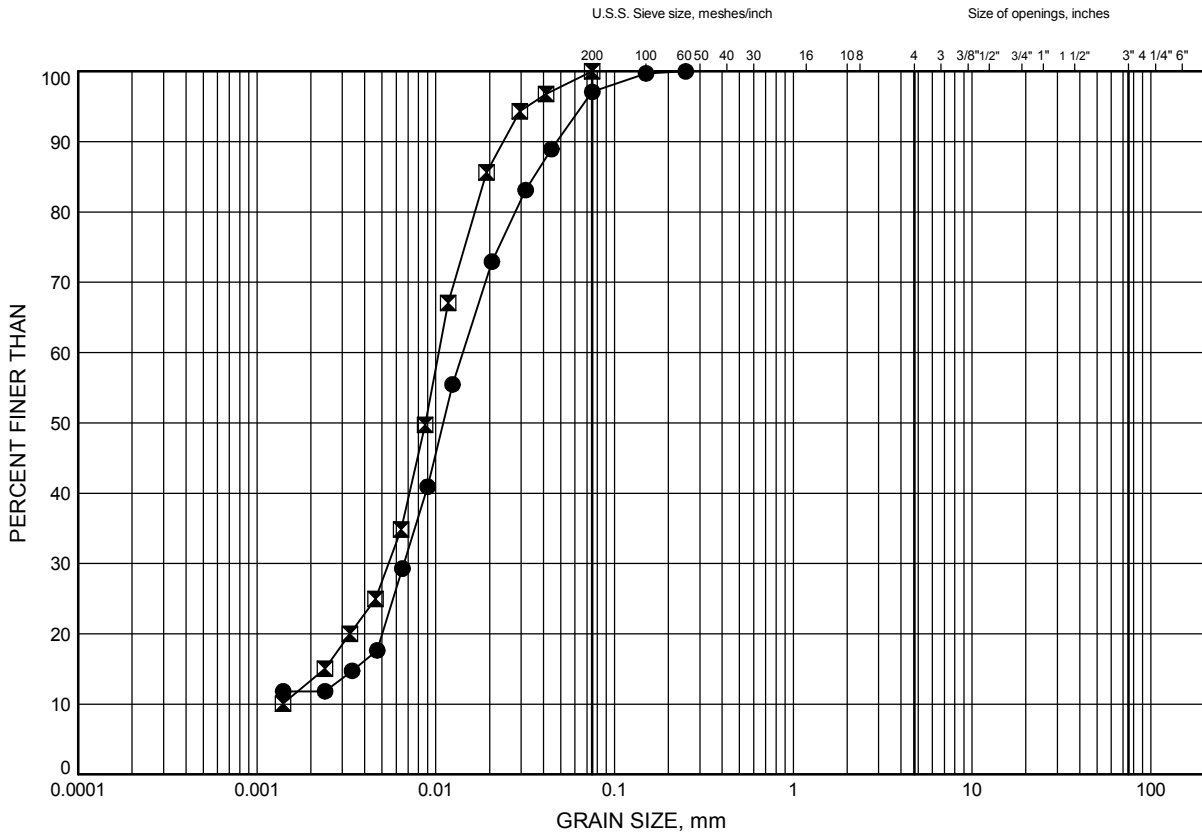


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

SILT, Some Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C17-01	4.88	212.32
⊠	C17-03	4.88	212.22

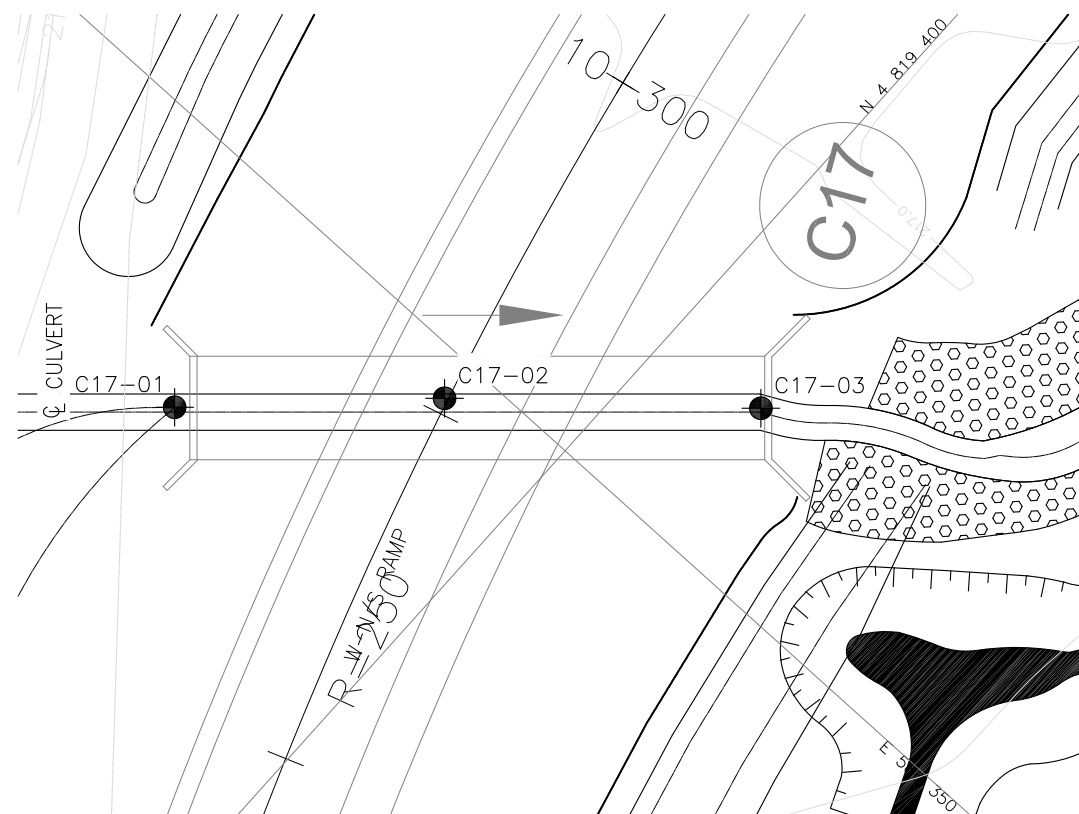
Date February 2015

W.P.

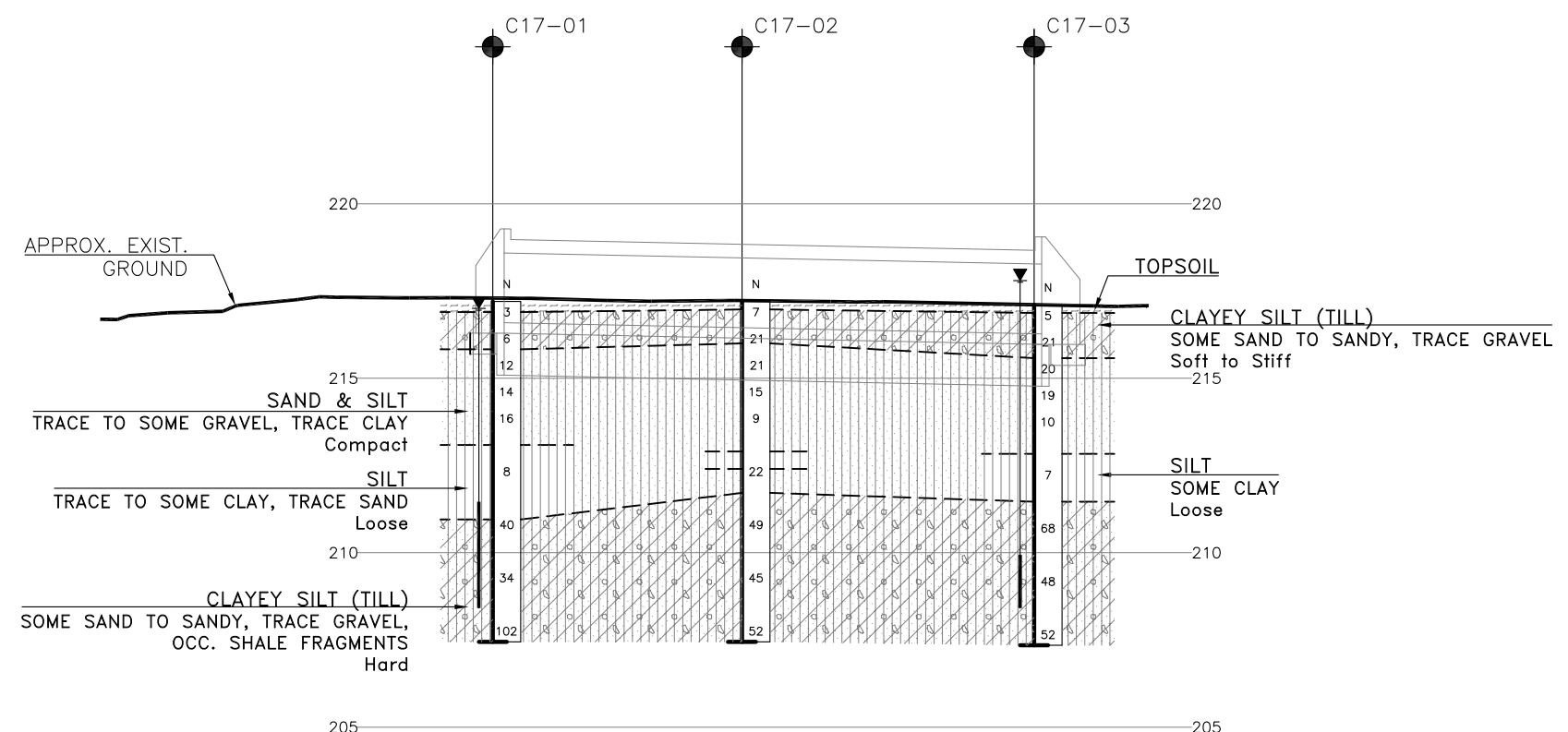
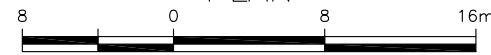


Prep'd AN

Chkd. KS



PLAN



PROFILE ALONG \mathbb{Q} CULVERT



H 1:400

V 1:200

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

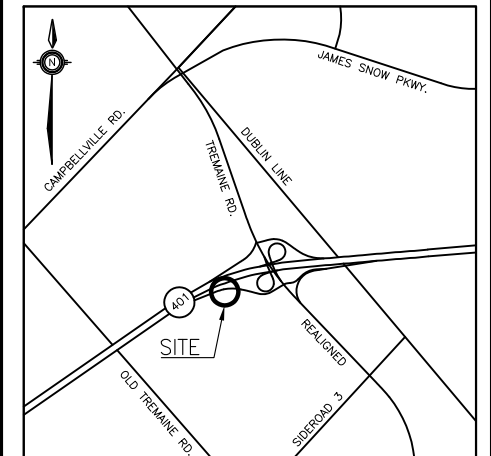


CONT No
WP No

NEW TREMAINE ROAD
INTERCHANGE AT HWY 401
CULVERT C17
BOREHOLE LOCATIONS AND SOIL STRATA








THURBER ENGINEERING LTD.



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 In Open Borehole
	Water Level In Well/Piezometer
	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. 30M12-381

REVISIONS									
	DATE	BY	DESCRIPTION						
DESIGN	KS	CHK	MRA	CODE	LOAD		DATE	OCT 2019	
DRAWN	AN	CHK	KS	SITE	STRUCT		DWG	1	

Appendix C

Culvert 18 (Extension)

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

RECORD OF BOREHOLE No C18-01

1 OF 2

METRIC

W.P. _____ LOCATION C18 Culvert N 4 819 437.0 E 586 216.3 ORIGINATED BY DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.08 - 2014.09.08 CHECKED BY KS

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 ³	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	20 40 60	W _p W W _L					
217.9	GROUND SURFACE													
0.0	TOPSOIL: (100mm)													
0.1	Clayey SILT, sandy Soft to Stiff Brown Moist (TILL)		1	SS	3									
			2	SS	15									
			3	SS	10								0 29 47 24	
215.8														
2.1	SILT, trace to some clay, trace sand Very Loose to Compact Brown to Grey Wet		4	SS	18									
			5	SS	13								0 5 85 10	
			6	SS	0								0 6 83 11	
			7	SS	5									
			8	SS	8									
			9	SS	7									
208.1														
9.8	END OF BOREHOLE AT 9.8m.													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C18-01

2 OF 2

METRIC

W.P. _____ LOCATION C18 Culvert N 4 819 437.0 E 586 216.3 ORIGINATED BY DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.08 - 2014.09.08 CHECKED BY KS

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 ³	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 _p	W	W _L			
	Continued From Previous Page BOREHOLE OPEN TO 3.0m AND WATER LEVEL AT 1.2m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 26/ 14 0.9* 218.8 Dec 19/ 14 0.4 217.5 * Above ground surface																

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C18-02

1 OF 2

METRIC

W.P. _____ LOCATION C18 Culvert N 4 819 435.9 E 586 243.5 ORIGINATED BY DJP
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.08 - 2014.09.08 CHECKED BY KS

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W P	W	W L	WATER CONTENT (%)		
217.9	GROUND SURFACE													
0.0	TOPSOIL: (300mm)													
217.6														
0.3	Clayey SILT, sandy, with organics Firm Brown Moist (TILL)		1	SS	6									
217.1														
0.8	SAND and SILT, trace to some clay, some gravel, trace organics Compact Brown to Grey Moist		2	SS	13									0 47 41 12
			3	SS	17									
215.5														
2.4	SILT, trace to some clay, trace sand Very Loose to Loose Grey Wet		4	SS	8									
			5	SS	10									0 2 89 9
			6	SS	0									
			7	SS	1									
			8	SS	4									0 8 81 11
			9	SS	7									
208.1														
9.8	END OF BOREHOLE AT 9.8m.													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C18-02

2 OF 2

METRIC

W.P. _____ LOCATION C18 Culvert N 4 819 435.9 E 586 243.5 ORIGINATED BY DJP
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.08 - 2014.09.08 CHECKED BY KS

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 ³	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		
	Continued From Previous Page																
	Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.																
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 26/ 14 0.7* 218.6 Dec 19/ 14 Frozen																
	* Above ground surface																

ONTMT4S 19-5161-155 (FOUNDATION).GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C18-03

1 OF 2

METRIC

W.P. _____ LOCATION C18 Culvert N 4 819 416.1 E 586 322.0 ORIGINATED BY MNW
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.08 - 2014.09.08 CHECKED BY KS

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 ³	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 ● QUICK TRIAXIAL × LAB VANE				W P W W L				
								20 40 60 80 100				20 40 60				
217.3	GROUND SURFACE															
0.0	TOPSOIL: (150mm)															
0.2	Clayey SILT, sandy, trace rootlets Firm to Stiff Brown Moist (TILL)		1	SS	3		217								0 26 53 21	
216.4																
0.9	SAND and SILT, trace clay, occasional gravelly pockets Compact Brown Wet		2	SS	22		216									
			3	SS	22											
			4	SS	13		215									
			5	SS	12		214									
213.2																
4.1	SILT, trace to some clay Compact Brown Wet		6	SS	11		213									
							212									
211.7																
5.6	Clayey SILT, some sand to sandy Very Stiff to Hard Brown Moist to Wet (TILL)		7	SS	36		211									
							210									
			8	SS	19										0 49 48 3	
							209									
			9	SS	65		208									
207.5																
9.8	END OF BOREHOLE AT 9.8m.															

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C18-03

2 OF 2

METRIC

W.P. _____ LOCATION C18 Culvert N 4 819 416.1 E 586 322.0 ORIGINATED BY MNW
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.08 - 2014.09.08 CHECKED BY KS

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 ³	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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					20 40 60 W P W W L						
	Continued From Previous Page BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																	

RECORD OF BOREHOLE No C18-04

1 OF 2

METRIC

WP# 19-5161-155 LOCATION C18 Culvert N 4 819 432.1 E 586 257.5 ORIGINATED BY OA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.03.29 - 2016.03.29 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
220.5	GROUND SURFACE												
0.0	ASPHALT:(225mm)												
0.2	SAND and GRAVEL , some silt Compact Brown Moist (FILL)		1	GS			220						
			1	SS	19								
			2	SS	21		219						
			3	SS	24		218						
217.5													
3.0	Clayey SILT , some sand and gravel, trace organics Stiff Brown Wet (TILL)		4	SS	15		217						
216.4													
4.1	SAND and SILT , some clay Compact to Dense Brown Moist		5	SS	23		216						
							215						
			6	SS	34		214						
213.3													
7.2	SILT , some clay, trace sand Loose Grey Wet		7	SS	4		213						
							212						
211.2													
9.3	Clayey SILT , some sand, trace gravel Very Stiff Grey		8	SS	20		211						
210.7													
9.8													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2015TEMPLATE(MTO) GDT 10/22/19

RECORD OF BOREHOLE No C18-04

2 OF 2

METRIC

WP# 19-5161-155 LOCATION C18 Culvert N 4 819 432.1 E 586 257.5 ORIGINATED BY OA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.03.29 - 2016.03.29 CHECKED BY MRA

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page Wet (TILL) END OF BOREHOLE AT 9.8m. WATER LEVEL AT 3.4m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, THEN CONCRETE AND ASPHALT TO SURFACE.																

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2015TEMPLATE(MTO) GDT 10/22/19

RECORD OF BOREHOLE No C18-04A

1 OF 1

METRIC

WP# 19-5161-155 LOCATION C18 Culvert N 4 819 417.9 E 586 240.7 ORIGINATED BY OA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.03.29 - 2016.03.29 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
220.5	GROUND SURFACE							20	40	60	80	100			
0.0	ASPHALT: (225mm)							20	40	60	80	100			
0.2	SAND and GRAVEL, some silt		1	GS			220								
219.8	Brown Moist (FILL)														
0.7	SAND, silty to some silt, some gravel		1	SS	16		219								
	Compact to Dense Brown Moist (FILL)		2	SS	31										
218.3	Clayey SILT, some sand, trace gravel		3	SS	8		218								
2.2	Stiff to Hard Brown Moist (TILL)		4	SS	50/										
217.2	END OF BOREHOLE AT 3.3m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND ASPHALT.				0.125										
3.3															


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

RECORD OF BOREHOLE No C18-04B

1 OF 1

METRIC

WP# 19-5161-155 LOCATION C18 Culvert N 4 819 424.4 E 586 248.4 ORIGINATED BY OA
HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2016.03.29 - 2016.03.29 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
220.5	GROUND SURFACE							20 40 60 80 100													
0.0	ASPHALT: (225mm)							20 40 60 80 100													
0.2	SAND and GRAVEL, trace silt Dense Brown Moist (FILL)		1	GS			220														
			1	SS	33																
			2	SS	33																
			3	SS	31																
	Compact		4	SS	10		218														
216.8							217														
3.7	END OF BOREHOLE AT 3.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG, CONCRETE AND ASPHALT.																				

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2015TEMPLATE(MTO) GDT 10/22/19

RECORD OF BOREHOLE No C18-04C

1 OF 1

METRIC

WP# 19-5161-155 LOCATION C18 Culvert N 4 819 436.6 E 586 262.8 ORIGINATED BY OA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.03.29 - 2016.03.29 CHECKED BY MRA

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
220.5	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT: (225mm)							20	40	60	80	100					
0.2	SAND and GRAVEL, trace silt Compact Brown Moist (FILL)		1	GS			220							○			
			1	SS	16									○			
219.0							219										
1.5	Silty CLAY, some sand and gavel Firm Brown Moist (FILL)		2	SS	7									○			
218.3																	
2.2	SAND and GRAVEL, some silt Dense Brown Moist (FILL)		3	SS	44		218							○			
217.5																	
3.0	Clayey SILT, some sand, some gravel Stiff Brown Moist (TILL)		4	SS	11		217							○			
216.8																	
3.7	END OF BOREHOLE AT 3.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG, CONCRETE AND ASPHALT.																

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2015TEMPLATE(MTO) GDT 10/22/19

RECORD OF BOREHOLE No C18-04D

1 OF 1

METRIC

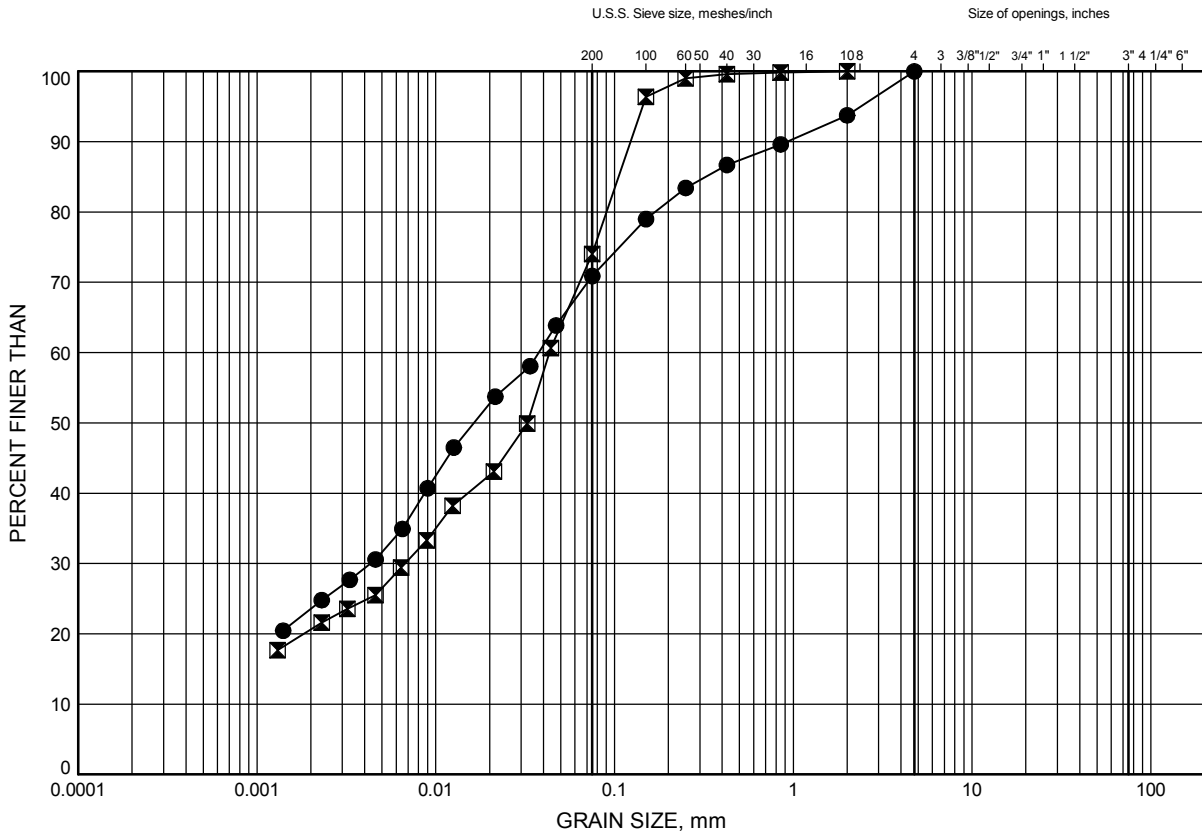
WP# 19-5161-155 LOCATION C18 Culvert N 4 819 441.1 E 586 268.2 ORIGINATED BY OA
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.03.29 - 2016.03.29 CHECKED BY MRA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
220.5	GROUND SURFACE												
0.0	ASPHALT: (225mm)												
0.2	SAND and GRAVEL, trace silt Compact Brown Moist (FILL)		1	GS			220						
219.6													
0.9	Silty CLAY, some sand and gravel Stiff to Firm Brown Moist (FILL)		1	SS	13		219						
			2	SS	7								
218.3													
2.2	Clayey SILT, some sand and gravel Stiff Brown Moist (TILL)		3	SS	13		218						
			4	SS	9								
216.8							217						
3.7	END OF BOREHOLE AT 3.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG, CONCRETE AND ASPHALT.												

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

GRAIN SIZE DISTRIBUTION

CLAYEY SILT (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C18-01	1.83	216.07
⊠	C18-03	0.38	216.92

Date February 2015

W.P.

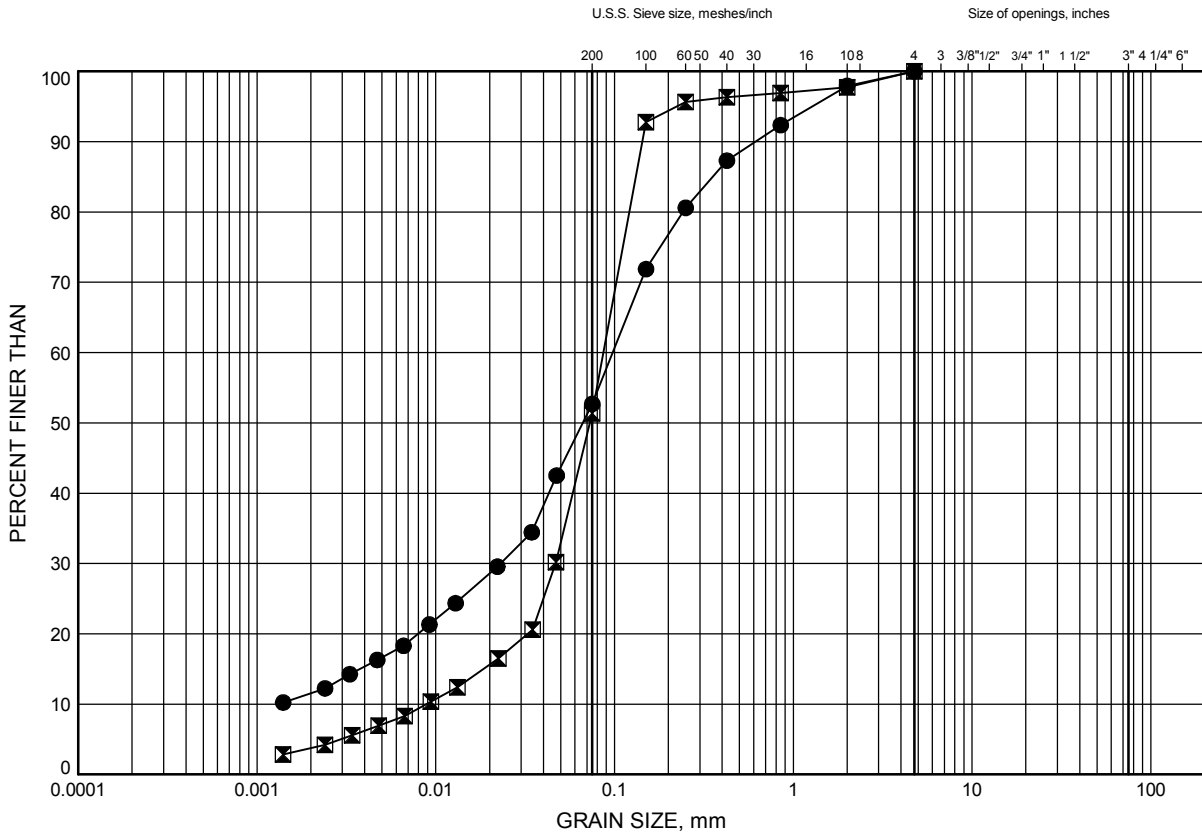


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C18-02	1.07	216.83
⊠	C18-03	7.92	209.38

Date February 2015

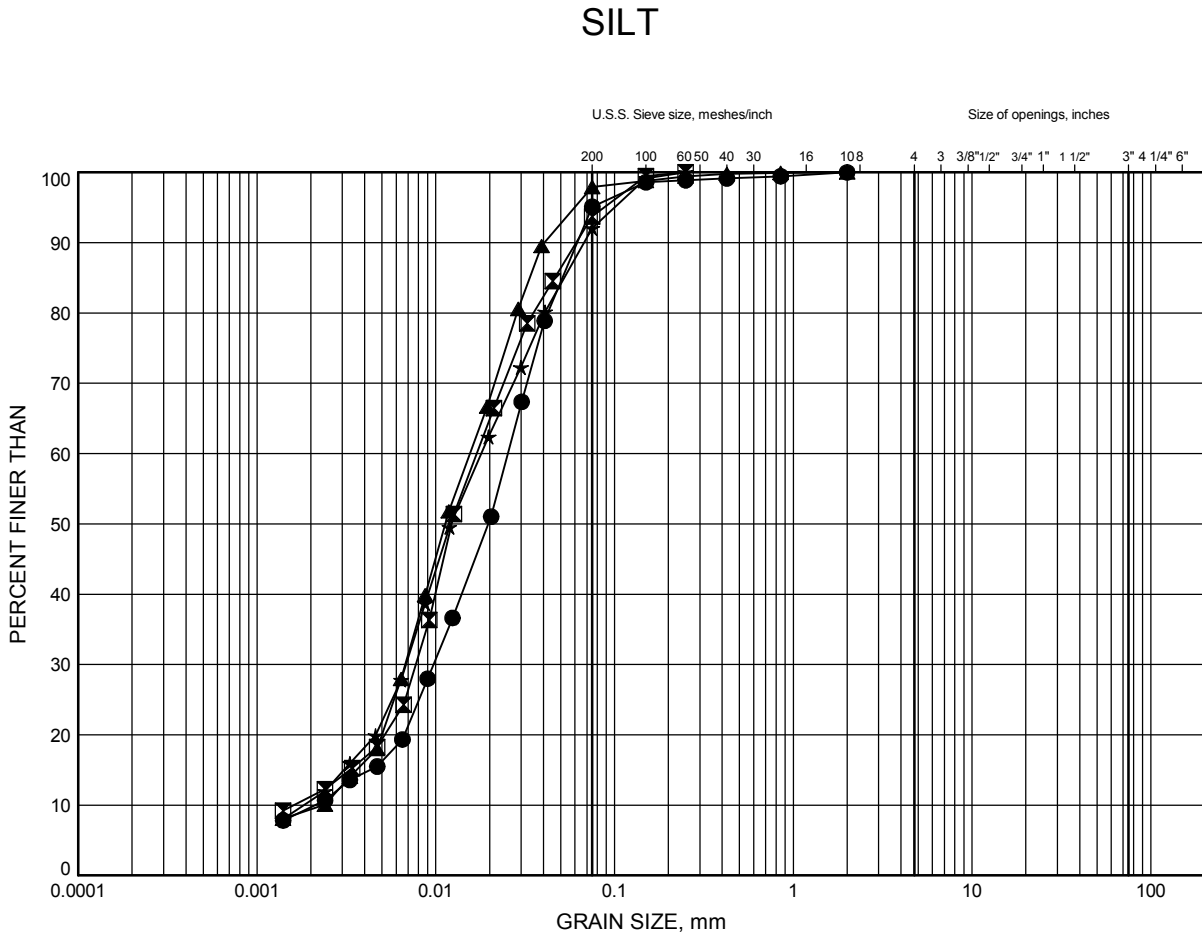
W.P.



Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C18-01	3.35	214.55
⊠	C18-01	4.88	213.02
▲	C18-02	3.35	214.55
★	C18-02	8.04	209.86

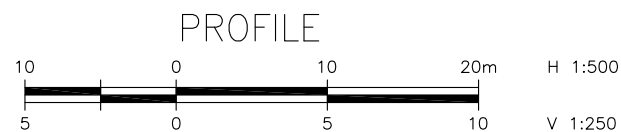
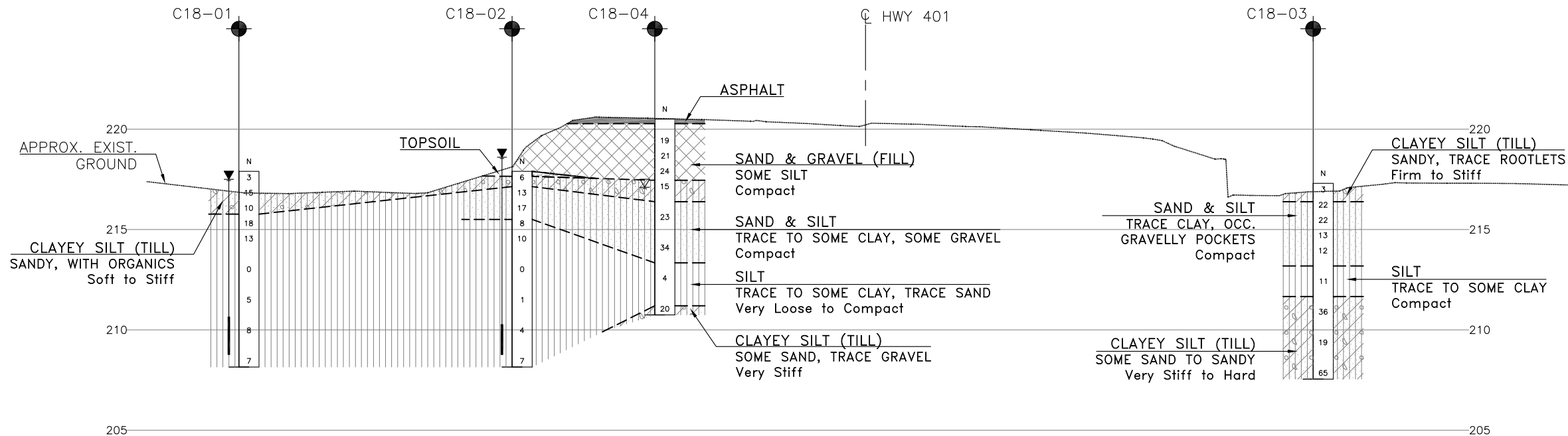
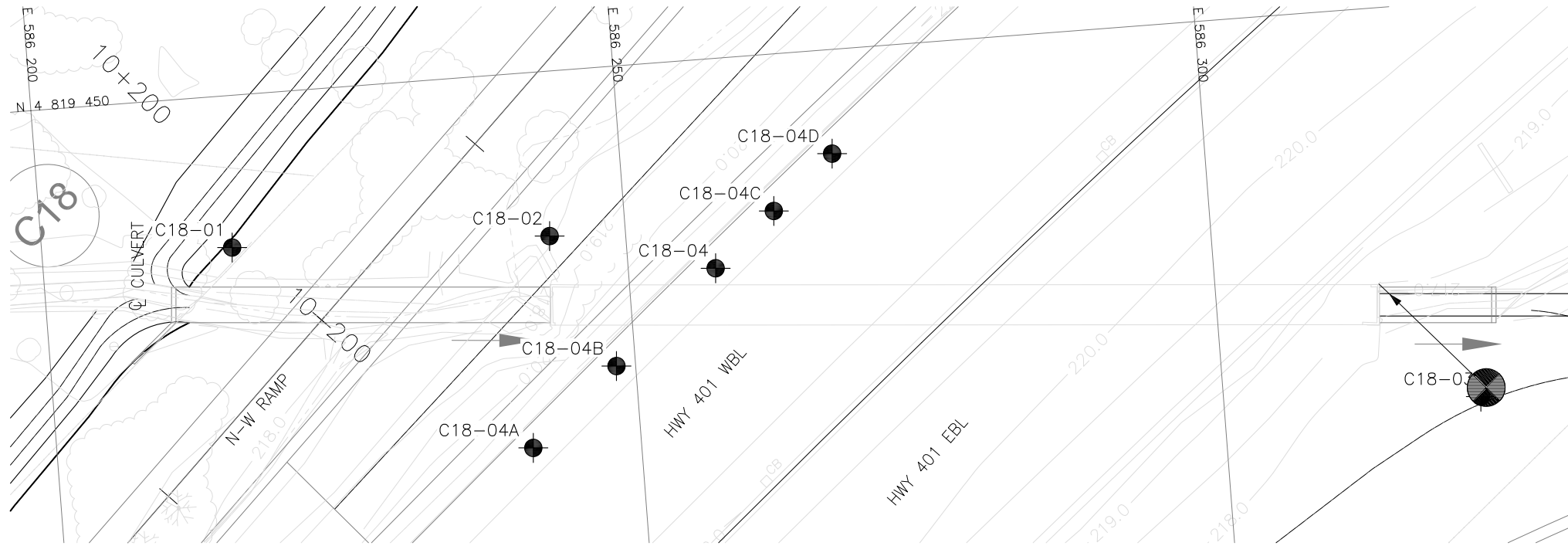
Date February 2015

W.P. _____

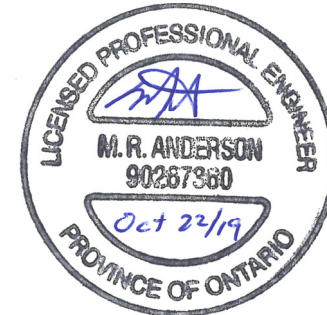


Prep'd AN

Chkd. KS



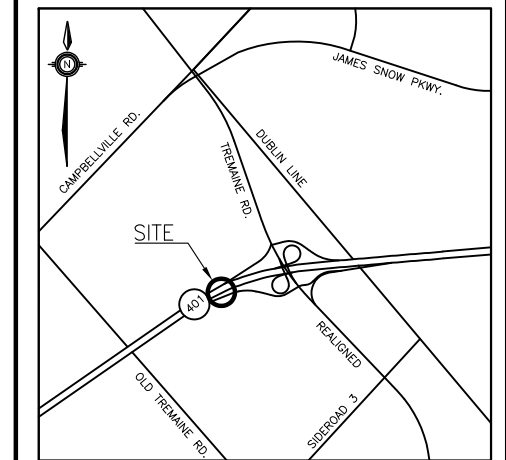
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No
WP No

NEW TREMAINE ROAD
INTERCHANGE AT HWY 401
CULVERT C18
BOREHOLE LOCATIONS AND SOIL STRATA

WSP



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 In Open Borehole
	Water Level In Well/Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
C18-01	217.9	4 819 437.0	586 216.3
C18-02	217.9	4 819 435.9	586 243.5
C18-03	217.3	4 819 416.1	586 322.0
C18-04	220.5	4 819 432.1	586 257.5
C18-04A	220.5	4 819 417.9	586 240.7
C18-04B	220.5	4 819 424.4	586 248.4
C18-04C	220.5	4 819 436.6	586 262.8
C18-04D	220.5	4 819 441.1	586 268.2

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.

GEOCRES No. 30M12-381

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	KS	CHK MRA	CODE
DRAWN	AN	CHK KS	SITE
			LOAD
			DATE
			OCT 2019
			STRUCT
			DWG 1

Appendix D

Culvert 19

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

RECORD OF BOREHOLE No C19-01

1 OF 2

METRIC

W.P. _____ LOCATION C19 Culvert N 4 819 445.1 E 586 479.0 ORIGINATED BY ES
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.09 - 2014.09.09 CHECKED BY KS

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
217.6	GROUND SURFACE													
0.0	TOPSOIL: (100mm)													
0.1	Silty CLAY , some sand, trace organics Very Stiff Dark Brown Moist (TILL)		1	SS	15									
			2	SS	25									0 19 45 36
			3	SS	28									
215.5														
2.1	SILT , some clay, trace sand Compact to Dense Grey Moist		4	SS	41									
			5	SS	22									0 3 82 15
213.5														
4.1	SAND and SILT , trace clay, trace gravel Compact Brown to Grey Wet		6	SS	11									
			7	SS	15									
209.9														
7.7	Clayey SILT , sandy, trace gravel Hard Brown Moist (TILL)		8	SS	44									
			9	SS	48									
207.8														
9.8	END OF BOREHOLE AT 9.8m.													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C19-01

2 OF 2

METRIC

W.P. _____ LOCATION C19 Culvert N 4 819 445.1 E 586 479.0 ORIGINATED BY ES
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.09 - 2014.09.09 CHECKED BY KS

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 ³	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 Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 25/ 14 2.6 215.0 Dec 19/ 14 1.5 216.1													



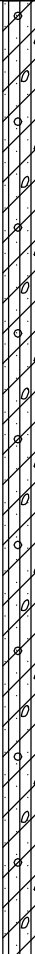
ONTMT4S 19-5161-155 (FOUNDATION).GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C19-02

1 OF 2

METRIC

W.P. _____ LOCATION C19 Culvert N 4 819 409.9 E 586 475.6 ORIGINATED BY MNW
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.11 - 2014.09.11 CHECKED BY KS

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE									
216.1	GROUND SURFACE						20	40	60	80	100						
0.0	TOPSOIL: (225mm)						20	40	60	80	100						
0.2	Clayey SILT , some sand, trace oxide staining Firm to Stiff Brown Moist to Wet (TILL)		1	SS	5												
			2	SS	14												
214.6																	
1.5	SAND and SILT , trace clay Compact Brown to Reddish Brown Wet		3	SS	12												
			4	SS	21												
212.7																	
3.4	Clayey SILT , sandy to some sand, trace gravel, occasional shale fragments Very Stiff to Hard Brown Moist (TILL)		5	SS	18												
					6	SS	40										
					7	SS	54										
			8	SS	68												

Continued Next Page

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

RECORD OF BOREHOLE No C19-02

2 OF 2

METRIC

W.P. _____ LOCATION C19 Culvert N 4 819 409.9 E 586 475.6 ORIGINATED BY MNW
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.11 - 2014.09.11 CHECKED BY KS

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 ³	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 _p	W	W _L				
	Continued From Previous Page																	
	BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																	

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C19-03

1 OF 1

METRIC

W.P. _____ LOCATION C19 Culvert N 4 819 380.8 E 586 472.6 ORIGINATED BY MKE
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.10.31 - 2014.10.31 CHECKED BY KS

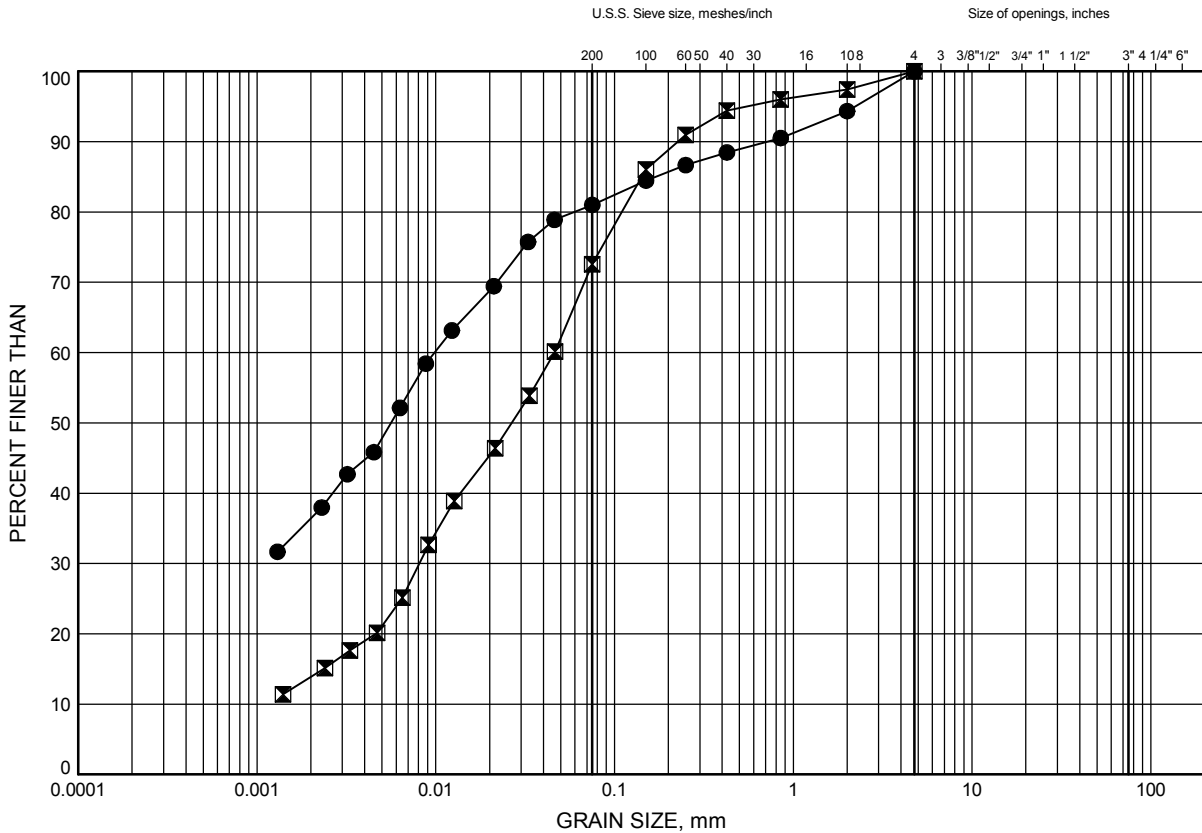
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
216.2	GROUND SURFACE												
0.0	TOPSOIL: (610mm)		1	SS	1		216						
215.6													
0.6	Clayey SILT, sandy Firm to Stiff Brown Moist to Wet (TILL)		2	SS	8		215						
			3	SS	12								
214.0							214						
2.2	SAND and SILT, trace clay Loose to Compact Brown to Grey Wet		4	SS	8								
			5	SS	13		213						
212.1							212						
4.1	Clayey SILT, sandy, trace gravel Stiff to Hard Brown Moist (TILL)		6	SS	15								
							211						
			7	SS	56		210						
							209						
			8	SS	64								
208.0							208						
8.2	END OF BOREHOLE AT 8.2m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 25/ 14 0.4* 216.6 Dec 19/ 14 0.5* 216.7 * Above ground surface												

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO) GDT 2/18/15

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

GRAIN SIZE DISTRIBUTION

CLAYEY SILT to SILTY CLAY (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C19-01	1.07	216.53
⊠	C19-03	1.83	214.37

Date February 2015

W.P.

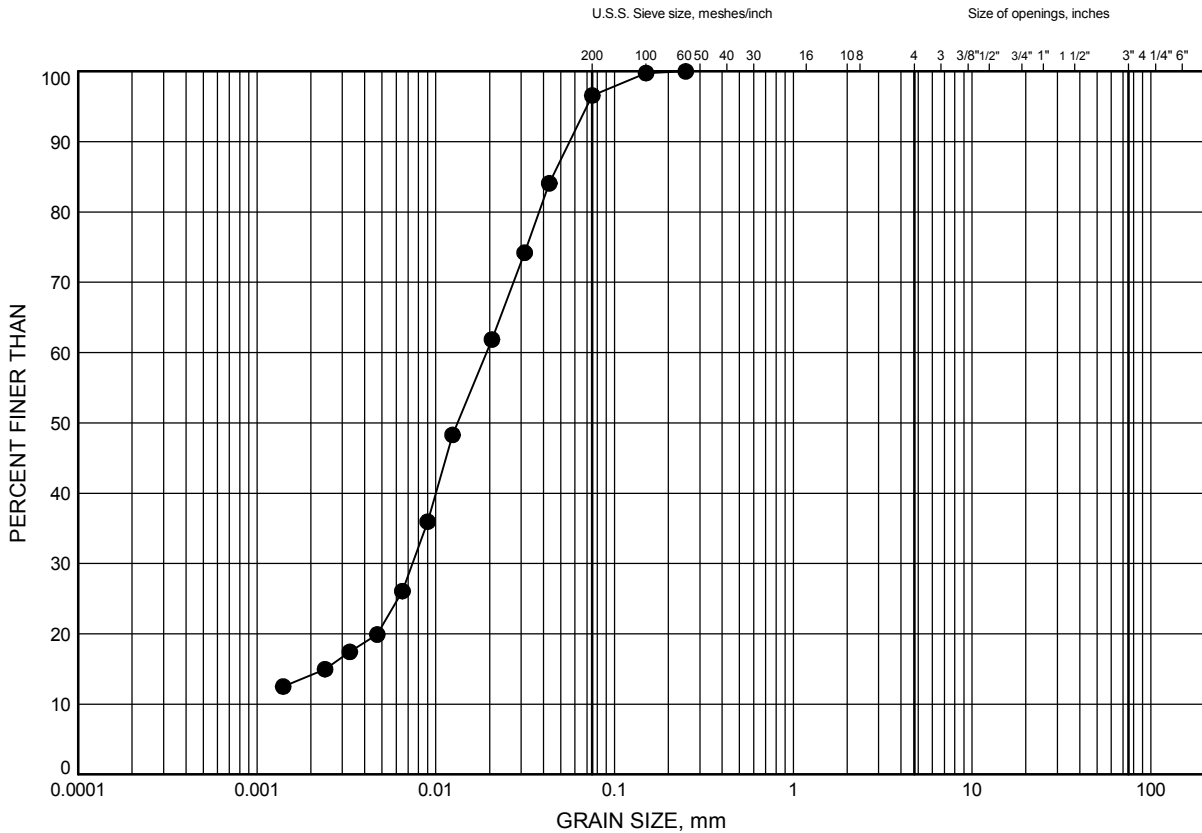


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C19-01	3.35	214.25

Date February 2015

W.P.

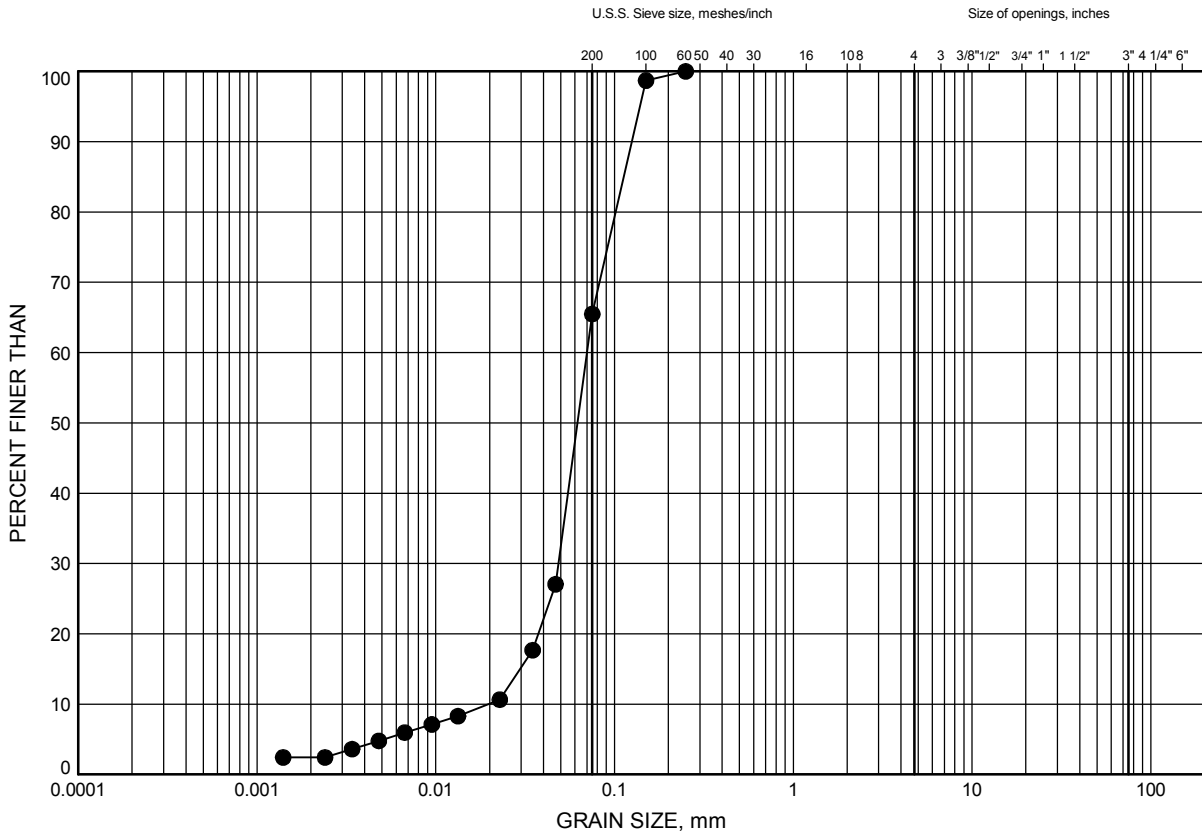


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C19-02	2.59	213.51

Date February 2015

W.P. _____

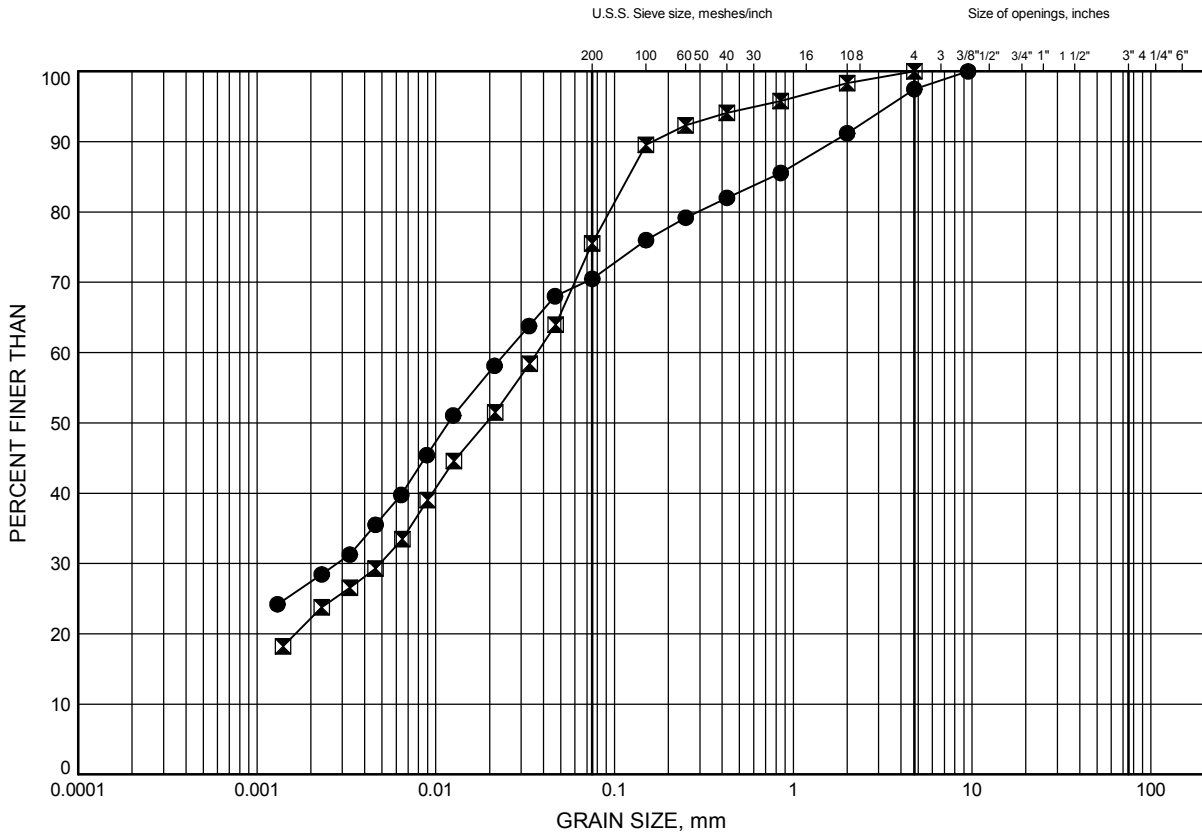


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

CLAYEY SILT (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C19-02	7.92	208.18
⊠	C19-03	4.88	211.32

Date February 2015

W.P.



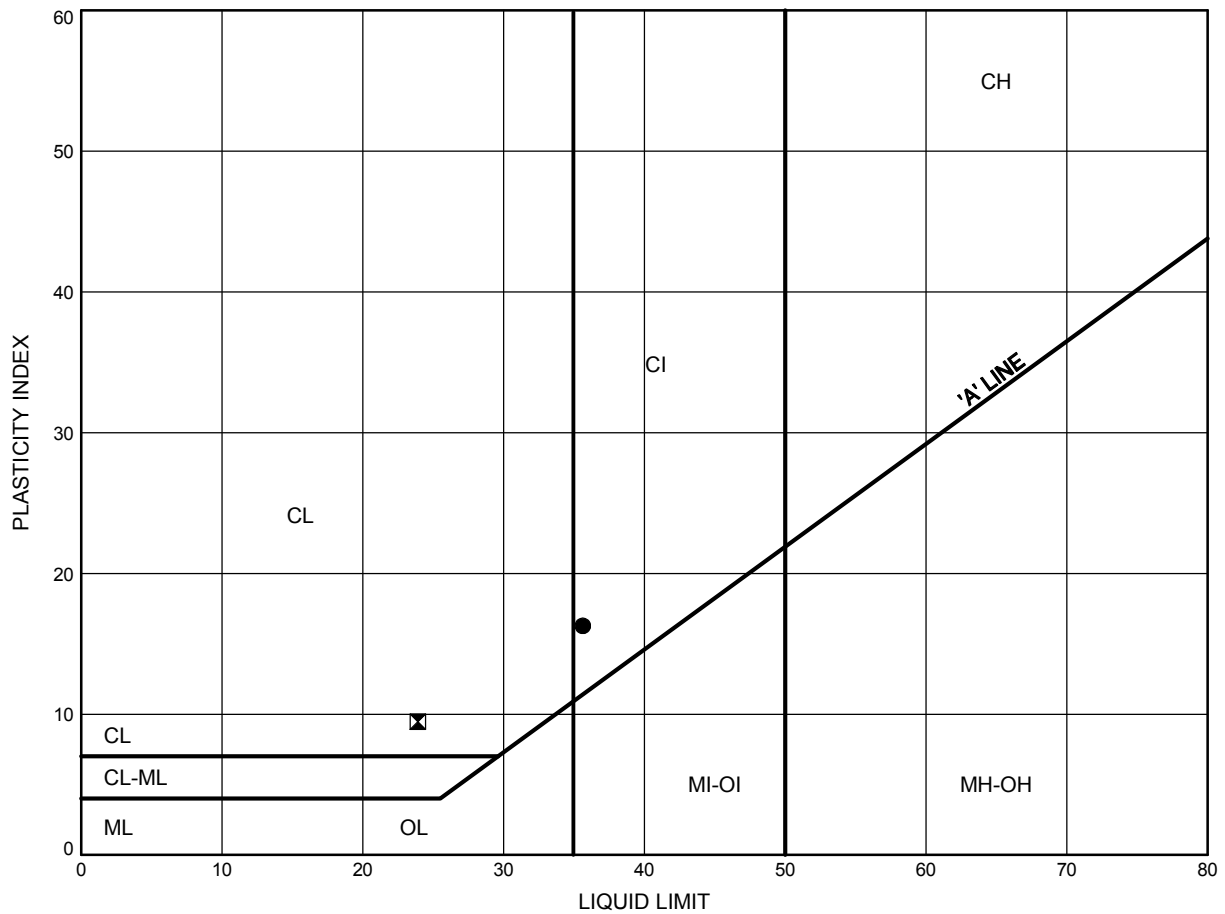
Prep'd AN

Chkd. KS

New Tremaine Road I/C at Hwy 401 - Culvert C19
ATTERBERG LIMITS TEST RESULTS

FIGURE D5

SILTY CLAY to CLAYEY SILT



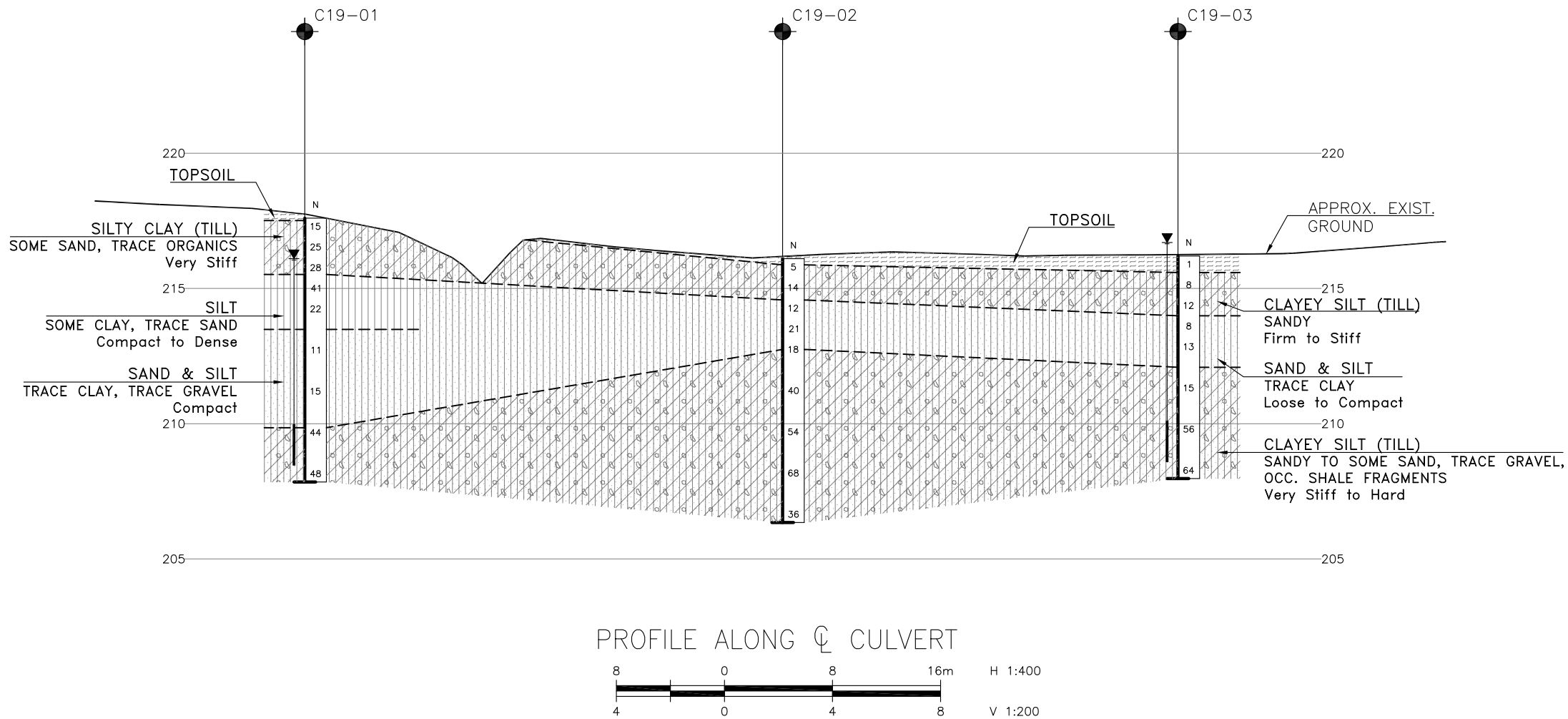
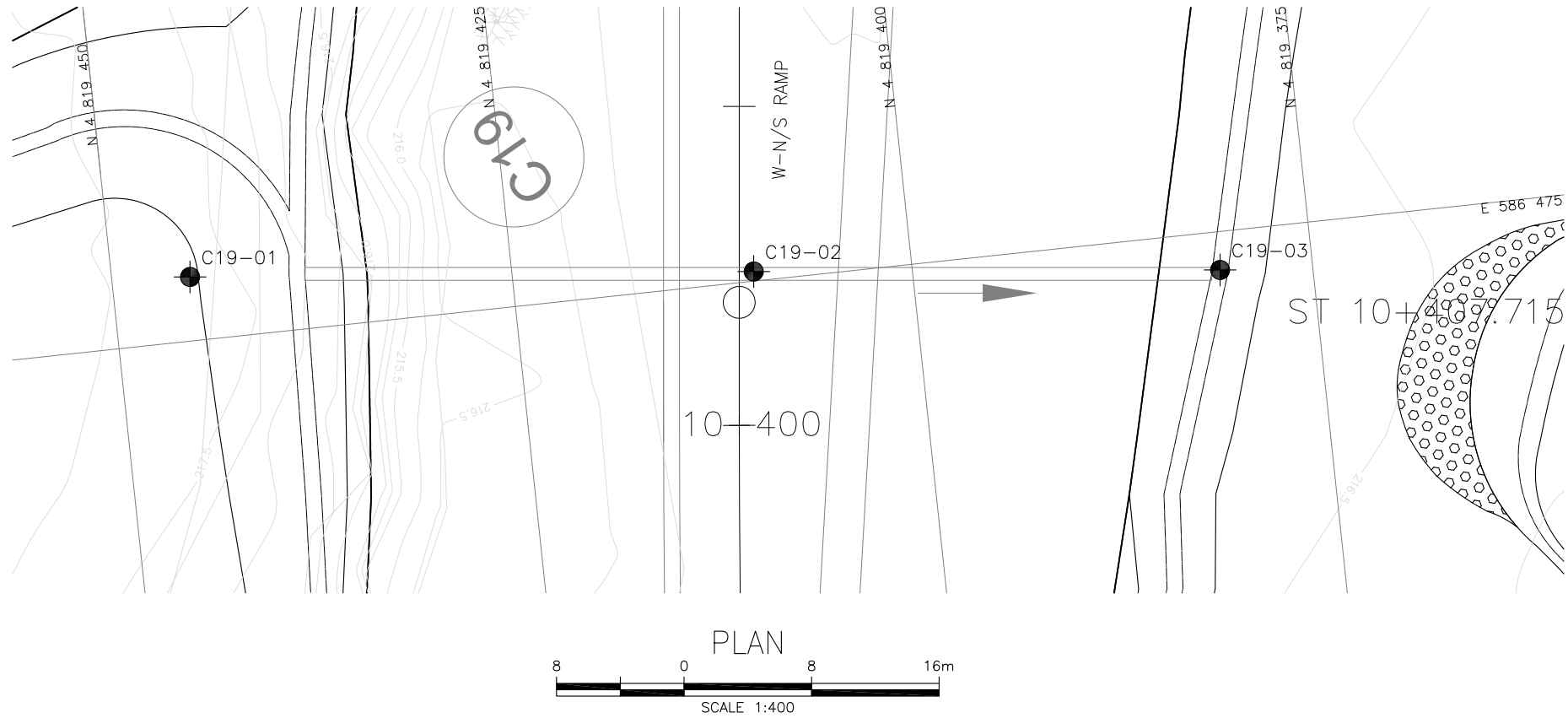
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C19-01	1.07	216.53
⊠	C19-03	4.88	211.32

Date February 2015
 W.P.



