THURBER ENGINEERING LTD.

FINAL

FOUNDATION INVESTIGATION AND DESIGN REPORT
STRUCTURE REPLACEMENT
HIGHWAY 417 NICHOLAS STREET UNDERPASS (SITE #3-224)
OTTAWA, ONTARIO

GWP 4048-11-00

Geocres No.: 31G5-289

Report to:

WSP Canada

Latitude: 45.4164
Longitude: -75.6738

April 2018
Thurber File: 17532

TABLE OF CONTENTS

PART 1. FACTUAL INFORMATION

1 INTRODUCTION 1
2 SITE DESCRIPTION 2
3 SITE INVESTIGATION AND FIELD TESTING 2
4 LABORATORY TESTING 3
5 DESCRIPTION OF SUBSURFACE CONDITIONS 4
5.1 Fill Material 4
5.1.1 Fill: Silty Sand 4
5.1.2 Fill: Silty Sand to Sand 4
5.1.3 Fill: Clay 4
5.1.4 Waste Fill 5
5.2 Silty Clay 5
5.3 Silty Sand and Sand 5
5.4 Silt (MH) 6
5.5 Clay 6
5.6 Silt to Sandy Silt (ML) 7
5.7 Glacial Till: Silty Sand (SM) 8
5.8 Bedrock 9
5.9 Groundwater 9
5.10 Analytical Testing 10
6 MISCELLANEOUS 11

PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL 12
7.1 Proposed Structure 12
7.2 Applicable Codes and Design Considerations 13
8 SEISMIC CONSIDERATIONS 13
8.1 Spectral and Peak Acceleration Hazard Values 13
8.2 Seismic Site Classification 14
8.3 Seismic Site-Specific Response Analyses 14

8.4 Seismic Liquefaction Assessment 15
8.5 Seismic Ground Deformation Assessment 16
9 STRUCTURE FOUNDATIONS 17
9.1 Foundation Type 17
9.2 Deep Foundations – Steel Piles 17
9.2.1 Axial Compression 18
9.2.2 Axial Tension 18
9.2.3 Abutment Type 19
9.2.4 Lateral Deflection 19
9.2.5 Pile Installation 21
9.2.6 Downdrag 21
9.2.7 Frost Protection 21
9.3 Deep Foundations – Caissons 22
9.3.1 Axial Compression 22
9.3.2 Caisson Installation 22
9.3.3 Lateral Deflection 23
9.3.4 Downdrag 23
10 APPROACH EMBANKMENTS 23
10.1 Assessment of Settlement 24
10.2 Assessment of Global Stability 25
10.3 Lateral Earth Pressures 25
10.3.1 Static Lateral Earth Pressure Coefficients 26
10.3.2 Combined Static and Seismic Lateral Earth Pressure Parameters 27
10.4 Approach Slab 29
11 RETAINING WALL FOUNDATIONS 29
12 CEMENT TYPE AND CORROSION POTENTIAL 30
13 CONSTRUCTION CONSIDERATIONS 31
13.1 Excavation 31
13.2 Temporary Protection Systems 31
13.3 Groundwater and Surface Water Control 31
13.4 Erosion Protection 33
13.5 Construction Concerns 33
14 CLOSURE 34

APPENDICES

APPENDIX A. BOREHOLE LOCATION PLAN AND STRATIGRAPHIC DRAWINGS
APPENDIX B. RECORD OF BOREHOLE SHEETS AND FIELD TESTING
APPENDIX C. LABORATORY TESTING
APPENDIX D. SITE PHOTOGRAPHS
APPENDIX E. FOUNDATION COMPARISON
APPENDIX F. GSC SEISMIC HAZARD CALCULATION, PRELIMINARY SITE-SPECIFIC RESPONSE SPECTRA, LIQUEFACTION TRIGGERING ANALYSIS, SEISMIC LIMIT EQUILIBRIUM ANALYSES, LATERAL DISPLACEMENT PROFILE
APPENDIX G. SLOPE STABILITY ANALYSIS
APPENDIX H. PILE ANALYSIS – P-Y CURVES
APPENDIX I. LIST OF SPECIAL PROVISIONS AND OPSS DOCUMENTS REFERENCED IN THIS REPORT

FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT
STRUCTURE REPLACEMENT
HIGHWAY 417 NICHOLAS STREET UNDERPASS (SITE #3-224)
OTTAWA, ONTARIO

GWP 4048-11-00

Geocres No.: 31G5-284

PART 1. FACTUAL INFORMATION

1 INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation completed for the proposed structure replacement of the Highway 417 Underpass at Nicholas Street within the City of Ottawa. Thurber Engineering Limited (Thurber) carried out the current investigation as a sub-consultant to WSP Canada (WSP) under G.W.P. 4048-11-00. This work was initially included as part of the 2011 Ottawa Queensway widening project which extended from Nicholas Street to the OR 174 split.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction was developed during the current investigation.

Six foundation investigation reports were obtained from the online Geocres library and reviewed in preparation of this report are as follows:

> Preliminary Foundation Investigation Report for Nicholas St. Underpass, Ottawa Queensway Br. #28, District #9, W.P. 954-59, dated January 30, 1961. [Geocres 31G05-002]
>
> Preliminary Site Investigation, Proposed Queensway – Nicholas Street Interchange, Bridges 38, 39, 40 and 41, Ottawa, Ontario, dated December 1963. [Geocres 31G05-056]
>
> Route Borings, Proposed Stage IV Interchange, Ottawa Queensway – Bridge 38, W.P. 949-59-3, Ottawa, Ontario, dated April 1964. [Geocres 31G05-061]
>
> Site Investigation, Proposed Canal Road Bridge No. 38, Stage IV Interchange, Ottawa Queensway, W.P. 954-59, Ottawa, Ontario, dated March 1964. [Geocres 31G05-062]
>
> Preliminary Foundation Report for Proposed Structure Sites, Hwy. #417 (Ottawa Extension), Ottawa Queensway (at Nicholas Street), Easterly to Alta Vista Drive, District No. 9 (Ottawa), W.J. 69-F-34 – W.P. 13-68, dated November 4, 1969. [Geocres 31G05-112]

Foundation Investigation and Design Report, Retaining Walls and Noise Barrier Walls, Highway 417 Widening, Nicholas Street to O.R. 174, Ottawa, Ontario, G.W.P. 4091-07-00 and 4320-06-00, dated August 24, 2012. [Geocres 31G5-250]

A review of these documents indicated that due to significant modifications to the area since the investigations were carried out, most available data provided only background information. However, five boreholes extracted from Reports 31G05-056, 31G05-062 and 31G-250 have been included in this document and indicate that the site is generally underlain by granular fill overlying a cohesive deposit of native silty clay to clayey silt over a non-cohesive silt to sand over glacial till. Shale bedrock was encountered at elevations ranging from 44.9 to 45.8 m within the depth of investigation. Groundwater was reported at elevations ranging from 55.7 to 57.5 m.

2 SITE DESCRIPTION

The existing bridge consists of three spans and was built in 1966. The bridge has two southbound lanes and two northbound lanes (only one is currently in use) divided with a raised median. It is approximately 22 m wide and approximately 77m long with a general north to south alignment and a road surface elevation of approximately 66.5 m.

At the location of the bridge (Linear Highway Referencing System Base Point: 49389, Offset: 0.00), Highway 417 is a six-lane divided highway. The bridge also spans the N-E ramp. Concrete jersey barrier guiderails are present on both sides of the highway in the vicinity of the bridge as well as between the eastbound and westbound lanes as a concrete median. The land adjacent to the highway is occupied by apartment buildings, single family dwellings and commercial use. The 2016 AADT traffic volumes on Highway 417 are understood to be 169,700 and 169,500, west and east of Nicholas Street, respectively.

Historical GA drawings of the existing structure show the abutment and pier structures supported on 12 BP53 steel H-pile foundations extending to bedrock (W.P. 954-59 Drawing D5474-1, dated January 1965). No obvious signs of settlement or instability of the structure foundations were observed during the investigation. The embankments in the vicinity of the structure are sloped at 2H:1V with manicured grass vegetation. At the time of the investigation, no obvious signs of instability or erosion of the embankments were noted.

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

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing program was carried out between October 12th to 25th, 2017. The field investigation consisted of advancing six boreholes identified as 17-01 through 17-06. The drilling was carried out using a track mounted CME 550 drill rig. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations. Although no boreholes were drilled on the roadway, traffic protection services were utilized to mobilize and demobilize the drilling equipment to and from the borehole locations. This included various shoulder and lane closures.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). In-situ vane shear testing was completed in the cohesive soil deposits using an MTO ‘N’ sized vane. One Thin Walled (Shelby) Tube sample of clay was retrieved from each Borehole (except from 17-06) to obtain a relatively undisturbed soil sample for further laboratory testing. The boreholes were drilled and sampled to depths ranging from 15.1 to 22.1 m (elev. 40.6 to 48.0 m) below the existing ground surface. Bedrock was encountered and cored in Boreholes 17-02, 17-03, 17-04 and 17-05.

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

A vibrating wire piezometer was installed in Borehole 17-04 with its sensor tip at a depth of 16.4 m (elev. 46.2 m) to allow for measurements of the groundwater level after completion of drilling. Following completion of the field investigation, the vibrating wire piezometer will be decommissioned. The boreholes were backfilled in general accordance with MOEE requirements (O.Reg. 903).

