

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGH MAST LIGHT POLES
HIGHWAY 417 WIDENING
NICHOLAS STREET TO O.R.174
OTTAWA, ONTARIO
G.W.P. 4320-06-00**

Geocres Number: 31G5-248

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings from a foundation investigation conducted at the location of thirteen proposed High Mast Light Poles (HMLP) to be installed between Nicholas Street and O.R.174 in connection with the proposed widening of Highway 417 in Ottawa, Ontario.

The locations of the HMLPs were defined by MRC on December 22, 2011 and February 1, 2012, Seven of the proposed HMLP locations are located at the Riverside Drive Interchange and six of the proposed HMLP locations are located at the St. Laurent Boulevard Interchange.

The purpose of this investigation was to determine the subsurface conditions at the proposed HMLP locations and, based on this data, to provide borehole location drawings, records of boreholes, laboratory test results and a written description of the subsurface conditions.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin Corporation (MRC), under the Ministry of Transportation Ontario (MTO) Agreement No. 4009-E-0007.

2 SITE DESCRIPTION

The existing Highway 417 is a three to four lane divided highway. The widening of Highway 417 from Nicholas Street to O.R.174 includes the installation of new HMLPs at the Riverside Drive Interchange and the St. Laurent Boulevard Interchange. The Riverside Drive Interchange is located approximately 235 m east of the Rideau River and the St. Laurent Boulevard Interchange is located approximately 1250 m east of the Riverside Drive Interchange.

The lands surrounding the Riverside Drive and St. Laurent Blvd Interchanges primarily comprise commercial and industrial developments. Southwest of the Riverside Drive Interchange is a landscaped area of trees and shrubs.

Both the Riverside Drive and St. Laurent Blvd. Interchanges lie within the Ottawa Valley Clay Plains physiographic region, a clay plains interrupted by ridges of sand or rock. The bedrock consists of the Carlsbad Formation, comprising dark grey shale interbedded with calcareous siltstone and limestone.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing at the proposed HMLP locations were carried out between February 6 and March 22, 2012. One borehole was drilled in the proximity of each proposed HMLP location, totalling thirteen boreholes (identified as P-200 to P-212). Boreholes P-200 to P-206 were located in the vicinity of the Riverside Drive Interchange while Boreholes P-207 to P-212 were located in the environs of the St. Laurent Boulevard Interchange. The approximate locations of the boreholes are shown on the drawings included in Appendix D.

During the course of our investigation, some boreholes were relocated from the proposed locations due to the presence of existing utilities or access constraints. A list of these relocated boreholes is presented below along with the distance and reason for relocation. It must be noted that the ground elevation and subsurface conditions may vary between the pole and borehole locations.

Table 3.1 – Relocated Boreholes due to Existing Utilities Obstructing Drilling

Relocated Boreholes	Distance Relocated (m)	Existing Utility Obstructing Drilling
P-203	8 m south along ramp	City of Ottawa Watermain
P-204	11 m east	Steep Ditch
P-205	6 m north, 1 m east	Enbridge Gas Main
P-208	6 m east, 2 m south	Enbridge Gas Main
P-209	3.5 m northeast	Enbridge Gas Main

The thirteen boreholes were drilled to depths of 4.2 m to 11.4 m. Bedrock was encountered in all thirteen boreholes, and 3.0 m to 4.0 m of rock coring was undertaken in all boreholes except in Boreholes P-204 and P-208. These boreholes were extended 1.7 m and 1.6 m into the bedrock to total depths of 9.2 and 10.7 m, after which the boreholes were terminated due to lane closure time restrictions.

The Record of Borehole Sheets for the boreholes at the Riverside Drive Interchange are included in Appendix A and for the boreholes at the St. Laurent Boulevard Interchange are presented in Appendix B.

The borehole locations were marked in the field by MMM Group and utility clearances were obtained by Underground Service Locators (USL) prior to commencement of drilling operations.

The drilling was carried out using both track-mounted and truck-mounted drill rigs. A combination of hollow-stem auger drilling techniques and NQ coring methods were used to advance the boreholes. Overburden samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). All rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

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 bedrock samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions observed in the open boreholes during the drilling operations were recorded. Standpipe piezometers consisting of 19 mm diameter PVC pipe with slotted screen were installed in selected boreholes for long term monitoring of groundwater levels. In general, the piezometers were installed in boreholes drilled off of travelled roadways to minimize the need for additional lane closures to measure water levels. The installation details of the piezometers are summarised in Table 3.2 along with the backfill details for the boreholes without a piezometer installation. Following the final water level reading, the piezometers will be decommissioned in general accordance with MOE Regulation 903.

Table 3.2 – Borehole Completion Details

Borehole Number	Piezometer Tip Depth / Elevation (m)	Completion Details
P-200	4.2 / 54.6	Filter sand from 4.2 m to 2.1 m, then bentonite to surface.
P-201	6.3 / 52.9	Filter sand from 6.3 m to 4.0 m, then bentonite holeplug to surface.
P-202	5.8 / 54.5	Filter sand from 5.8 m to 3.4 m, then bentonite holeplug to surface.
P-203	None Installed	Backfilled with bentonite holeplug from 10.3 m to 2.4 m, cuttings from 2.4 m to 0.2 m, then asphalt to surface.
P-204	9.2 / 52.7	Filter sand from 9.2 m to 7.2 m, bentonite holeplug from 7.2 m to 1.2 m, then cuttings to surface.
P-205	None Installed	Backfilled with bentonite holeplug from 9.5 m to 5.4 m, cuttings from 5.4 m to 0.9 m, holeplug from 0.9 m to 0.15 m, then asphalt to surface.
P-206	None Installed	Backfilled with bentonite holeplug from 7.8 m to 1.8 m, cuttings from 1.8 m to 0.2 m, then asphalt to surface.
P-207	None Installed	Backfilled with bentonite holeplug from 9.8 m to 1.8 m, cuttings from 1.8 m to 0.2 m, then asphalt to surface.

Borehole Number	Piezometer Tip Depth / Elevation (m)	Completion Details
P-208	None Installed	Backfilled with bentonite holeplug from 10.7 m to 2.4 m, cuttings from 2.4 m to 0.7 m, holeplug from 0.7 m to 0.1 m, then asphalt to surface.
P-209	2.6 / 64.4	Bentonite from 6.1 m to 2.6 m, filter sand from 2.6 m to 1.1 m, then bentonite holeplug to surface.
P-210	None Installed	Backfilled with bentonite holeplug from 11.4 m to 2.7 m, cuttings from 2.7 m to 0.9 m, holeplug from 0.9 m to 0.1 m, then asphalt to surface.
P-211	None Installed	Backfilled with bentonite holeplug from 8.6 m to 2.4 m, cuttings from 2.4 m to 0.1 m, then asphalt to surface.
P-212	None Installed	Backfilled with bentonite holeplug from 7.7 m to 1.5 m, cuttings from 1.5 m to 0.1 m, then asphalt to surface.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to gradation analysis (sieve and hydrometer) and Atterberg Limits testing, where appropriate. The results of these tests are presented on the Record of Borehole Sheets included in Appendices A and B.

Point load tests were carried out on selected samples of intact bedrock core to assist in evaluation of the unconfined compressive strength (UCS) of the bedrock. Results of the point load tests are included as average UCS per core run on the Record of Borehole Sheets in Appendices A and B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole Sheets included in Appendices A and B. An overall description of the stratigraphy encountered in the boreholes drilled at the Riverside Drive and the St. Laurent Boulevard Interchanges is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

In general, the area of the Riverside Drive Interchange is underlain by either topsoil or asphalt overlying sand fill. The fill lies either directly on the bedrock or on silty sand till. Shale bedrock was encountered at depth beneath the silty sand till. Clayey silt fill was encountered locally in Borehole P-203 and native sandy silt was encountered locally in Borehole P-204 beneath the fill.

The St. Laurent Boulevard Interchange is typically underlain by asphalt overlying sand fill containing varying amounts of silt and gravel. Topsoil overlying silt fill was encountered locally in Borehole P-209. In selected boreholes (P-208 to P-211) silty clay fill was found underlying the sand fill. The

fill is underlain by native sandy silt to silty sand till. Localized deposits of sand and clayey silt were encountered in some boreholes. These overburden deposits are underlain by shale bedrock.

5.1 Riverside Drive Interchange (Boreholes P-200 to P-206)

5.1.1 Topsoil

A thin layer of topsoil was encountered at surface in four of the seven boreholes drilled at the Riverside Drive Interchange (Boreholes P-200, P-201, P-202, and P-204).

The thickness of the topsoil ranged from 100 mm to 150 mm.

5.1.2 Asphalt (and Concrete)

Asphalt was encountered at surface in the other three boreholes drilled at the Riverside Drive Interchange (Boreholes P-203, P-205, and P-206).

The thickness of the asphalt ranged from 75 mm to 100 mm.

A layer of concrete was encountered directly below the asphalt in Borehole P-205. The concrete was 300 mm thick.

5.1.3 Sand Fill

Sand fill was encountered in all seven boreholes drilled at the Riverside Drive Interchange. The sand fill was encountered below the topsoil in Boreholes P-200, P-201, P-202 and P-204, and below the asphalt and/or concrete in Boreholes P-203, P-205 and P-206. The sand fill was brown, dark brown to grey, or dark grey and typically contained some silt, and trace to some clay and gravel. In Borehole P-206, the sand fill became silty with depth while the fill encountered in Boreholes P-200 and P-202 was silty. A thin layer (400mm) of sandy silt with trace gravel was encountered within the sand fill in Borehole P-205. Where the sand fill was encountered below topsoil, the upper portion of the sand fill contained mixture of organics.

The thickness of the sand fill ranged from 0.7 m to 4.8 m, with the lower boundary of the sand fill encountered at depths of 0.8 m to 4.9 m (Elevations 59.2 to 56.5).

SPT N-values recorded in the sand fill typically ranged from 11 to 51 blows for 0.3 m penetration, indicating a compact to dense relative density. Locally in Boreholes P-201 and P-204, SPT N-values between 4 and 7 blows for 0.3 m penetration were recorded indicating loose conditions.

Moisture contents of samples of the sand fill ranged from 2 to 26%. A moisture content of 42 % was recorded for a sample of the sandy silt pocket within the sand fill.

Four samples of the sand fill underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole

Sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figure A1.

	<u>Sand Fill</u>	<u>Silty Sand Fill (P-202)</u>
Gravel (%)	0 to 15	6
Sand (%)	68 to 77	52
Silt (%)	10 to 17	26
Clay (%)	4 to 7	16

5.1.4 Clayey Silt Fill

A layer of clayey silt fill was encountered locally in Borehole P-203 below the sand fill. The clayey silt fill was dark grey and contained some sand and trace gravel.

This layer of clayey silt fill was 1.2 m thick, with the lower boundary of the layer encountered at a depth of 6.1 m (Elevation 58.0).

An SPT N-value of 23 blows for 0.3 m penetration was recorded in the clayey silt fill, indicating a very stiff consistency.

The moisture content of a sample of the clayey silt fill was 26%.

5.1.5 Sandy Silt

A layer of native sandy silt was encountered locally in Borehole P-204 below the sand fill. The sandy silt was brown and contained trace clay and trace gravel.

The layer of sandy silt was 1.7 m thick, with the lower boundary of the layer encountered at a depth of 4.7 m (Elevation 57.2).

An SPT N-value of 21 blows for 0.3 m penetration was recorded in the sandy silt layer, indicating a compact relative density.

The moisture content of a sample of the sandy silt was measured to be 18%.

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

Gravel%	1
Sand%	32
Silt%	60
Clay%	7

5.1.6 Sandy Silt to Silty Sand Till

Sandy silt to silty sand till was encountered below the fill in Boreholes P-203, P-205, and P-206 and beneath the native sandy silt in Borehole P-204. The sandy silt to silty sand till was brown to dark grey and contained some clay, trace to some gravel, and occasional cobbles. This deposit is primarily cohesionless with localized zones of low plasticity.

The thickness of the till layer ranged from 1.2 m to 3.4 m, with the lower boundary of the till encountered at depths of 4.6 m to 7.5 m (Elevations 56.8 to 54.4). A 900 mm thick layer of sand and gravel was encountered within the silty sand till in Borehole P-205 at a depth of 4.1 m (Elevation 56.0).

In general, SPT N-values of 12 to 56 blows for 0.3 m penetration were recorded in the till indicating a compact to very dense relative density. An N-value of 8 blows for 0.3 m penetration (loose) was recorded near the upper boundary of the till deposit in Borehole P-205. The borehole sidewalls in the till generally remained upright (no cave) upon removal of the augers.

The natural moisture content of samples of the till ranged from 7% to 14%.