Prep'd AN
 Chkd. KS



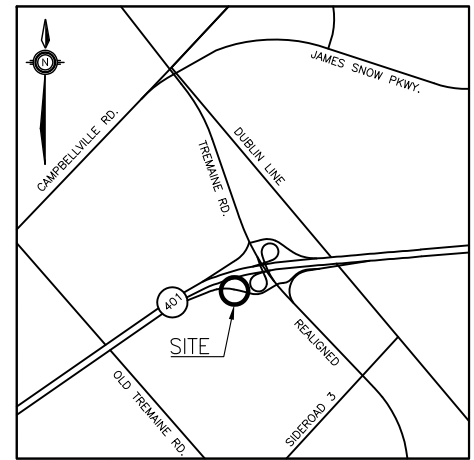
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No
WP No

NEW TREMAINE ROAD
INTERCHANGE AT HWY 401
CULVERT C19
BOREHOLE LOCATIONS AND SOIL STRATA

WSP



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 In Open Borehole
	Water Level In Well/Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
C19-01	217.6	4 819 445.1	586 479.0
C19-02	216.1	4 819 409.9	586 475.6
C19-03	216.2	4 819 380.8	586 472.6

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.

GEOCRES No. 30M12-381

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	KS	CHK MRA	CODE
DRAWN	AN	CHK KS	SITE
LOAD	DATE	OCT 2019	
STRUCT	DWG	1	

Appendix E

Culvert 20

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

RECORD OF BOREHOLE No C20-01

1 OF 1

METRIC

W.P. _____ LOCATION C20 Culvert N 4 819 462.4 E 586 530.6 ORIGINATED BY DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.15 - 2014.09.15 CHECKED BY KS

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
216.7	GROUND SURFACE																
0.0	TOPSOIL: (300mm)																
216.4																	
0.3	Clayey SILT, some sand to sandy, trace gravel, with oxide staining Stiff to Very Stiff Brown to Reddish Brown Moist (TILL)		1	SS	5												
			2	SS	24												
			3	SS	26												
			4	SS	23												
213.7																	
3.0	SAND and SILT, trace clay Compact to Loose Brown to Grey Wet		5	SS	11												
			6	SS	9												
211.5																	
5.2	END OF BOREHOLE AT 5.2m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 25/ 14 0.7 216.0 Dec 19/ 14 0.5 216.2																

ONTMT4S 19-5161-155 (FOUNDATION).GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C20-02

1 OF 1

METRIC

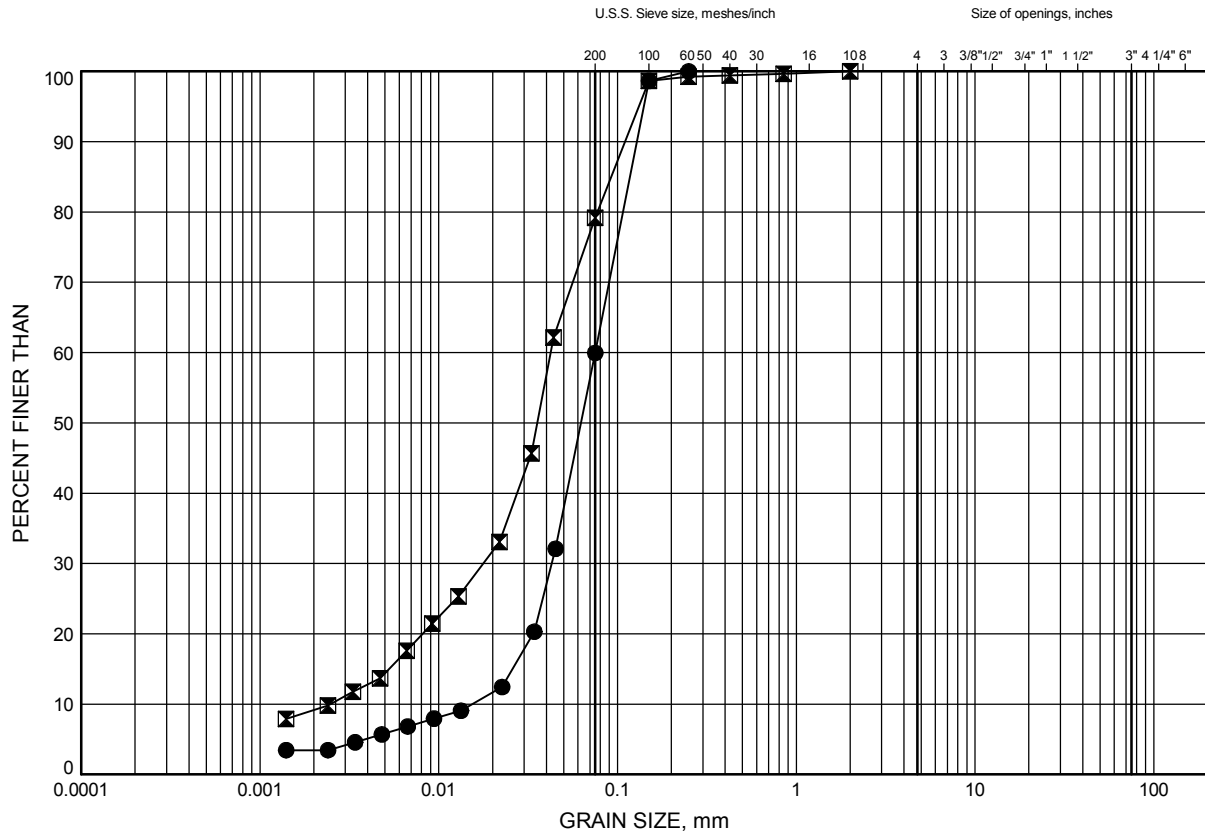
W.P. _____ LOCATION C20 Culvert N 4 819 440.4 E 586 505.4 ORIGINATED BY DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.12 - 2014.09.12 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
WATER CONTENT (%)					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L									
216.9	GROUND SURFACE													
0.0	TOPSOIL: (300mm)													
216.6														
0.3	Clayey SILT , some sand, trace gravel, with oxide staining Stiff to Very Stiff Brown Moist (TILL)		1	SS	6									
			2	SS	17									
215.3														
1.6	Sandy SILT , trace to some clay Compact Brown Moist		3	SS	22									
214.6														
2.3	SILT , trace to some clay Compact Brown Moist		4	SS	27									
213.9														
3.0	SAND and SILT , trace clay Compact to Loose Brown to Grey Wet		5	SS	13									
			6	SS	8									
211.7														
5.2	END OF BOREHOLE AT 5.2m. BOREHOLE OPEN TO 5.1m AND WATER LEVEL AT 4.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.													

ONTMT4S 19-5161-155 (FOUNDATION).GPJ 2012TEMPLATE(MTO).GDT 2/18/15

GRAIN SIZE DISTRIBUTION

SAND & SILT to SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C20-01	3.35	213.35
⊠	C20-02	1.83	215.07

Date February 2015

W.P.

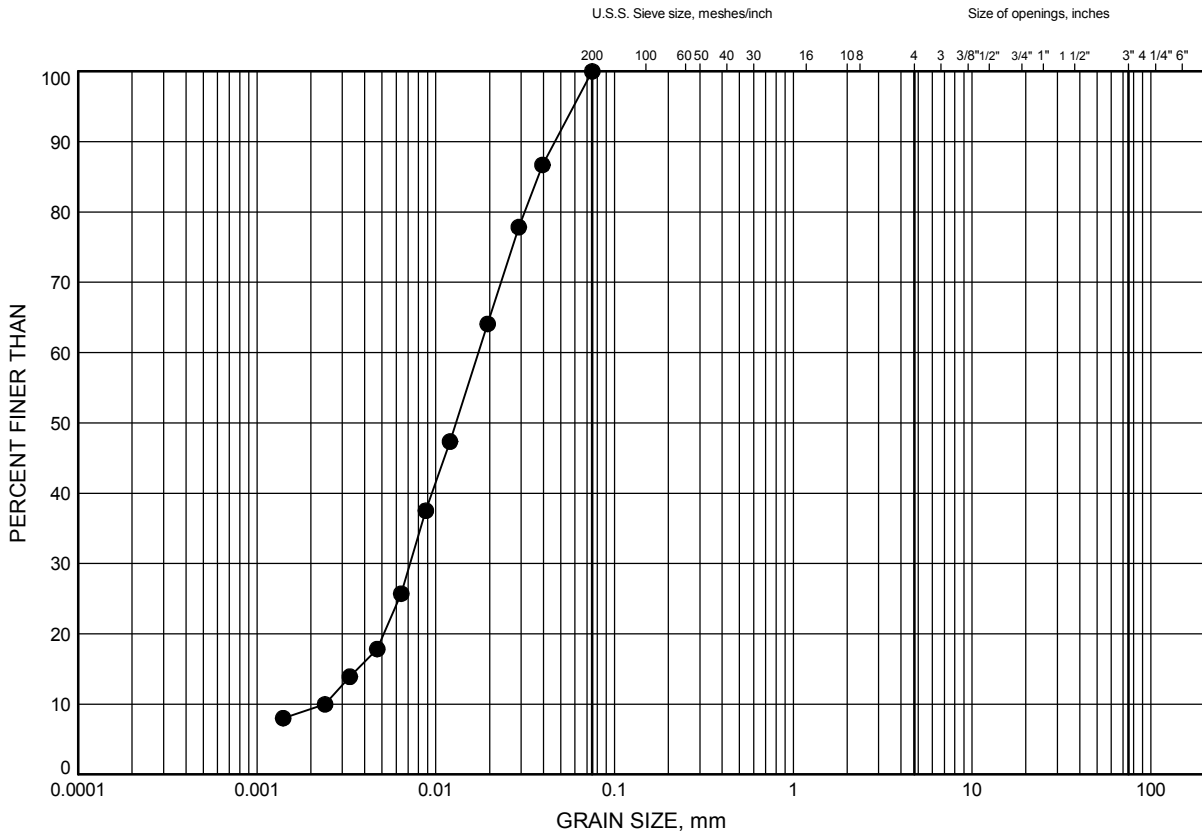


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Chkd. KS

GRAIN SIZE DISTRIBUTION

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C20-02	2.63	214.27

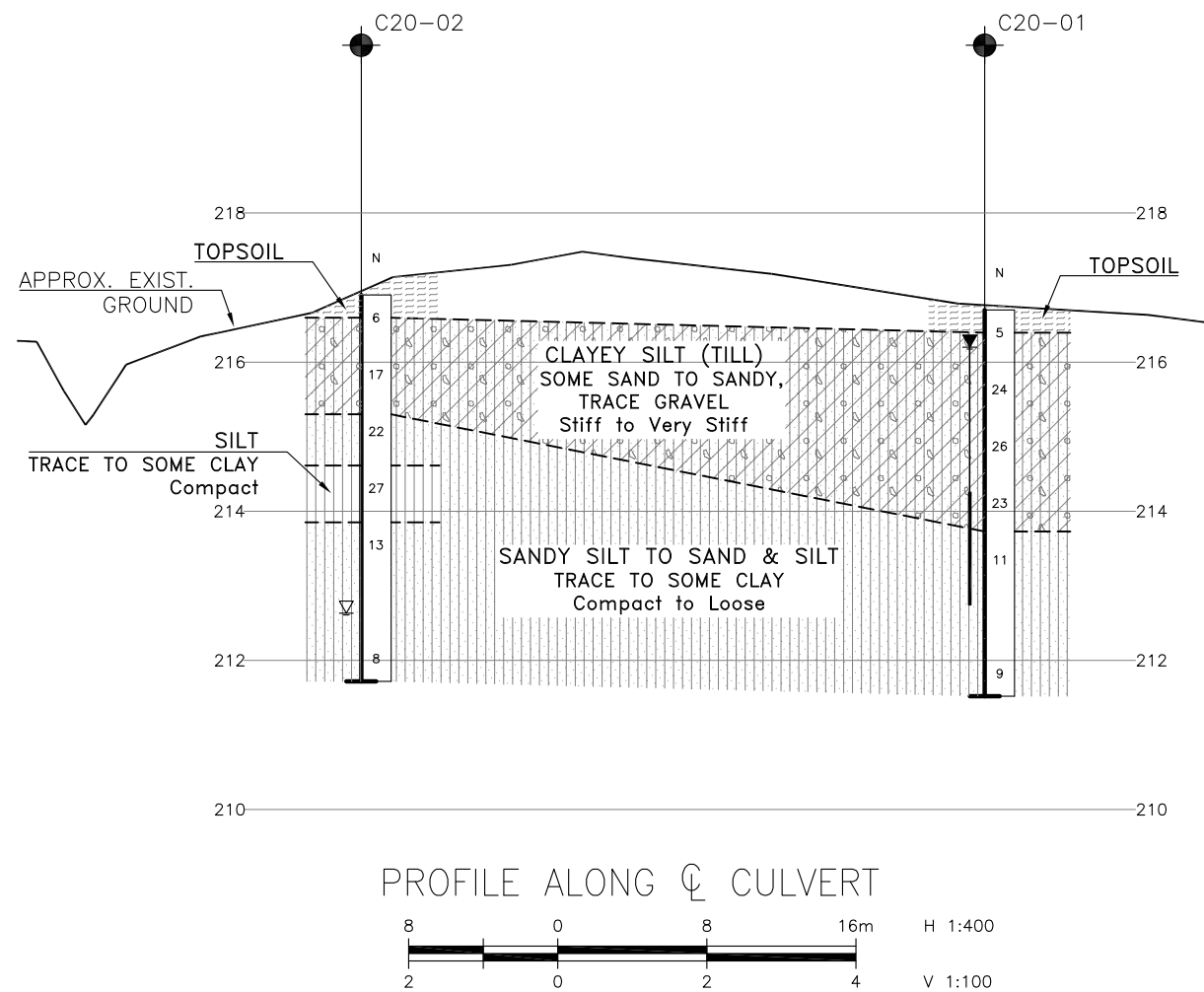
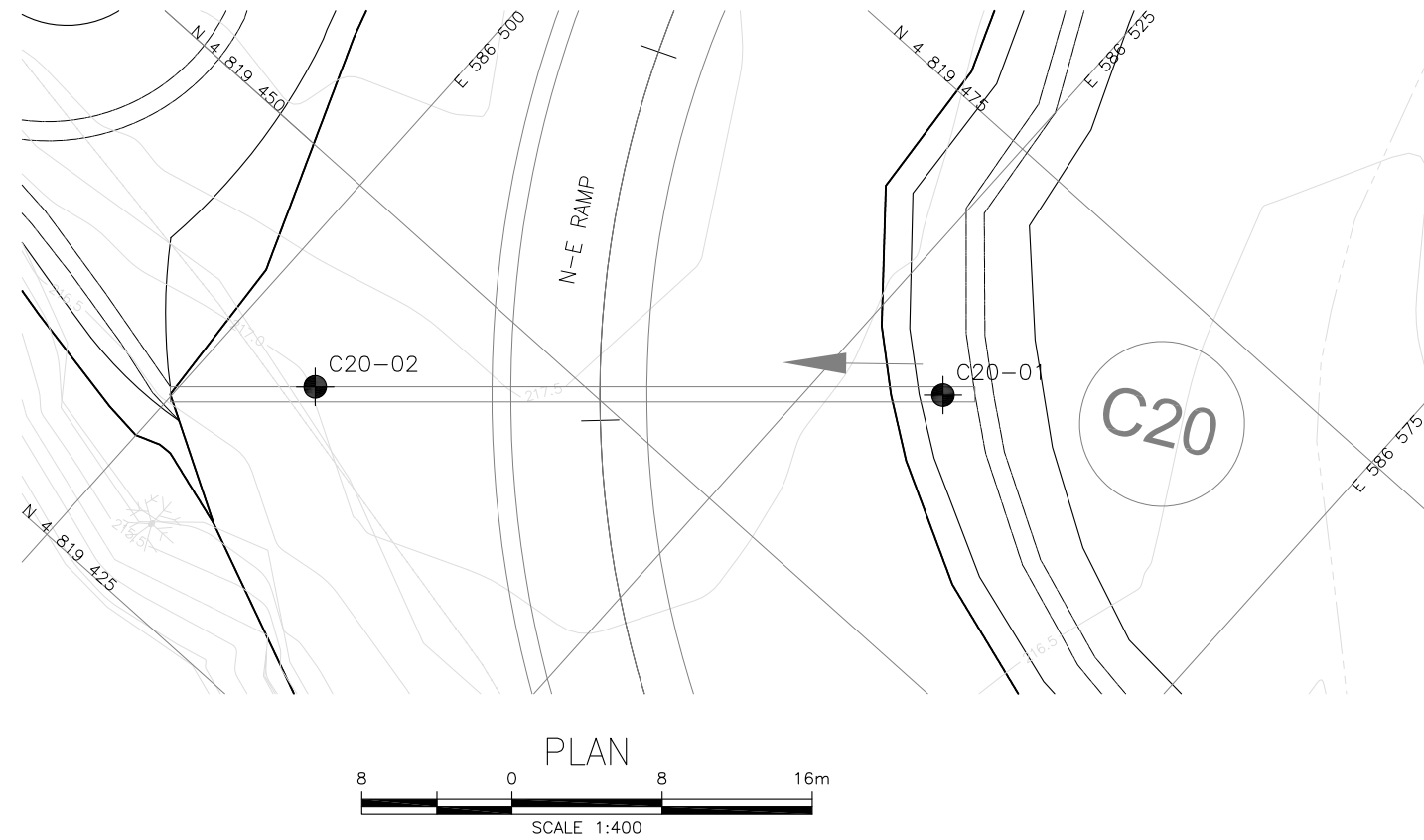
Date February 2015

W.P.



Prep'd AN

Chkd. KS



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

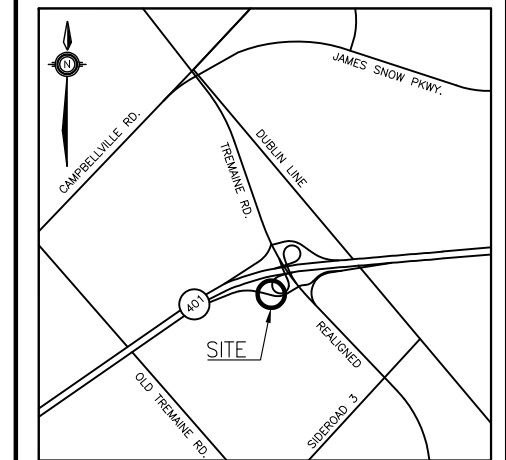


CONT No	
WP No	

NEW TREMAINE ROAD INTERCHANGE AT HWY 401 CULVERT C20 BOREHOLE LOCATIONS AND SOIL STRATA	SHEET
--------------------------------------------------------------------------------------------------	-------







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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 In Open Borehole
	Water Level In Well/Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
C20-01	216.7	4 819 462.4	586 530.6
C20-02	216.9	4 819 440.4	586 505.4

-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. 30M12-381

[illegible]

Appendix F

Culvert 21 (Extension)

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

RECORD OF BOREHOLE No C21-01

1 OF 2

METRIC

W.P. _____ LOCATION C21 Culvert N 4 819 605.4 E 586 461.1 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.02 - 2014.09.02 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
218.6	GROUND SURFACE							20 40 60 80 100					
0.0	TOPSOIL: (250mm)							20 40 60 80 100					
218.3								20 40 60 80 100					
0.3	Silty CLAY , sandy Firm to Very Stiff Brown Moist (TILL)		1	SS	6		218	20 40 60 80 100					
			2	SS	7			20 40 60 80 100					0 32 42 26
			3	SS	25		217	20 40 60 80 100					
			4	SS	27		216	20 40 60 80 100					
215.6								20 40 60 80 100					
3.0	SAND and SILT , trace clay Compact Brown to Grey Wet		5	SS	13		215	20 40 60 80 100					
								20 40 60 80 100					
			6	SS	12		214	20 40 60 80 100					
								20 40 60 80 100					
213.0							213	20 40 60 80 100					
5.6	SILT , some clay to clayey, trace sand, trace gravel, occasional limestone fragments Very Stiff to Hard Brown to Grey Moist (TILL)		7	SS	23		212	20 40 60 80 100					
								20 40 60 80 100					
			8	SS	52		211	20 40 60 80 100					0 6 82 12
								20 40 60 80 100					
			9	SS	57		210	20 40 60 80 100					
								20 40 60 80 100					
208.8							209	20 40 60 80 100					
9.8	END OF BOREHOLE AT 9.8m.							20 40 60 80 100					

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C21-01

2 OF 2

METRIC

W.P. _____ LOCATION C21 Culvert N 4 819 605.4 E 586 461.1 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.02 - 2014.09.02 CHECKED BY KS

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 ³	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 Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 26/ 14 0.6 218.0 Dec 19/ 14 Frozen													



ONTMT4S 19-5161-155 (FOUNDATION).GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C21-02

1 OF 2

METRIC

W.P. _____ LOCATION C21 Culvert N 4 819 581.1 E 586 472.1 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.03 - 2014.09.03 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								20 40 60 80 100						
217.7	GROUND SURFACE													
0.0	TOPSOIL: (200mm)													
0.2	Silty CLAY , some sand, trace rootlets Stiff Dark Brown to Brown Moist (TILL)		1	SS	10									
			2	SS	14									
216.3														
1.4	SILT , some sand, trace clay Compact Brown Moist to Wet		3	SS	24									
			4	SS	30									
			5	SS	39									
213.6														
4.1	SAND and SILT , trace clay Compact Brown Wet		6	SS	11									
212.1														
5.6	Clayey SILT , some sand to sandy, trace gravel, with silt seams Hard Grey Moist (TILL)		7	SS	37									
			8	SS	47									
			9	SS	43									
207.9														
9.8	END OF BOREHOLE AT 9.8m.													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C21-02

2 OF 2

METRIC

W.P. _____ LOCATION C21 Culvert N 4 819 581.1 E 586 472.1 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.03 - 2014.09.03 CHECKED BY KS

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 ³	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 _p	W	W _L			
	Continued From Previous Page BOREHOLE OPEN TO 4.1m AND WATER LEVEL AT 2.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 2.3m, THEN CUTTINGS TO SURFACE.																

ONTMT4S 19-5161-155 (FOUNDATION).GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C21-03

1 OF 2

METRIC

W.P. _____ LOCATION C21 Culvert N 4 819 527.6 E 586 496.4 ORIGINATED BY ADH
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.10.10 - 2014.10.10 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
217.3	GROUND SURFACE							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
0.0	TOPSOIL: (300mm)							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
217.0								<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
0.3	Silty CLAY , sandy Stiff to Very Stiff Brown Moist (TILL)		1	SS	8		217	<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
			2	SS	20		216	<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
			3	SS	25		215	<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
215.0								<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
2.3	SILT , some clay, trace sand Compact Brown Moist		4	SS	17		214	<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					0 0 82 18
			5	SS	18		213	<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
213.2								<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
4.1	SAND and SILT , trace clay Compact Brown to Grey Wet		6	SS	13		212	<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
							211	<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
210.1			7	SS	14		210	<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
7.2	Clayey SILT , some sand, trace gravel, occasional limestone fragments Very Stiff Brown to Grey (TILL)		8	SS	23		209	<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
							208	<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
			9	SS	23			<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					3 19 52 26
207.5								<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					
9.8	END OF BOREHOLE AT 9.8m.							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>					

Continued Next Page

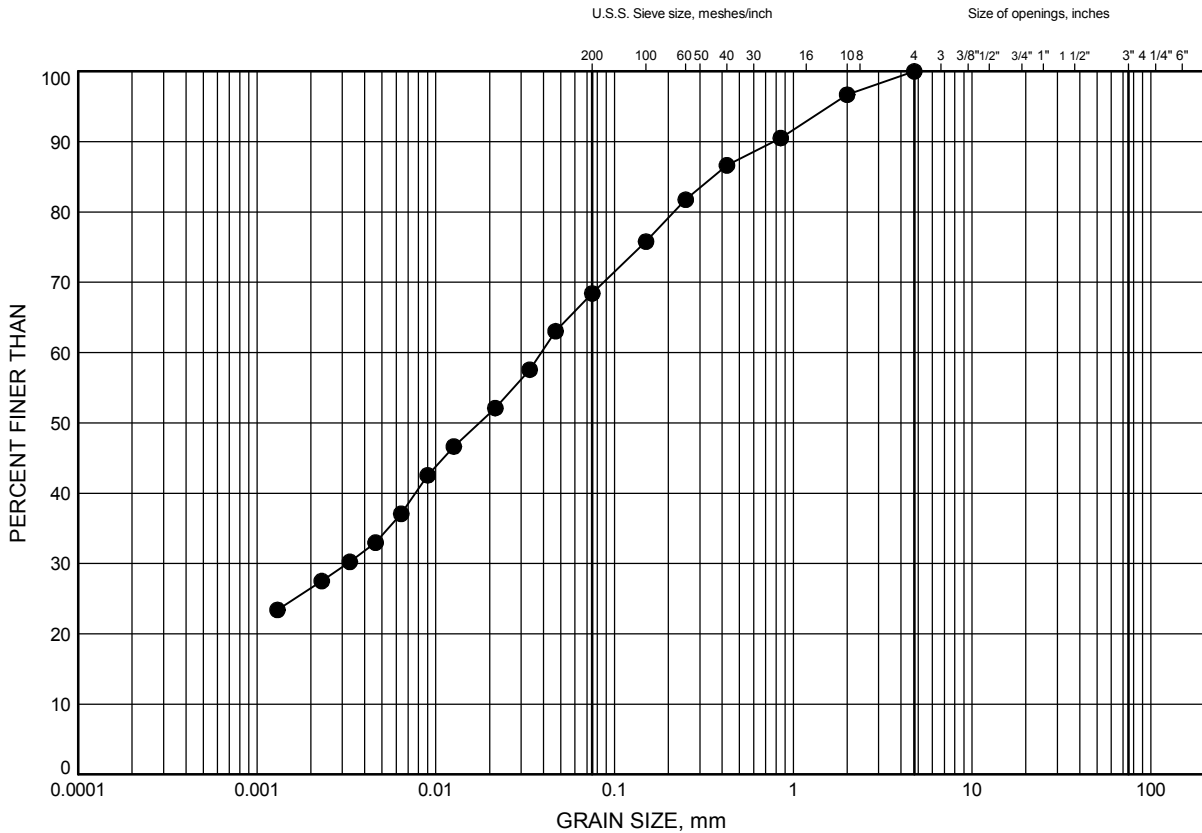
+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

METRIC

SOIL PROFILE										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	N° VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	Continued From Previous Page						<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE</div></div>	<div><div>w_P w w_L</div><div>WATER CONTENT (%)</div></div>	kN/m³	GR SA SI CL
	Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.									
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec 19/ 14 0.2 217.1									

GRAIN SIZE DISTRIBUTION

SILTY CLAY (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C21-01	1.07	217.53

Date February 2015

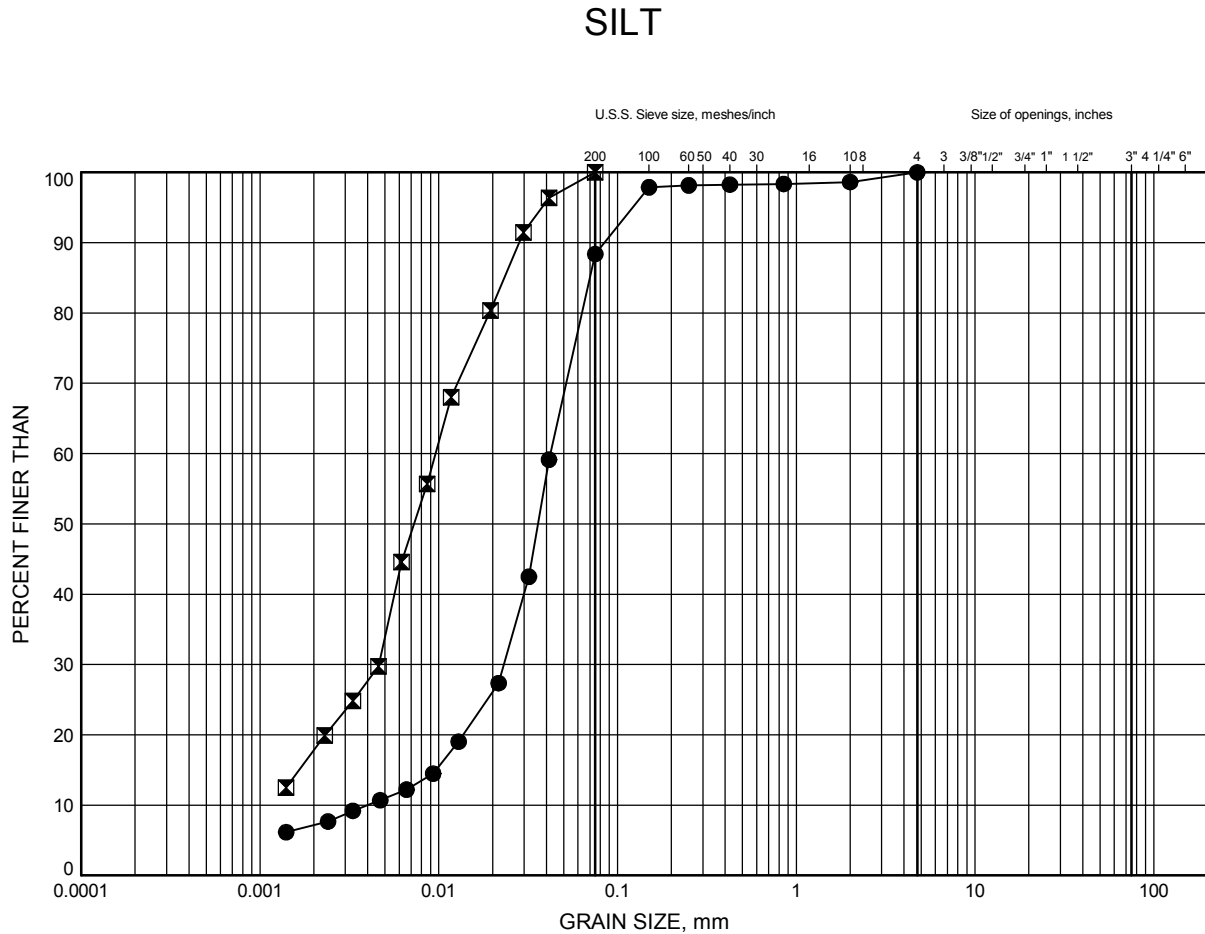
W.P.



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GRAIN SIZE DISTRIBUTION



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C21-02	2.59	215.11
⊠	C21-03	2.59	214.71

Date February 2015

W.P.