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

Multi-Channel Analysis of Surface Waves (MASW) testing was carried out by Geophysics GPR International Inc. on October 30, 2017. The results from the field investigation are provided in Appendix B. The MASW testing was completed on the north side of Highway 417 near parallel to the highway alignment. The approximate location of the MASW testing is included on Drawing 1 of Appendix A.

4 LABORATORY TESTING

The recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to gradation analysis (hydrometer and/or sieve) and Atterberg Limit testing. Three samples of soil recovered from within Boreholes 17-02, 17-03 and 17-05 were selected and submitted for analytical testing of corrosivity parameters and sulphate content. Two samples of waste fill material recovered within Boreholes 17-05 and 17-06 were selected and submitted for organic content testing. Selected waste fill samples recovered within Boreholes 17-04 and 17-5 were also submitted for gradation analysis and natural moisture content determination. One sample of the bedrock from Borehole 17-04 was selected and submitted for unconfined compressive strength testing. One consolidation test was carried out on a relatively undisturbed clay sample from within Borehole 17-01. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were determined.

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

5 DESCRIPTION OF SUBSURFACE CONDITIONS

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

In general terms, the site was found to be underlain by a thin layer of silty sand with organics at surface. The surficial material north of Highway 417 was generally underlain by granular fill over a non-cohesive silt and cohesive native clay deposit over a layer of silt to sand over glacial till over bedrock. The surficial material south of Highway 417 was generally underlain by granular fill over a fill with waste debris over a cohesive native clay deposit over a silt layer over glacial till over bedrock.

5.1 Fill Material

5.1.1 Fill: Silty Sand

All Boreholes encountered a layer of silty sand with organics at ground surface with a thickness of 100 mm to 300 mm. Recorded moisture contents ranged from 16 to 37%.

5.1.2 Fill: Silty Sand to Sand

Below the surficial organic silty sand in all boreholes was a layer of fill consisting of sand to silty sand with various amounts of gravel. Waste debris, such as coal, wood fragments, ash, glass, plastic and tar, was also encountered throughout the fill material in most boreholes. The fill was 1.4 to 5.2 m thick with the base elevation of the fill at 55.8 to 59.4 m.

The SPT tests conducted in the fill gave N-values typically ranging from 1 to 40 blows indicating a relative density of very loose to dense.

Recorded moisture contents ranged from 4 to 105% within the fill. The results of grain size analyses conducted on seven samples of the fill materials are summarized below and are illustrated on Figures C1 and C2 in Appendix C.

Soil Particle	Percentage (%)
Gravel	1 – 40
Sand	52 – 95
Silt	4 – 16
Clay	

5.1.3 Fill: Clay

Below the granular fill in Borehole 17-05 was a layer of fill consisting of cohesive clay with silty sand. Waste material, such as coal, wood fragments, ash, glass and plastic, was also encountered throughout this fill material. This clay fill was 1.7 m thick with the base elevation at 57.7 m.

The SPT tests conducted in the fill gave N-values typically ranging from 4 to 13 blows indicating a firm to stiff consistency.

No moisture contents were retrieved from this layer due to the presence of possible contamination. The result of a grain size analysis conducted on one sample of the material indicated 2% gravel, 44% sand, 33% silt and 21% clay and is illustrated on Figure C3 in Appendix C.

Atterberg Limit testing was completed on one sample of the clay fill material. The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limit graph is included in Figure C12 of Appendix C. The laboratory results were a Liquid Limit of 31%, a Plasticity Limit of 19% and a Plasticity Index of 12%, which indicate that the clay fill has low plasticity (CL).

5.1.4 Waste Fill

Boreholes 17-04, 17-05 and 17-06 drilled in the vicinity of the proposed south abutment and approach encountered a layer of fill material consisting of debris such as coal, tar, wood fragments and ash intermixed with silty sand with traces of gravel below the fill described above. The waste layer ranged in thickness from 1.9 to 3.1 m with a base elevation of 55.3 to 55.7 m.

Recorded moisture contents ranged between 41 and 56%. The results of grain size analyses conducted on two composite samples of the waste fill are summarized below and are provided in Figure C4 Appendix C.

Soil Particle	Percentage (%)
Gravel	6 – 7
Sand	65 – 71
Silt	23 – 28
Clay	

The organic content of this layer was measured and ranged from 15 to 24 %.

5.2 Silty Clay

A thin deposit of silty clay with sand pockets and a thickness of only 300 mm was encountered below the sand fill at Borehole 17-03. The recorded moisture content was 37%.

A single SPT test conducted in this silty clay gave an N-value of 9 blows indicating a stiff consistency for the layer.

5.3 Silty Sand and Sand

A layer of sand with silt to silty sand was encountered below the fill material in Borehole 17-02 and below the thin silty clay deposit in Borehole 17-03. Traces of gravel were also encountered in this layer at Borehole 17-02. It is noted that organics and frequent wood fragments were identified below 3.0 m in Borehole 17-03. A thickness of 0.4 to 2.5 m and an underside depth of 4.3 to 4.6 m (elev. 55.2 to 55.4 m) were recorded for this layer.

The SPT tests conducted in this sand gave N-values typically ranging from 2 to 9 blows indicating a relative density of very loose to loose. A single SPT N-value of over 100 blows for 152 mm was noted within Borehole 17-03, which indicated a very dense pocket containing wood fragments within the native sand deposit.

Recorded moisture contents typically ranged from 22 to 59%. A single moisture content as high as 77% was observed in Borehole 17-03. The large range in moisture content can be attributed to the variable presence of organic material encountered in this deposit and the presence of a low permeability layer directly below the sand. The result of a grain size analysis conducted on one sample of the native sand was 0% gravel, 89% sand, 11% silt and clay and is illustrated on Figure C5 in Appendix C.

5.4 Silt (MH)

A thin layer of silt with sand was encountered below the fill material in Borehole 17-01. A thickness of 0.9 m and an underside depth of 6.2 m (elev. 55.6 m) were recorded for this layer.

The SPT tests conducted in this silt gave N-values typically ranging from 2 to 3 blows indicating a relative density of very loose.

The moisture content of the samples tested ranged from 56 to 78%. The result of a grain size analysis conducted on one sample of the native silt was 0% gravel, 22% sand, 36% silt and 42% clay and is illustrated on Figure C6 in Appendix C.

Atterberg Limit testing was also completed on one sample of the native silt deposit. The result is summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limit graph on Figure C13 of Appendix C. The laboratory results yielded a Liquid Limit of 72%, a Plastic Limit of 39% and a Plasticity Index of 33%, which indicates that the silt is highly plastic (MH).

5.5 Clay

A native deposit of clay with occasional sand seams was encountered directly below the silt deposit (described in Section 5.4) in Borehole 17-01, below the sand deposits in Boreholes 17-02 and 17-03 and below the waste fill material in Boreholes 17-04, 17-05 and 17-06. The clay deposit had a thickness ranging from 2.6 to 3.8 m, reaching an underside depth of 7.6 to 10.7 m (elevation of 51.9 to 53.0 m). The SPT N-values ranged from 1 to 12 blows. Field vane tests were performed within the deposit and recorded undrained shear strengths ranging from 47 to 106 kPa indicating a general consistency of stiff to very stiff. Remolded field vane testing in this deposit yielded sensitivity values ranging from 3 to 10 indicating medium sensitivity to extra sensitive (CFEM 2010, errata).

The moisture content of the samples tested ranged from 32 to 59%. The results of grain size analyses conducted on seven samples of the native clay are summarized below and are illustrated on Figures C7 and C8 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0 – 1
Sand	1 – 5
Silt	43 – 67
Clay	32 – 56

Atterberg Limit testing was completed on seven samples of the native clay deposit. The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limit graphs are included in Figure C14 and C15 of Appendix C. The laboratory results are summarized below and indicate that the clay is of low to intermediate plasticity (CL - CI).

Parameter	Value
Liquid Limit	27 – 49
Plastic Limit	17 – 22
Plasticity Index	9 – 28

The consolidation test results that was carried out on a sample retrieved from Borehole 17-01 at a depth of approximately 7.9 m (elev. 54.0 m) are presented in Appendix C and are summarized below. The table below is supplemented with consolidation results from historic reports.

Parameter	BH17-01 Sample 10	BH1* Sample 7	BH1* Sample 9	BH2* Sample 7
Elevation	53.9 m	60.0 m	53.9 m	54.6 m
w	36.7%	28.0%	40.5%	39.5%
e_o	1.015	0.754	1.273	0.923
p_o'	150 kPa	105 kPa	115 kPa	110 kPa
p_c'	270 kPa	305 kPa	295 kPa	485 kPa
C_c	0.33	0.269	0.642	0.536
C_r	0.032	0.014	0.057	0.049
c_v	0.613 mm^2/s	0.43 mm^2/s	0.22 mm^2/s	0.108 mm^2/s
c_{vr}	0.826 mm^2/s	-	-	-

*From Geocres Report No. 31G05-056

5.6 Silt to Sandy Silt (ML)

A deposit of silt to sandy silt with varying amounts of gravel was encountered below the clay deposit in all boreholes. The silt deposit ranged in thickness from 1.6 to 3.4 m with an underside depth of 9.2 to 13.4 m (elev. 49.2 to 50.4 m).

The SPT N-values ranged from WH to 9 blows indicating a relative density of very loose to loose.

The moisture content of the samples tested ranged from 7 to 28%. The results of grain size analyses conducted on seven samples of the silt are summarized below and are illustrated on Figure C9 and C10 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0 – 26
Sand	1 – 38
Silt	30 – 90
Clay	5 – 9

Atterberg Limit testing was attempted on six samples of the native silt to sandy silt deposit. The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limit graphs are included in Figure C16 of Appendix C. The laboratory result for one sample in Borehole 17-01 is summarized below. The remaining five tests indicated that the silt is generally non-plastic.