Three samples of the silty sand to sandy silt till underwent laboratory gradation analysis and the results are summarized below. These results are also presented on the Record of Borehole Sheets in Appendix A and the grain size distribution curves for these samples are plotted on Figure A3 of Appendix A. One sample of the till contained sufficient clay content for Atterberg Limits testing. The results of the Atterberg Limits tests are presented below. These results are also summarized on the Record of Borehole Sheets in Appendix A and the results are plotted on Figure A4 of Appendix A.

Gravel%	5 to 12
Sand%	47 to 56
Silt%	24 to 27
Clay%	14 to 17
Liquid Limit %	21
Plastic Limit%	12
Plasticity Index%	9

The above results indicate that locally, the till is of low plasticity, with a group symbol of CL. Glacial tills are known to contain cobbles and boulders. Cobbles were encountered in the boreholes.

5.1.7 Bedrock

Bedrock was encountered below the till in Boreholes P-203 to P-206, and directly below the sand fill in Boreholes P-200 to P-202. The depths and elevations at which bedrock was encountered are summarized in Table 5.1.

The bedrock was described as laminated grey shale and typically contained hard limestone interbeds up to 75 mm in thickness. The shale was generally described as highly weathered at the till-bedrock interface and described as slightly weathered to fresh with increased depth. The bedding thickness was typically 25 to 150 mm. Occasional vertical fractures, rubbles zones, and clay seams were observed in the bedrock cores.

Total Core Recovery (TCR) in the bedrock ranged from 82 % to 100%. The RQD values ranged from 60 to 100%, indicating a variable rock quality ranging from fair to excellent. RQD values typically ranged from 76 to 100%, which is indicative of good to excellent rock quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was also quite variable and ranged from 0 to greater than 15.

Table 5.1 – Depths and Elevations of Bedrock Surface

Borehole	Bedrock Surface	
	Depth (m)	Elevation (m)
P-200	0.8	58.0
P-201	2.7	56.5
P-202	1.8	58.5
P-203	7.3	56.8
P-204	7.5	54.4
P-205	5.5	54.6
P-206	4.6	55.6

The estimated unconfined compressive strength of the rock, interpreted from point load tests conducted on intact rock cores, ranged from 8 to 33 MPa, indicating a weak to medium strong rock strength classification. It should be noted that higher rock strengths may be obtained in the hard limestone interbeds.

5.1.8 Groundwater Conditions

Groundwater was measured at 5.4 m depth (Elevation 56.5) in Borehole P-204 upon completion of drilling. Water was introduced into the remaining boreholes during coring and therefore water levels were not recorded upon completion.

Four standpipe piezometers were installed at the Riverside Drive Interchange, in Boreholes P-200, P-201, P-202, and P-204, to monitor water levels after completion of drilling. The water levels measured in the piezometers were at depths of 1.3 to 2.4 m (Elevations 56.9 and 59.5) and are summarized in Table 5.2.

Table 5.2 – Water Level Measurements

Borehole	Date	Water Level (m)		Comment
		Depth	Elevation	
P-200	20-Mar-2012	1.9	56.9	Piezometer
P-201	30-Mar-2012	1.3	57.9	Piezometer
P-202	30-Mar-2012	1.9	58.4	Piezometer
P-204	27-Mar-2012	2.4	59.5	Piezometer

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

5.2 St. Laurent Boulevard Interchange (Boreholes P-207 to P-212)

5.2.1 Topsoil

A 0.5 m thick layer of topsoil was encountered at surface in one of the six boreholes drilled at the St. Laurent Boulevard Interchange (Borehole P-209). The topsoil was described as dark brown and contained mixture of silty sand and some clay.

5.2.2 Asphalt

Asphalt was encountered at surface in the other five boreholes drilled at the St. Laurent Boulevard Interchange (Boreholes P-207, P-208, P-210, P-211, and P-212) as these boreholes were drilled on the left shoulder or left lane of the eastbound lanes of the existing highway.

The thickness of the asphalt ranged from 100 mm to 125 mm.

5.2.3 Sand Fill

Sand fill was encountered below the asphalt in Boreholes P-207, P-208, P-210, P-211, and P-212. The sand fill was brown to grey and contained some silt and some gravel to gravelly.

The thickness of the sand fill ranged from 0.8 m to 2.2 m, with the lower boundary of the sand fill encountered at a depth of 0.9 m to 2.3 m (Elevations 72.1 to 68.5).

SPT N-values recorded in the sand fill ranged from 28 to 52 blows for 0.3 m penetration, indicating a compact to very dense relative density.

Moisture contents of samples of the sand fill ranged from 1% to 7%.

One sample of the gravelly zone within the sand fill in Borehole P-207 was selected for laboratory grain size analysis testing, the results of which are summarized below. This result is also presented on the Record of Borehole Sheets included in Appendix B. The grain size distribution curve for this sample is plotted on Figure B1.

Gravel (%)	35
Sand (%)	49
Silt and Clay (%)	16

5.2.4 Silty Sand to Silt and Sand Fill

Silty sand to silt and sand fill was encountered in Boreholes P-207 and P-212, below the sand fill. The silty sand to silt and sand fill was typically brown to grey and contained trace to some gravel and trace clay.

The thickness of the fill was 3.2 m in Borehole P-207 and 1.8 m in Borehole P-212. The lower boundary of this fill was encountered at depths of 4.1 m and 3.1 m (Elevations 67.4 and 66.7) in Boreholes P-207 and P-212, respectively.

SPT N-values recorded in the silty sand to silt and sand fill typically ranged from 18 to 37 blows for 0.3 m penetration indicating a compact to dense relative density. One N-value of 72 blows for 0.3 m penetration (very dense) was recorded in Borehole P-212.

One sample of the silt and sand fill in Borehole P-212 was selected for laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole Sheets included in Appendix B. The grain size distribution curve for this sample is plotted on Figure B2.

Gravel (%)	3
Sand (%)	46
Silt (%)	37
Clay (%)	14

5.2.5 Sandy Gravel Fill

A layer of grey sandy gravel fill was encountered locally in Borehole P-208 below the sand fill.

The layer of sandy gravel fill was 2.0 m thick, with the lower boundary of the layer encountered at a depth of 4.3 m (Elevation 68.6).

SPT N-values recorded in the sandy gravel fill ranged from 16 to 17 blows for 0.3 m penetration, indicating a compact relative density.

The moisture content of samples of the sandy gravel fill ranged from 3% to 4%.

5.2.6 Silt Fill

A layer of silt fill was encountered locally in Borehole P-209, below the topsoil. The silt fill was dark brown and contained some sand, some gravel, and trace clay.

The silt fill layer was 1.0 m thick, with the lower boundary of this layer encountered at a depth of 1.5 m (Elevation 65.5).

A single SPT N-value was recorded in the layer. The recorded N-value was 22 blows for 0.3 m penetration, indicating a compact relative density.

The moisture content of a single sample of the silt fill was measured to be 15%.

5.2.7 Silty Clay Fill

A layer of silty clay fill was encountered below the cohesionless fill in Boreholes P-208 to P-211. The silty clay fill was brown and grey and contained trace sand to sandy, and trace gravel.

The thickness of the silty clay fill ranged from 0.9 m to 5.5 m, with the lower boundary of the silty clay fill encountered at a depth of 2.4 m to 6.6 m (Elevations 69.0 to 64.6). In Borehole P-210, a 700 mm thick layer of sandy silt fill was encountered within the silty clay fill at a depth of 2.3 m (Elevation 70.9).

SPT N-values recorded in the silty clay fill ranged from 4 to 22 blows for 0.3 m penetration, indicating a firm to very stiff consistency. Typically, the silty clay fill was stiff to very stiff in consistency.

The moisture content of samples of the silty clay fill ranged from 9% to 50%, and was typically greater than 30%.

Five samples of the silty clay fill underwent laboratory gradation analysis and Atterberg Limits testing. The results of this testing are presented on the Record of Borehole sheets included in Appendix B and the grain size distribution curves for these samples are plotted on Figure B3, Appendix B. The results of the Atterberg Limits tests are plotted on Figure B5. The results of these tests are as follows:

Gravel %	0 to 2
Sand %	3 to 29
Silt %	21 to 43
Clay %	35 to 71
Liquid Limit %	45 to 70
Plastic Limit %	18 to 28
Plasticity Index %	27 to 42

The results of the Atterberg Limits tests indicate that the silty clay fill has an intermediate to high plasticity with a group symbol of CI to CH.

5.2.8 Sand

A layer of native sand was encountered locally in Borehole P-208 below the silty clay fill. The sand was grey, fine grained and contained trace gravel.

This layer of sand was 1.9 m thick with the lower boundary of the sand encountered at a depth of 8.4 m (Elevation 64.5).

SPT N-values recorded in this layer of sand ranged from 23 to 28 blows for 0.3 m penetration, indicating a compact relative density. Auger refusal occurred at 6.9 m, indicating the possible presence of cobbles within the sand.

The moisture content of samples of the sand ranged from 6% to 24%.

5.2.9 Sandy Silt to Silty Sand Till

Sandy silt to silty sand till was encountered in all boreholes drilled at the St. Laurent Boulevard Interchange, with the exception of Borehole P-209. The till was encountered below the fill in Boreholes P-207, P-210, P-211, and P-212 and below the native sand in Borehole P-208. The sandy silt to silty sand till was brown to dark grey and contained trace to some clay and gravel.

SPT N-values recorded in the till ranged from 20 to 37 blows for 0.3 m penetration, indicating a compact to dense relative density. The borehole sidewalls in the till generally remained upright (no cave) upon removal of the augers.

Moisture contents of samples of the till ranged from 6% to 19%.

Three samples of the sandy silt to silty sand till were selected for gradation analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole Sheets included in Appendix B. The grain size distribution curves for these samples are plotted on Figure B4 in Appendix B.

Gravel%	0 to 13
Sand%	40 to 49
Silt%	25 to 42
Clay%	13 to 19

It should be noted that glacial till inherently contains cobbles and boulders.

5.2.10 Bedrock

Bedrock was encountered below the till in all of the boreholes drilled at the St. Laurent Blvd. Interchange, with the exception of Borehole P-209 where the bedrock was encountered below a layer of silty clay fill. Bedrock was proven by coring in all boreholes drilled at this site, except Borehole P-208, where the borehole was advanced 1.6 m into the bedrock with augers. The depths and elevations at which bedrock was encountered are summarized in Table 5.3.

Table 5.3 – Depths and Elevations of Bedrock Surface

Borehole	Bedrock Surface	
	Depth (m)	Elevation (m)
P-207	6.4	65.1
P-208	9.1	63.8
P-209	2.4	64.6
P-210	7.7	65.5
P-211	4.6	68.1
P-212	4.6	65.2

The bedrock was described as laminated grey to dark grey shale and typically contained hard limestone interbeds up to 25 mm in thickness. The shale was generally described as highly weathered to fresh, with the degree of weathering decreasing with depth. The bedding thickness was typically 25 to 150 mm. Occasional vertical fractures, rubbles zones, and clay seams were observed in the bedrock cores.

Total Core Recovery (TCR) in the bedrock ranged from 75 % to 100%. The RQD values ranged from 18 to 100%, indicating a widely variable rock quality ranging from very poor to excellent. RQD values typically ranged from 50 to 100%, which is indicative of fair to excellent rock quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was also quite variable and ranged from 0 to greater than 25.

The estimated unconfined compressive strength of the rock, interpreted from point load tests conducted on intact rock cores, ranged from 12 to 33 MPa, indicating a weak to medium

strong rock strength classification. Higher rock strengths may be obtained in the hard limestone interbeds.

5.2.11 Groundwater Conditions

A wet condition was noted in the sand above the till near 8 m depth (Elevation 64.9) in Borehole P-208. Water was introduced into all other boreholes during rock coring operations and therefore water levels were not recorded upon completion of drilling.

One standpipe piezometer was installed at the St. Laurent Boulevard Interchange, in Borehole P-209, to monitor water levels after completion of drilling. The water level measured in the piezometer is at depth of 0.8 m (Elevation 66.2) and is summarized in Table 5.4.

Table 5.4 – Water Level Measurements

Borehole	Date	Water Level (m)		Comment
		Depth	Elevation	
P209	27-Mar-2012	0.8	66.2	Piezometer

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

6 MISCELLANEOUS

Borehole locations were established based on information received from MRC and were marked out in the field by surveyors from the MMM Group. Where a borehole was relocated from the marked location, field measurements were made regarding the offset and elevation differences between the marked location and the drilled location, and the as-drilled coordinates and elevations were reported.

Underground Service Locators Inc. obtained utility clearances on behalf of Thurber for the selected borehole locations prior to drilling.

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied both track-mounted and truck-mounted drill rigs and conducted the drilling, sampling and in-situ testing operations.