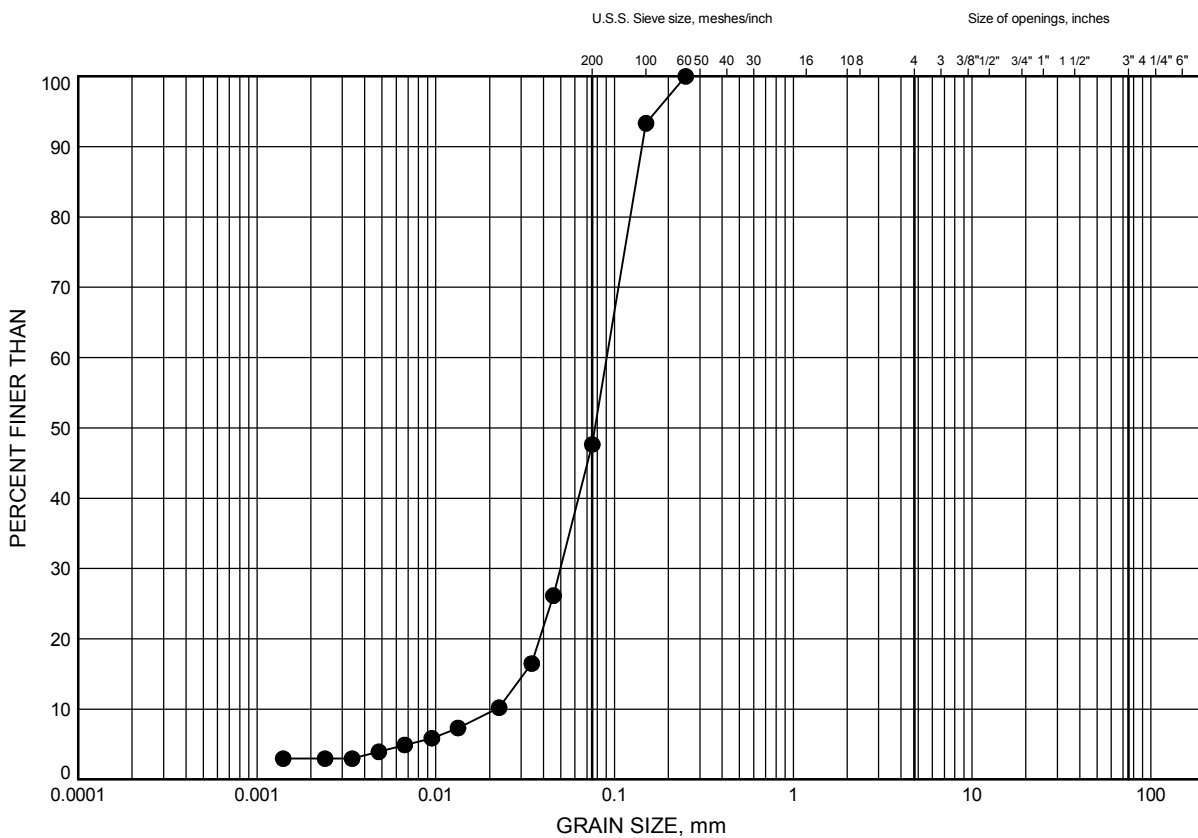


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C21-02	4.88	212.82

Date February 2015

W.P. _____

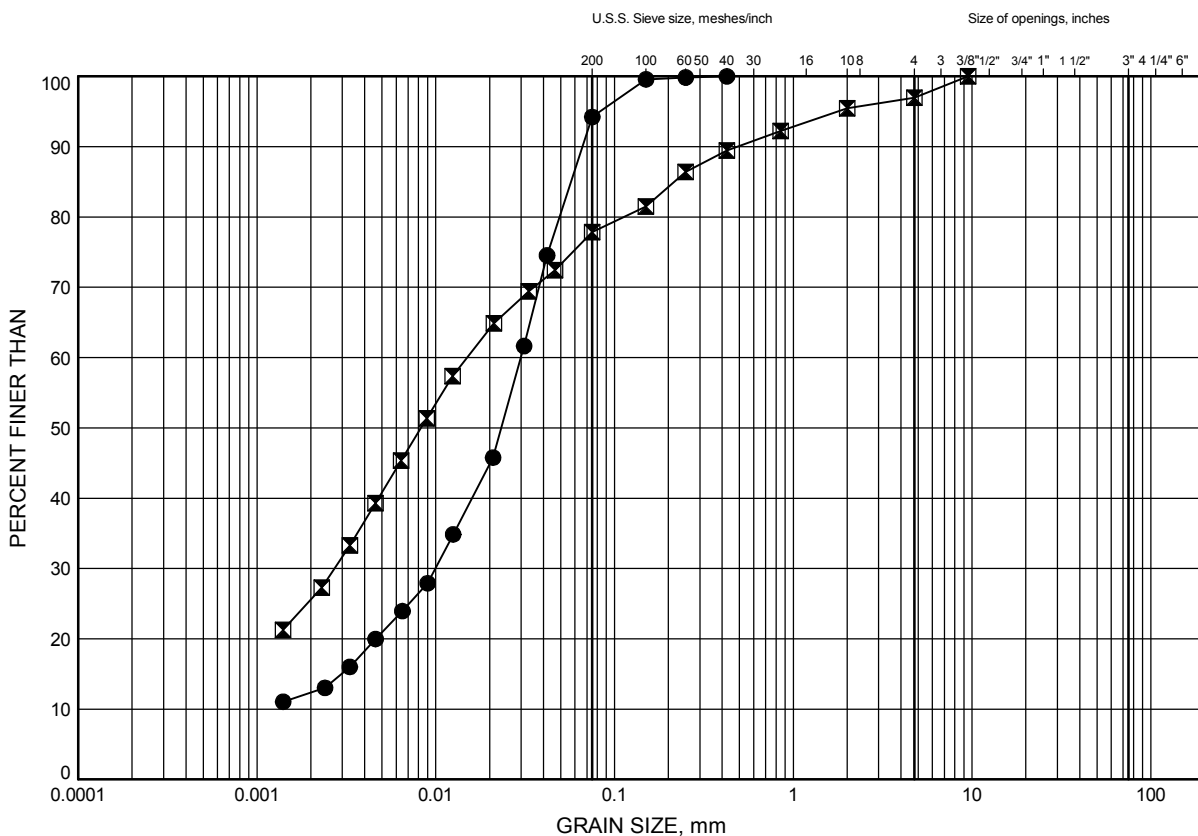


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GRAIN SIZE DISTRIBUTION

CLAYEY SILT to SILT, Some Clay (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C21-01	7.92	210.68
⊠	C21-03	9.45	207.85

Date February 2015

W.P.



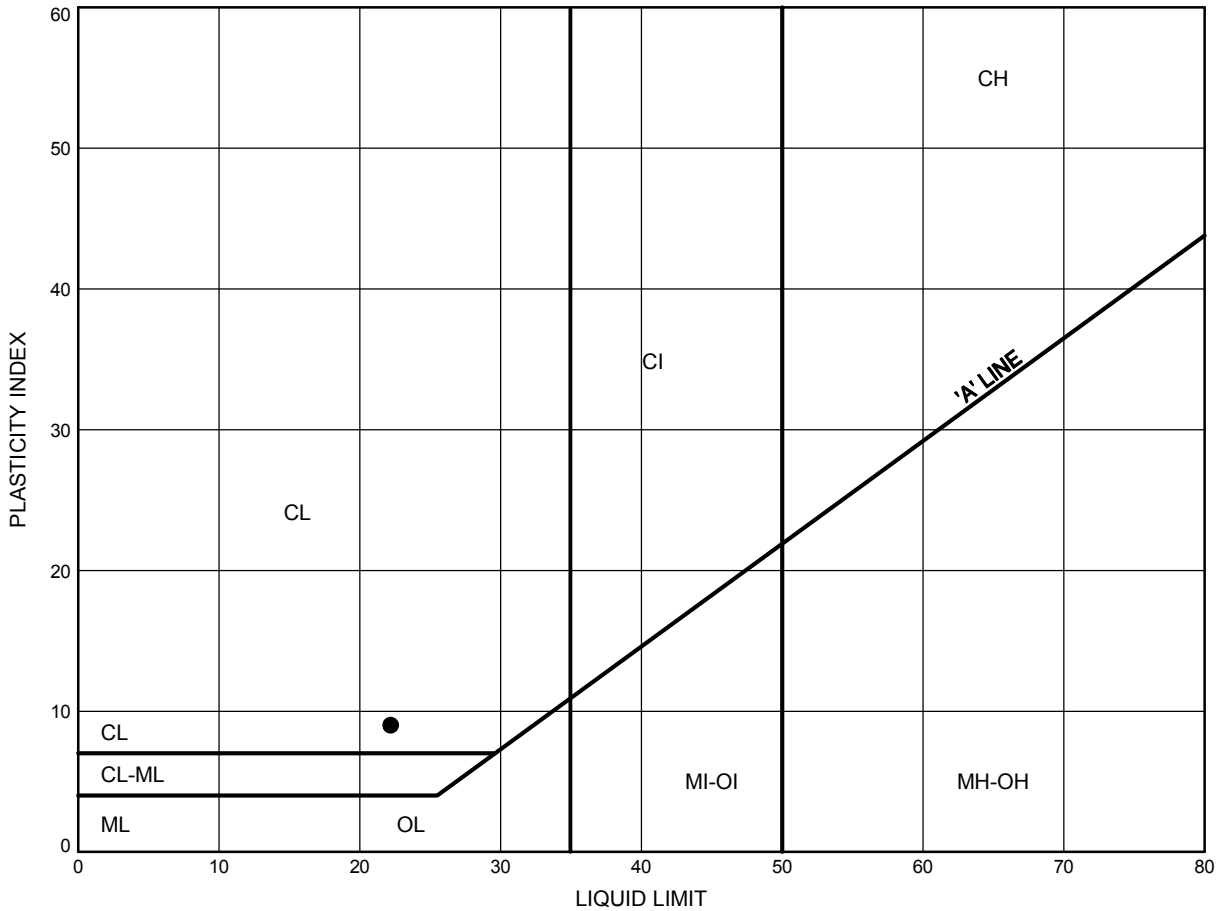
Prep'd AN

Chkd. KS

New Tremaine Road I/C at Hwy 401 - Culvert C21
ATTERBERG LIMITS TEST RESULTS

FIGURE F5

CLAYEY SILT to SILT, Some Clay (TILL)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C21-03	9.45	207.85

Date February 2015
 W.P. _____



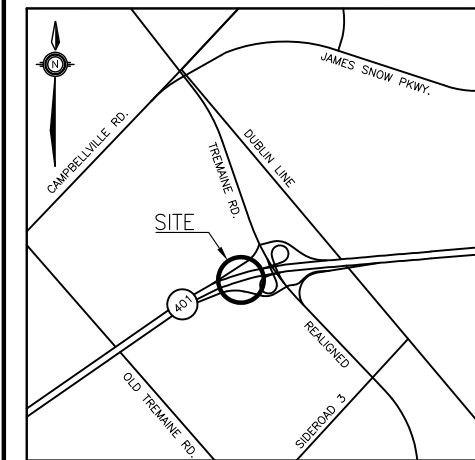
Prep'd AN
 Chkd. KS

A circular professional engineer seal for 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. Handwritten in blue ink are the license number "12345" in the upper half and the date "Oct 22/19" in the lower half.

A circular professional engineer seal for 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, there is a stylized signature in blue ink. Below the signature, the name "M. R. ANDERSON" and the license number "90267360" are printed. At the bottom of the seal, the expiration date "Oct 22/19" is handwritten in blue ink.







THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

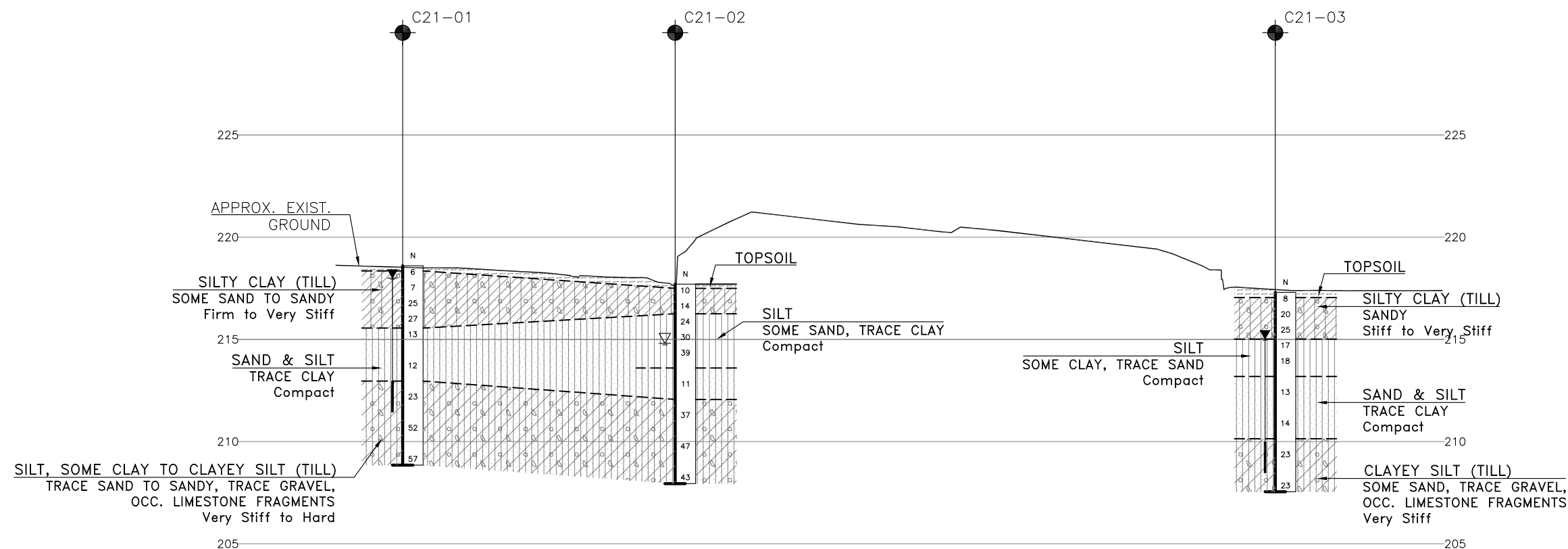
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level In Open Borehole
	Water Level In Well/Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
C21-01	218.6	4 819 605.4	586 461.1
C21-02	217.7	4 819 581.1	586 472.1
C21-03	217.3	4 819 527.6	586 496.4

-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. 30M12-381



PROFILE ALONG \mathbb{C} CULVERT



H 1:500

V 1:250

[illegible]

Appendix G

Culvert 22

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

RECORD OF BOREHOLE No C22-01

1 OF 2

METRIC

W.P. _____ LOCATION C22 Culvert N 4 819 623.5 E 586 384.4 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.08.29 - 2014.08.29 CHECKED BY KS

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
219.4	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL: (200mm)																
0.2	Silty CLAY , some sand Stiff to Very Stiff Brown Moist (TILL)		1	SS	10		219										
			2	SS	21												
218.0							218										
1.4	SILT , some clay to clayey Very Stiff Brown Moist		3	SS	17												
217.1							217										
2.3	SAND and SILT , trace clay Compact Brown Moist to Wet		4	SS	11												
			5	SS	10		216									0 53 44 3	
215.3							215										
4.1	SILT , trace to some clay Compact Brown Moist		6	SS	17												
							214										
			7	SS	14		213										
212.2							212										
7.2	SILT , some clay to clayey, some sand Hard to Very Stiff Grey Moist (TILL)		8	SS	39											0 14 69 17	
							211										
			9	SS	21		210										
209.6																	
9.8	END OF BOREHOLE AT 9.8m.																

Continued Next Page

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

RECORD OF BOREHOLE No C22-01

2 OF 2

METRIC

W.P. _____ LOCATION C22 Culvert N 4 819 623.5 E 586 384.4 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.08.29 - 2014.08.29 CHECKED BY KS

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 ³	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		
	Continued From Previous Page																
	Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.																
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 26/ 14 1.0 218.4 Dec 19/ 15 0.5 218.9																

ONTMT4S 19-5161-155 (FOUNDATION).GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C22-02

1 OF 2

METRIC

W.P. _____ LOCATION C22 Culvert N 4 819 604.4 E 586 403.9 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.08.28 - 2014.08.28 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
219.1	GROUND SURFACE											
0.0	TOPSOIL: (125mm)						219					
0.1	Silty CLAY , some sand to sandy, trace rootlets Stiff to Very Stiff Brown Moist (TILL)		1	SS	12							
			2	SS	22		218					0 19 47 34
217.7												
1.4	SILT , some clay to clayey Very Stiff Brown Moist		3	SS	18		217					
216.9												
2.2	SAND and SILT , trace clay Compact Brown Wet		4	SS	20		216					0 38 57 5
			5	SS	17		215					
214.7												
4.4	SILT , trace to some clay Compact Brown Moist to Wet		6	SS	15		214					
							213					
212.9												
6.2	Clayey SILT , some sand to sandy, trace gravel Very Stiff to Hard Grey Moist (TILL)		7	SS	20		212					
			8	SS	82		211					0 18 62 20
							210					
			9	SS	33							
209.3												
9.8	END OF BOREHOLE AT 9.8m.											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

[illegible]

RECORD OF BOREHOLE No C22-03

1 OF 2

METRIC

W.P. _____ LOCATION C22 Culvert N 4 819 586.5 E 586 421.9 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.08.28 - 2014.08.28 CHECKED BY KS

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
218.8	GROUND SURFACE															
0.0	TOPSOIL:(175mm)															
0.2	Clayey SILT , trace to some sand, trace rootlets Stiff to Very Stiff Brown Moist (TILL)		1	SS	13											
			2	SS	17											
217.3																
1.5	SILT , some clay to clayey Very Stiff Brown Moist		3	SS	26											0 0 81 19
216.6																
2.2	SAND and SILT , trace clay Compact Brown Wet		4	SS	21											
			5	SS	20											
214.5																
4.3	SILT , trace to some clay Compact Brown Moist		6	SS	18											0 0 87 13
213.1																
5.7	SILT , clayey to some clay, some sand, trace gravel Very Stiff Brown to Grey Moist (TILL)		7	SS	26											
			8	SS	28											
			9	SS	26											
209.0																
9.8	END OF BOREHOLE AT 9.8m.															

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

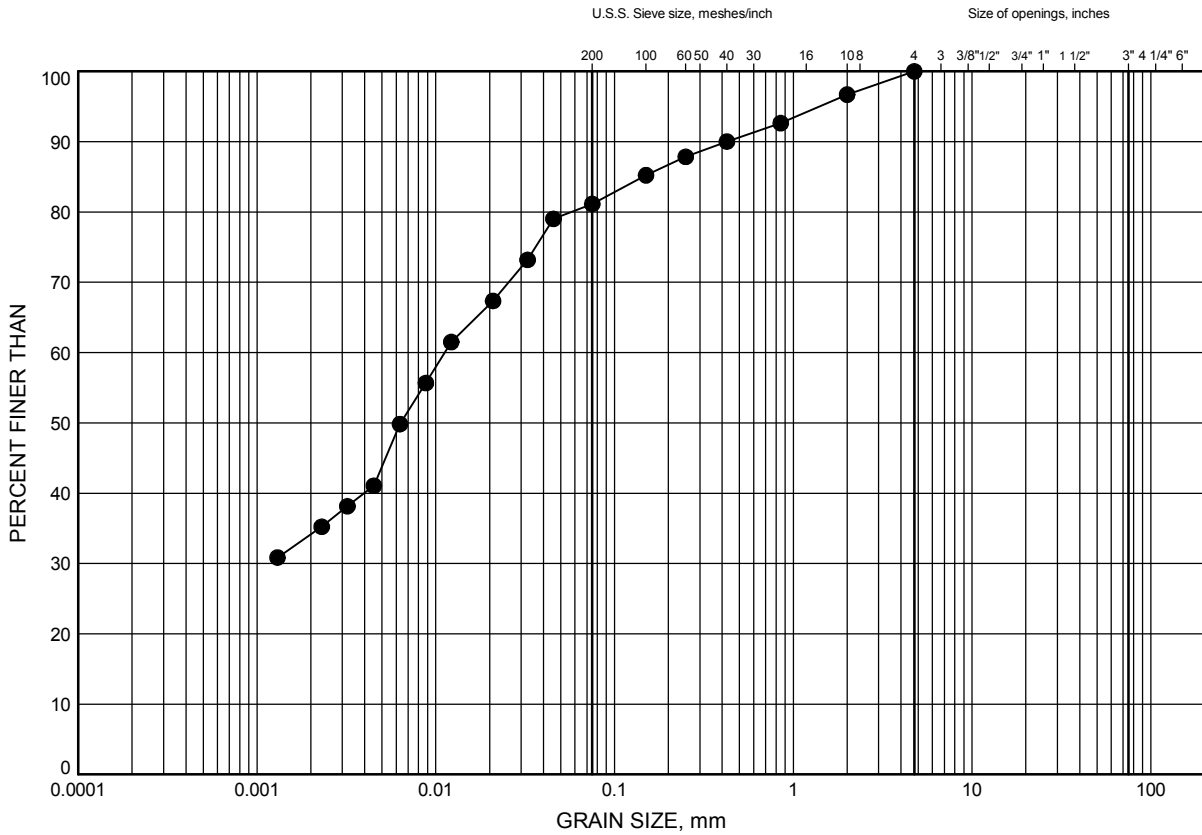
20
15
10
(%) STRAIN AT FAILURE

METRIC

[illegible]

GRAIN SIZE DISTRIBUTION

SILTY CLAY (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C22-02	1.07	218.03

Date February 2015

W.P.

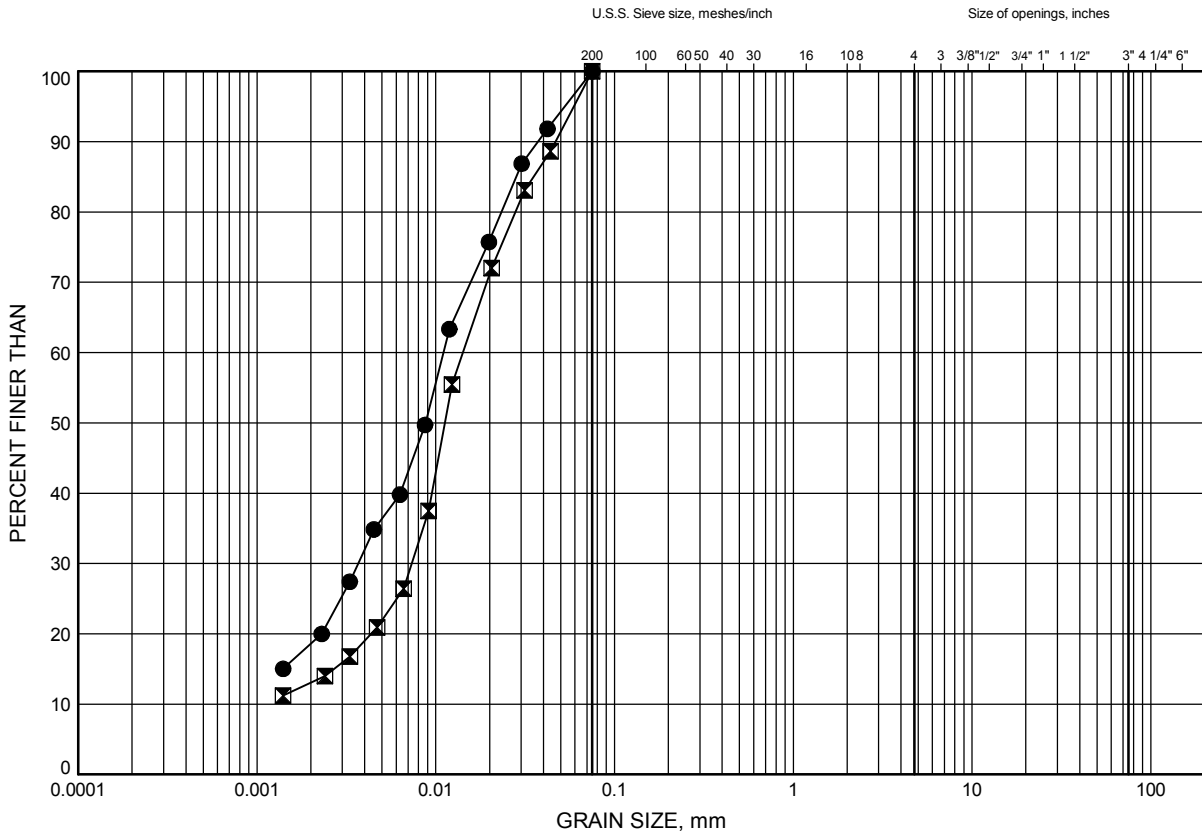


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C22-03	1.83	216.97
⊠	C22-03	4.88	213.92

Date February 2015

W.P.

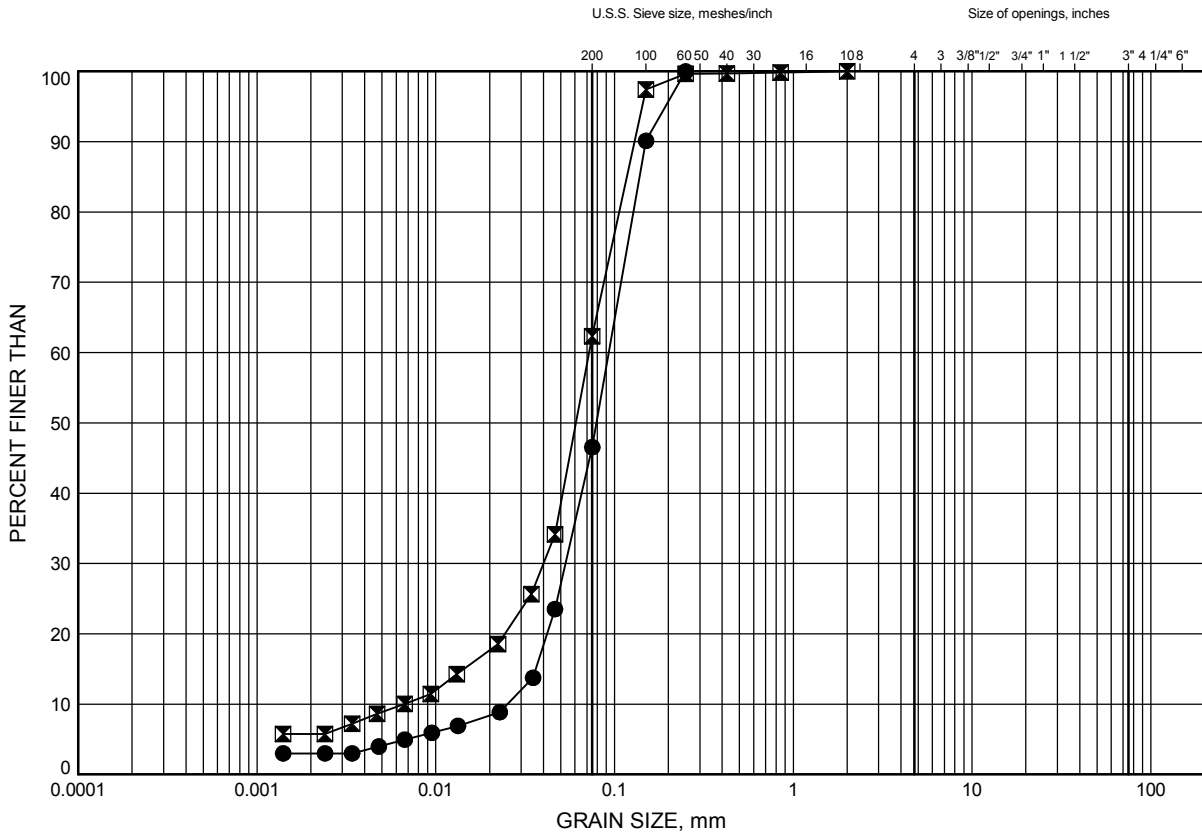


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C22-01	3.35	216.05
⊠	C22-02	3.35	215.75

Date February 2015

W.P. _____

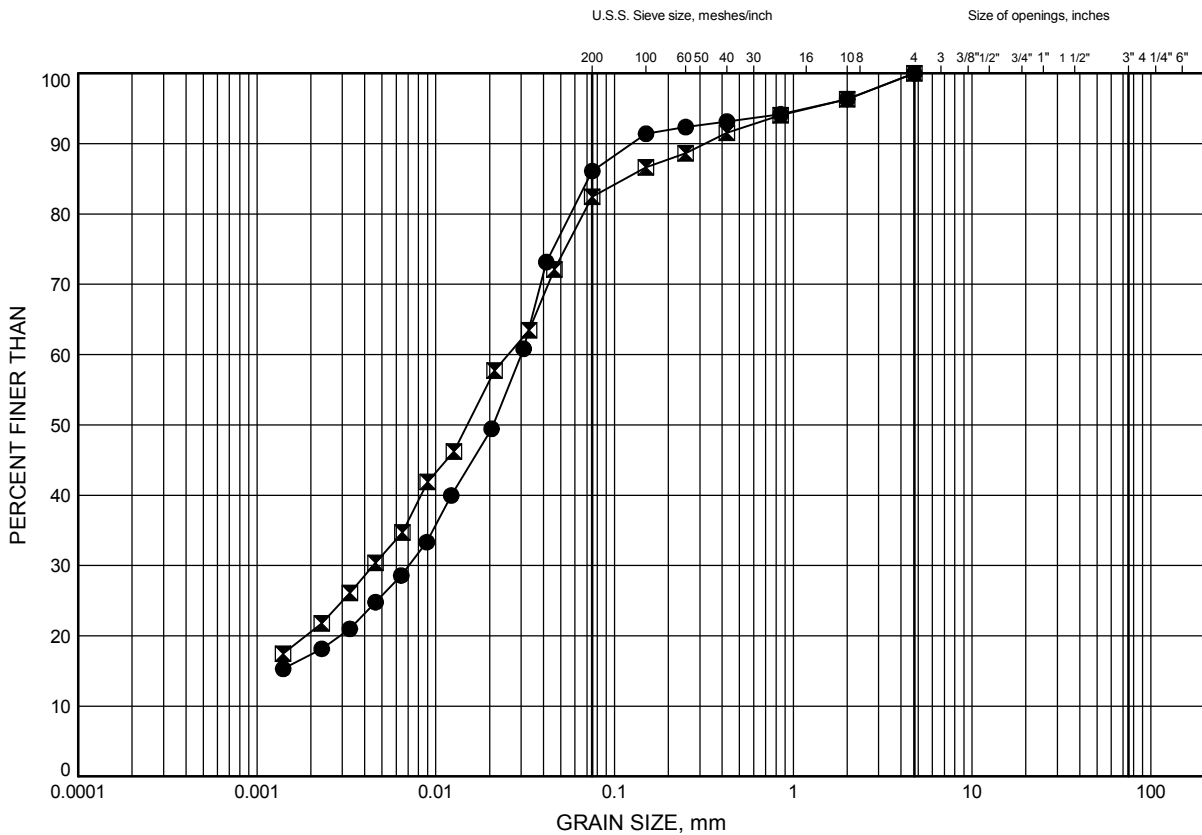


Prep'd AN

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GRAIN SIZE DISTRIBUTION

CLAYEY SILT to SILT, Some Clay (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C22-01	7.92	211.48
⊠	C22-02	7.77	211.33

Date February 2015

W.P.