Parameter	Value
Liquid Limit	10
Plastic Limit	9
Plasticity Index	1

5.7 Glacial Till: Silty Sand (SM)

Glacial till consisting of a silty sand with varying amounts of gravel and occasional sand beds was encountered below the silt deposit in all boreholes. The till contained occasional to frequent occurrences of cobbles, most notably in the lower part of the deposit. Boreholes 17-01 and 17-06 were terminated within this layer at final depths of 15.1 m (elev. 46.8 and 48.0 m). The glacial till deposit was fully penetrated in all remaining boreholes and the total thickness ranged from 3.7 to 6.0 m with an underside depth of 14.8 to 18.4 m (elev. 44.4 to 45.4 m).

The SPT N-values ranged from 2 to 63 blows indicating a relative density of very loose to very dense. Higher SPT N-values may indicate the presence of cobbles and boulders throughout the glacial till deposit. One high SPT N-value of 100 blows for 203 mm penetration in Borehole 17-02 indicates sample refusal at the bedrock surface rather than the density of the glacial till.

The moisture content of the samples tested ranged from 4 to 28%. The results of grain size analyses conducted on six samples of the glacial till are summarized below and are illustrated on Figure C11 in Appendix C.

<table>
<tr><th>Soil Particle</th><th colspan="2">Percentage (%)</th></tr>
<tr><td>Gravel</td><td colspan="2">6 – 31</td></tr>
<tr><td>Sand</td><td colspan="2">27 – 54</td></tr>
<tr><td>Silt</td><td>53</td><td rowspan="2">19 – 34</td></tr>
<tr><td>Clay</td><td>14</td></tr>
</table>

Atterberg Limit testing was attempted on one sample of the glacial till deposit. The laboratory results indicate that the material is non-plastic.

It should be noted that glacial tills inherently contain cobbles and boulders throughout their deposit.

5.8 Bedrock

Shale bedrock was encountered within Boreholes 17-02 to 17-05, inclusive. The bedrock surface ranges from elevation 44.4 to 45.4 m and is summarized in the table below:

Location	Borehole No.	Depth Below Existing Ground Surface (m)	Bedrock Surface Elevation (m)
Northern Abutment	17-02	15.1	44.8
Southern Pier	17-03	14.8	44.7
Southern Abutment - West	17-04	17.1	45.4
Southern Abutment - East	17-05	18.4	44.4

The Total Core Recovery (TCR) was consistently 100%, the Solid Core Recovery (SCR) ranged from 69 to 100% and the Rock Quality Designation (RQD) ranged from 40 to 90%. Based on the RQD values, the bedrock below a surficial weathered zone is classified as poor to good quality.

The unconfined compressive strength of the Shale Bedrock was measured to be 54.7 MPa from a core sample in Borehole 17-04, indicating strong bedrock. The results are included in Appendix C.

5.9 Groundwater

At the completion of drilling, a vibrating wire piezometer was installed in Borehole 17-04 with its sensor tip at a depth of 16.4 m (elev. 46.2 m) to allow for measurements of the groundwater level. The groundwater level was measured at approximately 10.4 m (elev. 52.2 m) on November 27th, 2017 and March 22, 2018. The groundwater level in the historic GEOCRES boreholes ranged from elevation 55.7 to 57.5 m.

It is noted that the OC Transpo line, approximately 150 m east of the Nicholas Interchange, was constructed in a cut section after the historic boreholes were drilled. The top of pavement has an elevation of approximately 54 m which will, at least partially, control groundwater levels in the area. These observations are considered short term and it should be noted that the groundwater level at the time of construction may be higher and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

5.10 Analytical Testing

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

Borehole	Sample	Depth (m)	Sulphate (μg/g)	pH (-)	Resistivity (Ohm-cm)	Chloride (μg/g)
17-02	SS3	1.5 – 2.1	487	7.46	1930	23
17-03	SS3B	1.8 – 2.1	87	7.60	750	838
17-05	SS3	1.5 – 2.1	<5	7.55	16200	<5

6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features and the anticipated foundation locations. The as-drilled locations and ground surface elevation were measured by Thurber following completion of the field program and reference Benchmark 001196530407 provided by WSP.

George Downing Estate Drilling Ltd. of Hawksbury, Ontario supplied and operated the drilling equipment to conduct the drilling, soil sampling, in-situ testing, vibrating wire piezometer installation and borehole decommissioning of the on-road boreholes. The field investigation was supervised on a full-time basis by Miss Katya Edney, P.Eng. of Thurber. Overall supervision of the investigation program was provided by Mr. Stephen Peters, P.Eng. MASW testing was completed by Geophysics GPR International Inc of Longueuil, Quebec.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario, however, selected routine geotechnical laboratory testing on the waste fill samples was completed by Stantec and Eurofins Laboratories in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario. Advanced geotechnical laboratory testing (consolidation testing and unconfined compressive strength testing) was carried out by Stantec laboratories. Interpretation of the factual data and preparation of this report were carried out by Miss Katya Edney, P.Eng. and Mr. Stephen Peters P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.

LICENSED PROFESSIONAL ENGINEER
K. L. EDNEY
100188777
April 10/18
PROVINCE OF ONTARIO

Katya Edney, P.Eng.
Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
F. J. GRIFFITHS
April 10/18
PROVINCE OF ONTARIO

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

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
April 10/16
PROVINCE OF ONTARIO

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

FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT STRUCTURE REPLACEMENT HIGHWAY 417 NICHOLAS STREET UNDERPASS (SITE #3-224) OTTAWA, ONTARIO

GWP 4048-11-00

Geocres No.: 31G5-284

PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This section of the report presents interpretation of the factual data in Part 1 of this report for the proposed structure replacement of the Highway 417 Underpass at Nicholas Street within the City of Ottawa. Geotechnical assessment and recommendations are provided to assist the design team in designing a suitable foundation for the proposed replacement bridge.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The construction or design-build contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The existing bridge consists of three spans and is understood to have been built in 1966. The bridge has two southbound lanes and one northbound lane and a raised median. The existing structure is approximately 22 m wide and the total span is approximately 77 m long with a general north to south alignment and a road surface elevation of approximately 65 m. The abutments and piers were designed to be supported on vertical and battered H-piles bearing on bedrock.

The following sections address the foundation aspects of the new bridge. The discussions and recommendations presented in this report are based on the information provided by WSP and on the factual data obtained during the course of the investigation.

7.1 Proposed Structure

Based on a preliminary General Arrangement (GA) drawing dated August 2017, it is understood that the existing bridge structure will be replaced on a new alignment approximately 45 m west of the existing alignment. The centerline of the approach embankments will be built approximately 4.0 and 8.0 m above the existing grades at the south and north approaches, respectively.

The structural design shown on the General Arrangement (GA) drawing consists of steel box girders with 2-spans and a total length of approximately 87.3 m. The base of the abutments are shown at approximate elevation 62.0 and 60.5 m for the north and south abutments, respectively. Concrete wingwalls will support the approach embankment backfill.

As part of the Nicholas Street Underpass Bridge replacement, it is understood that there are proposed modifications to the slope of the W-N Ramp of the Nicholas Interchange adjacent to Lees Avenue. An e-mail provided by WSP dated September 8, 2017 discussed the options for design. Further design recommendations are provided in this report.

7.2 Applicable Codes and Design Considerations

The geotechnical assessment presented below has been prepared based on the available data regarding the proposed foundations and existing ground conditions and in accordance with the Canadian Highway Bridge Design Code (CHBDC), version CSA S6-14. A memo to MTO Bridge Office from WSP dated March 23, 2018 outlined assumptions that were made for structural design to supplement the Code. These assumptions include:

- Load combination of kinematic and inertia loadings
- An exemption of Clause 6.17.3.1 of the CHBDC

In accordance with CHBDC CSA S6-14, the analysis and design of structures takes into consideration the importance of the structure and the consequence associated with exceeding limit states. The importance category and consequence classification are defined by the Regulatory Authority, which in this case is the Ministry of Transportation, Ontario (MTO).

It is understood that MTO has designated this structure as follows:

Table 7-1: Bridge Structure Classification

Criteria	Classification	CHBDC Section
Importance Category	Major-Route Bridge	4.4.2
Consequence Classification	Typical Consequence	6.5.1

Based on the above, a consequence factor (Ψ) of 1.0, as per Table 6.1 of the CHBDC, has been used in assessing factored geotechnical resistances. If the consequence classification changes, the geotechnical assessment and recommendations will need to be reviewed and revised.

As per Section 6.5.3.2 of the CHBDC, the degree of site and prediction model understanding is considered “Typical Understanding”.

8 SEISMIC CONSIDERATIONS

8.1 Spectral and Peak Acceleration Hazard Values

The seismic hazard data for the CHBDC is based on the fifth-generation seismic model developed by the Geological Survey of Canada (GSC). Seismic hazard data for this site has been obtained from the GSC’s seismic hazard calculator. The data includes peak ground acceleration (PGA), peak ground velocity (PGV), and the 5% damped spectral response acceleration values (Sa(T)) for the reference ground condition (Site Class C) for a range of periods (T) and for a range of return periods including the 475-year, 975-year and 2475-year events. The GSC seismic hazard calculation data sheet for this site is presented in Appendix F.