The field investigation was supervised by Ms. Eckie Siu and Mr. Ryan Kromer, E.I.T. of Thurber.

Routine laboratory testing was carried out by Thurber Engineering Ltd.

Overall planning and supervision of the field program was conducted by Ms. Lindsey Blaine, E.I.T. Interpretation of the data and preparation of the report were carried out by Ms. Lindsey Blaine, E.I.T. and Ms. Mei Cheong M.Phil.

The report was reviewed by Mr. M.R. Anderson, P.Eng., M.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

L. Blaine
July 6/12

Lindsey Blaine, E.I.T.
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Review Principal, Designated MTO Contact

FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGH MAST LIGHT POLES
HIGHWAY 417 WIDENING
NICHOLAS STREET TO O.R.174
OTTAWA, ONTARIO
G.W.P. 4320-06-00

Geocres Number: 31G5-248

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents foundation design recommendations for the thirteen proposed High Mast Light Poles (HMLP) located along Highway 417, Ottawa, Ontario.

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained in the course of this investigation. The plans and profiles used for preparation of this report were provided by McCormick Rankin Corporation (MRC).

8 HIGH MAST LIGHT POLE SUPPORT DESIGN RECOMMENDATIONS

8.1 Foundation Design Parameters

One borehole was drilled in the vicinity of the proposed foundation of each HMLP. At the Riverside Drive Interchange, the proposed location of HMLP P200 to P202 encountered shale bedrock at depths of 0.8 m to 2.7 m. Bedrock was encountered at depths of 4.6 m to 7.5 m at the other proposed HMLP locations at the Riverside Drive Interchange. The proposed HMLP locations at the St. Laurent Boulevard Interchange typically encountered bedrock at depths of 4.6 m to 9.1 m, except for HMLP P209, where bedrock was encountered at 2.4 m depth.

The design of the HMLP should be carried out in accordance with the following documents:

- Ministry of Transportation , Ontario (2003) “Guidelines for the Design of High Mast Pole Foundations”, Third Edition, BRO-006, Engineering Standards Branch, Bridge Office.

- Canadian Highway Bridge Design Code and Commentary (2006).

As per the Guidelines for the Design of High Mast Pole Foundations, a HMLP is typically supported on a single conventional augered caisson (drilled shaft). Tables 1 and 2, which are presented immediately following the text of this report, provide a listing of boreholes and geotechnical parameters relevant to the design of each HMLP.

Where downward sloping ground exists in front of a caisson, reduction of lateral passive resistance should be taken into account during design. For foundation design at the caissons, it can be assumed that full lateral resistance can only be mobilized where the width of the soil in front of the caisson is equal to or greater than approximately 4 times the diameter of the caissons. The mobilized passive resistance for sloping ground in front of a caisson can be estimated using the following reduction factors:

Table 8.1 - Slope Reduction Factors

Slope Inclination	Passive Resistance Reduction Factor
2H : 1V	0.60
2.5H : 1V	0.65
3H : 1V	0.70
4H : 1V	0.75

Where designing for portions of the caissons below the groundwater level in cohesionless soils (sands and silts), the submerged soil unit weight, γ' , should be used. The required embedment depth of the caisson will be governed by lateral loads, including wind loads acting on the pole. The length of the caisson should also be sufficient to counteract frost-jacking forces.

The depth of frost penetration at the site is 1.8 m. Accordingly, all adhesion/ skin friction or passive resistance within the top 1.8 m of overburden should be neglected in foundation design.

8.2 Caisson Installation

Caisson installation should generally be carried out in accordance with OPSS 631 and OPSS 903.

The contract documents should contain an NSSP alerting the contract bidders of the specific aspects relating to caisson construction for HMLP foundation supports at this site. Suggested wordings for this NSSP are provided in Appendix C.

Caisson installation equipment must be able to auger or core into weak to medium strong shale bedrock with hard limestone interbeds, and handle and remove cobbles and boulders in the overlying fill and till deposits if required.

The bedrock elevations may vary within short distances. The depth to rock at the location of the sign support may therefore be greater or less than that indicated by the borehole findings. The potential for encountering a sloping bedrock surface should also be anticipated.

Steel liners should be provided during caisson installation to support the sidewalls, minimise groundwater inflow and enable machine-cleaning of the base. Groundwater was observed in the boreholes during the field investigation at depths of 1.3 m to 2.4 m (Elevations 56.9 to 59.5) at the Riverside Drive Interchange and at a depth of 0.8 m (Elevation 66.2) at the St. Laurent Blvd. Interchange.

8.3 Construction Concerns

Concerns during caisson construction mainly involve the handling and removal of cobbles or boulders, possible soil sloughing and water seepage from caisson sidewalls, augering and/or coring of weak to medium strong rock with hard limestone interbeds, and a variable bedrock surface elevation.

9 CLOSURE

Engineering analysis and preparation of the report were carried out by Ms. Mei Cheong M.Phil.

The report was reviewed by Mr. Murray R. Anderson, P.Eng., M.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.



July 6, 12

Mei T. Cheong, M.Phil.
Geotechnical Specialist



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P.K. Chatterji, P.Eng., Ph.D.
Review Principal, Designated MTO Contact

**TABLE 1 FOUNDATION DESIGN PARAMETERS
HIGH MAST LIGHT POLES (HMLP)
HIGHWAY 417 WIDENING
RIVERSIDE DRIVE/ VANIER PARKWAY INTERCHANGE**

Pole Number	Reference Borehole	Reference Simplified Subsurface Stratigraphy For Design	Depth Below Existing Ground Surface (m)	Foundation Design Parameters								
				f _{horiz} (kPa)	q _u (kPa)	ϕ' (deg.)	n _h (MN/m ³)	K _p	γ (kN/m ³)	γ' (kN/m ³)	Groundwater Level	
											Depth [#] (m)	Elev. (m)
P200	P-200	Sand (Fill) Shale Bedrock	0.1 – 0.8 0.8	- 1000	- -	30 -	3.0 -	3.0 -	21 -	- -	1.9 *	56.9
P201	P-201	Sand (Fill) Sand (Fill) Shale Bedrock	0.1 – 1.3 1.3 – 2.7 2.7	- - 1000	- - -	30 30 -	3.0 2.0 -	3.0 3.0 -	21 - -	- 11 -	1.3 *	57.9
P202	P-202	Silty Sand (Fill) Shale Bedrock	0.2 – 1.8 1.8	- 1000	- -	30 -	3.0 -	3.0 -	21 -	- -	1.9*	58.4
P203	P-203	Sand (Fill) Clayey Silt (Fill) Sandy Silt Till Sandy Silt Till Shale Bedrock	0.1 – 4.9 4.9 – 6.1 6.1 – 6.6 6.6 – 7.3 7.3	- - - - 1000	- - - - -	32 29 35 35 -	5.0 1.5 10.0 7.0 -	3.3 2.9 3.7 3.7 -	21 20 21 - -	- - - 11 -	6.6	57.5
P204	P-204	Sand (Fill) Sand (Fill) Sandy Silt Silty Sand Till Shale Bedrock	0.1 – 2.4 2.4 – 3.0 3.0 – 4.7 4.7 – 7.5 7.5	- - - - 1000	- - - - -	30 30 30 32 -	3.0 2.0 2.0 4.0 -	3.0 3.0 3.0 3.3 -	21 - - - -	- 11 10 11 -	2.4 *	59.5

Notes:

1. This table must be read in conjunction with the text of this report.
 2. In order to take into account frost action and surficial disturbance, the ultimate lateral passive resistance in front of the caisson within the upper 1.8 m below final grade should be neglected in the foundation design.
- # Depth below existing grade
* Groundwater level based on piezometer readings

High Mast Light Poles
Highway 417 Widening – Riverside Drive/ Vanier Parkway Interchange

Pole Number	Reference Borehole	Reference Simplified Subsurface Stratigraphy For Design	Depth Below Existing Ground Surface (m)	Foundation Design Parameters								
				f _{horiz} (kPa)	q _u (kPa)	ϕ' (deg.)	n _h (MN/m ³)	K _p	γ (kN/m ³)	γ' (kN/m ³)	Groundwater Level	
											Depth [#] (m)	Elev. (m)
P205	P-205	Sand (Fill)	0.4 – 2.1	-	-	30	3.0	3.0	21	-	2.4	57.7
		Silty Sand Till	2.1 – 2.4	-	-	30	3.0	3.0	21	-		
		Silty Sand Till	2.4 – 4.1	-	-	30	2.0	3.0	-	11		
		Sand and Gravel	4.1 – 5.0	-	-	35	7.0	3.7	-	11		
		Silty Sand Till	5.0 – 5.5	-	-	35	7.0	3.7	-	11		
		Shale Bedrock	5.5	1000	-	-	-	-	-	-		
P206	P-206	Sand (Fill)	0.1 – 0.9	-	-	30	3.0	3.0	21	-	2.2	58.0
		Silty Sand (Fill)	0.9 – 2.2	-	-	32	5.0	3.3	21	-		
		Silty Sand Till	2.2 - 4.6	-	-	30	2.0	3.0	-	11		
		Shale Bedrock	4.6	1000	-	-	-	-	-	-		

LEGEND

f_{horiz}	=	Horizontal bearing resistance for bedrock at factored ULS (kPa)
q_u	=	Unconfined Compressive Strength (= 2 x C_u , undrained shear strength) (kPa)
ϕ'	=	Angle of Internal Friction (degrees)
n_h	=	Coefficient of Horizontal Subgrade Reaction (MN/m ³ or X 10 ³ kN/m ³)
K_p	=	Coefficient of Passive Earth Pressure
γ	=	Soil Unit Weight (kN/m ³)
γ'	=	Submerged Soil Unit Weight (kN/m ³) – to be used only for cohesionless soils below the groundwater table

Notes:

1. This table must be read in conjunction with the text of this report.
 2. In order to take into account frost action and surficial disturbance, the ultimate lateral passive resistance in front of the caisson within the upper 1.8 m below final grade should be neglected in the foundation design.
- # Depth below existing grade
- * Groundwater level based on piezometer readings

**TABLE 2 FOUNDATION DESIGN PARAMETERS
HIGH MAST LIGHT POLES (HMLP)
HIGHWAY 417 WIDENING
ST. LAURENT BOULEVARD INTERCHANGE**

Pole Number	Reference Borehole	Reference Simplified Subsurface Stratigraphy For Design	Depth Below Existing Ground Surface (m)	Foundation Design Parameters								
				f _{horiz} (kPa)	q _u (kPa)	ϕ' (deg.)	n _h (MN/m³)	K _p	γ (kN/m³)	γ' (kN/m³)	Groundwater Level	
											Depth # (m)	Elev. (m)
P207	P-207	Sand (Fill)	0.1 – 0.9	-	-	30	3.0	3.0	21	-	7.0	64.5
		Silty Sand (Fill)	0.9 – 4.1	-	-	30	3.0	3.0	21	-		
		Silt and Sand Till	4.1 – 6.4	-	-	32	5.0	3.3	21	-		
		Shale Bedrock	6.4	1000	-	-	-	-	-	-		
P208	P-208	Sand (Fill)	0.1 – 2.3	-	-	32	5.0	3.3	21	-	7.9	65.0
		Sandy Gravel (Fill)	2.3 – 4.3	-	-	32	5.0	3.3	21	-		
		Silty Clay (Fill)	4.3 – 6.5	-	60	-	-	2.8	19	-		
		Sand	6.5 – 7.9	-	-	32	5.0	3.3	21	-		
		Sand	7.9 – 8.4	-	-	32	4.0	3.3	-	11		
		Silty Sand Till	8.4 – 9.1	-	-	32	4.0	3.3	-	11		
		Shale Bedrock	9.1	1000	-	-	-	-	-	-		
P209	P-209	Silt (FILL)	0.5 – 1.5	-	-	30	2.0	3.0	-	10	0.8 *	66.2
		Silty Clay (FILL)	1.5 – 2.4	-	50	-	-	2.8	-	9		
		Shale Bedrock	2.4	1000	-	-	-	-	-	-		
P210	P-210	Sand (Fill)	0.1 – 1.1	-	-	30	3.0	3.0	21	-	7.7	65.5
		Silty Clay (Fill)	1.1 – 2.3	-	100	-	-	2.9	20	-		
		Sandy Silt (Fill)	2.3 – 3.0	-	-	30	3.0	3.0	21	-		
		Silty Clay (Fill)	3.0 – 6.6	-	100	-	-	2.9	20	-		
		Sandy Silt Till	6.6 – 7.7	-	-	32	5.0	3.3	21	-		
		Shale Bedrock	7.7	1000	-	-	-	-	-	-		

Notes:

1. This table must be read in conjunction with the text of this report.
 2. In order to take into account frost action and surficial disturbance, the ultimate lateral passive resistance in front of the caisson within the upper 1.8 m below final grade should be neglected in the foundation design.
- # Depth below existing grade
- * Groundwater level based on piezometer readings

High Mast Light Poles
Highway 417 Widening - St. Laurent Boulevard Interchange

Pole Number	Reference Borehole	Reference Simplified Subsurface Stratigraphy For Design	Depth Below Existing Ground Surface (m)	Foundation Design Parameters								
				f _{horiz} (kPa)	q _u (kPa)	ϕ' (deg.)	n _h (MN/m ³)	K _p	γ (kN/m ³)	γ' (kN/m ³)	Groundwater Level	
											Depth # (m)	Elev. (m)
P211	P-211	Sand (Fill)	0.1 – 1.0	-	-	30	3.0	3.0	21	-	7.2	65.5
		Silty Clay (Fill)	1.0 – 3.7	-	100	-	2.9	20	-			
		Silty Sand Till	3.7 – 4.6	-	-	32	5.0	3.3	21	-		
		Shale Bedrock	4.6	1000	-	-	-	-	-			
P212	P-212	Sand (Fill)	0.1 – 1.3	-	-	32	5.0	3.3	21	-	5.8	64.0
		Silt and Sand (Fill)	1.3 – 3.1	-	-	32	5.0	3.3	21	-		
		Sandy Silt Till	3.1 – 4.6	-	-	32	5.0	3.3	21	-		
		Shale Bedrock	4.6	1000	-	-	-	-	-			

LEGEND

f_{horiz}	=	Horizontal bearing resistance for bedrock at factored ULS (kPa)
q_u	=	Unconfined Compressive Strength (= 2 x C_u , undrained shear strength) (kPa)
ϕ'	=	Angle of Internal Friction (degrees)
n_h	=	Coefficient of Horizontal Subgrade Reaction (MN/m ³ or X 10 ³ kN/m ³)
K_p	=	Coefficient of Passive Earth Pressure
γ	=	Soil Unit Weight (kN/m ³)
γ'	=	Submerged Soil Unit Weight (kN/m ³) – to be used only for cohesionless soils below the groundwater table

Notes:

- This table must be read in conjunction with the text of this report.
 - In order to take into account frost action and surficial disturbance, the ultimate lateral passive resistance in front of the caisson within the upper 1.8 m below final grade should be neglected in the foundation design.
- # Depth below existing grade
- * Groundwater level based on piezometer readings

Appendix A

**Riverside Drive Interchange (Boreholes P-200 to P-206)
Record of Borehole Sheets
and
Laboratory Test Results**

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


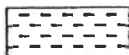



C_{pm} Shear Strength Determination by Pocket Penetrometer

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

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	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 percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

RECORD OF BOREHOLE No P-200

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION Riverside Drive N 5 031 219.7 E 370 747.9 ORIGINATED BY ES
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.02.08 - 2012.02.08 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
58.8								20 40 60 80 100						
0.0	TOPSOIL: (100mm)							○ UNCONFINED + FIELD VANE						
0.1	Silly SAND, mixed with organics, some clay Dark Brown Moist (FILL)		1	GS				● QUICK TRIAXIAL × LAB VANE						
58.0			1	SS	50/		58						FI	
0.8	SHALE, highly to moderately weathered, thinly bedded, horizontally laminated, grey Cored from 0.9m Limestone interbed at 1.0m, 1.1m		1	RUN	0.125								>5	RUN #1 TCR=90% SCR=60% RQD=60% UCS=17MPa (Average)
	Sub-horizontal fracture (75mm) at 1.2m		2	RUN			57						>10	RUN #2 TCR=100% SCR=85% RQD=70% UCS=20MPa (Average)
	Vertical fracture (200mm) at 1.3m												2	
	Sub-vertical fractures (75mm to 100mm) at 1.2m, 1.6m and 200mm at 2.2m						56						3	
	Limestone interbeds (25mm thick) at 1.5m, 1.7m, 2.0m, 2.2m, 2.8m, 2.9m, 3.0m, 3.3m, 3.4m, 3.5m, 3.6m, 3.9m, 4.0m		3	RUN			55						>5	RUN #3 TCR=100% SCR=100% RQD=93% UCS=27MPa (Average)
54.6													1	
													1	
													2	
4.2	END OF BOREHOLE AT 4.2m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2011.03.20 1.9 56.9													

+ 3, X 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P-201

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION Riverside Drive N 5 031 131.3 E 370 606.2 ORIGINATED BY ES
HWY 417 BOREHOLE TYPE Hollow Stem Augers/Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2012.02.06 - 2012.02.06 CHECKED BY LRB

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								
59.2								20	40	60	80	100				
0.0	TOPSOIL: (125mm)							20	40	60	80	100				
0.1	SAND, trace to some gravel, some silt, trace clay Loose Brown Moist (FILL)		1	SS	7		59									15 71 10 4
	Wet		2	SS	4		58									
							57									
56.5			3	SS	41											
2.7	SHALE, highly weathered, grey		4	SS	100		56									
	Cored from 3.0m				0.050		55									
	slightly weathered to fresh, thinly bedded, horizontally laminated, thin limestone interbeds through out		1	RUN												RUN #1 TCR=95% SCR=95% RQD=88% UCS=18MPa (Average)
	Sub-vertical fracture (50mm) at 3.0m															
	Vertical fracture (50mm) at 4.0m															
	Limestone interbeds at 4.3m, 4.4m, 4.5m, 4.6m, 4.8m, 4.9m, 5.1m, 5.3m, 5.5m		2	RUN			54									RUN #2 TCR=100% SCR=100% RQD=100% UCS=33MPa (Average)
	Limestone interbeds at 5.7m, 6.0m															
			3	RUN												RUN #3 TCR=100% SCR=100% RQD=100% UCS=23MPa (Average)
52.9																
6.3	END OF BOREHOLE AT 6.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.															
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2011.03.30 1.3 57.9															

+ 3 x 3 : Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P-202

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION Riverside Drive N 5 031 064.4 E 370 743.9 ORIGINATED BY ES
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.02.08 - 2012.02.08 CHECKED BY LRB

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 (%)				
60.3								20 40 60 80 100						GR SA SI CL
0.0	TOPSOIL: (150mm)							20 40 60 80 100						
0.2	Silty SAND, mixed with organics, some clay, trace gravel Compact Dark Brown Moist (FILL)		1	SS	13		60							6 52 26 16
58.5							59							
1.8	SHALE, highly weathered, grey, thinly bedded, occasional limestone interbeds Soft zone (25mm to 50mm thick) at 2.3m, 2.4m Cored from 2.3m Moderately weathered to fresh Limestone interbed (25mm to 50mm thick) at 2.6m, 3.5m, 3.6m, 4.0m Vertical fracture (100mm) at 3.7m		2	SS	65		58							
			3	SS	100									
			1	RUN	0.075									
	Broken zone (75mm thick) at 3.9m		2	RUN			57							
	Limestone interbed (25mm to 50mm thick) at 4.3m, 4.8m, 5.7m						56							
	Sub-vertical fractures (25mm to 75mm) at 4.3m, 4.7m, 4.9m, 5.2m		3	RUN			55							
	Broken zone (75mm thick) at 5.0m Borken zone (125mm thick) at 5.2m													
54.5														
5.8	END OF BOREHOLE AT 5.8m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2011.03.30 1.9 58.4													

+ 3, X 3: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P-203

1 OF 2

METRIC

W.P. 4320-06-00 LOCATION Riverside Drive N 5 031 163.8 E 370 872.8 ORIGINATED BY ES
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2012.03.22 - 2012.03.22 CHECKED BY LRB

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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
64.1	ASPHALT: (75mm)												
0.0													
0.1	SAND, some silt, trace to some gravel, trace clay Very Dense to Dense Brown Damp (FILL)		1	GS									
			1	SS	51								
			2	SS	38								
	Occasional cobbles		3	SS	37								
			4	SS	46								
59.2			5	SS	23								
4.9	Clayey SILT, some sand, trace gravel Very Stiff Dark Grey Moist (FILL)												
58.0													
6.1	Sandy SILT, some clay, trace gravel, occasional cobbles Very Dense Grey Moist (TILL)		6	SS	56								
56.8													
7.3	SHALE, moderately to slightly weathered, thinly bedded, horizontally laminated, grey Clay seams at 7.2 to 7.3, 7.7 to 7.8, and 7.9 to 8.0m Broken zones at 7.5 to 7.6, and 8.5 to 8.6m Sub-horizontal fracture at 7.9 to 8.0m Sub-vertical fracture at 8.5 to 8.6m Limestone interbeds at 8.8, 8.9, 9.6, 10.0, 10.1 to 10.2, 10.3, and 10.4m Sub-vertical fractures at 9.2 to 9.3, 9.6 to 9.8, and 9.9 to 10.0m		1	RUN									
			2	RUN									

Continued Next Page

+ 3 x 3: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P-203

2 OF 2

METRIC

W.P. 4320-06-00 LOCATION Riverside Drive N 5 031 163.8 E 370 872.8 ORIGINATED BY ES
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2012.03.22 - 2012.03.22 CHECKED BY LRB

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															
53.8						54										
10.3	END OF BOREHOLE AT 10.3m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 2.4m, CUTTINGS TO 0.2m, THEN ASPHALT TO SURFACE.															

RECORD OF BOREHOLE No P-204

1 OF 2

METRIC

W.P. 4320-06-00 LOCATION Riverside Drive N 5 031 367.7 E 370 907.8 ORIGINATED BY ES
HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.02.08 - 2012.02.08 CHECKED BY LRB

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 (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
61.9								20 40 60 80 100								
0.0	TOPSOIL: (140mm)							20 40 60 80 100								
0.1	SAND, some silt, trace clay, trace gravel, mixed with organics Compact Dark Brown Fozen (FILL)		1	SS	11					○						
60.7																
1.2	SAND, some silt, trace gravel Loose lo Compact Dark Brown to Brown Moist to Wet (FILL)		2	SS	4					○						
			3	SS	11						○					
58.9																
3.0	Sandy SILT, trace clay, trace gravel Compact Brown Moist		4	SS	21						○			1 32 60 7		
57.2																
4.7	Silty SAND, some clay, trace gravel, occasional cobbles Compact to Dense Dark Grey Damp (TILL)		5	SS	21					○				5 56 25 14		
			6	SS	31						○					
54.4																
7.5	SHALE, highly weathered, thinly bedded, grey		7	SS	100/0.050						○					
53																
52.7																
9.2	END OF BOREHOLE AT 9.2m. WATER LEVEL AT 5.4m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe		8	SS	100/0.025											

Continued Next Page

+ 3 . X 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P-204

2 OF 2

METRIC

W.P. 4320-06-00 LOCATION Riverside Drive N 5 031 367.7 E 370 907.8 ORIGINATED BY ES
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.02.08 - 2012.02.08 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					FLASTIC 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 with a 1.52m slotted screen.																
	WATER LEVEL READINGS DATE DEPTH (m) ELEV. (m) 2011.03.27 2.4 59.5																

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

RECORD OF BOREHOLE No P-205

1 OF 2

METRIC

W.P. 4320-06-00 LOCATION Riverside Drive N 5 031 305.7 E 371 010.8 ORIGINATED BY ES
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2012 02 15 - 2012 02 15 CHECKED BY LRB

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 (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE			
60.1							20 40 60 80 100	20 40 60			GR SA SI CL	
0.0	ASPHALT: (75mm)											
0.1												
59.7	CONCRETE: (300mm)		1	GS							0 77 16 7	
0.4	SAND, some silt, trace clay Compact Brown Damp (FILL)		1	SS	17							
58.9												
1.2	Sandy SILT, trace gravel Dark Brown Damp (FILL)		2	SS	13							
58.5												
1.6												
58.0	SAND, trace gravel, trace silt Compact Dark Grey Moist (FILL)		3	SS	8							
2.1												
	Silty SAND, some clay, trace to some gravel Loose to Compact Brown Moist (TILL)		4	SS	12						12 47 24 17	
56.0												
4.1	SAND and GRAVEL Dense Brown Wet		5	SS	37							
55.1												
5.0	Silty SAND, trace gravel Dense Brown Moist (TILL)		6	SS	50/ 0.050							
54.6												
5.5	SHALE, highly weathered, grey Cored from 6.2m Slightly weathered to fresh, thinly bedded, horizontally laminated, limestone interbeds throughout		1	RUN						FI 1 1 4	RUN #1 TCR=100% SCR=100% RQD=97% UCS=28MPa (Average)	
	Limestone interbed (25mm to 50mm thick) at 6.2m, 7.0m, 6.3m, 6.4m, 6.5m, 6.6m, 6.9m, 7.1m											
	Sub-vertical fracture (100mm) at 7.5m											
	Limestone interbed (25mm to 75mm thick) at 7.3m, 7.7m, 7.9m, 8.0m, 8.1m, 8.2m, 8.4m, 8.5m		2	RUN						3 >5 3	RUN #2 TCR=100% SCR=98% RQD=92% UCS=29MPa (Average)	
	Limestone interbed at 8.9m, 9.0m, 9.1m, 9.3m 100mm at 8.7m		3	RUN						1 1 0 1	RUN #3 TCR=100% SCR=100% RQD=100% UCS=31MPa (Average)	
50.6										0		
9.5	END OF BOREHOLE AT 9.5m. WATER LEVEL AT 3.7m DURING DRILLING.											