Prep'd AN

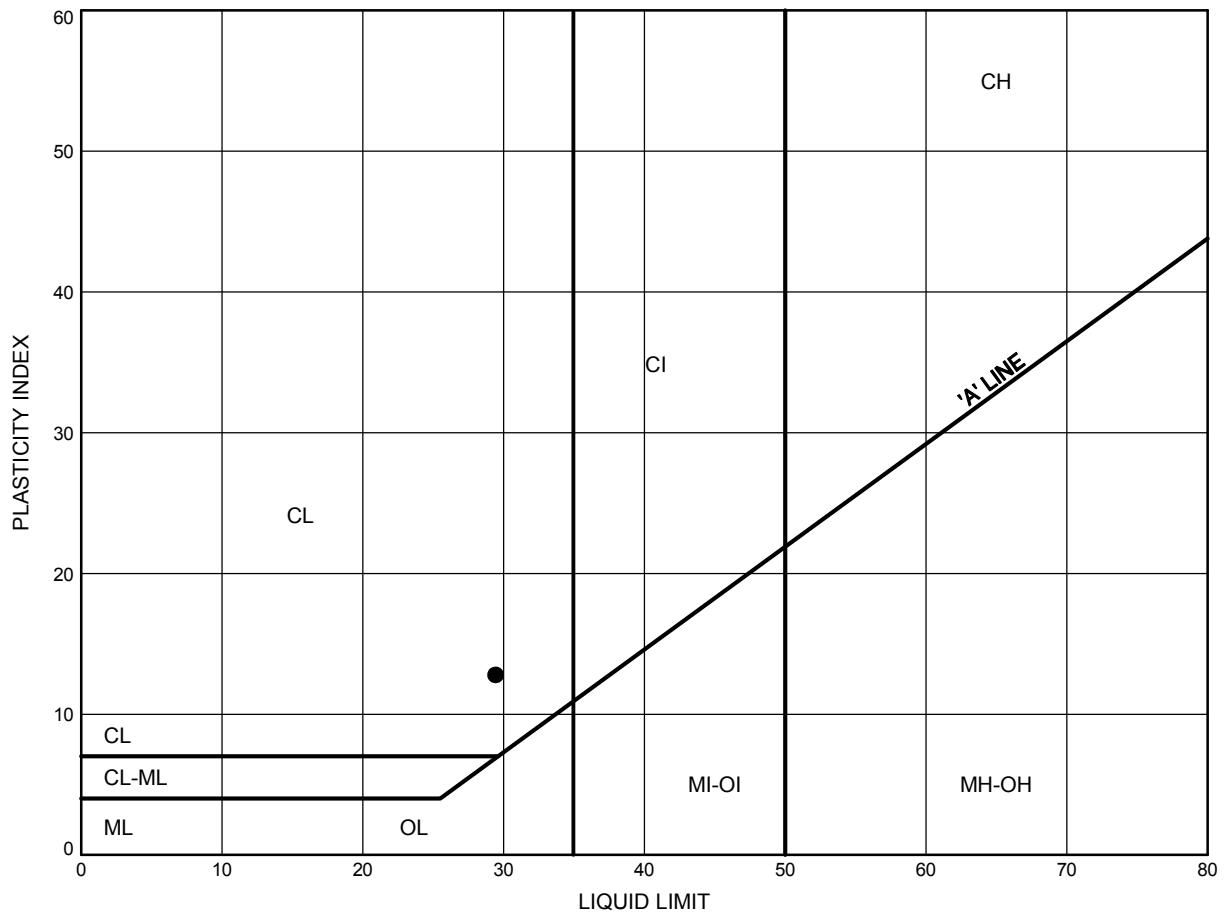
Chkd. KS

New Tremaine Road I/C at Hwy 401 - Culvert C22

ATTERBERG LIMITS TEST RESULTS

FIGURE G5

SILTY CLAY



LEGEND

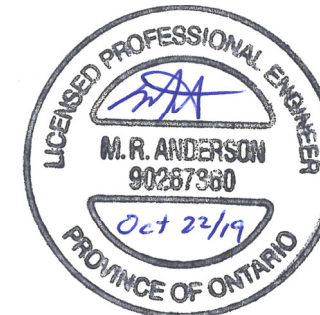
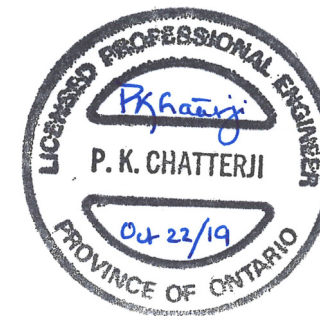
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C22-02	1.07	218.03

Date February 2015
W.P.



Prep'd AN
Chkd. KS

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

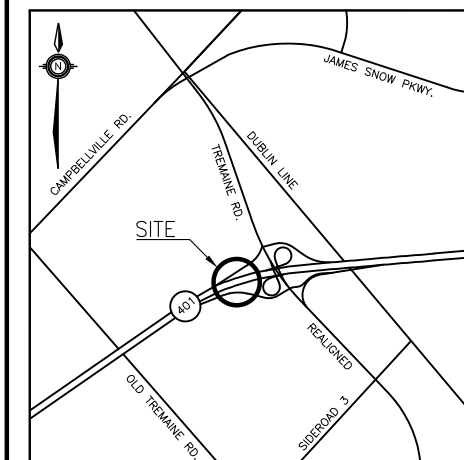


CONT No
WP No

NEW TREMAINE ROAD
INTERCHANGE AT HWY 401
CULVERT C22
BOREHOLE LOCATIONS AND SOIL STRATA







THURBER ENGINEERING LTD.



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 In Open Borehole
	Water Level In Well/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. 30M12-381

C22-01

APPROX. EXIST. GROUND

220

SILTY CLAY (TILL)
SOME SAND TO SANDY
Stiff to Very Stiff

10
21
17
11
10
215
17
14
39
210

C22-02

TOPSOIL

12
22
18
20
17
15
20
62
33

C22-03

SILT
SOME CLAY TO CLAYEY
Very Stiff

220

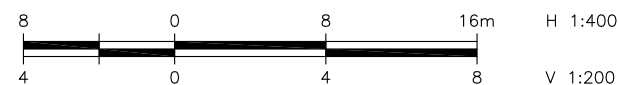
SAND & SILT
TRACE CLAY
Compact

215
18
26
28
26

SILT, SOME CLAY TO CLAYEY SILT (TILL)
SOME SAND TO SANDY, TRACE GRAVEL
Very Stiff to Hard

210

PROFILE ALONG CULVERT

[illegible]

Appendix H

Culvert 23

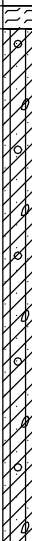


- Record of Borehole Sheets
- Laboratory Test Results
- Borehole Locations and Soil Strata Drawing

RECORD OF BOREHOLE No C23-01

1 OF 1

METRIC

W.P. _____ LOCATION C23 Culvert N 4 819 597.1 E 586 813.2 ORIGINATED BY DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.15 - 2014.09.15 CHECKED BY KS

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				WATER CONTENT (%) w _P w w _L				GR	SA	SI	CL			
217.0	GROUND SURFACE							20	40	60	80	100										
0.0	TOPSOIL: (200mm)							20	40	60	80	100										
0.2	Silty CLAY , some sand to sandy, with oxide staining Stiff to Hard Brown Moist (TILL)		1	SS	11		216							○					0 20 52 28			
			2	SS	25												○					
			3	SS	26													○		— —		
			4	SS	37		214							○								
213.4			5	SS	26									○								
3.6	SILT, trace to some clay, trace sand Dense Grey Moist						213															
	Sand seam (125mm) at 4.6m		6	SS	32		212							○					0 7 82 11			
211.8																						
5.2	END OF BOREHOLE AT 5.2m. BOREHOLE OPEN TO 5.2m AND DRY. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 25/ 14 0.6 216.4 Dec 19/ 14 0.3 216.7																					



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RECORD OF BOREHOLE No C23-02

1 OF 1

METRIC

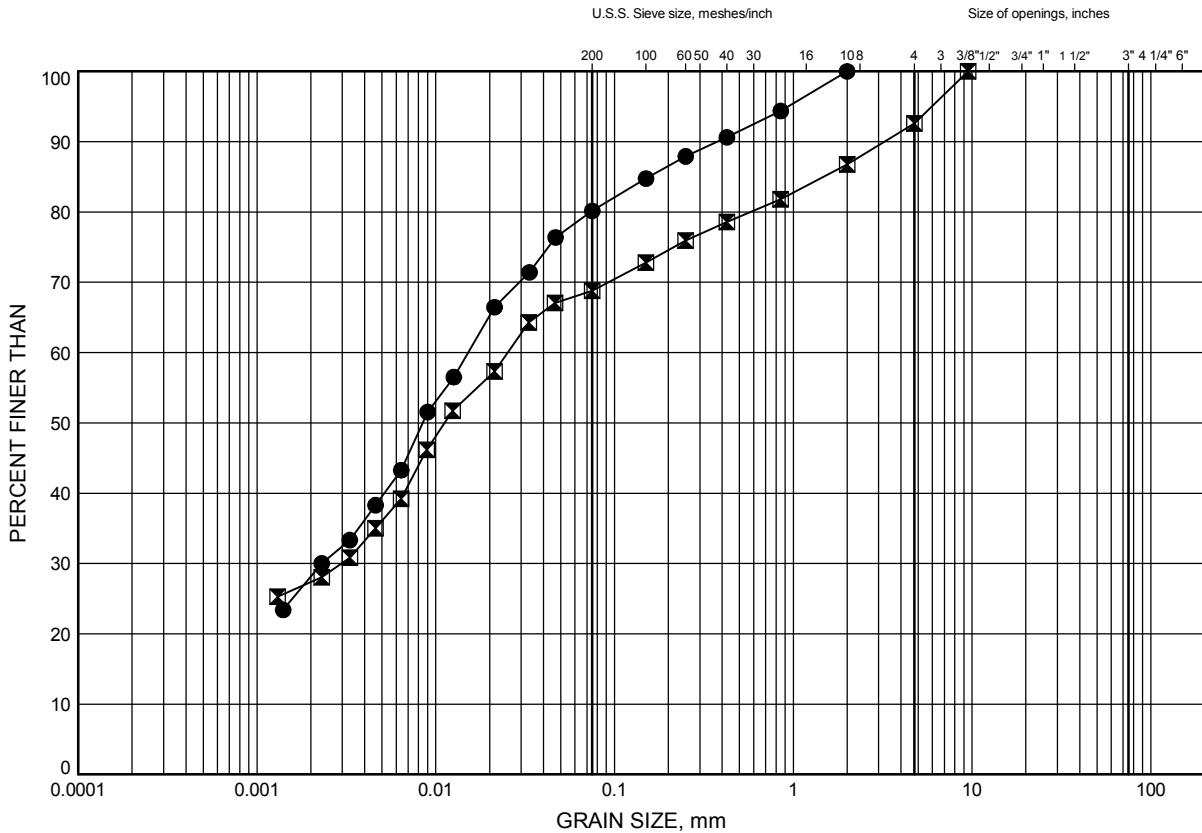
W.P. _____ LOCATION C23 Culvert N 4 819 589.8 E 586 858.7 ORIGINATED BY DJP
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.12 - 2014.09.12 CHECKED BY KS

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
216.7	GROUND SURFACE							20	40	60	80	100						
0.0	TOPSOIL: (100mm)																	
0.1	Silty CLAY , some sand to sandy, trace gravel, with oxide staining Firm to Very Stiff Brown to Reddish Brown Moist (TILL)		1	SS	5													
			2	SS	25													
			3	SS	25													
			4	SS	28													
			5	SS	26													
212.6																		
4.1	SILT , trace to some clay, trace sand Dense Grey Moist		6	SS	30													
211.5																		
5.2	END OF BOREHOLE AT 5.2m. BOREHOLE OPEN TO 5.2m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 25/ 14 0.6 216.1 Dec 19/ 14 0.4 216.3																	

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO).GDT 2/18/15

GRAIN SIZE DISTRIBUTION

SILTY CLAY (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C23-01	1.83	215.17
☒	C23-02	2.59	214.11

Date February 2015

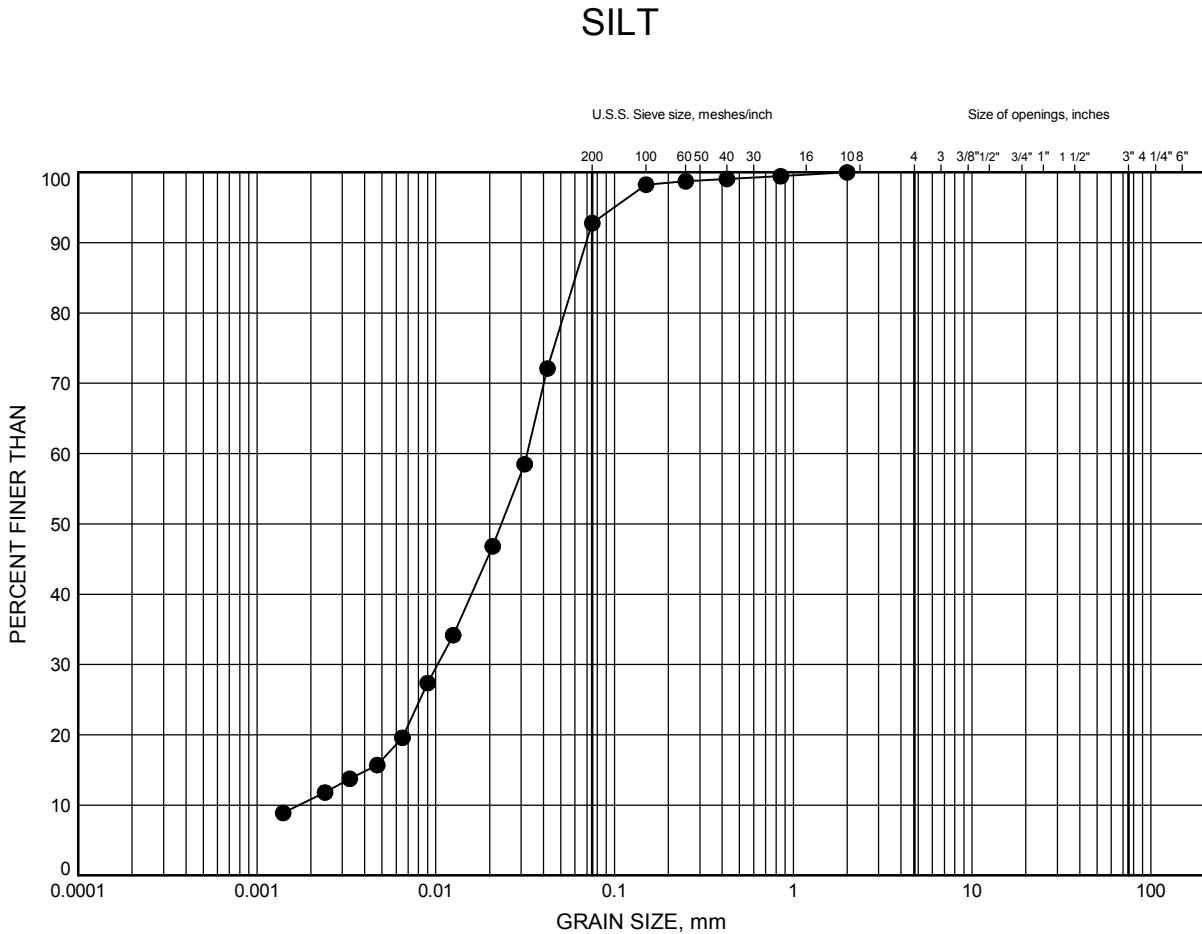
W.P.



Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

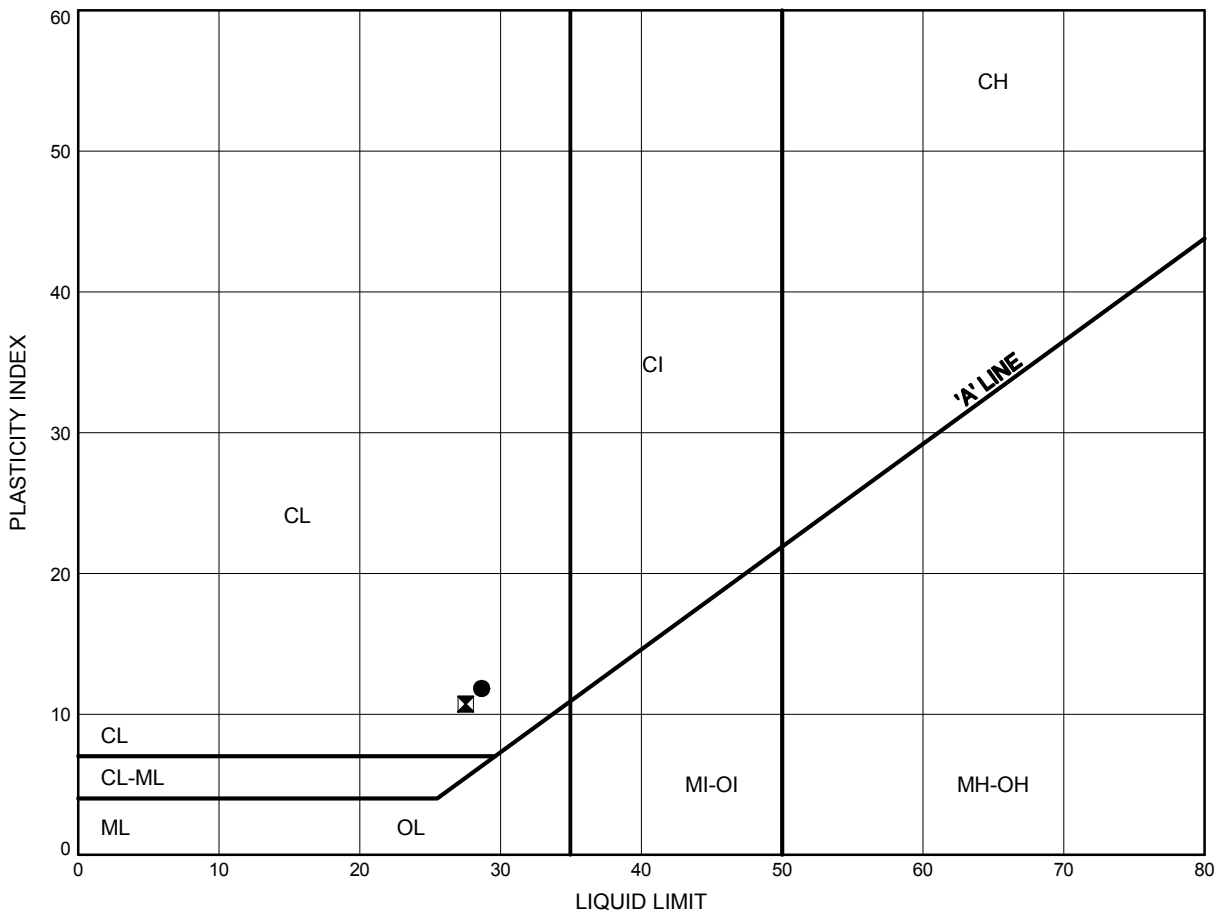


New Tremaine Road I/C at Hwy 401 - Culvert C23

ATTERBERG LIMITS TEST RESULTS

FIGURE H3

SILTY CLAY (TILL)



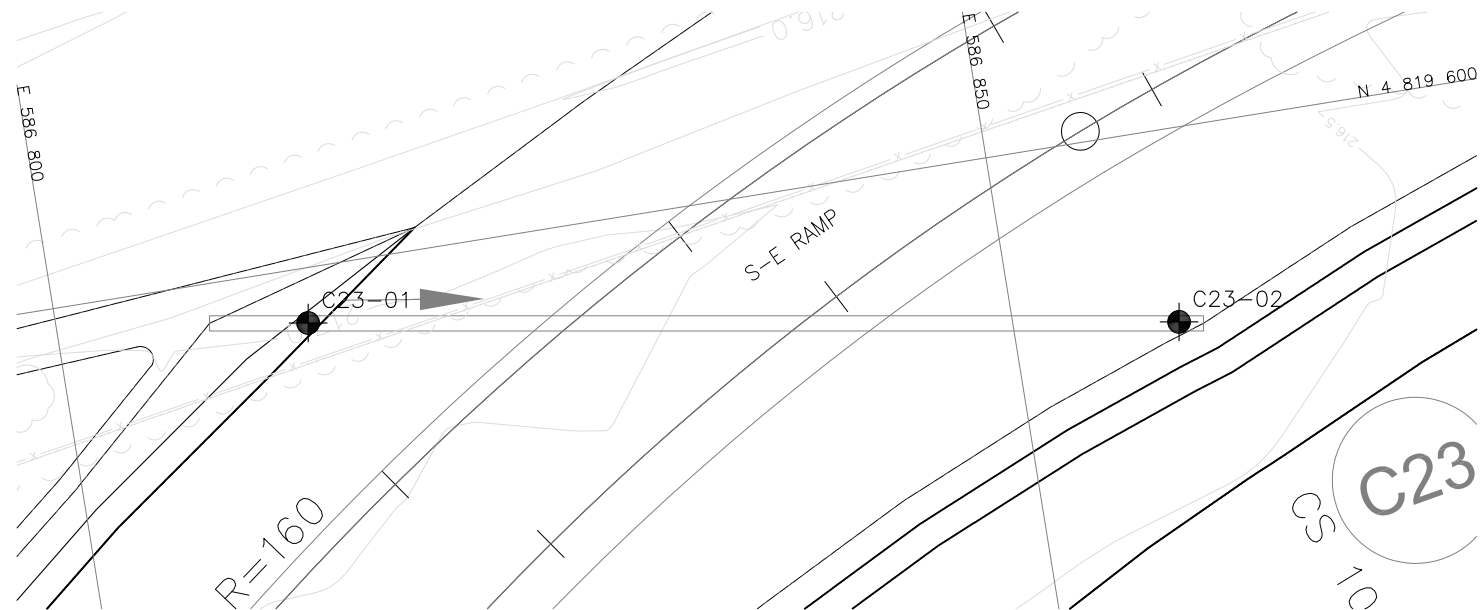
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C23-01	1.83	215.17
⊗	C23-02	2.59	214.11

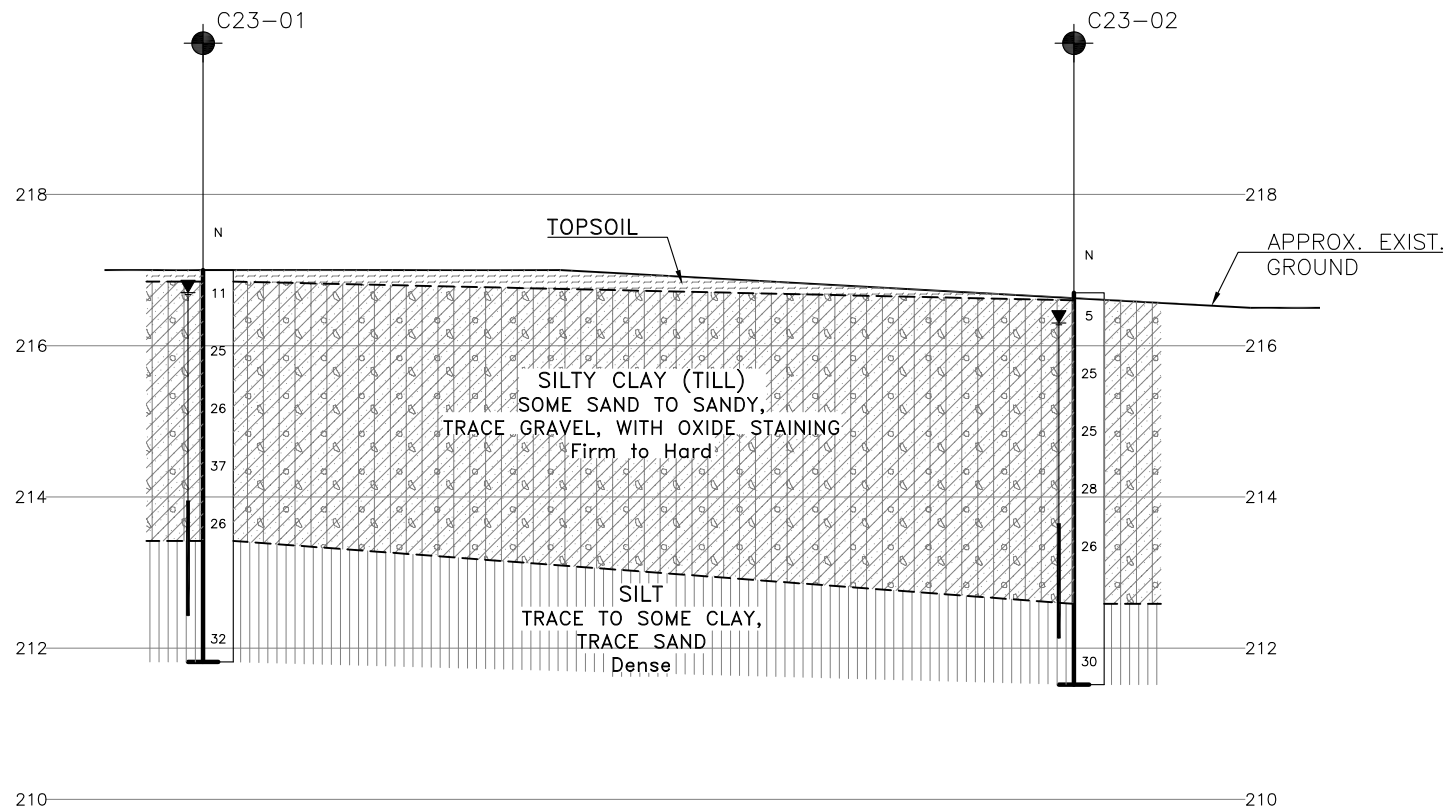
Date February 2015
W.P.



Prep'd AN
Chkd. KS



PLAN
SCALE 1:400



PROFILE ALONG ϕ CULVERT

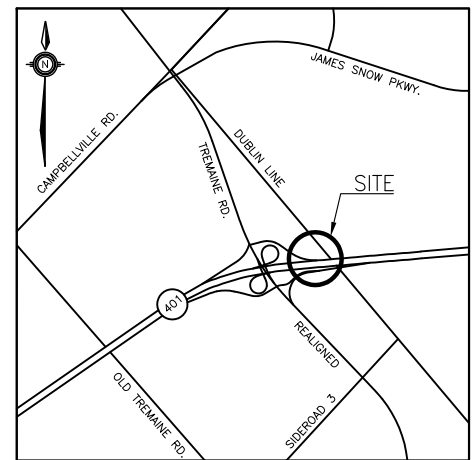
SCALE 1:400
SCALE 1:100

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



CONT No
WP No

NEW TREMAINE ROAD
INTERCHANGE AT HWY 401
CULVERT C23
BOREHOLE LOCATIONS AND SOIL STRATA



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 In Open Borehole
	Water Level In Well/Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
C23-01	217.0	4 819 597.1	586 813.2
C23-02	216.7	4 819 589.8	586 858.7

-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.

GEOCRES No. 30M12-381

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	KS	CHK MRA	CODE
DRAWN	AN	CHK KS	SITE
			LOAD
			STRUCT
			DWG 1
			DATE OCT 2019

Appendix I

Culvert 24

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

RECORD OF BOREHOLE No C24-01

1 OF 1

METRIC

WP# 19-5161-155 LOCATION N 4 819 676.1 E 586 646.7 ORIGINATED BY ES
 HWY 401 BOREHOLE TYPE Solid Stem Augers/Geoprobe COMPILED BY AN
 DATUM Geodetic DATE 2016.04.14 - 2016.04.14 CHECKED BY KS

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) w _p w w _L				
219.8	GROUND SURFACE							20	40	60	80	100					
0.0	Clayey SILT , some sand, trace gravel		1	SS	13									○			
219.4	Stiff													○			
0.4	Brown																
219.2	Moist																
0.6	(FILL)																
	SHALE weathered		2	SS	12									○			
	Grey																
	Dry																
	(FILL)																
	Silty CLAY , some sand, trace gravel		3	SS	21									○			
	Stiff to Very Stiff																
	Brown																
	Moist																
	(TILL)																
			4	SS	17									○			
			5	SS	17									○			
215.0																	
4.8	SAND and SILT , trace clay		6	SS	22									○			
214.8	Compact																
5.0	Grey																
	Wet																
	END OF BOREHOLE AT 5.0m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																

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RECORD OF BOREHOLE No C24-02

1 OF 1

METRIC

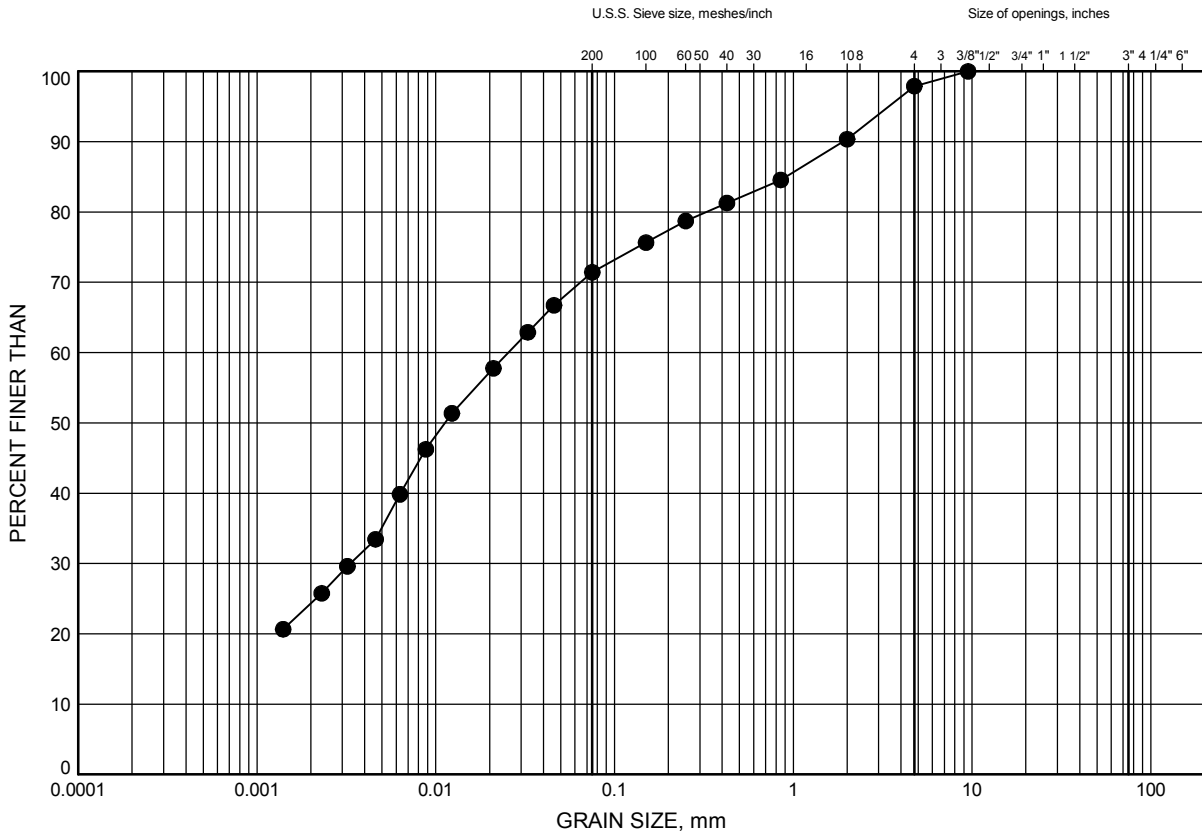
W.P. _____ LOCATION C24 Culvert N 4 819 659.4 E 586 672.4 ORIGINATED BY MKE
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.10.29 - 2014.10.29 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							WATER CONTENT (%)			
218.2	GROUND SURFACE							20	40	60	80	100	PLASTIC LIMIT W P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W L			
0.0	TOPSOIL: (100mm)							20	40	60	80	100						
0.1	Silty CLAY , sandy to some sand, trace gravel Firm to Hard Brown Moist (TILL)		1	SS	4		218								○			
			2	SS	16		217								○			
			3	SS	32		216								○			2 26 47 25
			4	SS	29		215								○			
			5	SS	23		214								○			
214.1																		
4.1	SAND and SILT , trace clay Loose Brown to Grey Wet		6	SS	8		214								○		0 45 50 5	
213.0																		
5.2	END OF BOREHOLE AT 5.2m. BOREHOLE OPEN TO 4.4m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 26/ 14 0.8* 219.0 Dec 19/ 14 0.6 217.6 * Above ground surface																	

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO).GDT 2/18/15

GRAIN SIZE DISTRIBUTION

SILTY CLAY (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C24-02	1.83	216.37

Date February 2015

W.P.