The site coefficients used to determine the design spectral acceleration and displacement values are a function of the Site Class and the peak ground acceleration (PGA). The Site Class C equivalent PGA_{ref} value for this site with a 2% probability of exceedance in 50 years (2475-year event) is 0.281g. This value is to be scaled by the F(PGA) as outlined in Section 10.3.2.

8.2 Seismic Site Classification

The Site Class was assessed, in part, based on the harmonic mean of the shear wave velocity within the upper 30 m, Vs_{30}, measured during the geophysical investigation using Multi-Channel Analysis of Surface Waves (MASW). The results of the seismic testing conducted in the vicinity of the north abutment indicate that the average Vs_{30} for the project site is 390 m/s (a copy of the results is provided in Appendix B). It is noted that the MASW testing undertaken near the north abutment did not capture the anticipated ground response of the waste fill present near the south abutment. The seismic site classification based on the MASW testing corresponds to a Site Class C (Vs = 360 to 760 m/s). **However, the saturated and loose non-cohesive soils present below the clay and extending across the site are likely to liquefy during the design seismic event (see Section 8.4).** Therefore, the structure should be designed based on a site-specific response. Additional discussion is presented in the following section.

8.3 Seismic Site-Specific Response Analyses

One dimensional site-specific response analyses (SSRA) were completed using the program Deepsoil to determine the 5% damped spectral acceleration (Sa) at a depth corresponding to the base of the abutments for earthquakes with a return period of 2,475, 975 and 475 years. The layers forming the analyzed soil column are characterized by thickness, total mass density, shear wave velocity (Vs) and shear modulus degradation and damping ratio curves, which depend on soil type. Ground motion time histories from past earthquakes were scaled to match the uniform hazard associated with 2%, 5% and 10% probabilities of exceedance in 50 years, which corresponds to 2,475, 975 and 475-year return periods, respectively.

Figures 1 to 3 in Appendix F show the recommended site-specific response spectrum for the site for earthquakes with 2,475, 975 and 475 year return periods, respectively. For comparison purposes, the code based response spectra for Site Class A, B, C, D and E are also plotted. A summary of the site-specific response spectrums for the three earthquake return periods is presented in Table 8-1.

Table 8-1: Site Specific Response Spectra Envelopes for

Period, T (s)	Spectral Acceleration, Sa (g)		
	475-Year (Figure 3*)	975-Year (Figure 2*)	2475-Year (Figure 1*)
10	0.002	0.003	0.004
5	0.005	0.006	0.009
2	0.01	0.02	0.03
1	0.03	0.05	0.07
0.7	0.05	0.08	0.15
0.5	0.08	0.14	0.20
0.35	0.20	0.35	0.68
0.25	0.62	0.93	1.40
0.01	0.62	0.93	1.40

Note: (*) figures provided in Appendix F

As shown on Figure 1, significant amplification of the spectral acceleration due to the presence of the waste material is estimated if the period of interest of the replacement structure is less than 0.4 seconds. If the period of the structure is greater than 0.4 seconds, the importance of the presence of the waste material is significantly reduced.

If the natural period of the structure is assessed to be less than 0.4 seconds, the Structural Engineer should determine if the bridge could be designed with Sa values provided in Figure 1. If the structure has a period of less than 0.4 seconds and cannot be designed based on parameters provided in Figure 1, consideration should be given to increasing the pile/caisson size.

Additionally, a cost assessment could be completed taking into consideration the replacement of the waste material in the vicinity of the south abutment with engineered fill to reduce the design spectral acceleration values shown in Figures 1 to 3 (Appendix F). However, It is anticipated that the cost implications of soil replacement will be high due to the environmental quality of the material and the potential need to install roadway protection near the existing bridge and embankment.

8.4 Seismic Liquefaction Assessment

The potential for liquefaction has been assessed in accordance with CHBDC Section 4.6.6.1.

Preliminary assessment indicates that the cohesive material at this site is not liquefiable. However, sensitive clays with a natural water content that exceeds the liquid limit or a sensitivity greater than 7 are generally assumed to have a post-seismic residual strength equal to the remoulded strength of the soil (which is significantly low for the clay at this site). Site specific cyclic testing of the clay is not available at this site however, based on the laboratory testing conducted on clays with the same geologic origin at other locations in the

Ottawa region the post cyclic shear strength (seismically reduced undrained shear strength) of the clay is anticipated to be about 75% of its undisturbed undrained shear strength.

The assessment of the potential liquefaction of non-cohesive soils is generally conducted based on SPT and CPT tests and shear wave velocity measurements. Liquefaction assessment of the saturated non-cohesive soils encountered below the clay indicates that the very loose to loose sandy silt to silt will likely be liquefiable for an earthquake with a return period of 2,475 years (Figure 5 in Appendix F). The approximate zones of potential liquefaction at each of the structure elements are as follows:

- **North Abutment:** 1.9 m to 3.4 m thick layer of very loose to compact saturated silt to silt and sand which was encountered in Boreholes 17-01 and 17-02 at Elevation 53.0 m and 52.1 m, respectively.
- **Pier:** 1.6 m thick layer of saturated non-plastic silt which was encountered in Borehole 17-03 at about Elevation 51.9 m.
- **South Abutment:** 2.3 m to 3.0 m thick layer of very loose to loose saturated non-plastic silt which was encountered in Boreholes 17-04 to 17-06 at Elevation 51.9 m to 52.8 m.

The results of the analysis indicate that the subsurface soils at the site will likely not liquefy under earthquakes with a return period of 475 or 975 years (Figure 5 in Appendix F).

The General Arrangement (GA) drawings provided by WSP proposed the use of integral abutments for the replacement bridge. However, Section 6.17.3.1 of the CHBDC indicates that integral abutments shall not be used where the soil is susceptible to liquefaction. As indicated in Section 7.2, WSP has submitted a memo to MTO Bridge Office with justification for an exemption to this clause.

8.5 Seismic Ground Deformation Assessment

An evaluation of the potential for lateral displacement was completed utilizing limit equilibrium methods. The results of pseudo-static (seismic) slope stability analysis using Slope/W with reduced shear strength of the soils at the site indicates that the factor of safety against instability immediately following an earthquake with a return period of 2,475 years is greater than 1.1 (Figure 6 in Appendix F). Therefore, a flow slide (i.e., very large deformations) is not anticipated at the site after an earthquake with a return period of 2,475 years. However, some liquefaction-induced permanent deformation is expected during the 2,475-year earthquake.

The potential magnitude of lateral deformation was evaluated to be as much as 12 mm using limit equilibrium and Newmark methods. Liquefied and reduced strength parameters were used to estimate a yield acceleration (Figure 7 of Appendix F). The yield acceleration was used to estimate lateral displacements using the rigorous Newmark method. Time histories for the rigorous Newmark analysis were output from the site-specific response analysis discussed in Section 8.3. the results of the analysis indicate that there is potential for lateral displacement in the longitudinal direction. The potential for lateral displacement in the transverse direction is considered to be negligible.

Post-liquefaction settlements were estimated in the very loose to loose layers near the abutments and pier using Figure C4.29a of the CHBDC. Vertical settlements of 60 mm to 150 mm are anticipated in the liquefied layer based on estimated volumetric strains correlated from CSR and corrected standard penetration values. This will induce downdrag loads on deep foundations.

9 STRUCTURE FOUNDATIONS

9.1 Foundation Type

The results of the field and laboratory investigation with reference to historical data indicate that the soil stratigraphy consists of fill material, localized waste deposits, and native sandy material over a clay deposit over a silt and glacial till on bedrock.

Key elevations are as follows:

• Existing ground surface at the proposed pier	59.5 m
• Existing ground surface at the proposed abutments	60.0 to 61.8 m
• Surface of glacial till deposit	49.2 to 50.4 m
• Surface of bedrock where cored (Boreholes 17-02 to 17-05)	44.4 to 45.4 m

The clay across the site ranges in thickness from 2.6 to 3.8 m and can generally be characterized as medium sensitivity to extra sensitive with intermediate to high plasticity (see Section 5.5). The clay is generally stiff to very stiff with strength increasing gradually with depth. There is a risk of differential settlement if the bridge abutments and pier were to be supported on the clay stratum. Therefore, from a geotechnical perspective, it is not recommended to support the foundation loads associated with the proposed abutments and piers with spread footing foundation bearing on the clay stratum.

The glacial till deposit generally consisted of silty sand with gravel and occasional cobbles and boulders.

Based on the soil stratigraphy, proximity of sound bedrock and anticipated structural loads, deep foundations driven or founded into bedrock are recommended at this site for the abutment and pier locations.

The slenderness of the deep foundation element becomes relevant when taking into consideration the lateral demands due to seismic events. Therefore, the following deep foundation alternatives were considered feasible, with a comparison of the technical advantages and disadvantages presented in Appendix E:

1. Steel H-piles
2. Caissons (drilled shaft piles)

9.2 Deep Foundations – Steel Piles

Due to the anticipated length of the piles, it is recommended that steel pile design use H-piles driven to refusal on shale bedrock. It is anticipated that HP 310x110 and HP 360x132 piles sections could be used to support the abutment foundations.

9.2.1 Axial Compression

Steel HP 310x110 and 360x132 piles driven to practical refusal on shale bedrock may be designed with a factored geotechnical ULS resistance for axial compression of 2,000 and 2,400 kN, respectively. The geotechnical resistance was evaluated with respect to the methods outlined in the CFEM, 2010. The structural resistance of the pile under static and seismic conditions must be checked by a structural engineer. The factored geotechnical resistance at SLS will not govern steel piles bearing on bedrock. Likewise, H-piles founded on bedrock will not experience differential settlement. The static *axial* capacities presented can be used for seismic analysis, however lateral capacities will be reduced during a seismic event as discussed further in Section 9.2.4.