Continued Next Page

+ 3, X 3, Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P-205

2 OF 2

METRIC

W.P. 4320-06-00 LOCATION Riverside Drive N 5 031 305.7 E 371 010.8 ORIGINATED BY ES
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.02.15 - 2012.02.15 CHECKED BY LRB

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	20 40 60		
	Continued From Previous Page												
	BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 5.4m, CUTTINGS TO 0.9m, HOLEPLUG TO 0.15m THEN ASPHALT TO SURFACE.												

ONTMT4S 1201B.GPJ 5/10/12

+³, X³: Numbers refer to Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P-206

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION Riverside Drive N 5 031 348 6 E 371 108.1 ORIGINATED BY ES
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/Casing/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2012 03 20 - 2012 03 20 CHECKED BY LRB

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 (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				w _p w w _L				
							20	40	60	80	100	20	40	60		
60.2																
0.0	ASPHALT: (100mm)															
0.1	SAND, some gravel, some silt Brown Damp (FILL)		1	GS			60						○			
59.3																
0.9	Silty SAND, trace gravel, trace clay, trace rootlets Dense Brown to Grey Damp to Moist (FILL)		1	SS	33		59						○			
			2	SS	33								○			
58.0							58									
2.2	Silty SAND, some clay, trace gravel Compact Dark Brown to Grey Moist (TILL)		3	SS	12								○		5 54 27 14	
			4	SS	13		57						○			
							56									
55.6			5	SS	50											
4.6	SHALE, moderately to slightly weathered, thinly bedded, horizontally laminated, grey Limestone interbeds at 4.7, 4.8 to 4.9, 5.0 to 5.1, 5.2 to 5.4, 5.6, 5.7, and 5.8m Sub-vertical fractures at 4.8 to 4.9, and 5.2 to 5.3m Limestone interbeds at 5.8 to 5.9, 6.0 to 6.1, 6.2 to 6.3, 6.4 to 6.5, 6.6, 6.7 to 6.8, and 6.9 to 7.0m Sub-vertical fractures at 6.4, 6.5, and 6.7m Broken zone at 6.5 to 6.6m		1	RUN	.050		55							1 1 2	RUN #1 TCR=100% SCR=100% RQD=100% UCS=10MPa (Average)	
			2	RUN			54							1 3 3	RUN #2 TCR=100% SCR=97% RQD=97% UCS=10MPa (Average)	
			3	RUN			53							0 0	RUN #3 TCR=100% SCR=100% RQD=100% UCS=9MPa (Average)	
52.4																
7.8	END OF BOREHOLE AT 7.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.8m, CUTTINGS TO 0.2m, THEN ASPHALT TO SURFACE.															

ONTMT4S 1201B GPJ 5/10/12

+ 3 x 3 Numbers refer to
Sensitivity

20
15
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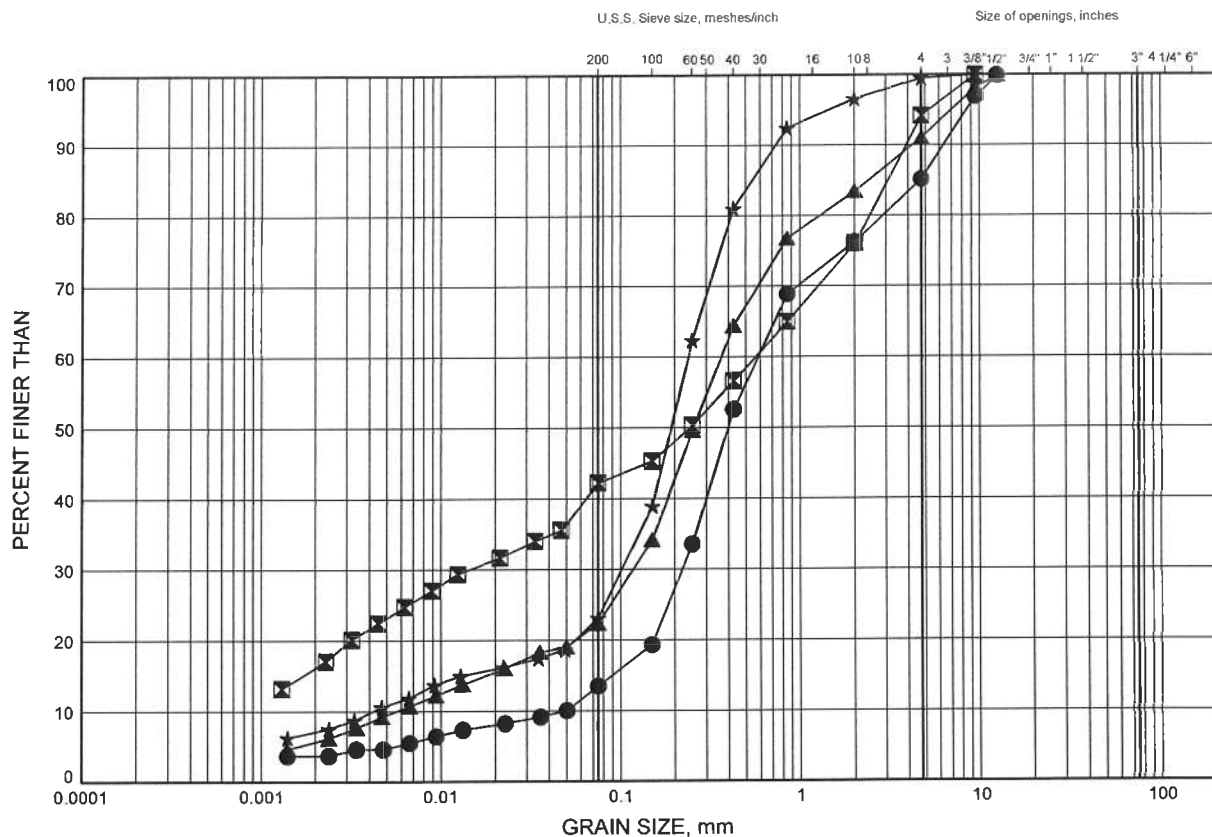
(%) STRAIN AT FAILURE

Highway 417 Ottawa: Vanier to OR 174

GRAIN SIZE DISTRIBUTION

FIGURE A1

Sand to Silty Sand Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P-201	1.07	58.13
⊠	P-202	1.07	59.23
▲	P-203	1.83	62.26
★	P-205	0.38	59.72

Date May 2012
W.P.# 4320-06-00

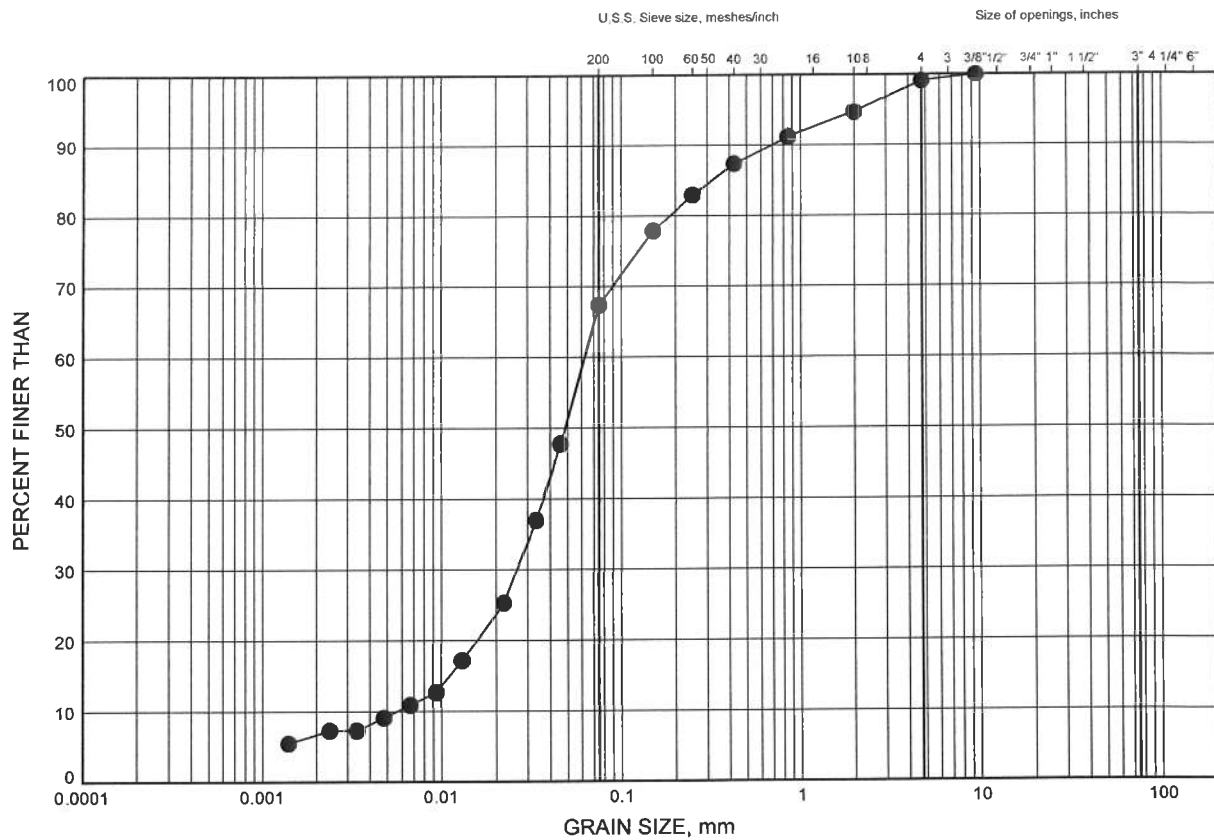


Prep'd MFA
Chkd. LRB

Highway 417 Ottawa: Vanier to OR 174
GRAIN SIZE DISTRIBUTION

FIGURE A2

Sandy Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P-204	3.35	58.55

GRAIN SIZE DISTRIBUTION - THURBER 1201B.GPJ 5/10/12

Date May 2012
W.P.# 4320-06-00



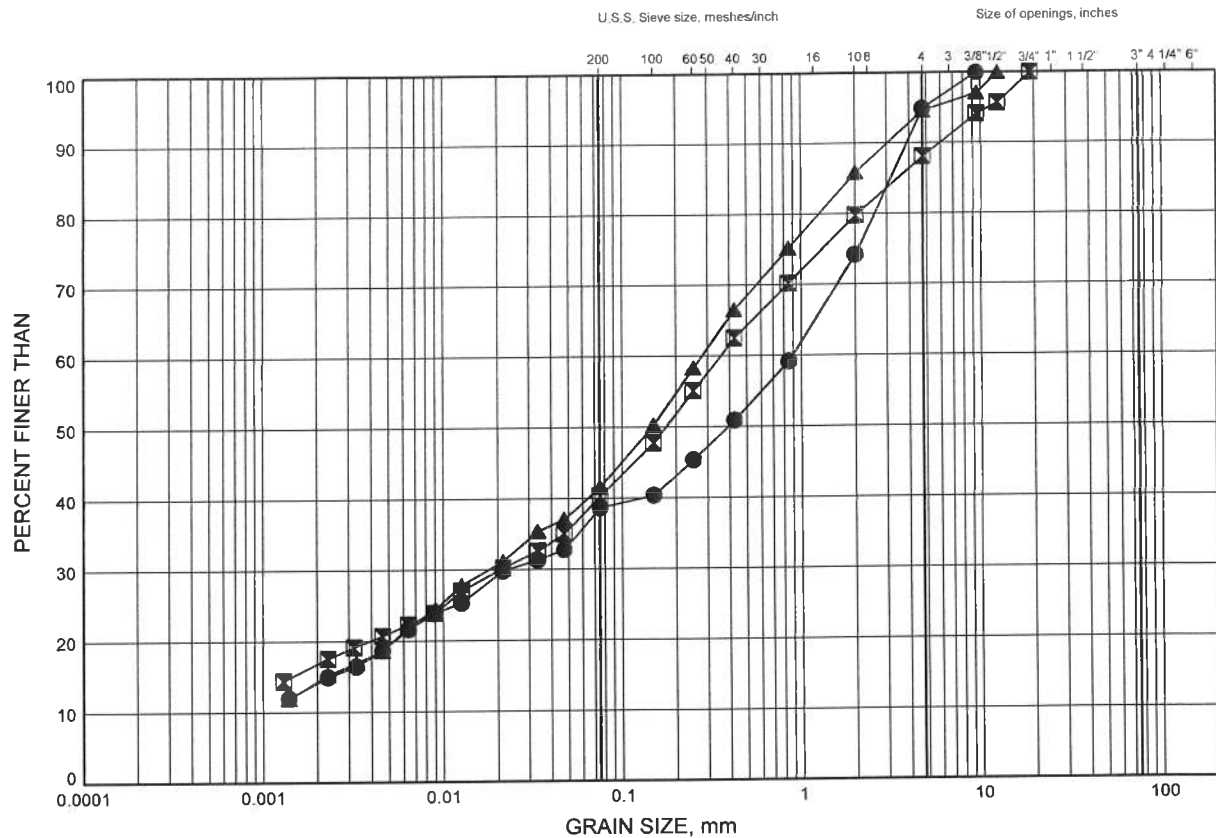
Prep'd MFA
Chkd. LRB

Highway 417 Ottawa: Vanier to OR 174

GRAIN SIZE DISTRIBUTION

FIGURE A3

Silty Sand Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P-204	4.88	57.02
■	P-205	3.35	56.75
▲	P-206	2.59	57.61