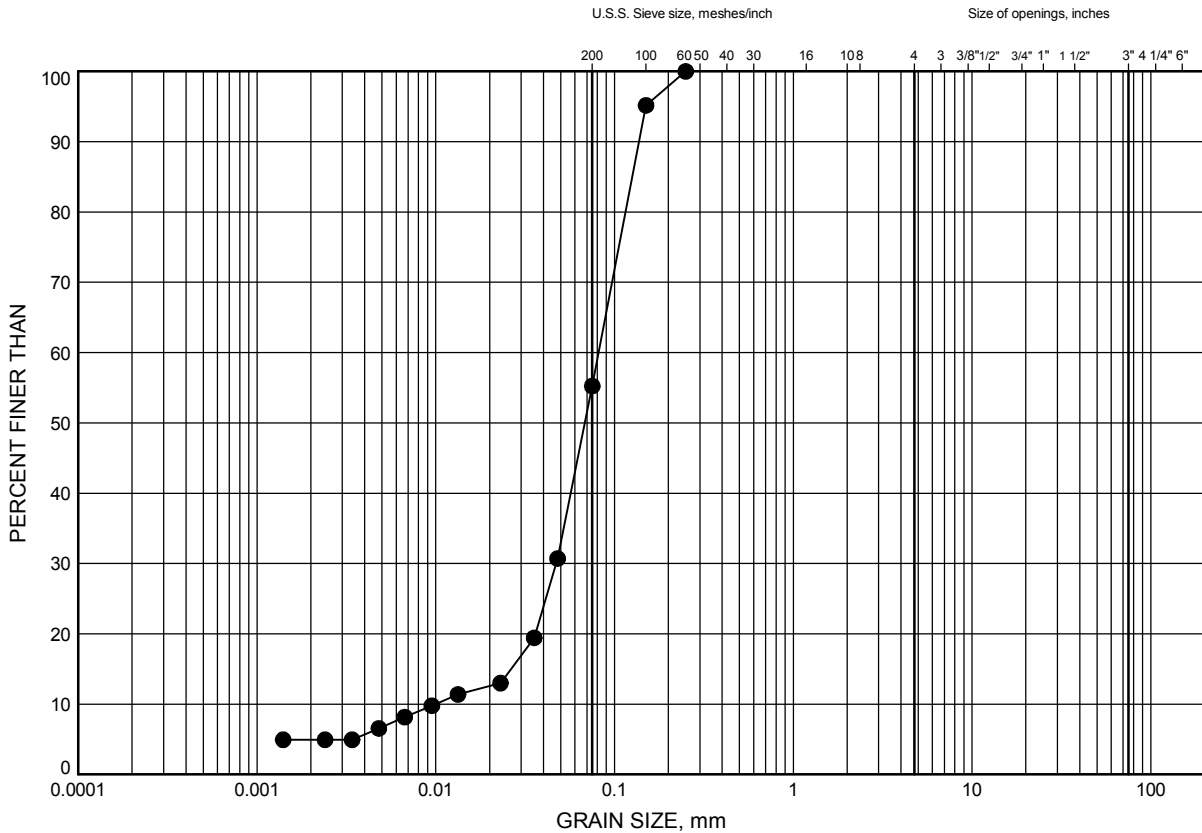


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

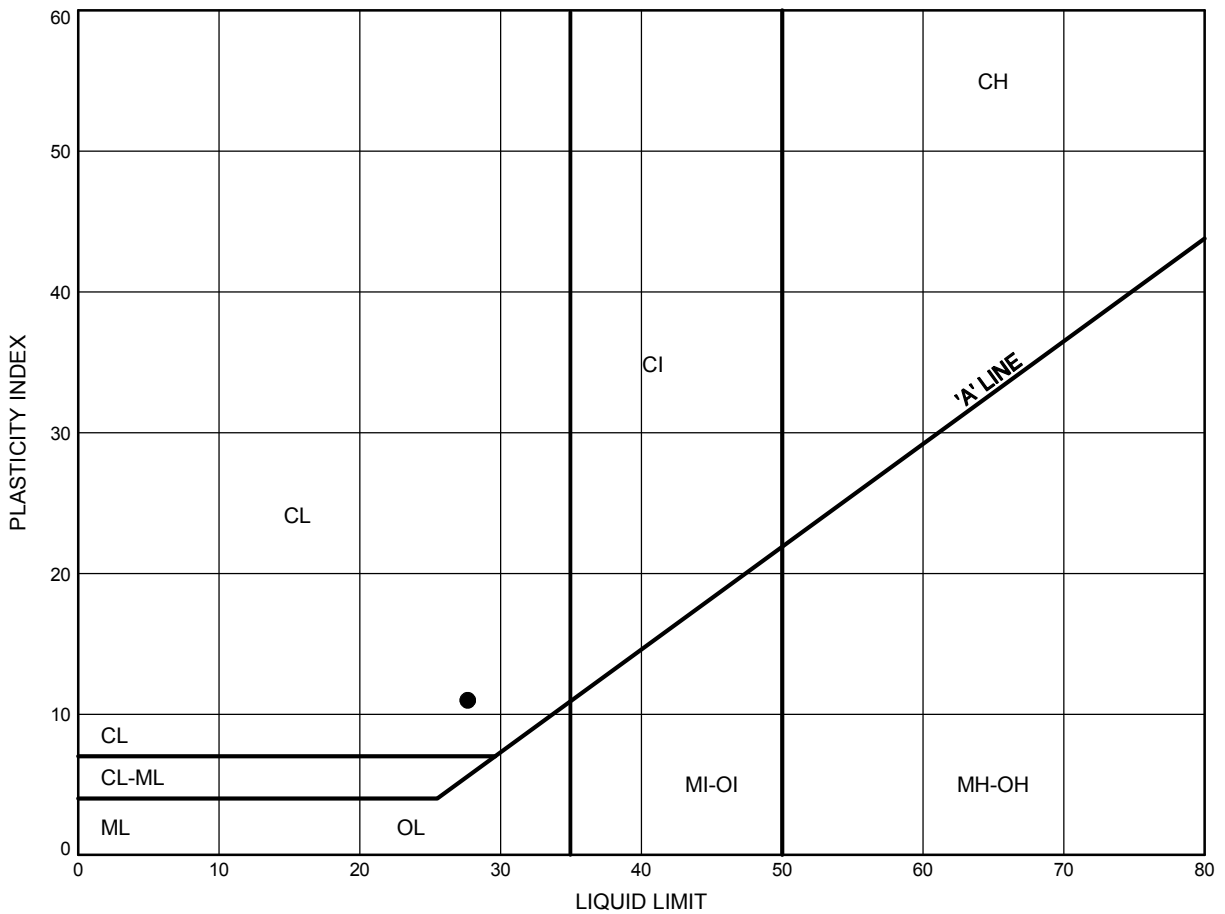
SAND & SILT



New Tremaine Road I/C at Hwy 401 - Culvert C24
ATTERBERG LIMITS TEST RESULTS

FIGURE 13

SILTY CLAY (TILL)



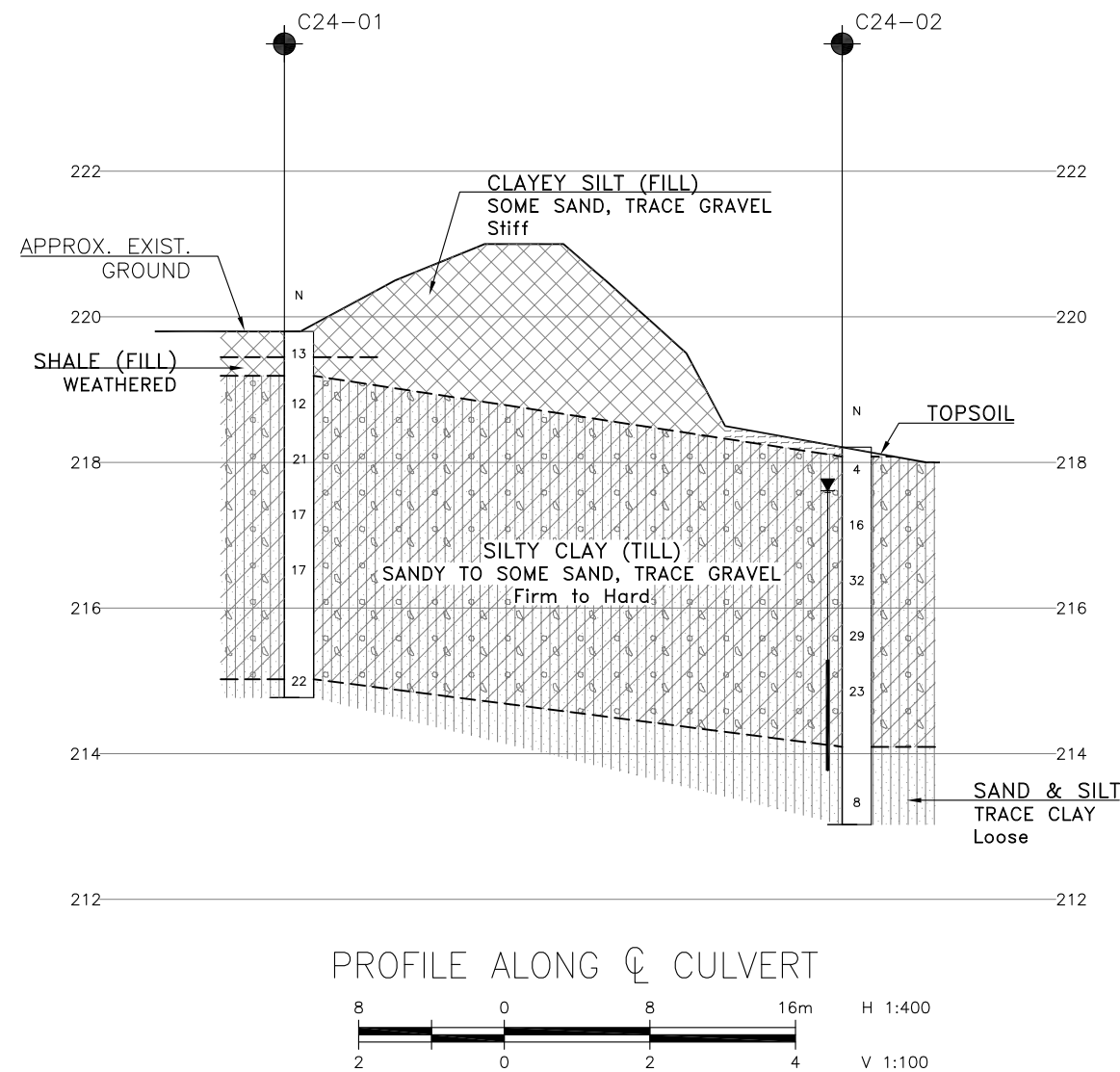
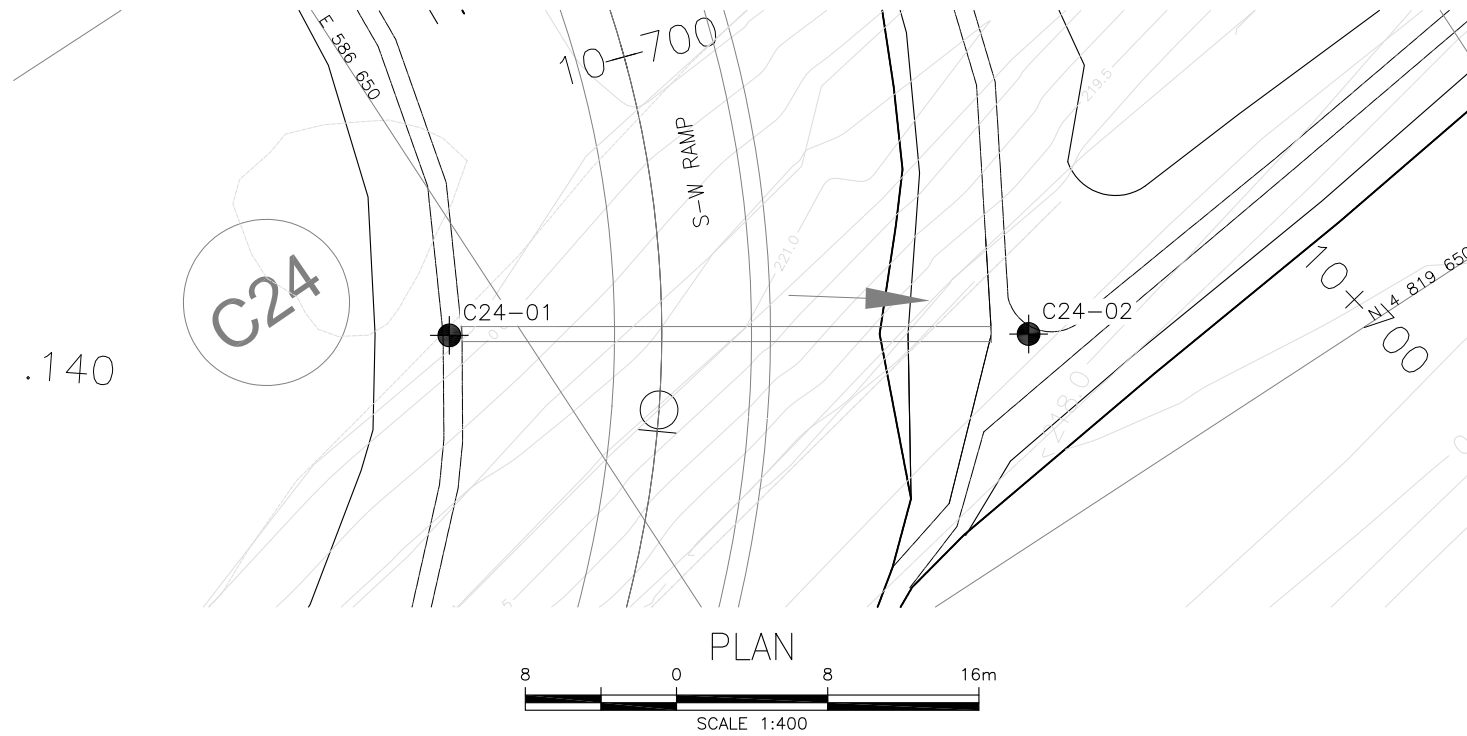
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C24-02	1.83	216.37

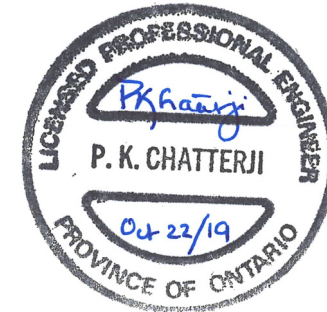
Date February 2015
 W.P.



Prep'd AN
 Chkd. KS

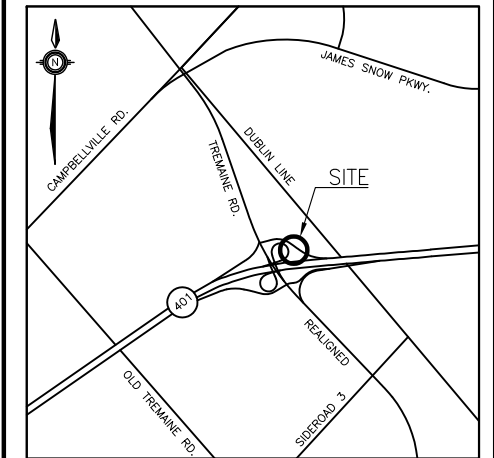


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN







CONT No
WP No

NEW TREMAINE ROAD
INTERCHANGE AT HWY 401
CULVERT C24
BOREHOLE LOCATIONS AND SOIL STRATA



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 In Open Borehole
	Water Level In Well/Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
C24-01	219.8	4 819 676.1	586 646.7
C24-02	218.2	4 819 659.4	586 672.4

-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. 30M12-381

REVISIONS									
	DATE	BY	DESCRIPTION						
DESIGN	KS	CHK	MRA	CODE	LOAD		DATE	OCT 2019	
DRAWN	AN	CHK	KS	SITE	STRUCT		DWG	1	

Appendix J

Culvert 25

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

RECORD OF BOREHOLE No C25-01

1 OF 1

METRIC

WP# 19-5161-155 LOCATION C25 Culvert N 4 819 708.6 E 586 816.8 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.05.02 - 2014.05.02 CHECKED BY KS

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
218.0	GROUND SURFACE															
0.0	ASPHALT:(50mm)															
217.6	SAND and GRAVEL															
0.4	Brown Moist (FILL)															
	ClayeySILT, sandy, trace gravel Very Stiff to Hard		1	SS	16		217									
	Brown Moist (TILL)		2	SS	29		216									0 24 53 23
			3	SS	50		215									
			4	SS	52		214									
214.3	SAND and SILT, trace clay															
3.7	Dense to Compact Grey Wet		5	SS	30		213									0 37 59 4
			6	SS	16											
212.8	END OF BOREHOLE AT 5.2m. BOREHOLE OPEN TO 4.2m AND WATER LEVEL AT 3.5m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, THEN SAND TO 0.1m, THEN ASPHALT TO SURFACE.															
5.2																

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

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No C25-01A

2 OF 2

METRIC

WP# 19-5161-155 LOCATION C25 Culvert N 4 819 708.6 E 586 816.8 ORIGINATED BY TM
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.01.28 - 2016.01.28 CHECKED BY MRA

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page		5	SS	3		207										
206.7																	
11.3	END OF BOREHOLE AT 11.3m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Oct 12/ 16 Destroyed																



ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2015TEMPLATE(MTO) GDT 10/22/19

RECORD OF BOREHOLE No C25-02

1 OF 1

METRIC

W.P. _____ LOCATION C25 Culvert N 4 819 682.6 E 586 811.9 ORIGINATED BY MKE
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.10.27 - 2014.10.27 CHECKED BY KS

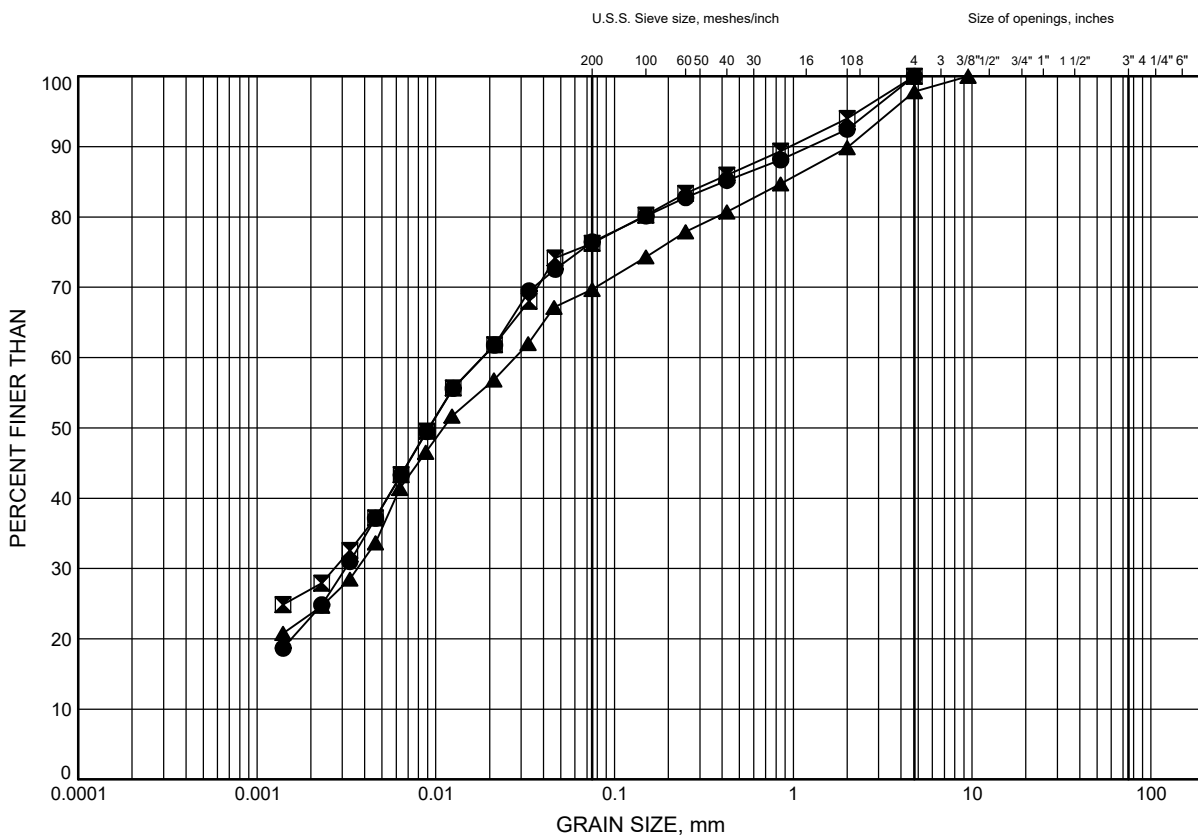
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							WATER CONTENT (%) w _P w w _L	
217.6	GROUND SURFACE															
0.0	TOPSOIL: (225mm)															
0.2	Clayey SILT, sandy, trace gravel, with oxide staining Firm to Very Stiff Brown to Grey Moist (TILL)		1	SS	5											
			2	SS	17											
			3	SS	24											
			4	SS	29											
			5	SS	21											
213.5																
4.1	SILT, trace sand, trace clay Compact Grey Wet															
			6	SS	19											
212.4																
5.2	END OF BOREHOLE AT 5.2m. BOREHOLE OPEN TO 4.7m AND WATER LEVEL AT 4.6m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 26/ 14 0.2* 217.8 Dec 19/ 15 0.5* 218.1 * Above ground surface															

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO).GDT 2/18/15

New Tremaine Road I/C at Hwy 401 - Culvert 25
GRAIN SIZE DISTRIBUTION

FIGURE J1

CLAYEY SILT (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C25-01	1.83	216.17
⊠	C25-01A	7.92	210.08
▲	C25-02	1.83	215.77

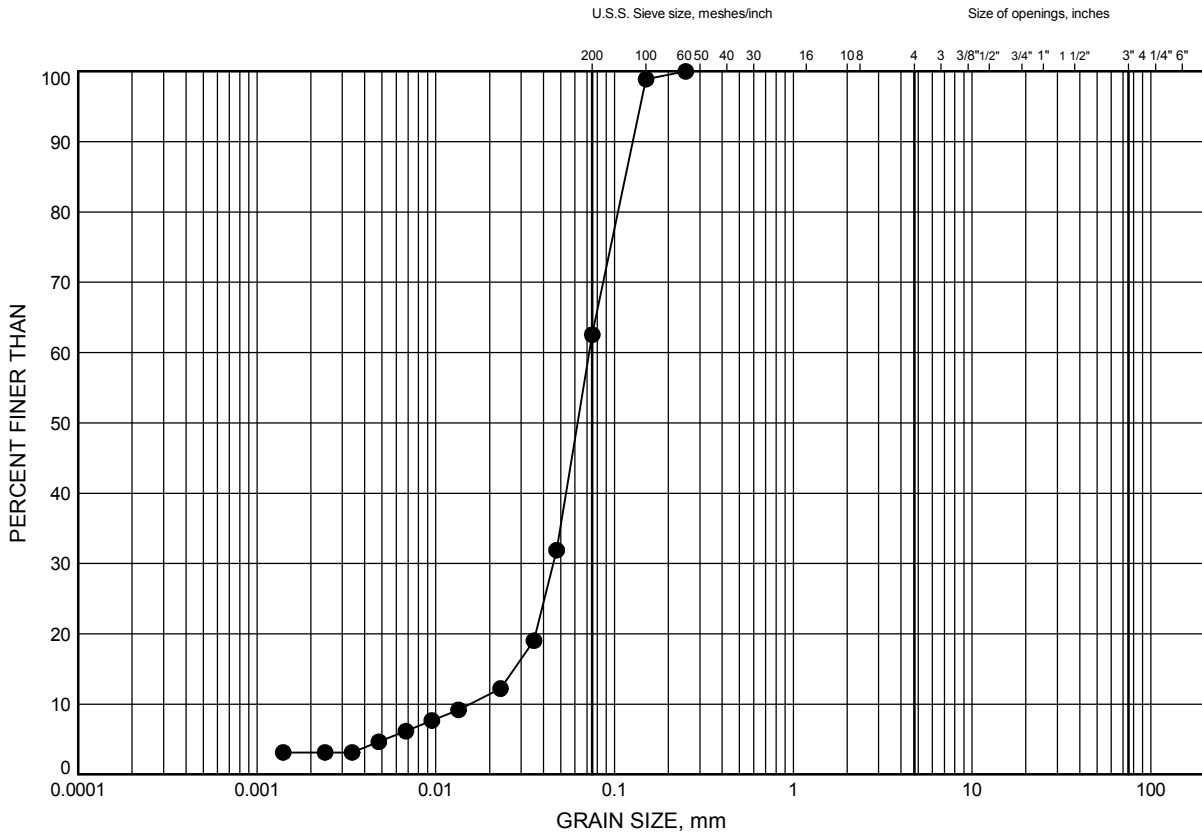
Date October 2019
 WP# 19-5161-155



Prep'd AN
 Chkd. MRA

GRAIN SIZE DISTRIBUTION

SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C25-01	4.88	213.12

Date February 2015

W.P. _____

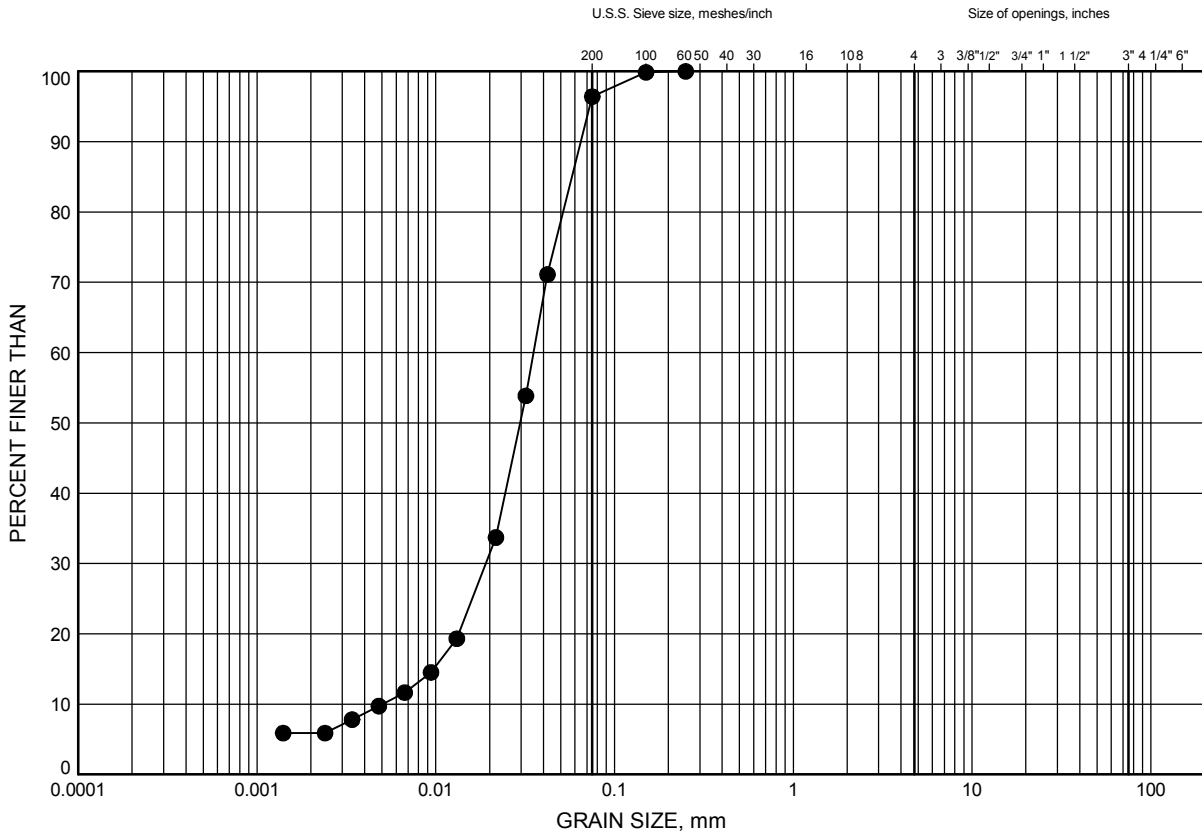


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C25-02	4.88	212.72

Date February 2015

W.P.



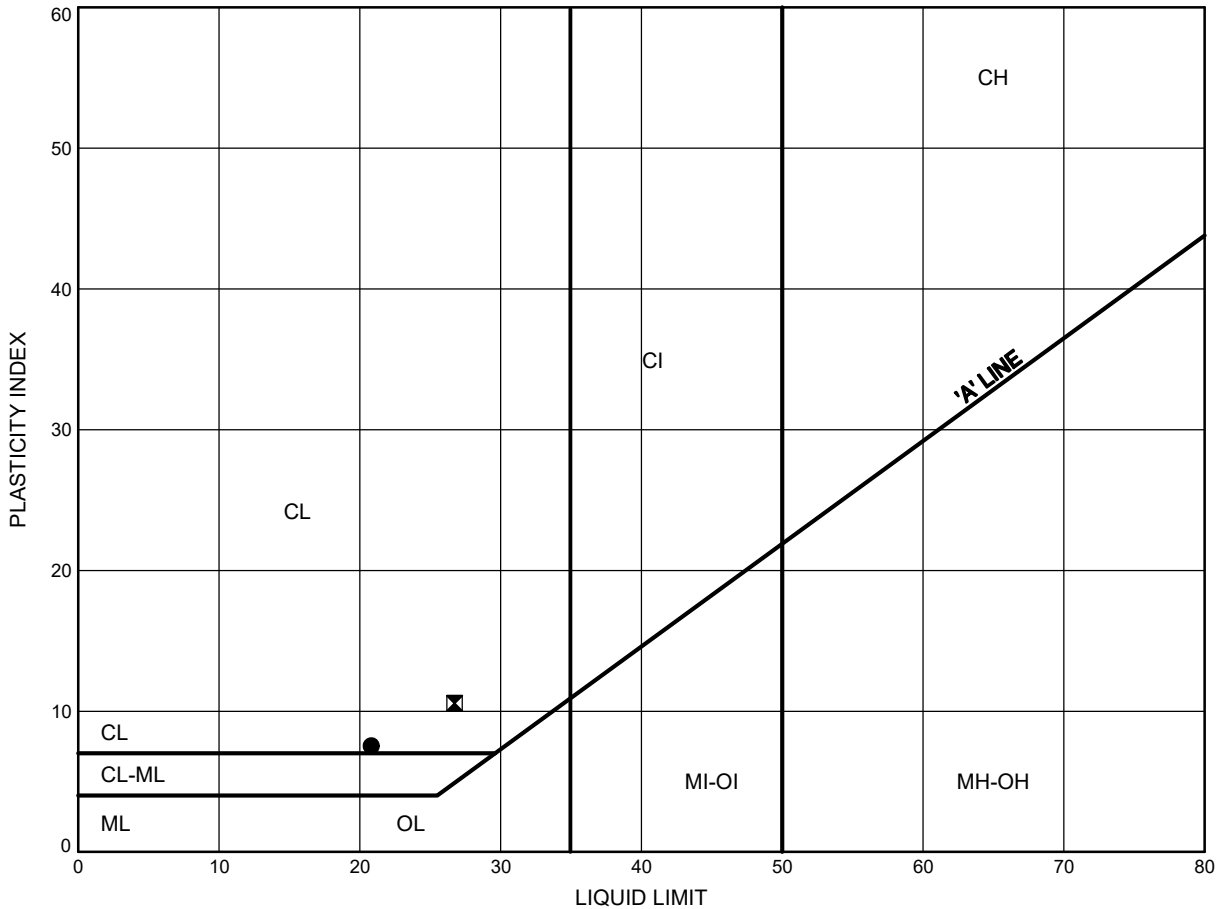
Prep'd AN

Chkd. KS

New Tremaine Road I/C at Hwy 401 - Culvert 25
ATTERBERG LIMITS TEST RESULTS

FIGURE J4

CLAYEY SILT (TILL)