The factored geotechnical resistances include the following factors:

- Consequence factor (Ψ) of 1.0
- Geotechnical resistance factors (CHBDC Table 6.2) of ϕ_{gu} = 0.4 (static analysis; typical degree of understanding)

The estimated pile tip elevations for piles end bearing on bedrock are summarized in Table 9-1.

Table 9-1: Estimated Pile Tip Elevations

Foundation Element	Proposed Underside of Abutment Elevation (m)	Estimated Pile Tip Elevation (m)
North Abutment	62.0	44.4
South Abutment	60.5	44.1

The geotechnical axial resistance was selected assuming that the piles meet refusal in the sound shale bedrock. Some pile penetration into the bedrock is anticipated. Static or dynamic load testing should be carried out to confirm pile capacity during construction.

9.2.2 Axial Tension

Steel piles (Grade 350W steel) at this site may be designed on the basis of the following factored geotechnical resistances for axial tension:

Table 9-2 Capacities of H-Piles founded on Bedrock

Location	Pile Size	Pile Length (m)	Factored Geotechnical Resistance at ULS (kN) (Axial Tension)	
			Static (ϕ_{gu}=0.3)	Seismic (ϕ_{gu}=1.0) *
North Abutment	HP 310 x 110	17.2	300	1,000
	HP 360 x 132		340	1,150
South Abutment	HP 310 x 110	16.1	275	920
	HP 360 x 132		320	1,500

NOTE (*): The factored geotechnical resistance at ULS under seismic conditions must not exceed the structural resistance of the pile section.

It is noted that there is no substantial variation in the tensile resistances between the north and south abutments as the soil stratigraphy and pile lengths are similar.

The factored geotechnical resistances in tension include the following factors:

- Consequence factor (Ψ) of 1.0
- Geotechnical resistance factors (CHBDC Table 6.2):
  - ϕ_{gu} = 0.3 (static analysis; typical degree of understanding)
  - ϕ_{gu} = 1.0 (seismic analysis)

9.2.3 Abutment Type

The subsurface conditions at this site are considered suitable for semi-integral or conventional type abutment design. The use of piles at the abutments allows for the design of an integral abutment structure provided that an exemption is granted by MTO (see Section 7.2) and the piles can adequately resist the lateral loads (see Section 9.2.4).

The integral abutment design would require that the piles possess flexibility in the upper 3 m of the pile length. To provide the required flexibility, the upper 3 m of the piles should be surrounded by a column of loose sand as specified by the integral abutment design requirements. A corrugated steel pipe (CSP) may be used to contain the sand and provide separation from the waste materials present on site. Piles should be driven first before placing the sand backfill in the CSP. A 600 mm diameter CSP is frequently used for this application. It is noted that the abutments are to be perched within the approach fills, however, the CSPs will extend below the base of the approach fills.

An NSSP has been provided in Appendix I outlining the gradation requirements for the sand backfill to be used in the CSP.

9.2.4 Lateral Deflection

Piles can be installed with a batter to resist lateral loads. During a seismic event, a battered pile foundation may become too rigid therefore resistance to lateral movement of a vertical pile will be provided by the passive earth pressure developed on the face of the pile embedded in the foundation soils using p-y curves.

The p-y curves for static and seismic conditions are shown in Appendix H to allow for the calculation of the ultimate lateral capacity of an individual pile. A suitable reduction factor should be applied to these ultimate values in accordance with Table 6.2 of the CHBDC.

Where lateral spacing between an adjacent pile or another structural element is less than four equivalent pile diameters, the lateral resistance will need to be reduced based on the center-to-center spacing. The reduction factors to be used can be obtained from Figures C6.11.3(r), C6.11.3(s) andC6.11.3(t) of the CHBDC.

The response of the pile foundation under inertial loading should be checked using both static and "seismically reduced" lateral load transfer (p-y) curves. Both sets of curves were generated using appropriate soil models in the commercially available LPILE software. The "seismically reduced strength" p-y curves represent either liquefied soil conditions (e.g., for very loose to loose silt/sand) or reduced strength conditions (for clay) depending on the anticipated soil behaviour. These reduced curves were developed using soft clay Matlock p-y models as recommended in CalTrans' publication "*Guidelines on Foundation Loading and Deformation due to Liquefaction Induced Lateral Spreading*" dated October 2013. In this method, the equivalent residual strength of the liquefied soil is represented by modeling the layer with an undrained shear strength of the soft clay. The residual strengths were produced using the Kramer and Wang method. Additional p-y curves can be provided for evaluation of alternate pile sizes, if required.

The liquefaction-induced permanent deformations (see Section 8.5) during an earthquake with a return period of 2,475 years will induce kinematic loading on the deep foundations at the abutments and pier. Kinematic loading during earthquakes with return periods of 475 and 975 years is expected to be negligible.

The estimated lateral displacement for both abutments is anticipated to be up to 12 mm (see Section 8.5); it is anticipated that the pier will also experience a similar level of deformation. The estimated lateral displacement profile is provided in Figure 8 in Appendix F in graphical format. The deep foundations will need to be designed to resist this loading and can be evaluated in a structural model using the p-y curves for the seismic load case and imposing the displacement profile.

If the H-piles for the abutments cannot resist the kinematic loading, consideration should be given to increasing the number of piles or increasing the strength of the piles using concrete encasement or larger piles. Concrete encasement could comprise H-piles installed in 600 mm diameter pre-drilled holes which are filled with structural concrete from about Elevation 47 m to the underside the abutment stem.

To eliminate kinematic loading, it would be necessary to conduct ground improvement below the approach embankments, which will be challenging at this site due to the presence of waste and highly sensitive clay overlying the liquefiable layers. Therefore, it is considered preferable to design the foundations to resist kinematic loads.

The lateral subgrade reaction of the abutment can be assessed based on the values provided in Section 10.3.

9.2.5 Pile Installation

Driven piles must be installed in accordance with OPSS.PROV 903.

Piles are to be driven to refusal on bedrock. Cobbles were noted near the base of the glacial till deposit. Pile tips should be protected from damage during driving. The tips of all piles must be protected with a driving shoe from an approved manufacturer such as Titus Steel (standard H-Point) or approved equivalent. Some pile penetration into the bedrock is anticipated. Static or dynamic load testing should be carried out to confirm pile capacity during construction.

It is recommended that a settlement and vibration monitoring program be implement during pile driving operations for the existing structure and adjacent buried utilities. The monitoring program should consist of survey targets at each foundation element with baseline readings taken prior to initiation of construction. Readings should be taken daily during the time of construction of the new pile/caisson foundation elements.

9.2.6 Downdrag

Piles will need to be designed to include downdrag loads in response to settlement induced by liquefaction (see Section 8.5) from the design earthquake. The current CHBDC is not clear on the load combination and factors to be used for this case. We recommend that the pile foundations be designed such that the structural capacity of the pile be greater then unfactored dead load plus unfactored downdrag load. Post liquefaction negative skin friction values should be taken as 50% of the pre-liquefaction skin friction as per Rollins et al (2018).

The new alignment of Nicholas Street will result in placement of fill in order of 4 to 8 m high at the abutments to meet the proposed road elevation. To reduce the possibility of imposing downdrag forces on the piles, it is recommended that the approach fills be substantially constructed in advance of the pile installation to allow for a preload period.

If preloading can not be completed, the piles will need to be designed to carry the additional static downdrag loads developed along the length of the piles embedded in the silty clay layer due to consolidation under the weight of additional fill placement. The unfactored downdrag load of 400 kN and 550 kN are estimated for HP 310x110 and HP360x132, respectively. This downdrag load should be multiplied by a load factor of 1.25 (Table 3.3, CHBDC) as per CHBDC Commendatory Clause 6.11.4.10 to obtain a factored downdrag load. In accordance with Section 6.11.4.10 of the CHBDC and Clause C6.11.4.10 of the Commentary, in the structural design of a pile, the factored downdrag load should be added to the factored permanent loads to assess the effects of downdrag. In geotechnical analysis of downdrag, live load effects should not be considered.

The neutral plane for both static and seismic downdrag calculations can be taken as the top of the till layer which is at approximate elevation 50 m.

9.2.7 Frost Protection

The frost penetration depth at this site is 1.8 m as per OPSD 3090.101. Accordingly, a minimum of 1.8 m of earth cover, or equivalent insulation, must be provided above the base of the pile caps to serve as frost protection.

9.3 Deep Foundations – Caissons

9.3.1 Axial Compression

Caissons with a diameter of 1500 mm are feasible at this site. It is recommended that the design use rock socketed caissons with a minimum socket length of twice the caisson diameter (3.0 m) into sound bedrock to support the foundations. The actual socket length required should be determined based on the required lateral capacity (see Section 9.3.3), moment capacity requirements and seismic analysis. A deeper socket length may therefore be required based on the structural analysis.

The shale bedrock surface is at elevation of 44.7 in Borehole 17-03 drilled near the pier and was measured to have an unconfined compressive strength of approximately 55 MPa. Shale bedrock inherently contains hard interbeds that could interfere with socket drilling. An NSSP to alert the Contractor is provided. Below a surficial weathered zone of the bedrock, the Rock Quality Designation (RQD) results also classified the rock as good quality.