Date May 2012
W.P.# 4320-06-00

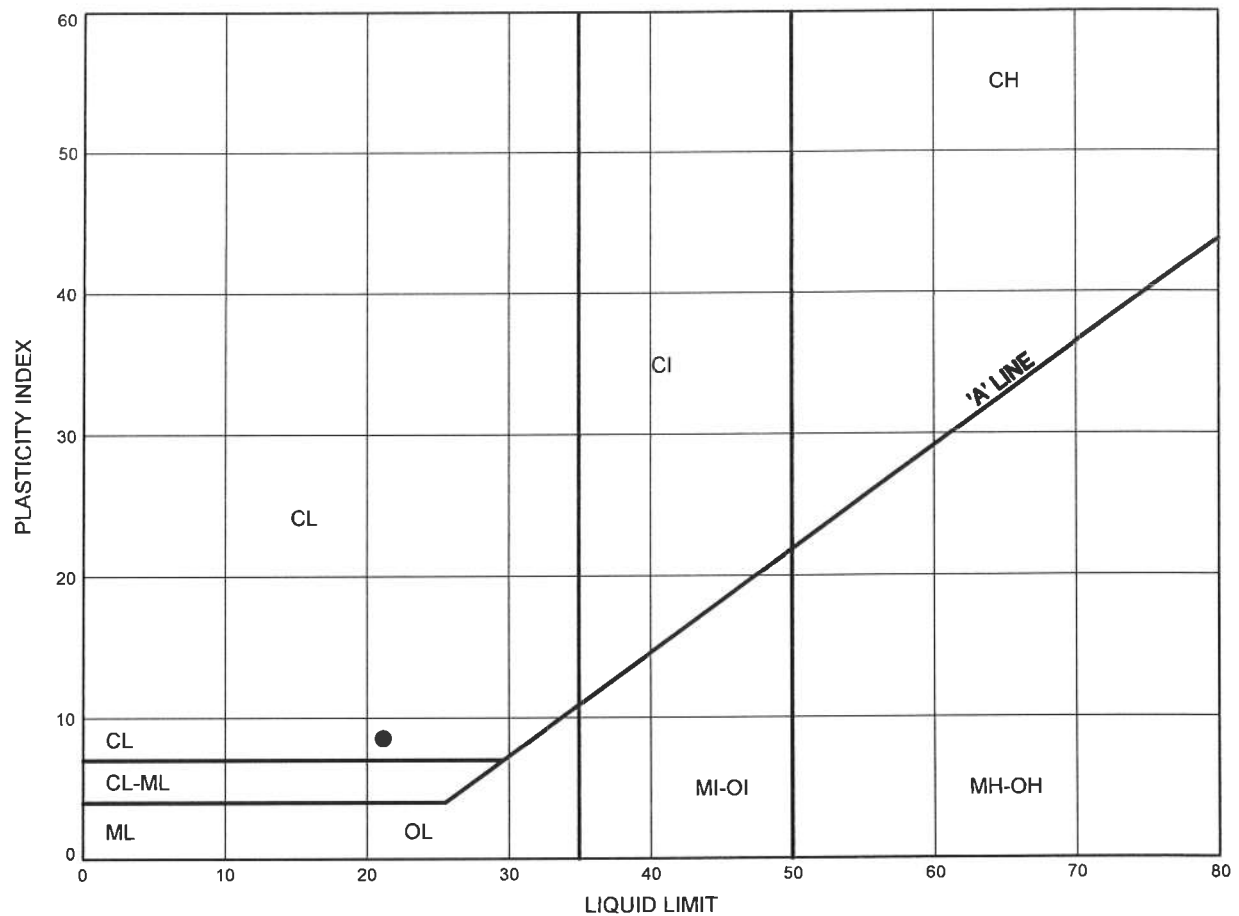


Prep'd MFA
Chkd. LRB

Highway 417 Ottawa: Vanier to OR 174
ATTERBERG LIMITS TEST RESULTS

FIGURE A4

Silty Sand Till



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P-204	4.88	57.02

Date May 2012
W.P.# 4320-06-00



Prep'd MFA
Chkd. LRB

Appendix B

St. Laurent Blvd. Interchange (Boreholes P-207 to P-212)
Record of Borehole Sheets
and
Laboratory Test Results

RECORD OF BOREHOLE No P-207

1 OF 2

METRIC

W.P. 4320-06-00 LOCATION St. Laurent Blvd. N 5 031 490.7 E 372 306.1 ORIGINATED BY ES
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012 03 11 - 2012 03 11 CHECKED BY LRB

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												
71.5								20	40	60	80	100								
0.0	ASPHALT: (100mm)																			
0.1	SAND, some gravel to gravelly, some silt Brown Damp (FILL)		1	GS			71													35 49 16 (SI+CL)
70.6																				
0.9	Silty SAND, some gravel, trace clay Dense to Compact Grey/Brown Damp (FILL)		2	SS	37		70													
			3	SS	28															
			4	SS	18		69													
			5	SS	31		68													
67.4																				
4.1	SILT and SAND, some clay, trace gravel Compact Brown to Dark Grey Moist (TILL)		6	SS	29		67													0 40 42 18
							66													
65.1	Sand seam (250mm) at 6.4m		7	SS	20		65													
6.4	SHALE, highly to moderately weathered, thinly bedded, grey Cored from 6.7m Clay seam (25mm) at 7.0m Limestone interbed at 7.8m, 8.1m Sub-vertical fracture at 7.2m, 7.3m Slightly weathered to fresh Limestone interbeds at 8.3m, 8.5m, 8.6m, 9.0m, 9.1m, 9.3m, 9.6m Vertical fracture at 8.3m, 8.6m		1	RUN			64													RUN #1 TCR=100% SCR=95% RQD=74% UCS=17MPa (Average)
			2	RUN			63													RUN #2 TCR=100% SCR=100% RQD=98% UCS=15MPa (Average)
61.7							62													
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 P-207

2 OF 2

METRIC

W.P. 4320-06-00 LOCATION St. Laurent Blvd. N 5 031 490.7 E 372 306.1 ORIGINATED BY ES
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.03.11 - 2012.03.11 CHECKED BY LRB

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					FLASTIC 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	WATER CONTENT (%)							
	Continued From Previous Page																	
	BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.8m, CUTTINGS TO 0.2m THEN ASPHALT TO SURFACE																	

ONTMT4S 1201B.GPJ 5/10/12

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P-208

1 OF 2

METRIC

W.P. 4320-06-00 LOCATION St. Laurent Blvd. N 5 031 507.2 E 372 454.6 ORIGINATED BY ES
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
 DATUM Geodetic DATE 2012 03 12 - 2012 03 12 CHECKED BY LRB

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 (%)				
72.9								20 40 60 80 100		w _p w w _L				
0.0	ASPHALT: (100mm)							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
0.1	SAND, some silt, some gravel to gravelly Very Dense to Compact Grey Damp (FILL)		1	GS			72							
			1	SS	52									
			2	SS	28		71							
70.6														
2.3	Sandy GRAVEL Compact Grey Damp (FILL)		3	SS	16		70							
			4	SS	17									
							69							
68.6														
4.3	Silty CLAY, trace sand, trace gravel Firm Grey Moist (FILL)		5	SS	6		68							
							67							
66.4			6	SS	28									2 6 21 71
6.5	SAND, fine grained, trace gravel Compact Grey Moist to Wet Auger refusal at 6.9m, switch to casing, probable cobble						66							
			7	SS	23		65							
64.5														
8.4	Silty SAND, some clay, some gravel Compact Dark Grey Moist (TILL)						64							13 49 25 13
63.8														
9.1	SHALE, highly weathered, grey													
			8	SS	100/		63							
					0.050									

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15 10 5
10 (%) STRAIN AT FAILURE

ONTMT4S 1201B.GPJ 5/10/12

RECORD OF BOREHOLE No P-208

2 OF 2

METRIC

W.P. 4320-06-00 LOCATION St. Laurent Blvd. N 5 031 507.2 E 372 454.6 ORIGINATED BY ES
HWY 417 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
DATUM Geodetic DATE 2012 03 12 - 2012 03 12 CHECKED BY LRB

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							20	40	60	80	100					
62.2			0	SS	100/												
10.7	END OF BOREHOLE AT 10.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 2.4m, CUTTINGS TO 0.7m, HOLEPLUG TO 0.1m THEN ASPHALT TO SURFACE.				0.025												

+³, ×³: Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

METRIC

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No P-210

1 OF 2

METRIC

W.P. 4320-06-00 LOCATION St. Laurent Blvd. N 5 031 522.8 E 372 596.2 ORIGINATED BY ES
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012 03 12 - 2012 03 12 CHECKED BY LRB

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						
73.2								20 40 60 80 100						
0.0	ASPHALT: (100mm)							20 40 60 80 100						
0.1	SAND, some gravel, some silt Grey Damp (FILL)		1	GS			73							
72.1														
1.1	Silty CLAY, some sand Very Stiff Brown (FILL)		1	SS	17		72							0 19 30 51
			2	SS	22									
70.9							71							
2.3	Sandy SILT, some clay, trace gravel, occasional red brick fragments Compact Grey Moist (FILL)		3	SS	22									
70.2							70							
3.0	Silty CLAY, trace sand Stiff to Very Stiff Grey (FILL)		4	SS	12									
							69							
			5	SS	11									0 3 33 64
							68							
							67							
66.6			6	SS	16									
6.6	Sandy SILT, some clay, trace gravel Compact Dark Brown Moist (TILL)						66							
65.5														
7.7	SHALE, highly weathered, grey		7	SS	50/ 0.125		65						FI	RUN #1 TCR=100% SCR=82% RQD=70% UCS=33MPa (Average)
	Cored from 8.0m Moderately to slightly weathered, thinly bedded, horizontally laminated Limestone interbed (25mm thick) at 8.1m, 8.2m, 8.3m, 8.4m, 8.5m, 8.6m, 8.7m Vertical fracture at 8.2m Clay seam (50mm) at 8.8m Soft zone (25mm to 50mm thick) at 8.9m, 9.0m Limestone interbed at 9.1m, 9.3m, 9.4m, 9.5m, 9.6m, 9.8m, 9.9m, 10.0m Sub-vertical fracture (50mm) at 9.2m, (275mm) at 10.2m		1	RUN									>15	RUN #2 TCR=100% SCR=97% RQD=97% UCS=24MPa (Average)
							64						2	
			2	RUN									>10	
													2	

Continued Next Page

+ 3 . X 3 .

Numbers refer to
Sensitivity

20
15
10


(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P-210

2 OF 2

METRIC

W.P. 4320-06-00 LOCATION St Laurent Blvd N 5 031 522.8 E 372 596.2 ORIGINATED BY ES
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2012.03.12 - 2012.03.12 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				FLASTIC 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							20 40 60 80 100									
	Clay seam (25mm thick) at 10.4m, 10.6m Limestone interbed at 10.4m, 10.5m, 10.6m, 10.7m, 10.8m, 10.9m, 11.0m, 11.1m, 11.3m						63								1	RUN #3 TCR=100% SCR=100% RQD=100% UCS=24MPa (Average)	
			3	RUN													>5
																	2
61.8							62								1		
11.4	END OF BOREHOLE AT 11.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 2.7m, CUTTINGS TO 0.9m, HOLEPLUG TO 0.1m THEN ASPHALT TO SURFACE.																