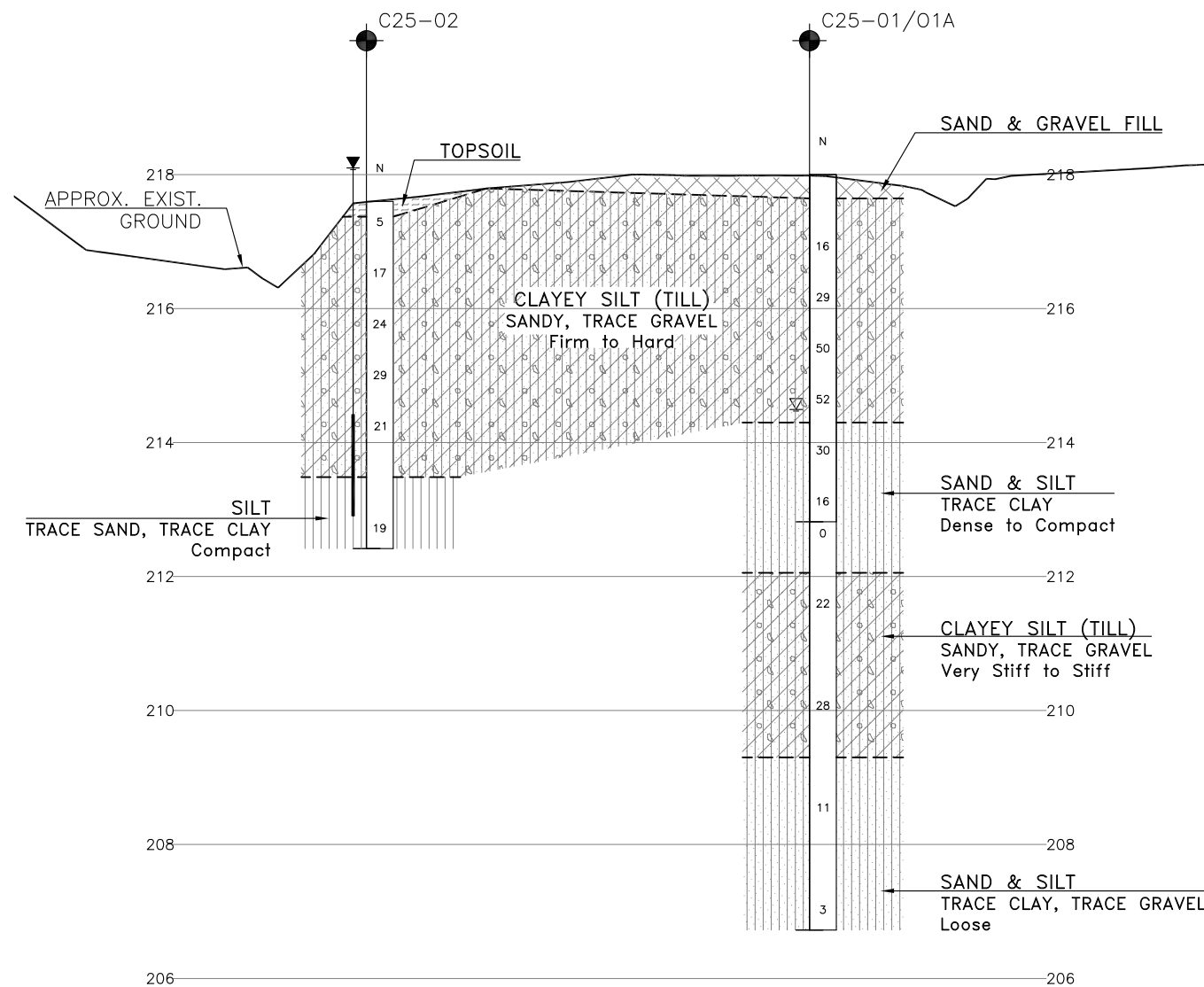
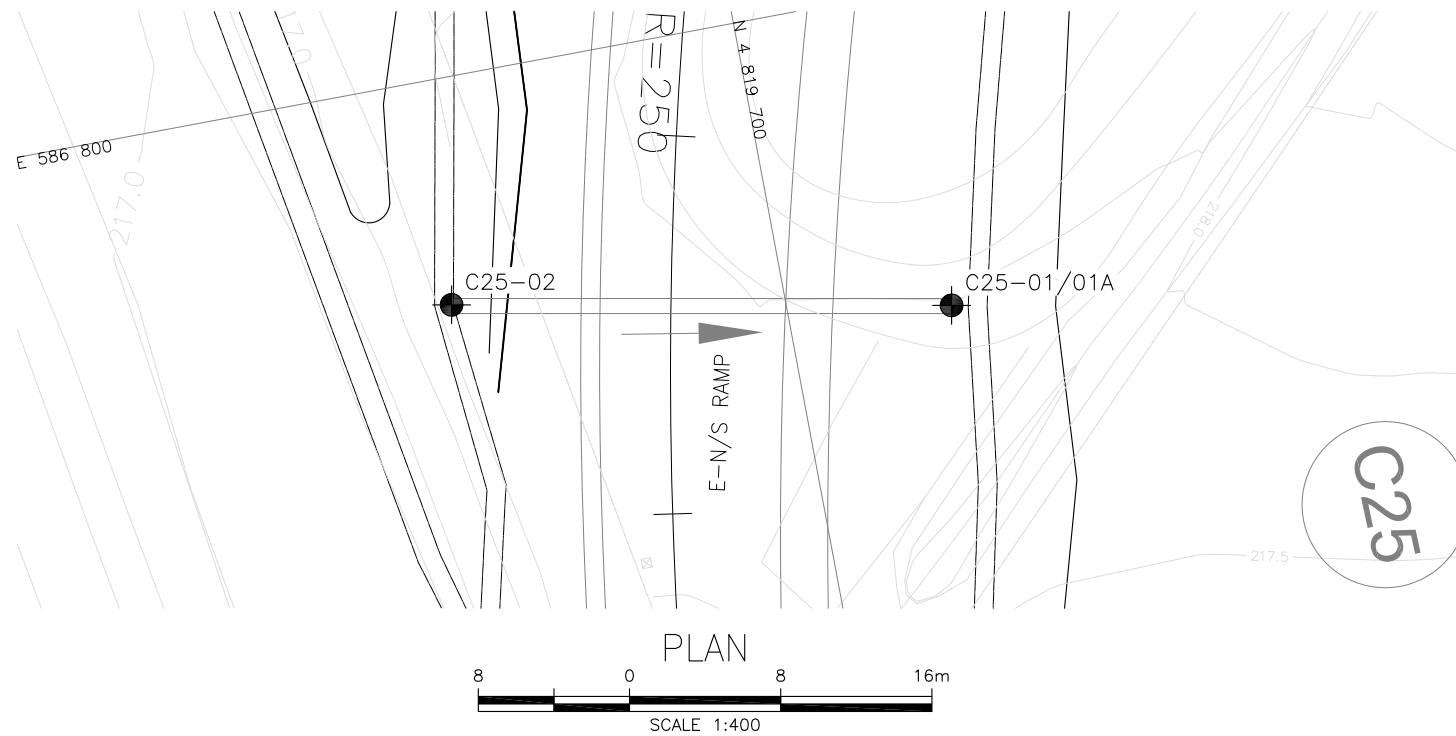
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C25-01A	7.92	210.08
⊠	C25-02	1.83	215.77

Date October 2019
 WP# 19-5161-155



Prep'd AN
 Chkd. MRA



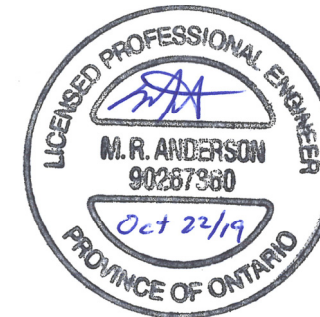
PROFILE ALONG CULVERT



H 1:400

V 1:100

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

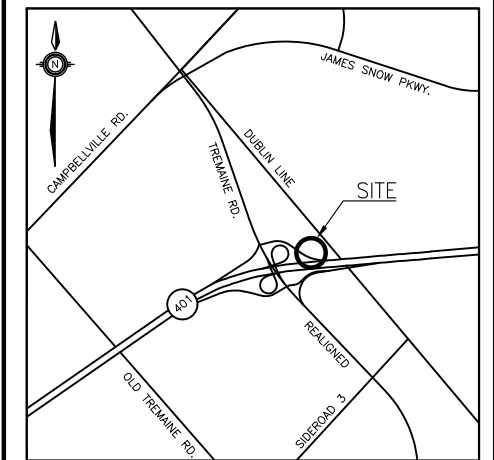


CONT No
WP No

NEW TREMAINE ROAD
INTERCHANGE AT HWY 401
CULVERT C25
BOREHOLE LOCATIONS AND SOIL STRATA







THURBER ENGINEERING LTD.



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 In Open Borehole
	Water Level In Well/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. 30M12-381

[illegible]

Appendix K

Culvert 26 (Extension)

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

RECORD OF BOREHOLE No C26-01

1 OF 1

METRIC

W.P. _____ LOCATION C26 Culvert N 4 819 719.8 E 587 065.7 ORIGINATED BY MKE
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.10.27 - 2014.10.27 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
214.2	GROUND SURFACE													
0.0	TOPSOIL: (75mm) Clayey SILT , sandy, trace gravel, trace rootlets Firm to Hard Brown to Grey Moist (TILL)		1	SS	6									
0.1														
			2	SS	23									
			3	SS	30									
		4	SS	34										
		5	SS	17										
210.1														
4.1	SILT , trace sand, trace clay Dense Grey Wet													
			6	SS	32									
209.0														
5.2	END OF BOREHOLE AT 5.2m. BOREHOLE OPEN TO 5.2m AND WATER LEVEL AT 5.0m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 26/ 14 0.9* 215.1 Dec 19/ 14 Frozen * Above ground surface													

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C26-02

1 OF 1

METRIC

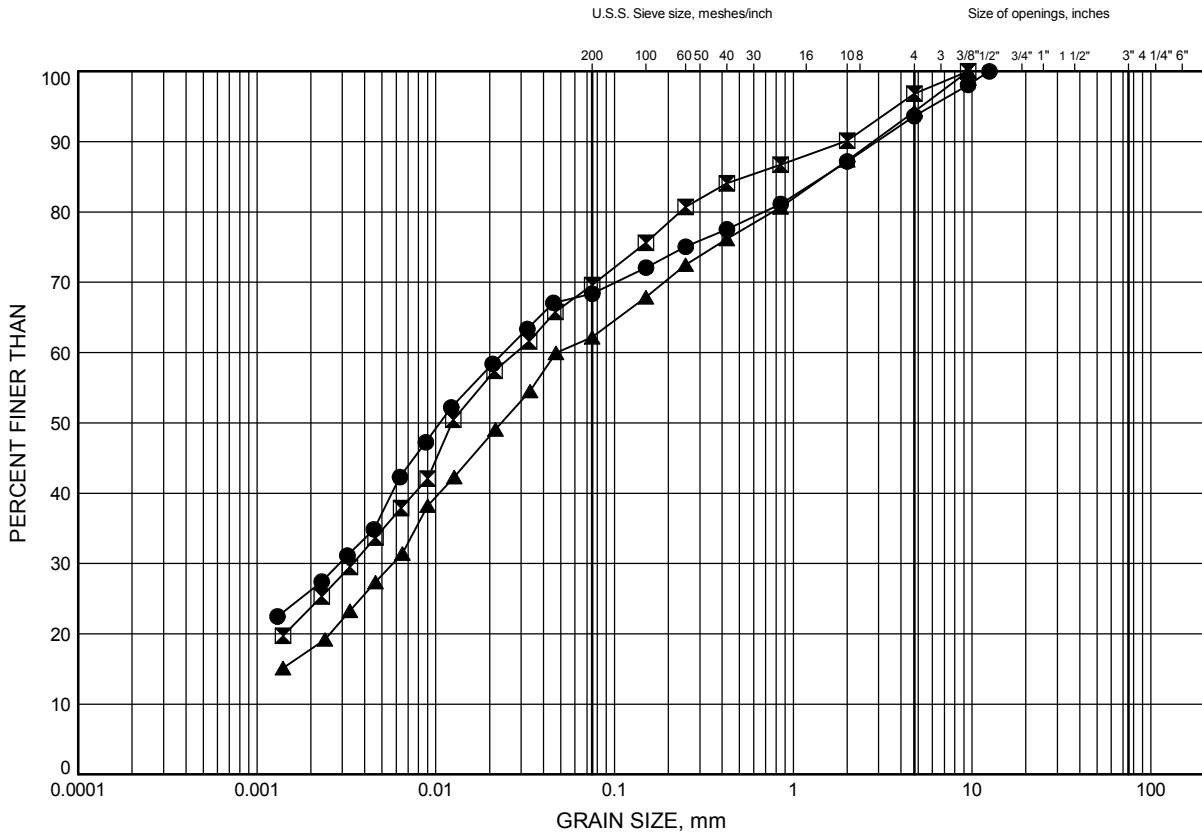
W.P. _____ LOCATION C26 Culvert N 4 819 655.6 E 587 122.2 ORIGINATED BY ADH
HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2014.10.10 - 2014.10.10 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								WATER CONTENT (%)					
214.2	GROUND SURFACE												
0.0	TOPSOIL: (50mm)												
	Clayey SILT , sandy, trace gravel, occasional cobbles Stiff to Hard Brown Moist (TILL)		1	SS	8								
			2	SS	26								
			3	SS	26								
			4	SS	69								
			5	SS	62								
			6	SS	63								
209.0	END OF BOREHOLE AT 5.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.												
5.2													

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2012TEMPLATE(MTO) GDT 2/18/15

GRAIN SIZE DISTRIBUTION

CLAYEY SILT (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C26-01	1.83	212.37
◻	C26-02	1.83	212.37
▲	C26-02	4.88	209.32

Date February 2015

W.P. _____

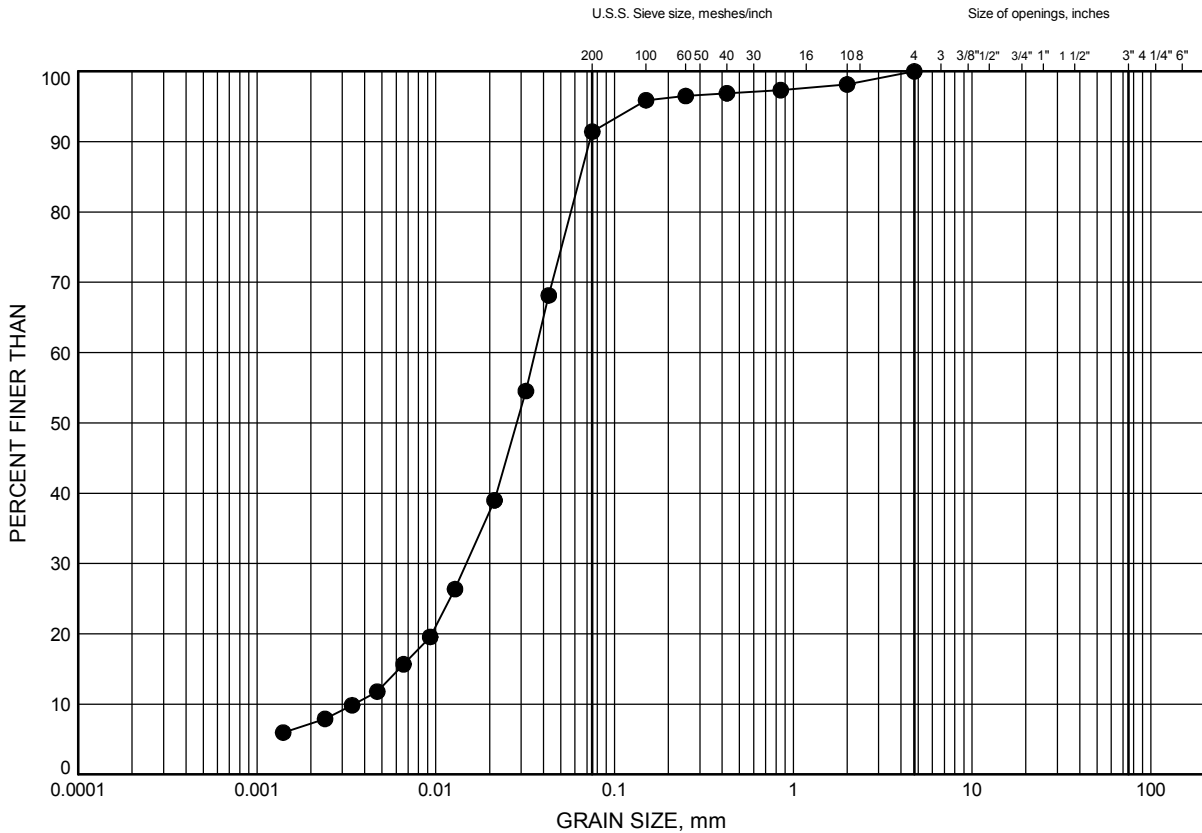


Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C26-01	4.88	209.32

Date February 2015

W.P.



Prep'd AN

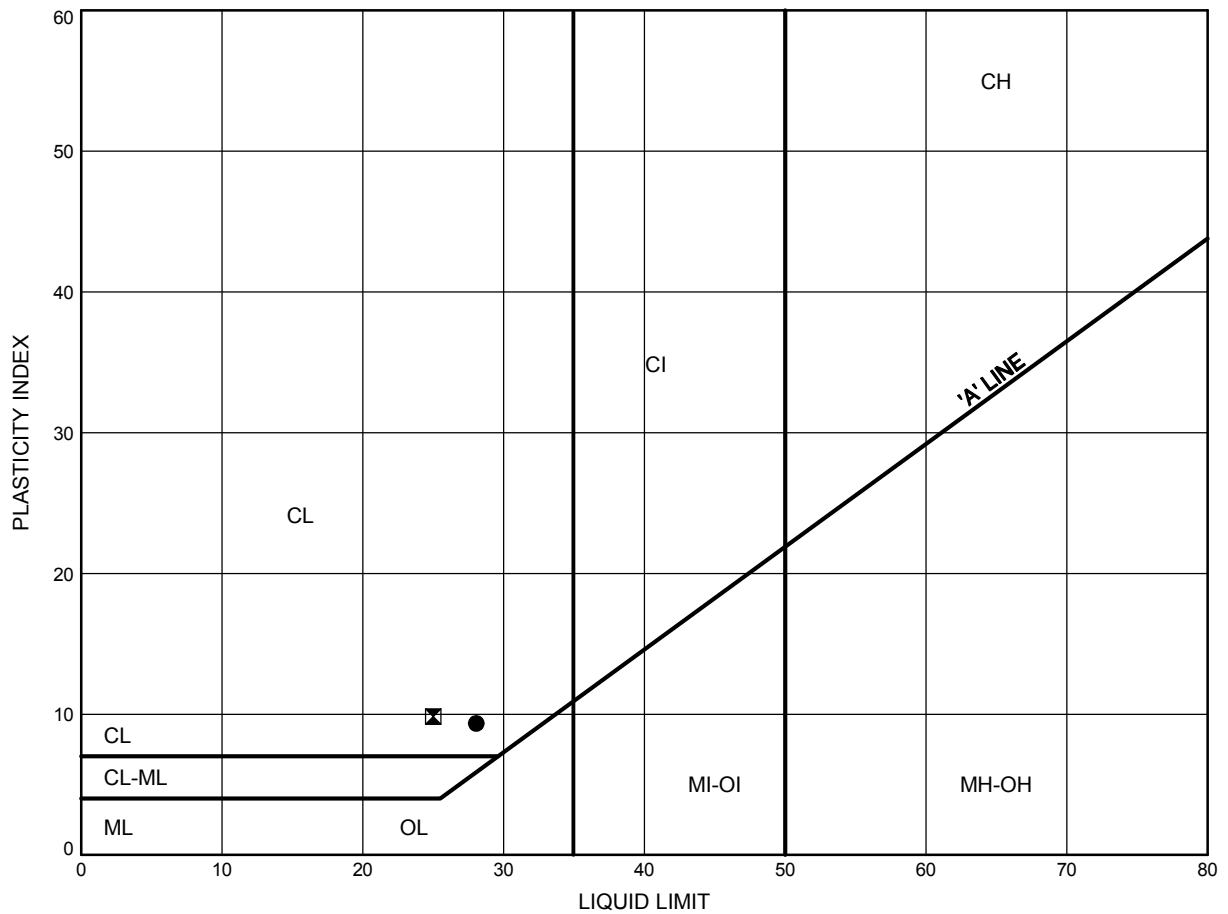
Chkd. KS

New Tremaine Road I/C at Hwy 401 - Culvert C26

ATTERBERG LIMITS TEST RESULTS

FIGURE K3

CLAYEY SILT (TILL)



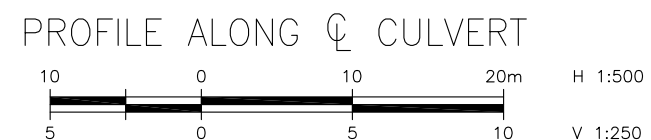
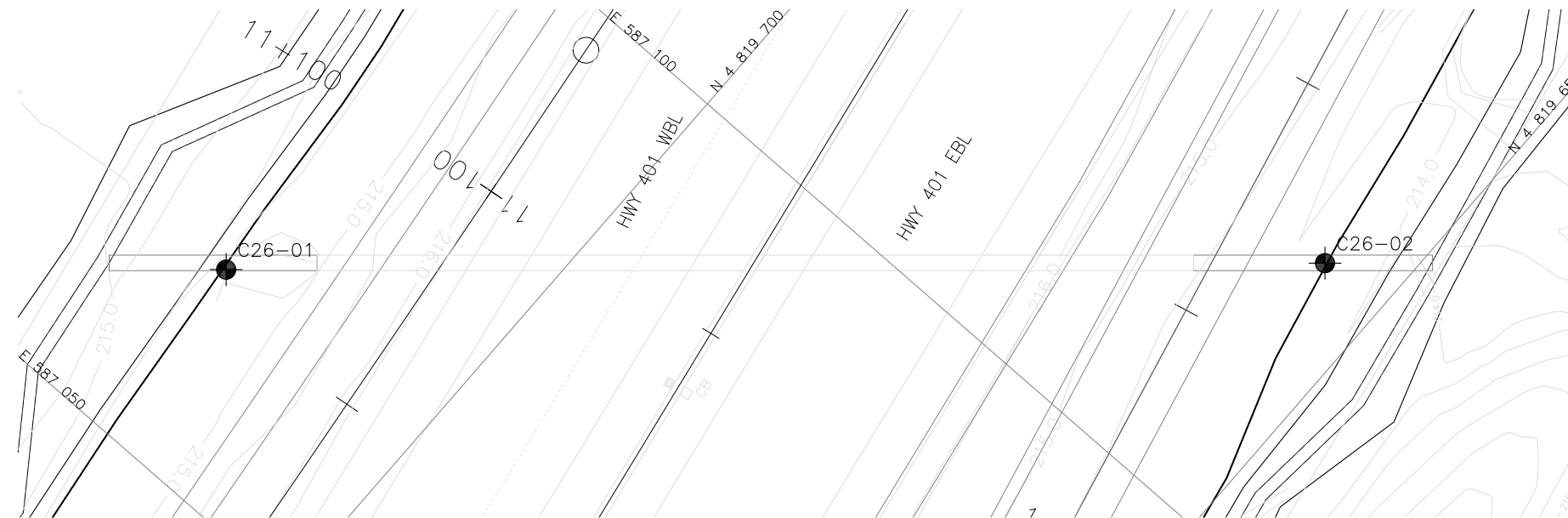
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C26-01	1.83	212.37
⊠	C26-02	1.83	212.37

Date February 2015
W.P.



Prep'd AN
Chkd. KS



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

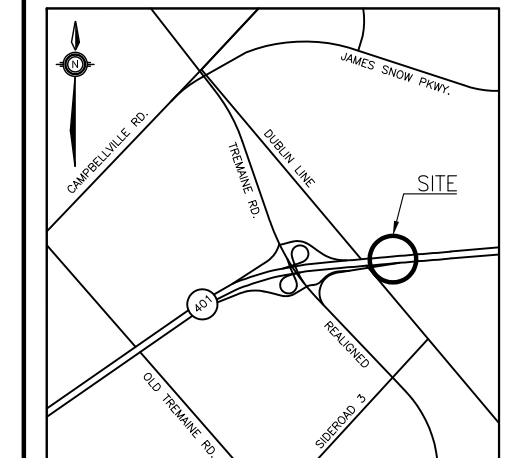


CONT No
WP No

NEW TREMAINE ROAD
INTERCHANGE AT HWY 401
CULVERT C26
BOREHOLE LOCATIONS AND SOIL STRATA







THURBER ENGINEERING LTD.



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 in Open Borehole
	Water Level in Well/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. 30M12-381

REVISIONS									
	DATE	BY	DESCRIPTION						
DESIGN	KS		CHK	MRA	CODE		LOAD	DATE	OCT 2019
DRAWN	AN		CHK	KS	SITE		STRUCT	DWG	1

Appendix L

Culvert 27



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

RECORD OF BOREHOLE No C27-01

1 OF 1

METRIC

W.P. _____ LOCATION C27 Culvert N 4 819 529.3 E 586 673.2 ORIGINATED BY ADH
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.18 - 2014.09.18 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
217.0	GROUND SURFACE															
0.0	TOPSOIL: (150mm)															
0.2	Silty CLAY , some sand to sandy, trace gravel Firm to Hard Brown Moist (TILL)		1	SS	5										0 18 50 32	
			2	SS	26											
			3	SS	20											
			4	SS	48											
214.0																
3.0	SAND and SILT , trace clay Compact to Dense Grey Wet		5	SS	31										0 41 55 4	
			6	SS	24											
211.8																
5.2	END OF BOREHOLE AT 5.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.															

ONTMT4S 19-5161-155 (FOUNDATION).GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C27-02

1 OF 1

METRIC

W.P. _____ LOCATION C27 Culvert N 4 819 484.7 E 586 712.7 ORIGINATED BY ADH
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.09.18 - 2014.09.18 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
216.3	GROUND SURFACE													
0.0	TOPSOIL: (300mm)													
216.0														
0.3	Silty CLAY , sandy, trace gravel Firm to Very Stiff Brown to Reddish Brown Moist (TILL)		1	SS	5		216							0 23 48 29
			2	SS	22		215							
			3	SS	20		214							
			4	SS	26		213							
			5	SS	21		212							
			6	SS	19									
213.3														
3.0	SAND and SILT , trace clay Compact Grey Moist to Wet													
211.1														
5.2	END OF BOREHOLE AT 5.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.													

ONTMT4S 19-5161-155 (FOUNDATION).GPJ 2012TEMPLATE(MTO).GDT 2/18/15

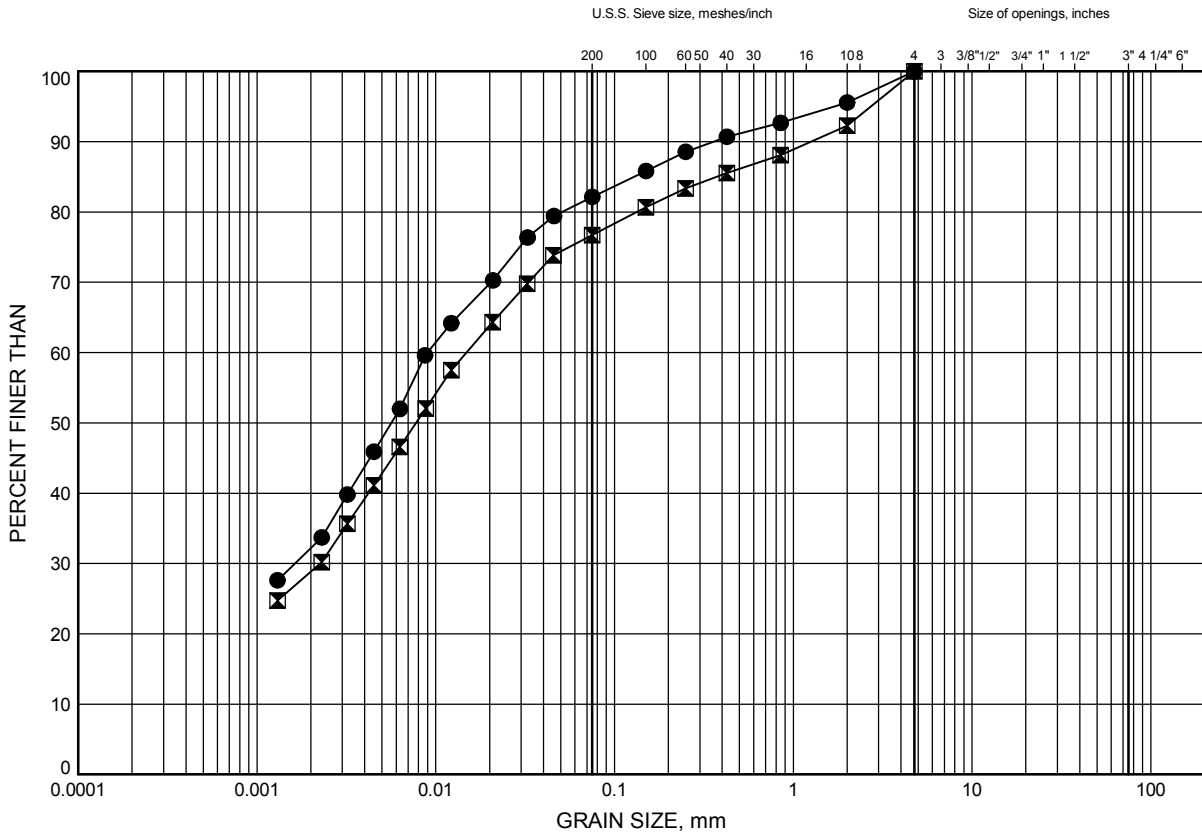
+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

GRAIN SIZE DISTRIBUTION

SILTY CLAY (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C27-01	0.30	216.70
⊠	C27-02	1.75	214.55

Date February 2015

W.P.