Rock socketed caissons at this site may be designed based on the factored ULS geotechnical resistances for axial compression and tension provided in the Table 9-3. The factored geotechnical resistance at SLS will not govern caisson socketed into bedrock. Likewise, caissons socketed into bedrock will not experience differential settlement. The static *axial* capacities presented can be used for seismic analysis, however lateral capacities will be reduced during a seismic event as discussed further in Section 9.3.3

Table 9-3 Capacities of Rock Socketed Caisson

Location	Caisson Diameter (m)	Minimum Socket Length (m)	Factored Geotechnical Resistance at ULS (kN) (Axial Compression)	Factored Geotechnical Resistance at ULS (kN) (Axial Tension)
			Static (ϕ_{gu}=0.4)	Static (ϕ_{gu}=0.3)
North Abutment	1.5	3.0	10,000	3,000
Pier	1.5	3.0	10,000	3,000
South Abutment	1.5	3.0	10,000	3,000

9.3.2 Caisson Installation

Caisson installation must be in accordance with OPSS 903.

The caisson drilling equipment supplied by the Contractor must be capable of advancing through the existing soils and penetrating or pushing aside potential obstructions. Augering/coring equipment must be able to penetrate shale bedrock with frequent hard interbeds.

Construction of caissons will require use of slurry methods or a water filled steel liner advanced into the bedrock surface to support the sidewalls, minimize groundwater inflow and enable machine-cleaning of the socket base. After the liner is installed, the bedrock socket must be advanced to found the caisson in sound bedrock with a minimum embedment length as recommended in Section 9.3.1.

Caisson concrete should be placed within 8 hours of excavation to minimize softening of the shale bedrock in the socket.

An NSSP notifying the Contractor of the specific subsurface conditions and installation requirements at this site should be included in the contract documents. Suggested wording is presented in Appendix I. Selection of the type of equipment and method of installation is the responsibility of the Contractor.

9.3.3 Lateral Deflection

The lateral resistance provided by the soils above the bedrock may be calculated using p-y curves. The p-y curves for static and seismic conditions are shown in Appendix H to allow for the calculation of the ultimate lateral capacity of an individual caisson. A similar approach as outlined in Section 9.2.4 if followed for the caisson design to calculate the “seismically reduced” lateral load transfer (p-y) curves which are provided in Appendix H.

A suitable reduction factor should be applied to these ultimate values in accordance with Table 6.2 of the CHBDC.

The ultimate passive resistance force that can be mobilized by the embedded portion of a caisson socketed within sound bedrock is constant with depth and for a 1.5 m diameter caisson can be taken as 4,500 kN/m length of caisson into sound bedrock. A minimum weathered thickness of 0.3 m at the surface of the bedrock should be used in design. A suitable reduction factor should be applied to this ultimate value in accordance with Table 6.2 of the CHBDC.

Where lateral spacing between an adjacent caisson or another structural element is less than four equivalent pile diameters, the lateral resistance will need to be reduced based on the center-to-center spacing. The reduction factors to be used can be obtained from Figures C6.11.3(r), C6.11.3(s) and C6.11.3(t) of the CHBDC.

9.3.4 Downdrag

Downdrag may be calculated as outlined in Section 9.2.6 using an unfactored downdrag load of 1,700 kN for a 1.5 m diameter caisson. The application of downdrag and the appropriate load factors should follow the recommendations provided in Section 9.2.6.

10 APPROACH EMBANKMENTS

The proposed centerline profile requires the placement of new fill approximately 4 m and 8 m high to construct the south and north approach embankments respectively. The proposed embankment construction would also result in a widening of the approach embankments in order to maintain the platform width at the top and the existing embankment side slope geometry (2H:1V). The embankments should be constructed using OPSS Select Subgrade Material (SSM) or Granular B Type I.

Prior to placement of fill, the topsoil should be stripped. In areas without excavations for foundation construction, it has been assumed that the existing fill and waste fill will remain in place for economic reasons.

Where newly placed embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, benching of the fill existing slope should be carried out in accordance with OPSD 208.010.

10.1 Assessment of Settlement

An assessment of the estimated short term and time dependent settlement from construction of the proposed approach fills was carried out using the Rocscience Settle^{3D} modelling software. The design pre-consolidation pressure profile has been derived from the oedometer tests as well as correlations with the undrained shear strength and plasticity. Compression characteristics have been modelled using C_c, C_r, c_v and c_{vr} values from the current oedometer test results (see Section 5.5 for values).

The settlement analyses indicate that approximately 100 to 130 mm of settlement is expected in the soils underlying the abutments of which 80-90 mm is elastic settlement and remaining settlement is recompression settlement. Majority of the recompression settlement is expected to occur relatively quick with only 15 mm expected to occur after completion of construction. The predicted settlement values reflect the maximum embankment height, after the approach embankment construction, of 8 m as well as the distribution of fill and fill height. Since the estimated settlements can be mitigated with preloading alone, no further mitigation measures are considered necessary.

The compression of the granular fill materials under the self-weight is estimated to be 0.5% of the embankment height. For the proposed centerline grade raise of 4 to 8 m, the expected embankment compression is in the order of 20 to 40 mm. The embankment compression should be substantially completed with 6 months following completion of fill placement. It is recommended that paving be delayed for 2 months following completion of fill placement.

The estimated settlement of the approach embankments at the abutments meets the MTO Guidelines for post construction settlement criteria as summarized below if paving occurs at least 2 months after completion of fill placement:

- 25 mm within 20 m behind bridge abutment
- 50 mm from 20 to 50 m from the bridge abutment
- 100 mm for greater than 50 m from the bridge abutment

The settlement predictions in this report have been carried out based on a field and laboratory program and on assumptions based on our experience with other embankments founded on similar soils. Notwithstanding the care taken in predicting the embankment performance, the settlement values observed in the field could vary from the predictions. This is due to the degree of variability of the soil properties along the embankment alignment. The presence of waste fill adds uncertainty to the prediction of the performance of the embankment proposed in this project. Therefore, the results of the settlement analysis should be used to assess the most likely performance of the embankments.

It is recommended that a settlement monitoring program of the approach fills be initiated after substantial completion of fill has been placed. The monitoring program should consist of a survey target placed directly behind the new abutments and three additional points at 10 m intervals behind each new abutment. Readings should be taken weekly for a duration of 2 months following completion of the fill placement. During construction, the Contract Administrator should employ experienced geotechnical staff to observe foundation performance related to construction activities and to assess the settlement monitoring results.

Post-liquefaction settlements were estimated (see Section 8.5) in the very loose to loose layers near the abutments and pier using Figure C4.29(a) of the CHBDC. Vertical settlements of 60 to 150 mm are anticipated in the liquefied layer. Post-liquefication settlements will induce downdrag on the piles/caissons (see Sections 9.2.6 and 9.3.4).

10.2 Assessment of Global Stability

The global stability under static and seismic loading conditions for the proposed approach embankments constructed using OPSS Select Subgrade Material or Granular B Type I with 2H:1V side slopes was evaluated using GeoStudio 2012 Slope/W software for limit equilibrium analysis. Input parameters for undrained analysis are based on the in-situ shear vane test results. Typical outputs are presented in Appendix G.

The following additional parameters were used in the analysis:

- A traffic surcharge load as per Section 6.12.5 of the CHBDC
- A seismic horizontal loading 0.141 equal to ½ of the PGA value (0.281g) was used for seismic analysis
- Proposed embankment side slope geometry (2H:1V)

Table 10-1: Global Stability Analysis Results – Approach Embankments Constructed with Granular Fill

Location	Factory of Safety		
	Static Conditions		Seismic Conditions
	Undrained	Drained	
North Approach	1.4	1.4	1.0
South Approach	1.3	1.3	1.0

The factor of safety meets the target value of 1.3 under static conditions and 1.0 under seismic condition for both the north and south approach fills.

10.3 Lateral Earth Pressures

The lateral earth pressures parameters provided in Table 10-2 and Table 10-3 are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in design.

10.3.1 Static Lateral Earth Pressure Coefficients

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC but generally are given by the following expression:

$$\sigma_h = K * (\gamma * d + q)$$

where:

σ_h = horizontal pressure on the wall at depth d (kPa)
K = earth pressure coefficient (see table below)
γ = unit weight of retained soil (adjusted for groundwater level)
d = depth below top of fill where pressure is computed (m)
q = stress from any surcharge (kPa)

A lateral earth pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with Clause 6.12.3 of the CHBDC. Typical earth pressure coefficients for backfill are shown in Table 10-2.

Table 10-2: Earth Pressure Coefficients

Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^o$, $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32^o$, $\gamma = 21.2$ kN/m^3		OPSS SSM and Existing Sand Fill $\phi = 30^o$, $\gamma = 21.0$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active, K_A (Yielding Wall)	0.27	0.39	0.31	0.47	0.33	0.54
At Rest, K_O (Non-Yielding Wall)	0.43	-	0.47	-	0.50	-
Passive, K_P (Movement towards Soil Mass)	3.7	-	3.3	-	3.0	-
Soil Group(*)	"medium dense sand"		"loose to medium dense sand"		"loose sand"	

Note: (*) Figure C6.16 of the Commentary to the CHBDC.

The use of a material with a high friction angle and low active earth pressure coefficient (Granular A or Granular B Type II) is preferred as it results in lower earth pressures acting on the abutment and walls.