+ 3, x 3, Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P-211

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION St. Laurent Blvd. N 5 031 537.9 E 372 725.3 ORIGINATED BY ES
 HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.03.14 - 2012.03.14 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		FLASTIC 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 (%)					
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE	W _P	W	W _L			
72.7								20	40	60	80	100			
0.0	ASPHALT: (100mm)														
0.1	SAND, some gravel, some silt Brown Damp (FILL)		1	GS											
71.7															
1.0	Silty CLAY, some sand to sandy, trace gravel Very Stiff to Stiff Brown/Grey (FILL)		1	SS	19										
			2	SS	17										0 29 30 41
			3	SS	13										
			4	SS	10										
69.0															
3.7	Silty SAND, some clay, trace gravel Dense Dark Brown Damp (TILL)		5	SS	37										4 48 29 19
68.1			6	SS	100/										
4.6	SHAI F, highly weathered, thinly bedded, horizontally laminated, grey				0.025										
	Cored from 5.3m Limestone interbed at 5.7m, 5.8m, 6.0m, 6.2m, 6.4m, 6.5m, 6.9m Moderately to slightly weathered Highly broken zone (75mm) at 6.6m Sub-vertical fracture at 6.4m, 6.7m		1	RUN									FI >5		RUN #1 TCR=100% SCR=50% RQD=50% RUN #2 TCR=100% SCR=95% RQD=92% UCS=23MPa (Average)
			2	RUN									4 3 3		
	Clay seam (25mm) at 7.1m												>5		
													1		
	Limestone interbeds at 7.2m, 7.3m, 7.4m, 7.8m, 7.9m, 8.1m		3	RUN									>5		RUN #3 TCR=92% SCR=92% RQD=92% UCS=15MPa (Average)
	Sub-vertical fracture at 8.4m												0		
													0		
													1		
													1		
64.1															
8.6	END OF BOREHOLE AT 8.6m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 2.4m, CUTTINGS TO 0.1m, THEN ASPHALT TO SURFACE.														

ONTMT4S 1201B.GPJ 5/10/12

RECORD OF BOREHOLE No P-212

1 OF 1

METRIC

W.P. 4320-06-00 LOCATION St. Laurent Blvd. N 5 031 474.4 E 372 160.0 ORIGINATED BY ES
HWY 417 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2012.03.11 - 2012.03.11 CHECKED BY LRB

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 (%) w _p w w _L						
69.8								20	40	60	80	100							
0.0	ASPHALT: (125mm)																		
0.1	SAND, some gravel, some silt Dense Brown Damp (FILL)		1	GS			69												
68.5			1	SS	49														
1.3	SILT and SAND, trace clay, trace gravel Very Dense to Compact Brown Damp (FILL)		2	SS	72		68											3 46 37 14	
			3	SS	25		67												
66.7																			
3.1	Sandy SILT, trace gravel, trace clay Compact Dark Brown Moist (TILL)		4	SS	23		66												
65.2			5	SS	50/														
4.6	SHALE, moderately to slightly weathered, thinly bedded, horizontally laminated, grey, limestone interbeds through out Soft zone (25mm) at 5.2m 																		

+ 3, X 3 Numbers refer to
Sensitivity

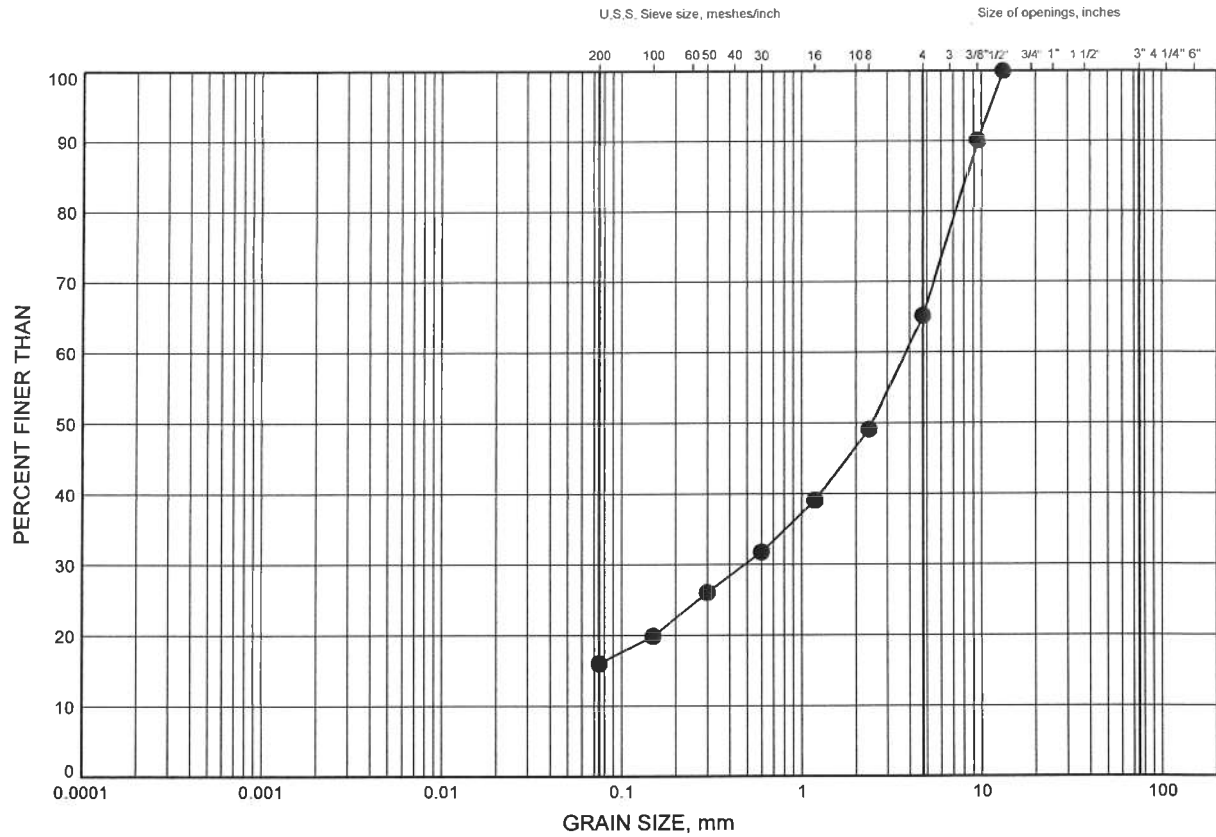
20
15
10

(%) STRAIN AT FAILURE

Highway 417 Ottawa: Vanier to OR 174 GRAIN SIZE DISTRIBUTION

FIGURE B1

Gravelly Sand Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P-207	0.30	71.20

Date May 2012
W.P.# 4320-06-00



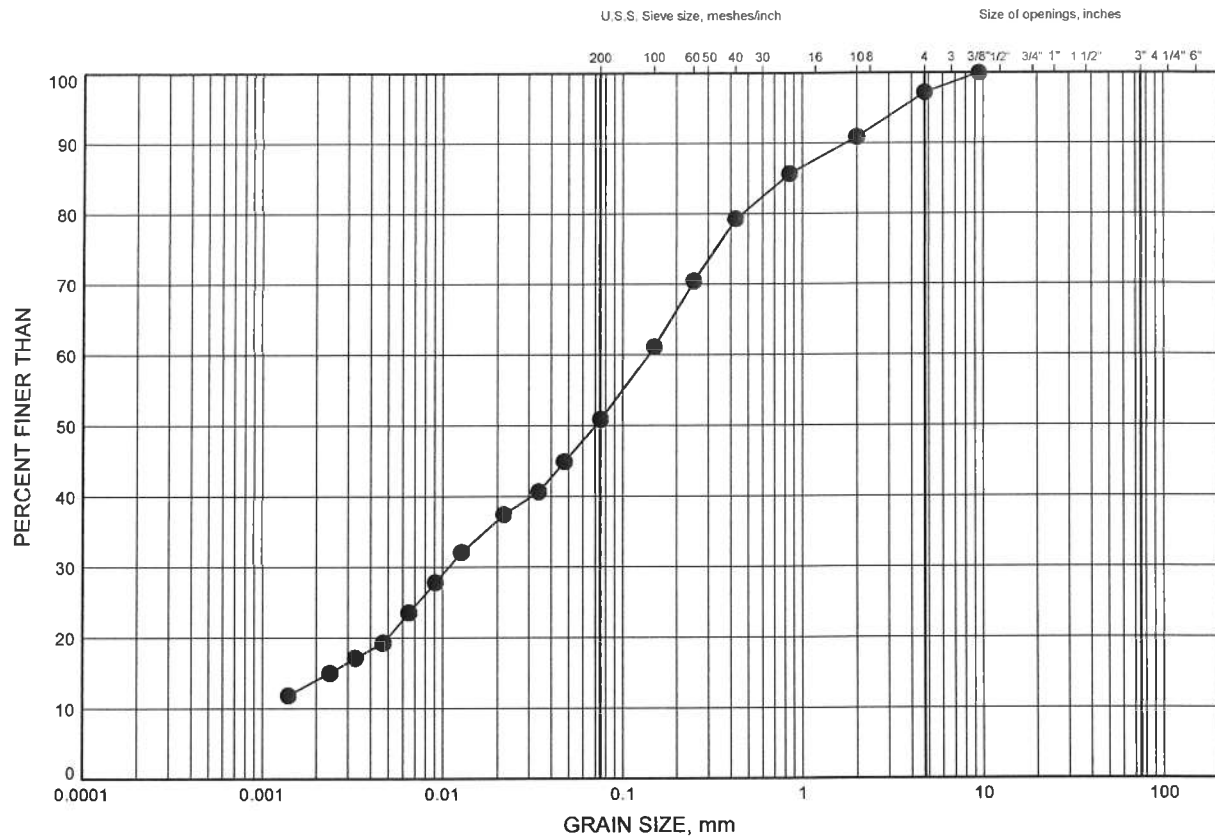
Prep'd MFA
Chkd. LRB

Highway 417 Ottawa: Vanier to OR 174

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silt and Sand Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P-212	1.52	68.28

Date May 2012
W.P.# 4320-06-00

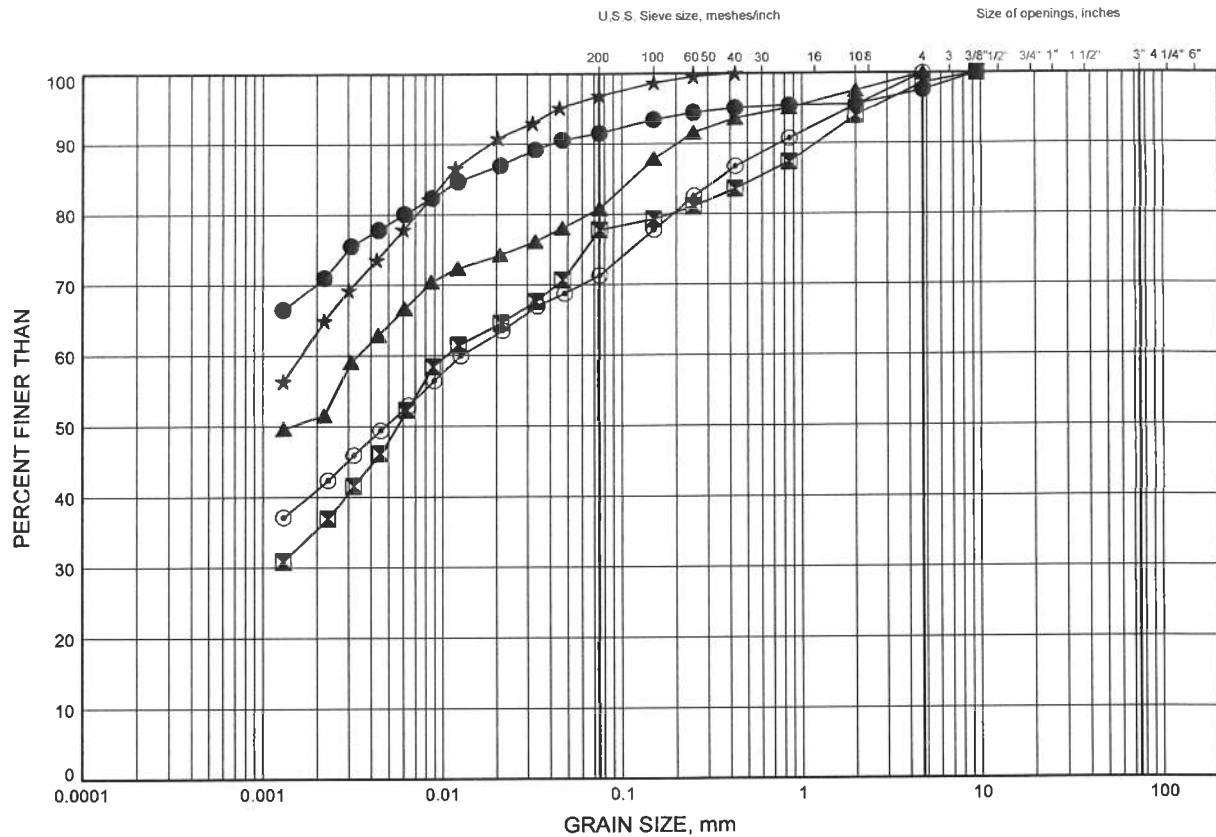


Prep'd MFA
Chkd. LRB

Highway 417 Ottawa: Vanier to OR 174 GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty Clay Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P-208	6.31	66.59
⊠	P-209	1.83	65.16
▲	P-210	1.22	71.98
★	P-210	4.88	68.32
⊙	P-211	1.83	70.87