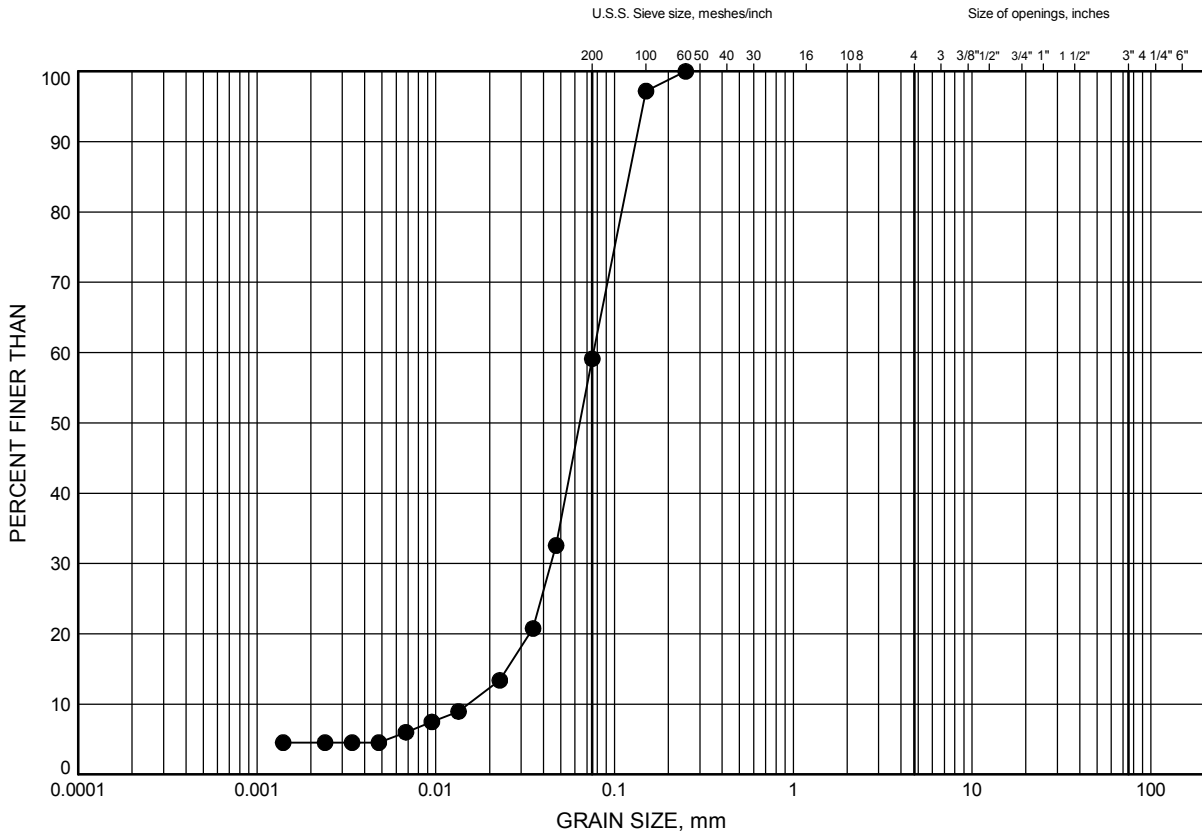


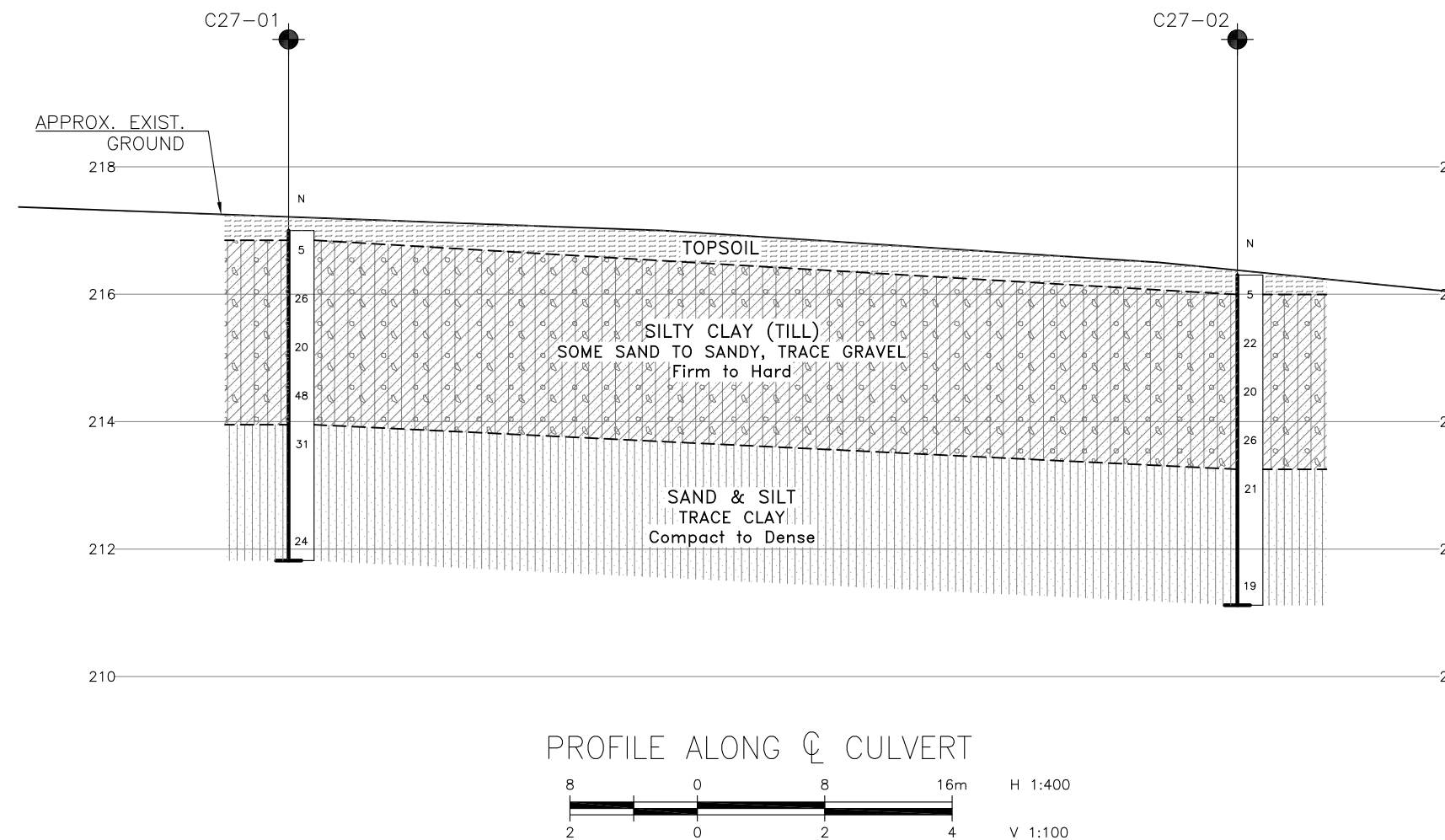
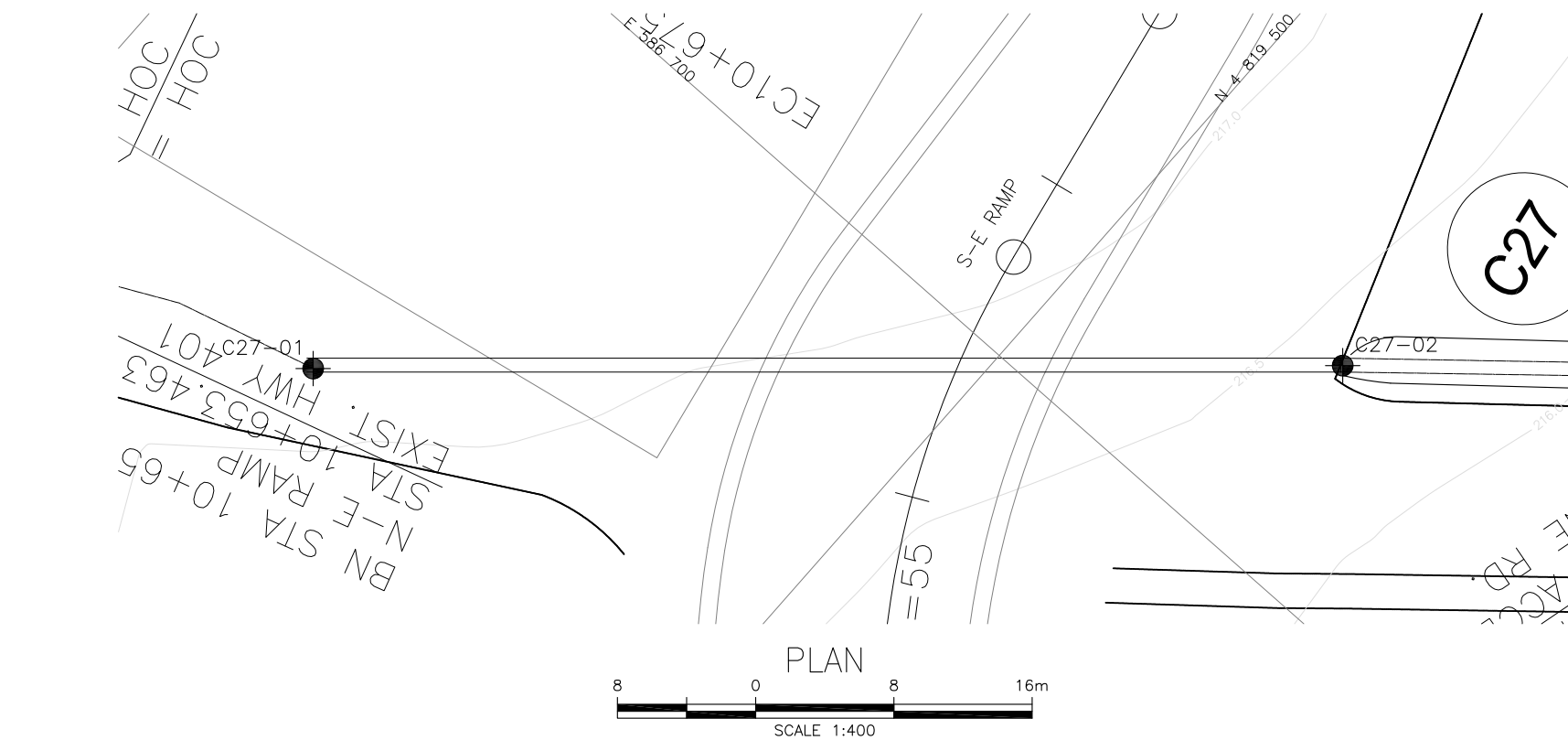
Prep'd AN

Chkd. KS

GRAIN SIZE DISTRIBUTION

SAND & SILT





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

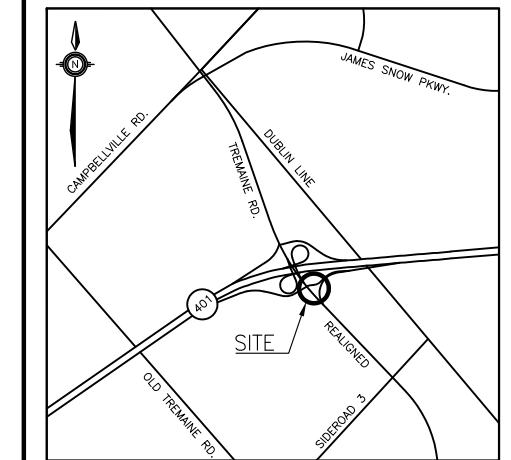


S	CONT No
	WP No

NEW TREMAINE ROAD
INTERCHANGE AT HWY 401
CULVERT C27
BOREHOLE LOCATIONS AND SOIL STRATA







THURBER ENGINEERING LTD.



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 In Open Borehole
	Water Level In Well/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. 30M12-381

REVISIONS									
	DATE	BY				DESCRIPTION			
DESIGN	KS	CHK	MRA	CODE		LOAD	DATE	OCT 2019	
DRAWN	AN	CHK	KS	SITE		STRUCT	DWG	1	

Appendix M

3rd Side Road Channel Structure

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

RECORD OF BOREHOLE No C3S-01

1 OF 2

METRIC

W.P. _____ LOCATION C3S Culvert N 4 819 409.3 E 587 094.5 ORIGINATED BY ADH
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.10.07 - 2014.10.07 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
212.5	GROUND SURFACE							20	40	60	80	100						
0.0	TOPSOIL: (300mm)																	
212.2			1	SS	3		212											
0.3	Silty CLAY , some sand, trace organic matter Firm to Very Stiff Light Brown Moist (TILL)		2	SS	17		211											
			3	SS	26													
210.2																		
2.3	SILT , trace to some clay, trace sand Compact Brown to Grey Moist		4	SS	28		210											
209.0			5	SS	11		209											
3.5	Clayey SILT , some sand to sandy, trace gravel Stiff to Hard Reddish Brown Moist (TILL)						208											
			6	SS	30													
							207											
			7	SS	49		206											
			8	SS	30		205											
							204											
			9	SS	28		203											
202.7																		
9.8	END OF BOREHOLE AT 9.8m.																	

Continued Next Page

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

METRIC

[illegible]

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No C3S-02

2 OF 2

METRIC

W.P. _____ LOCATION C3S Culvert N 4 819 382.4 E 587 106.4 ORIGINATED BY ADH
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.10.07 - 2014.10.07 CHECKED BY KS

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 ³	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 _p	W	W _L			
	Continued From Previous Page																
	Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.																
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 26/ 14 0.8 212.0 Dec 19/ 14 0.3* 213.1 * Above ground surface																

ONTMT4S 19-5161-155 (FOUNDATION).GPJ 2012TEMPLATE(MTO).GDT 2/18/15

RECORD OF BOREHOLE No C3S-03

1 OF 2

METRIC

WP# 19-5161-155 LOCATION C3S Culvert N 4 819 387.5 E 587 090.1 ORIGINATED BY TM
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.01.28 - 2016.01.28 CHECKED BY MRA

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
213.2	GROUND SURFACE							20	40	60	80	100	20	40	60	
0.0	SAND and GRAVEL , some silt Brown Moist (FILL)						213									
212.7																
0.5	Silty CLAY , some sand to sandy, trace gravel, trace shale Firm to Hard Brown to Grey Moist (TILL)		1	SS	7		212						○			
			2	SS	16		211						○			
			3	SS	27		210						○			0 24 43 33
			4	SS	23		209						○			
			5	SS	17		208						○			
			6	SS	36		207						○			
			7	SS	27		206						○			4 16 48 32
			8	SS	43		205									
							204						○			

Continued Next Page

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

RECORD OF BOREHOLE No C3S-03

2 OF 2

METRIC

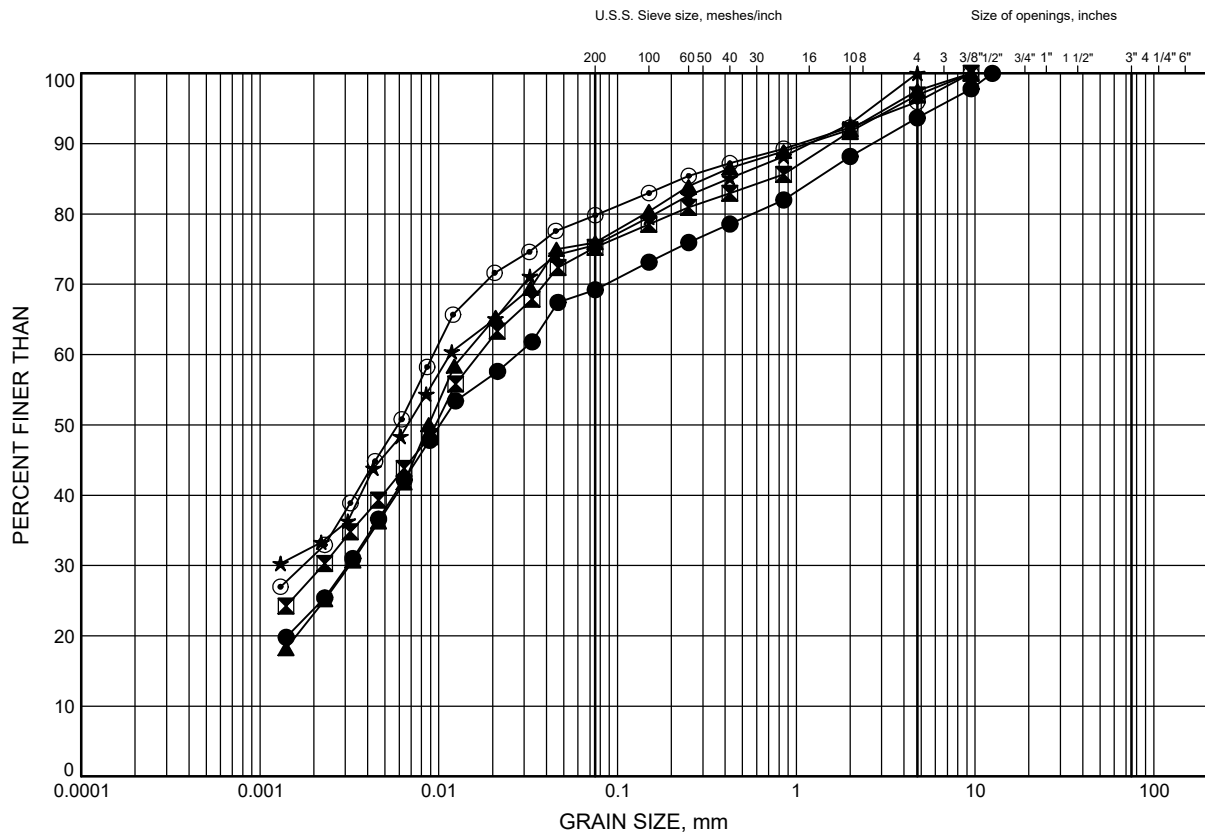
WP# 19-5161-155 LOCATION C3S Culvert N 4 819 387.5 E 587 090.1 ORIGINATED BY TM
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.01.28 - 2016.01.28 CHECKED BY MRA

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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page							20	40	60	80	100					
							203										
			9	SS	17		202										
			10	SS	21		201										
200.4																	
12.8	END OF BOREHOLE AT 12.8m. BOREHOLE OPEN AND DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG MIXED WITH CUTTINGS TO SURFACE.																

ONTMT4S 19-5161-155 (FOUNDATION) GPJ 2015TEMPLATE(MTO) GDT 10/22/19

GRAIN SIZE DISTRIBUTION

SILTY CLAY to CLAYEY SILT (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C3S-01	6.40	206.10
⊠	C3S-02	1.07	211.73
▲	C3S-02	9.45	203.35
★	C3S-03	2.59	210.61
⊙	C3S-03	7.92	205.28

Date ..October 2019.....

WP# ..19-5161-155.....

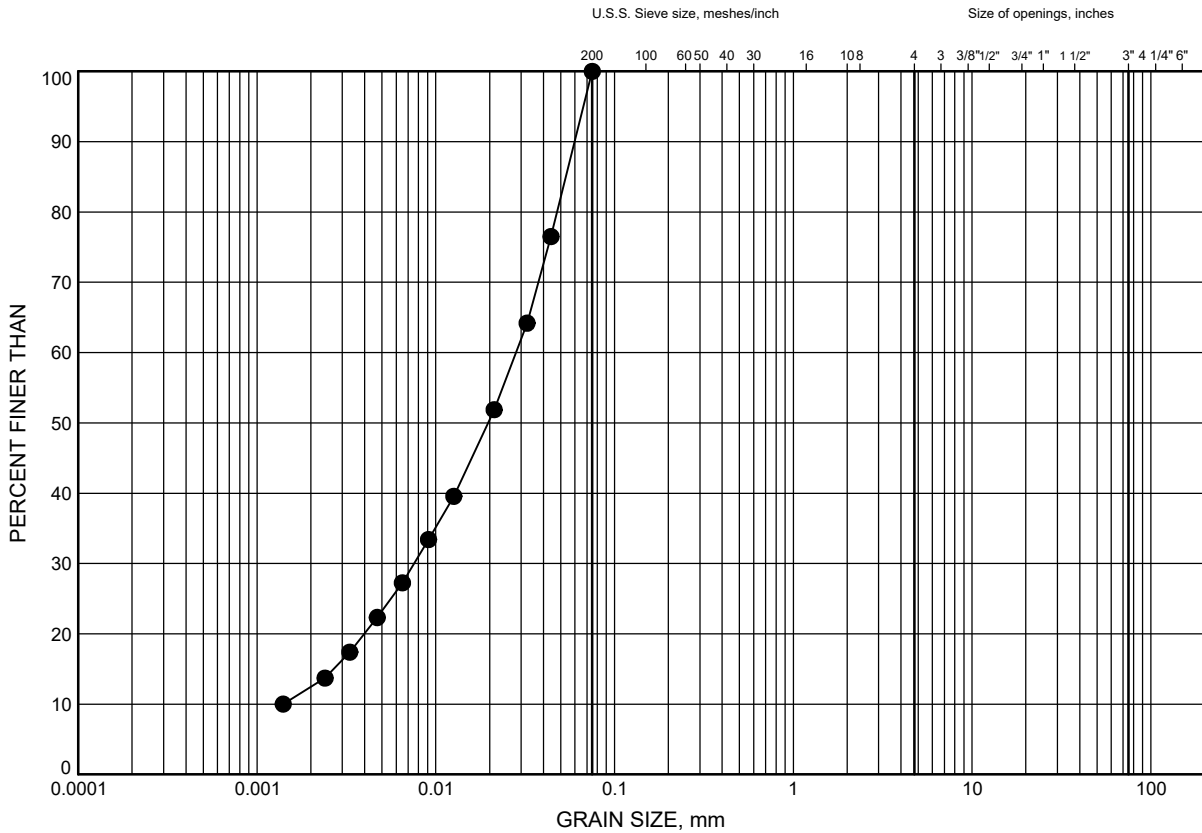


Prep'dAN.....

Chkd.MRA.....

GRAIN SIZE DISTRIBUTION

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C3S-01	2.59	209.91

Date ..October 2019.....

WP# ..19-5161-155.....



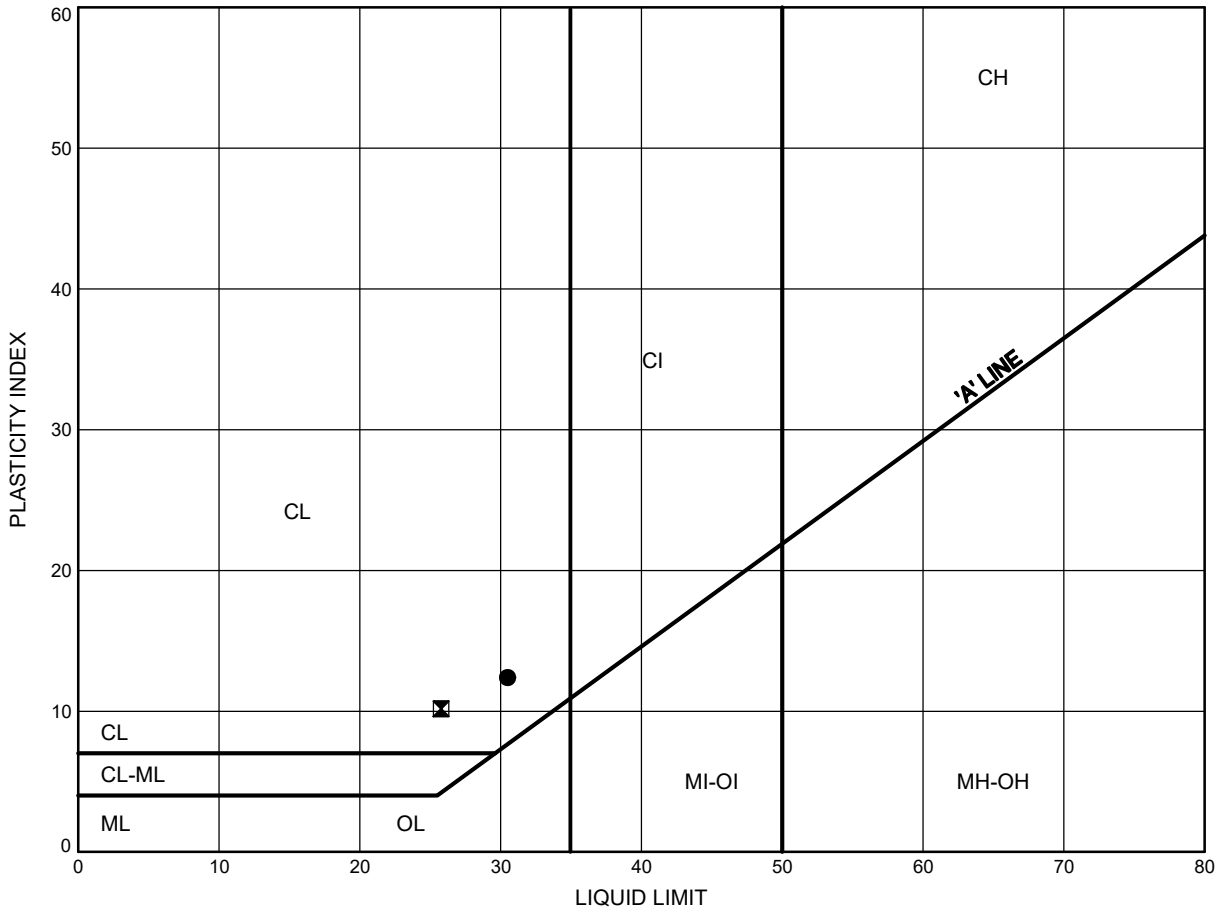
Prep'dAN.....

Chkd.MRA.....

New Tremaine Road I/C at Hwy 401 - Culvert C3S
ATTERBERG LIMITS TEST RESULTS

FIGURE M3

SILTY CLAY (TILL)



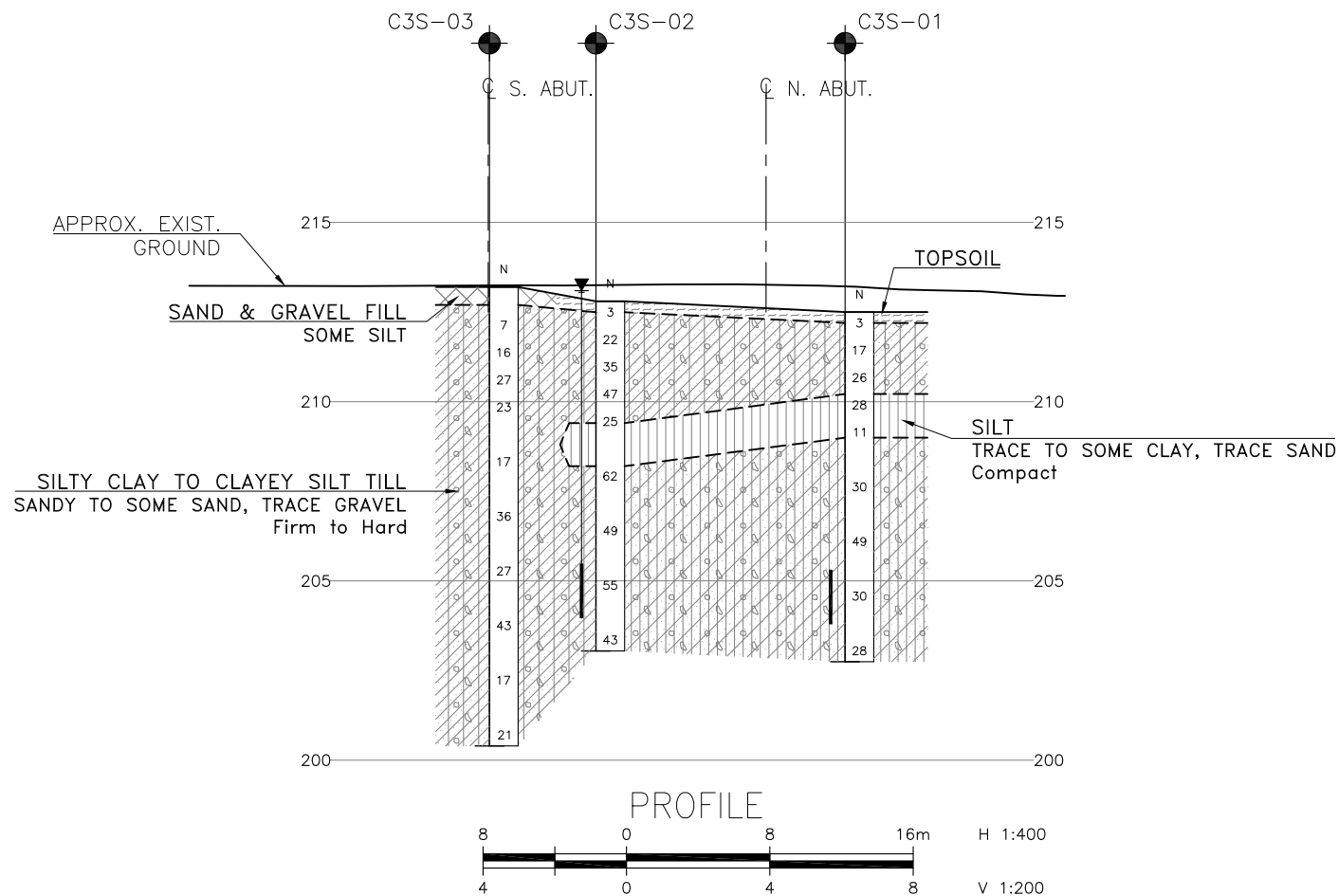
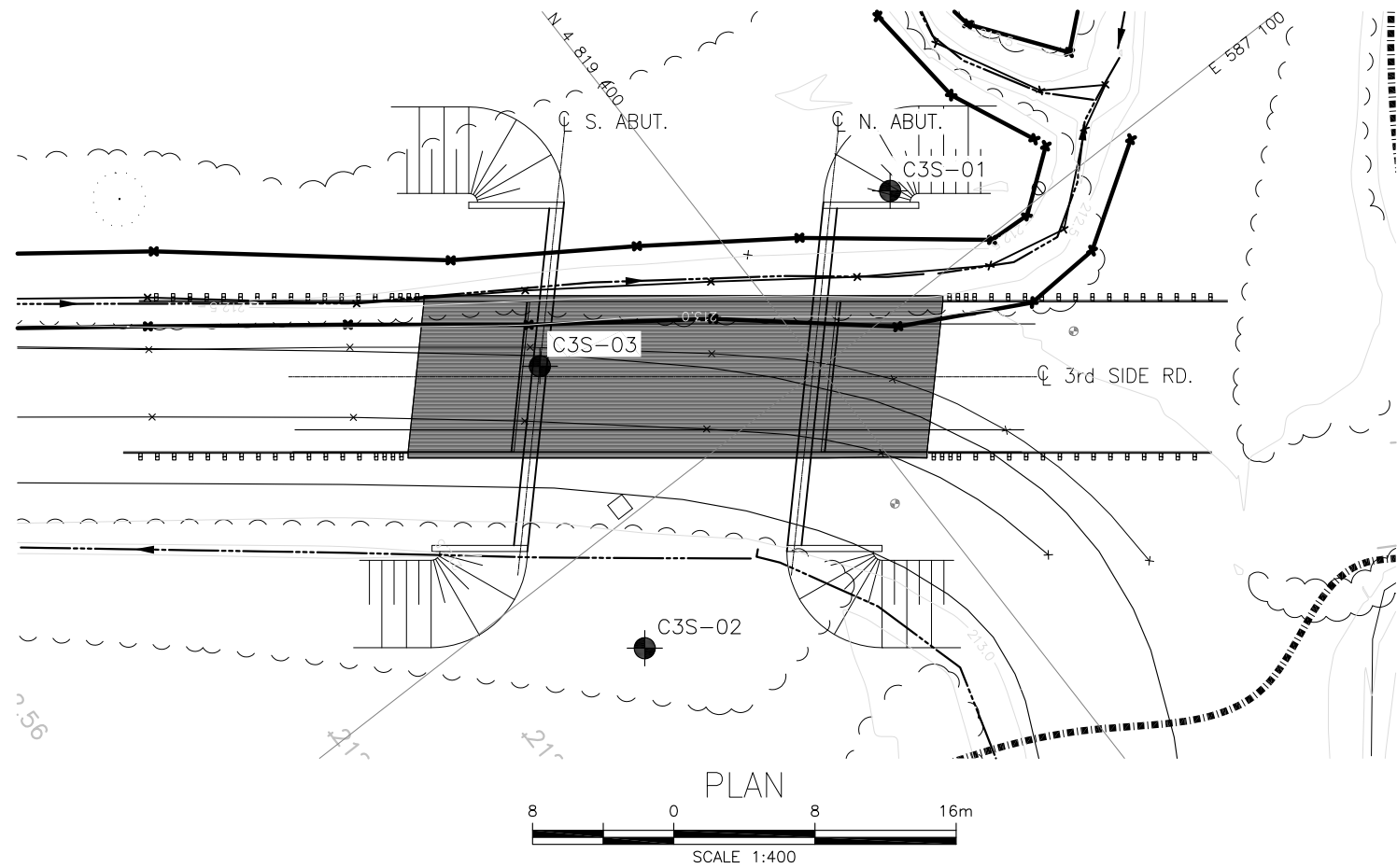
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	C3S-03	2.59	210.61
⊠	C3S-03	7.92	205.28

Date October 2019
 WP# 19-5161-155



Prep'd AN
 Chkd. MRA

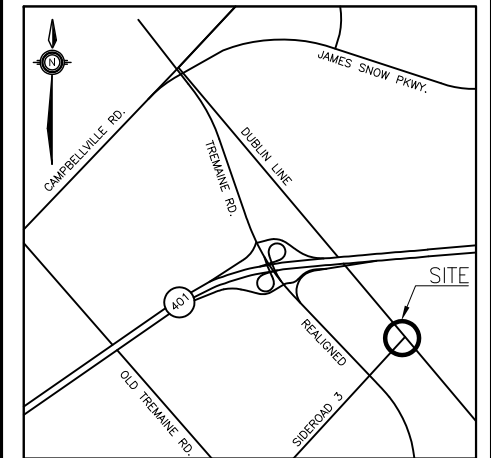


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No
WP No

NEW TREMAINE ROAD
INTERCHANGE AT HWY 401
3RD SIDE RD. CHANNEL STRUCTURE
BOREHOLE LOCATIONS AND SOIL STRATA



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 In Open Borehole
	Water Level In Well/Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
C3S-01	212.5	4 819 409.3	587 094.5
C3S-02	212.8	4 819 382.4	587 106.4
C3S-03	213.2	4 819 387.5	587 090.1

-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.

GEOCRES No.

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	KS	CHK MRA	CODE
DRAWN	AN	CHK KS	SITE
			LOAD
			STRUCT
			DWG 1
			DATE OCT 2019

Appendix N
Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES

Closed Box Culvert	Footings on Native Soil	Footings on Engineered Fill	Deep Foundations (Driven H-Piles or Caissons)
<p>Advantages:</p> <ul style="list-style-type: none"> i. Ease of construction. ii. Minimizes differential settlement. iii. Applies lower bearing pressures on foundation soils. iv. Lower cost than deep foundations. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Requires subexcavation of soft or organic material from streambed if encountered. ii. Potential settlement due to embankment loading must be addressed in culvert design. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. Ease of construction. ii. Eliminates bedding requirement. iii. Compared to closed box, potentially less subexcavation required to remove soft organic materials. iv. Lower cost than deep foundations. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Subexcavation may be required to penetrate upper soft or organic material. ii. Dewatering, shoring and roadway protection is required. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. Would permit use of higher geotechnical resistance than is available on the native soil. ii. Founding level is not governed by soil conditions. iii. Lower cost than deep foundations. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Cost of constructing engineered fill. ii. Deeper excavation is required, including dewatering, shoring and roadway protection. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. High resistance is available for piles or caissons founded on bedrock. ii. Construction could continue in freezing weather. iii. Eliminates potential for foundation settlement. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Much higher cost than shallow footings or box culvert. ii. Possibility of encountering cobbles and boulders in the underlying soils. iii. Temporary steel liner is required to install caisson through cohesionless soils under groundwater table.
FEASIBLE	RECOMMENDED	NOT RECOMMENDED	RECOMMENDED FOR STRUCTURES 16A & 16B

Appendix O

List of Standard Specifications and Special Provisions

1) The following Standard Specifications and Special Provisions are referenced in this report:

OPSS 501
OPSS 539
OPSS 572
OPSS 902
OPSS 903
OPSS 942
OPSS 1205
OPSD 803.010