For rigid structures, it is recommended that at-rest horizontal lateral earth pressures be used for design. Active pressures should be used for the design of unrestrained walls. The parameters in the table correspond to full mobilization of active and passive earth pressure and require certain relative movements between the wall and adjacent soil to produce these conditions. The values used in design can be assessed from Figure C6.16 of the

Commentary to the CHBDC using the soil group designate as outlined in Table 10-2. Where ground surfaces are sloped behind the walls, the corresponding coefficients should be used.

The factored lateral subgrade reaction (k_s) and ultimate unfactored lateral resistance (p_{ult}) for backfill behind the abutment and wingwalls can be calculated *per meter width* with the following equations.

$k_s = \phi_{gu} * 2000 * d$ (per meter width)
$p_{ult} = K_p * \gamma * d$ (per meter width)

where:

k_s = factored lateral subgrade reaction on wall at depth d (kPa/m)
p_{ult} = ultimate unfactored ultimate lateral resistance at depth d (kPa)
ϕ_{gu} = 0.5 (CHBDC, Table 6.2)
d = depth below top of fill where pressure is computed (m)
γ = unit weight of retained soil (kN/m^3)

At the base of the 5.5 m abutment wall, the factored lateral subgrade reaction for Granular B Type I, as a minimum, backfill behind the abutment can be calculated to be 5,500 kPa/m. The ultimate unfactored resistance of the backfill for which no further strength increase is obtained, using the soil parameters provided in Table 10-2, is in the order of 365 kPa at the base of the 5.5 m abutment wall. A similar calculation can be completed for a different backfill soil type and wall height.

10.3.2 Combined Static and Seismic Lateral Earth Pressure Parameters

In accordance with Clause 4.6.5 of the CHBDC (S6-14), a structure should be designed using dynamic earth pressure coefficient that incorporate the effects of earthquake loading. The following recommendations are as per Section C4.6.5 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using Mononobe-Okabe Method with:

- $k_h = ½ * F(PGA) * PGA$, for structures that allow 25 to 50 mm of movement, and
- $k_h = F(PGA) * PGA$, for non-yielding walls

The ratio of wall movement to wall height required to mobilize the active conditions would be approximately 0.002 for a yielding structure with respect to the assessment of seismically induced lateral earth pressures.

The coefficients of horizontal earth pressure for seismic loading presented in Table 10-3 may be used. The provided earth pressure coefficients are for a **Seismic Site Class C**, PGA_{ref} with a 2% probability of exceedance in 50 years (2475-year event) of 0.281g (Geological Survey of Canada – Fifth Generation) and a F(PGA) of 1.0 as per Table 4.8 of the CHBDC (S6-14 update No. 1, April 2016).

Table 10-3. Dynamic Earth Pressure Coefficients, Site Class C

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^o$, $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32^o$, $\gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Slope Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Slope Surface Behind Wall (2H:1V)
Active, K_{AE} Yielding Wall	0.35	0.63	0.40	0.78
Active, K_{AE} Non-Yielding Wall	0.46	1.04	0.51	1.24

The coefficients of horizontal earth pressure for seismic loading presented in Table 10-4 may be used. The provided earth pressure coefficients are based on a **Seismic Site Class F**, PGA with a 2% probability of exceedance in 50 years of 0.281g (Geological Survey of Canada – Fifth Generation) and a F(PGA) of 3.025 based on a site-specific analysis.

Table 10-4. Dynamic Earth Pressure Coefficients, Site Class F

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^o$, $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32^o$, $\gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Slope Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Slope Surface Behind Wall (2H:1V)
Active, K_{AE} Yielding Wall	0.61	1.67	0.68	1.99
Active, K_{AE} Non-Yielding Wall	-	-	-	-

The total pressure due to combined static and seismic loads acting at a specific depth below the top of the wall may be determined using the following equation that includes consideration of material properties and the soils profile.

$$\sigma_h = K * \gamma * d + (K_{AE} - K_A) * \gamma * (H - d)$$

where:

σ_h = lateral earth pressure at depth d (kPa)
d = depth below the top of the wall (m)
K = static earth pressure coefficient
(K_a for yielding walls, K_o for non-yielding walls)
γ = unit weight of retained soil (adjusted for groundwater level)
K_{AE} = combined static and seismic earth pressure coefficient
H = total height of the wall (m)

The factored lateral subgrade reaction (k_s) and ultimate unfactored lateral resistance (p_{ult}) for backfill behind the abutment and wingwalls can be calculated *per meter width* with the following equations.

$k_{s(seis)} = (\phi_{gu} + \phi_{gu(BC)}) * 2000 * d$ (per meter width)

$p_{ult} = K_p * \gamma * d$ (per meter width)

where:

$k_{s(seis)}$ = seismic factored lateral subgrade reaction on wall at depth d (kPa/m)

$\phi_{gu(BC)}$ = 0.2 for force based analysis (BC supplement to CHBDC)

$\phi_{gu(BC)}$ = 0.5 for performance based analysis (BC supplement to CHBDC)

At the base of the 5.5 m abutment wall, the factored lateral subgrade reaction for Granular B Type I, as a minimum, backfill behind the abutment can be calculated to be 7,700 kPa/m and 11,000 kPa/m for seismic-force based and seismic-performance based analysis, respectively. The ultimate unfactored resistance of the backfill for which no further strength increase, using the soil parameters provided in Table 10-2, is in the order of 365 kPa at the base of the 5.5 m abutment wall. A similar calculation can be completed for a different backfill soil type and wall height.

10.4 Approach Slab

Settlement will occur below the approach slab, therefore full contact is not to be expected. A maximum of 1/3 of the approach slab area could be incorporated into the frictional resistance design of the abutment. The horizontal resistance against sliding between the cast-in-place approach slab and the granular abutment backfill can be computed assuming the following factored ultimate coefficients of friction:

Case	*Factored* Coefficient of Friction
Static	0.360
Seismic – Force Based	0.450
Seismic – Performance Based	0.450

11 RETAINING WALL FOUNDATIONS

It is understood that the elevation of the W-N ramp of the Nicholas Street Interchange is to increase to approximately elev. 64.0 m from it's existing elevation of approximately 60.8 m at Station 10+170. It is indicated that the existing 40 m long retaining wall structure at this location is to be replaced with a new retaining wall structure with a proposed total length of 50 m. An RSS retaining wall or conventional concrete retaining wall is considered feasible.

An RSS wall is considered to have a foundation base width determined by the width of the reinforced mass. In addition, RSS walls frequently have a small footing to support the facing material. The following geotechnical resistance values, for vertical concentric loading, can be used in the design for a facing supported footing as wide as 1 m:

- Factored Geotechnical Resistance at ULS of 300 kPa
- Geotechnical Resistance at SLS of 115 kPa

Design of internal stability of an RSS wall should be carried out by the proprietary designer/supplier. The entire block of reinforced earth must be designed against various modes of failure including, but not limited to, sliding and overturning.

The retaining wall at this site shall be founded on an engineered fill pad consisting of Granular 'A' material with a minimum thickness of 0.5 m. The foundation should be constructed in the dry. An RSS wall should be constructed in accordance with MTO RSS Design Guidelines manual. The following geotechnical resistance values are recommended for an RSS or conventional concrete retaining wall design at this site:

- Factored Geotechnical Resistance at ULS of 300 kPa
- Geotechnical Resistance at SLS of 115 kPa

The recommended values presented above are for an assumed 2.5 m base width and for vertical concentric loads only. Effects of load eccentricity and inclination need to be considered. The SLS value provided is based on 25 mm of settlement.

The embedment of an RSS retaining wall should follow the recommendation provided in the most recent version of MTO's *RSS Design Guidelines* manual. The Geometry, Appearance and Performance of an RSS wall shall follow the requirements outlined in the manual.

The base of a concrete retaining wall should be founded below the depth of frost (see Section 9.2.7).

12 CEMENT TYPE AND CORROSION POTENTIAL

Analytical tests were completed to determine the potential for degradation of the concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel. The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. Soluble sulphate concentrations less than 1000 μg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. Type GU Portland Cement should therefore be suitable for use in concrete at this site.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The tests results provided in Section 5.10 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. The soil resistivity results indicate the soil is mildly to very corrosive.

With a 75 year design life, the minimum design loss for corrosion for each surface in contact with soil/water should be: 0.9 mm loss within the soils below the waste, 2.25 mm within the waste and 1.7 mm in the fill above the waste (reference to Table 4-1 from "EN 1993-5 (2007)"). Section 3.1.3 of the 2016 MTO Structural Manual should also be referenced for additional corrosion requirements for the length of pile within the 3 m encased in a corrugated steel pile for the integral abutment.

13 CONSTRUCTION CONSIDERATIONS

13.1 Excavation

All excavations must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The non-waste fills above the water level at the site should be classified as Type 3 in accordance with OHSA. The cohesionless soils below the water table and all waste fill should be classified as Type 4.

Open excavations and caisson drilling may encounter layers of waste fill. The Contractor should be made aware of these conditions so that an appropriate handling and disposal plan can be instituted.

Subgrade preparation and placement of the backfill and pile caps must be carried out in the dry.

Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor.

13.2 Temporary Protection Systems

Roadway protection, where needed, should be supplied in accordance with OPSS 539 and designed for Performance Level 2. The protection system should be designed by a licenced Professional Engineer experienced in design of shoring with consideration of adjacent traffic loads and any sloping retained surfaces.

It is the Contractors responsibility to select a suitable roadway protection system based on their evaluation of the data presented in Part 1 of this report. A braced excavation or system of rakers may be required.

13.3 Groundwater and Surface Water Control

All excavations for foundations must be dewatered prior to the placement of concrete, as per OPSS 902 and Special Provision (SP) No. FOUN0003, dated March 8, 2018.