GRAIN SIZE DISTRIBUTION - THURBER 1201B.GPJ 5/10/12

Date May 2012
W.P.# 4320-06-00

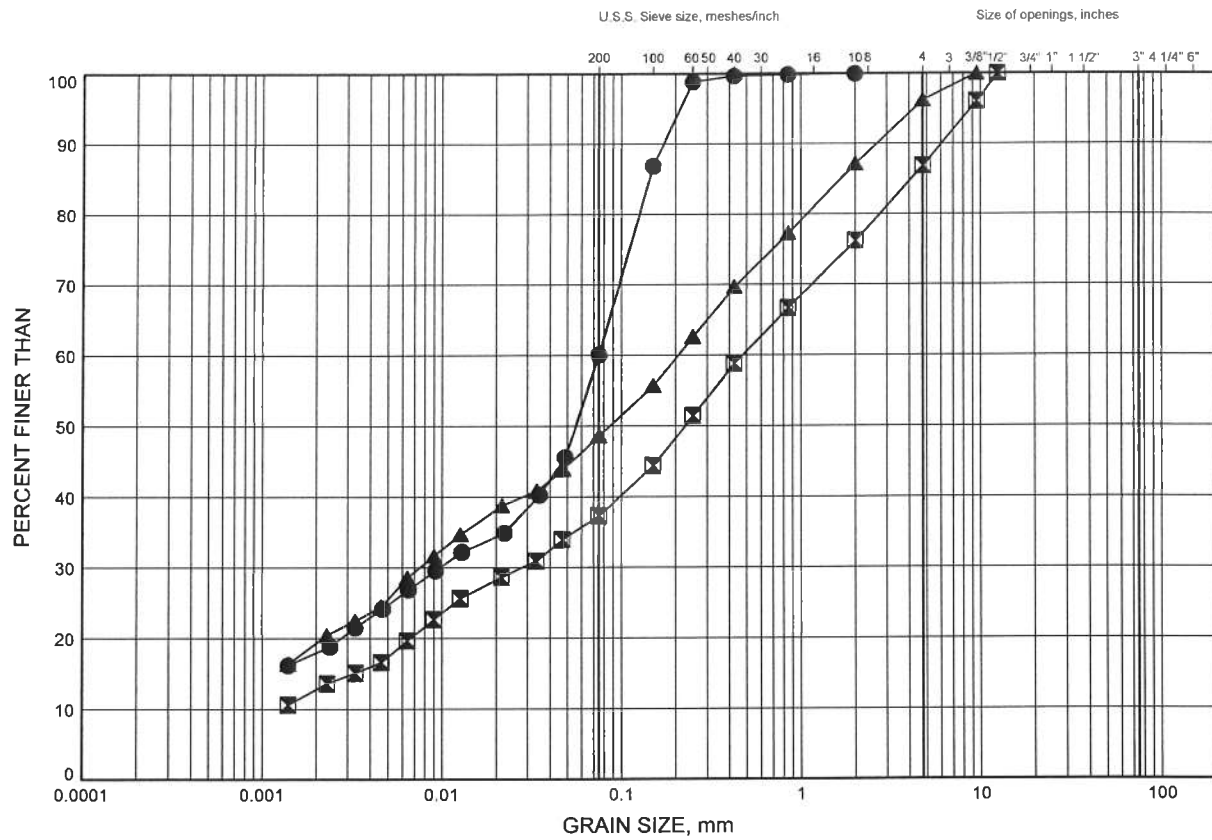


Prep'd MFA
Chkd. LRB

Highway 417 Ottawa: Vanier to OR 174 GRAIN SIZE DISTRIBUTION

FIGURE B4

Silty Sand to Silt and Sand Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P-207	4.88	66.63
⊠	P-208	8.47	64.43
▲	P-211	4.11	68.59

Date May 2012
W.P.# 4320-06-00



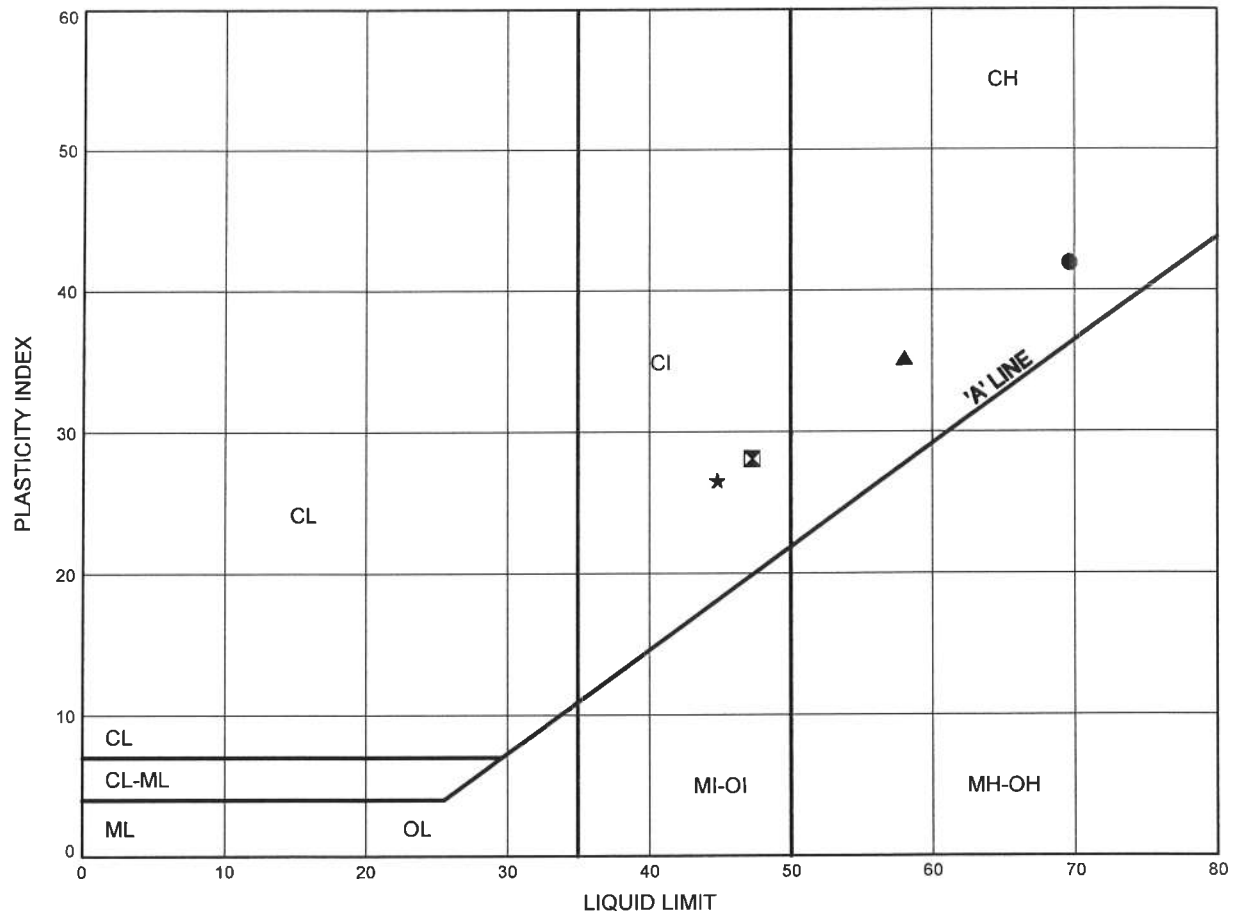
Prep'd MFA
Chkd. LRB

Highway 417 Ottawa: Vanier to OR 174

ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty Clay Fill



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	P-208	6.31	66.59
⊠	P-210	1.22	71.98
▲	P-210	4.88	68.32
★	P-211	1.83	70.87

Date May 2012
W.P.# 4320-06-00



Prep'd MFA
Chkd. LRB

Appendix C

List of Selected SPs and OPSS, and Suggested Text for NSSP

1. List of Special Provisions and OPSS Documents Referenced in this Report

- OPSS 631
- OPSS 902
- OPSS 903

2. Suggested Text for NSSP on:

“Augered Caisson Construction for High Mast Light Pole (HMLP) Foundations”

The Contractor is advised that variable subsurface conditions and bedrock at potentially variable depths/elevations may be encountered at the locations of the HMLP foundations. For additional information regarding subsurface conditions, the Contractor is referred to the Foundation Investigation Report.

The soils on site consist of fill and silty sand till which may contain cobbles, boulders and shale slabs. Further, the till is underlain by shale bedrock containing hard limestone layers. These materials will potentially have an impact on the installation of caissons, such as:

- impeding the advance of the caissons resulting in lower production and faster wear of drilling bits.
- requiring alternate equipment or procedures in cases where obstructions in the fill/till or thick layers of hard limestone in the bedrock are encountered.
- affecting the alignment of the caissons during advancement.

The Contractor is further advised that non-cohesive soils and high groundwater levels are present on site. Non-cohesive soil is susceptible to disturbance under conditions of unbalanced hydrostatic head.

The Contractor is responsible for constructing the caisson excavation without disturbing the sides or base of the excavation, and for cleaning of the socket base. The construction method is the responsibility of the Contractor.

Appendix D

Drawings titled “Borehole Location Plans”

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

CONT No
WP No 4320-06-00



SHEET

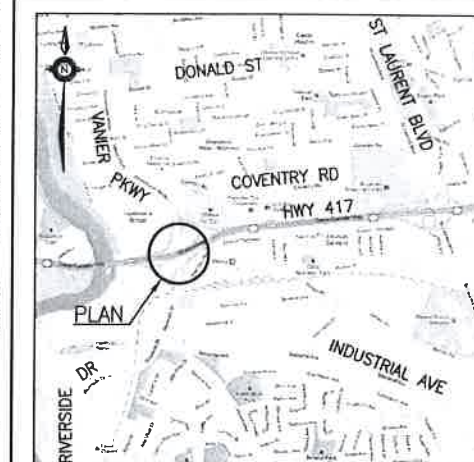
HIGHWAY 417
HIGH MAST LIGHT POLES
RIVERSIDE DR. INTERCHANGE
BOREHOLE LOCATIONS



McCORMICK RANKIN
A member of  MMR GROUP








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
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
P200	58.8	5 031 219.7	370 747.9
P201	59.2	5 031 131.3	370 606.2
P202	60.3	5 031 064.4	370 743.9
P203	64.1	5 031 163.8	370 872.8
P204	61.9	5 031 367.7	370 907.8
P205	60.1	5 031 305.7	371 010.8
P206	60.2	5 031 348.6	371 108.1

-NOTES-

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

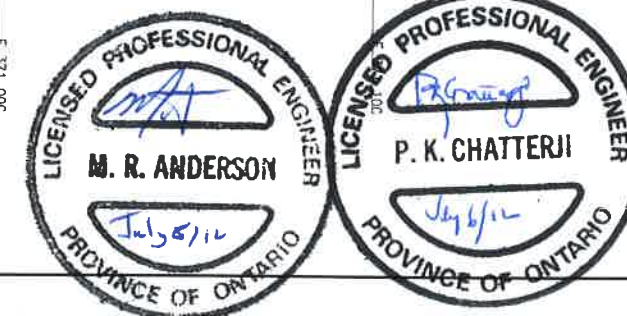
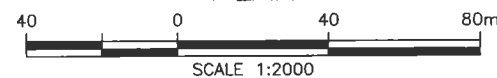
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PLAN



DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

SHEET

LEGEND

- [illegible]

2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS										
	DATE	BY	DESCRIPTION							
DESIGN LRB	CHK MRA	CODE	LOAD				DATE JUL. 2012			
DRAWN MFA	CHK PKC	SITE	STRUCT				DWG 2			

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