The deepest open excavation anticipated for this project is to approximate elevation 57.2 m for the caisson cap at the pier. Groundwater was observed as high as at elevation 57.5 m. It is anticipated that temporary protection system (TPS) will be required to complete the excavation for the caisson installations. It is recommended that the TPS also be designed as a water tight enclosure.

The Contractor must be prepared to control the groundwater and surface water flow at the site to permit construction in a dry and stable excavation. Water from either surface flow and/or groundwater must be diverted away from the excavation at all times. Groundwater perched within the embankment fill and, surface runoff will tend to seep into, and accumulate in proposed excavations. Temporary groundwater and surface water control measures will be required to remain operational during construction until the pile caps are installed and backfilled.

The design of any dewatering system that may be required is the responsibility of the Contractor. The Contract Documents must alert them to this responsibility and to design the system in accordance with SP No. FOUN0003.

The Dewatering Systems Designer Fill-in information for SP No. FOUN0003 are as follows:

Design Storm Return Period	**Preconstruction Survey Distance**
*	**
Where required, fill-in information will be provided in the Hydraulic Report	N/A

In accordance with SP FOUN0003, the dewatering system is to be designed in accordance with OPSS.PROV 517 and SP 517F01; Amendment to OPSS 517, July 2017.

The Table A Fill-ins for SP 517F01 are as follows:

<table>
<tr><td>IDF Curve Location</td><td colspan="2">Latitude: 46.18885°</td><td colspan="4">Longitude: -82.80792°</td></tr>
<tr><td colspan="7">Temporary Flow Passage Systems</td></tr>
<tr><td rowspan="2">Site Name / Station Reference</td><td rowspan="2">Minimum Return Period (Years)</td><td colspan="4">Return Period Flow Estimates (m^3/s)</td><td rowspan="2">Design Engineer Requirements (Note 1)</td></tr>
<tr><td>2 Year</td><td>5 Year</td><td>10 Year</td><td>25 Year</td></tr>
<tr><td>**</td><td>***</td><td>****</td><td>****</td><td>****</td><td>****</td><td>*****</td></tr>
<tr><td>Site #3-224, Highway 417 Nicholas Street Underpass</td><td colspan="6">Where required, fill-in information will be provided in the Hydraulic Report</td></tr>
<tr><td colspan="7">Dewatering Systems</td></tr>
<tr><td colspan="3">Site Name / Station Reference</td><td colspan="2">Preconstruction Survey Distance (Note 2) (m)</td><td colspan="2">Design Engineer Requirements (Note 1)</td></tr>
<tr><td colspan="3">**</td><td colspan="2">******</td><td colspan="2">*****</td></tr>
<tr><td colspan="3">Site #3-224, Highway 417 Nicholas Street Underpass</td><td colspan="2">N/A</td><td colspan="2">Yes</td></tr>
<tr><td colspan="7">Note:
1. “Yes” means the design Engineer and design-checking Engineer shall have a minimum of 5 years of experience in designing systems of similar nature and scope to the required work. “No” means a minimum experience level is not required for the design Engineer and design-checking Engineer.
2. “N/A” indicates a preconstruction survey is not required.</td></tr>
</table>

The Contract Documents must alert them to this responsibility and the need to engage a dewatering specialist. In addition, waste material was observed in the boreholes; groundwater quality may have been impacted and could affect disposal requirements.

13.4 Erosion Protection

Based on the subsurface conditions encountered at the drilled locations through the embankment at this site the existing fill soils are considered to have low susceptibility to erosion as per the Wischmeier Nomograph.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. Slope vegetation should be established as soon as possible after completion of the embankment fills in order to control surficial erosion in general accordance with OPSS.PROV 804. The contractor should provide silt fences and erosion control blankets, as required, throughout the duration of the construction to prevent silt/sediments from running off the site as per OPSS 805. Road side ditches are expected to provide an adequate level of long term surface drainage.

13.5 Construction Concerns

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

- Waste fill was encountered in the boreholes and will need to be properly handled and disposed. Excavated waste fill should not be reused or placed on site. Groundwater may also have been impacted and may require special disposal. The extent of waste is not known.
- Cobbles and boulders, or other obstructions may be encountered within the fill and glacial till deposits. Recommended wording for an NSSP alerting the Contractor to this condition and the requirement to use appropriate equipment and techniques to penetrate the obstructions is provided in Appendix I.
- Confirmation that the granular backfill is adequately placed and compacted to specifications.
- The potential for encountering debris within the existing waste / fill material during excavation or pile driving
- The potential for encountering hard interbeds in the shale bedrock during excavation for caisson installation
- The Contractor's selection of construction equipment and methodology should include assessment of the capability of the subgrade soils to support the proposed construction equipment and any temporary structures or fill (i.e. as a pad for crane support). Site conditions may limit the type of equipment suitable for use. The design and safety of any temporary works is the responsibility of the Contractor. Recommended wording for an NSSP addressing this issue is provided in Appendix I.

The successful performance of the construction of this structure will depend largely upon good workmanship and quality control during construction. Observation of the excavation and backfilling operations will be required as per MTO SP No. 109S12, amendment to OPSS 902 during construction to confirm that the foundation recommendations are correctly implemented and material specifications are met.

14 CLOSURE

Engineering analysis and preparation of this report was completed Katya Edney, P.Eng. and Stephen Peters, P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundations Projects.

LICENSED PROFESSIONAL ENGINEER
K. L. EDNEY
100188777
April 10/18
PROVINCE OF ONTARIO

Katya Edney, P.Eng.
Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
S. PETERS
[illegible]
Apr 10/18
PROVINCE OF ONTARIO

Stephen Peters, P.Eng.
Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
F. J. GRIFFITHS
April 10/18
PROVINCE OF ONTARIO

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

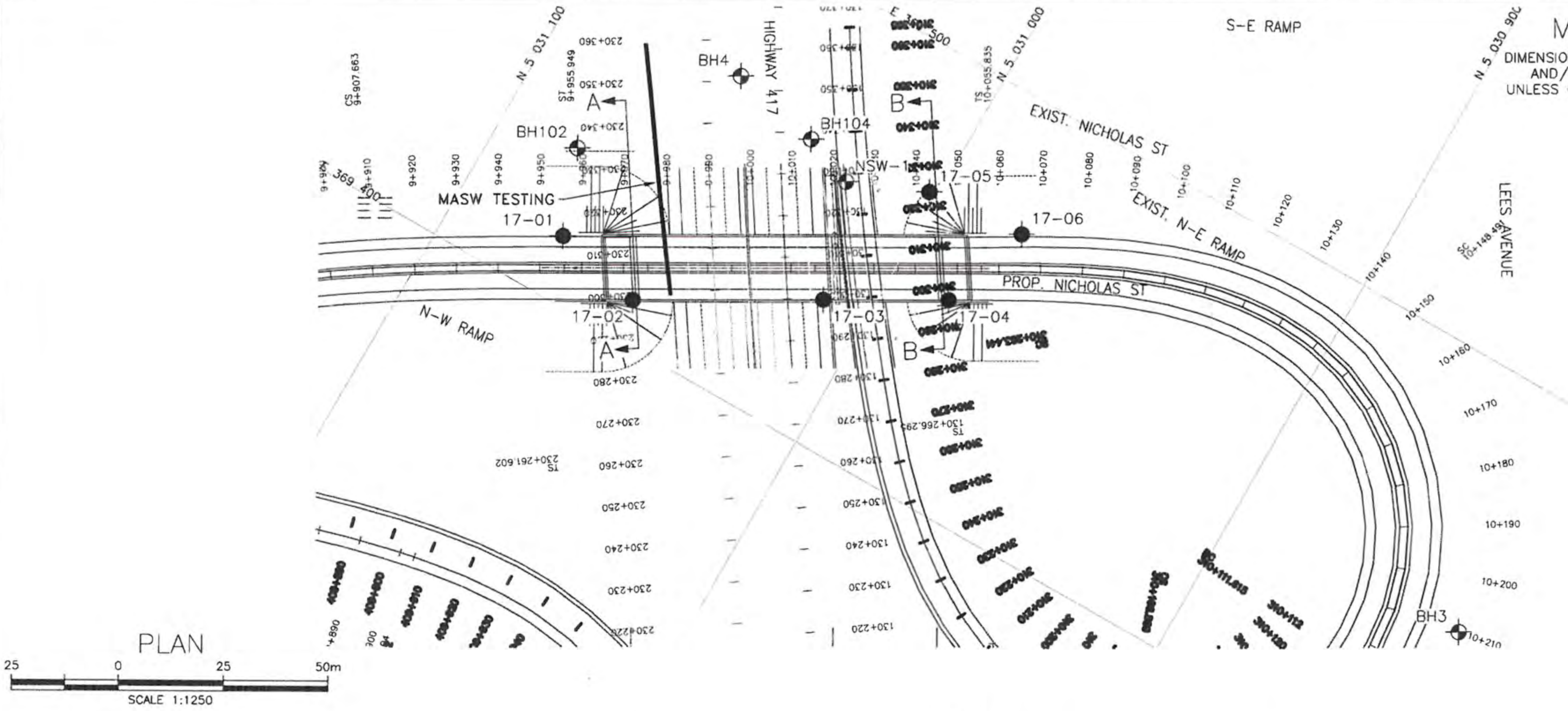
LICENSED PROFESSIONAL ENGINEER
PKChatterji
P. K. CHATTERJI
April 10/18
PROVINCE OF ONTARIO

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

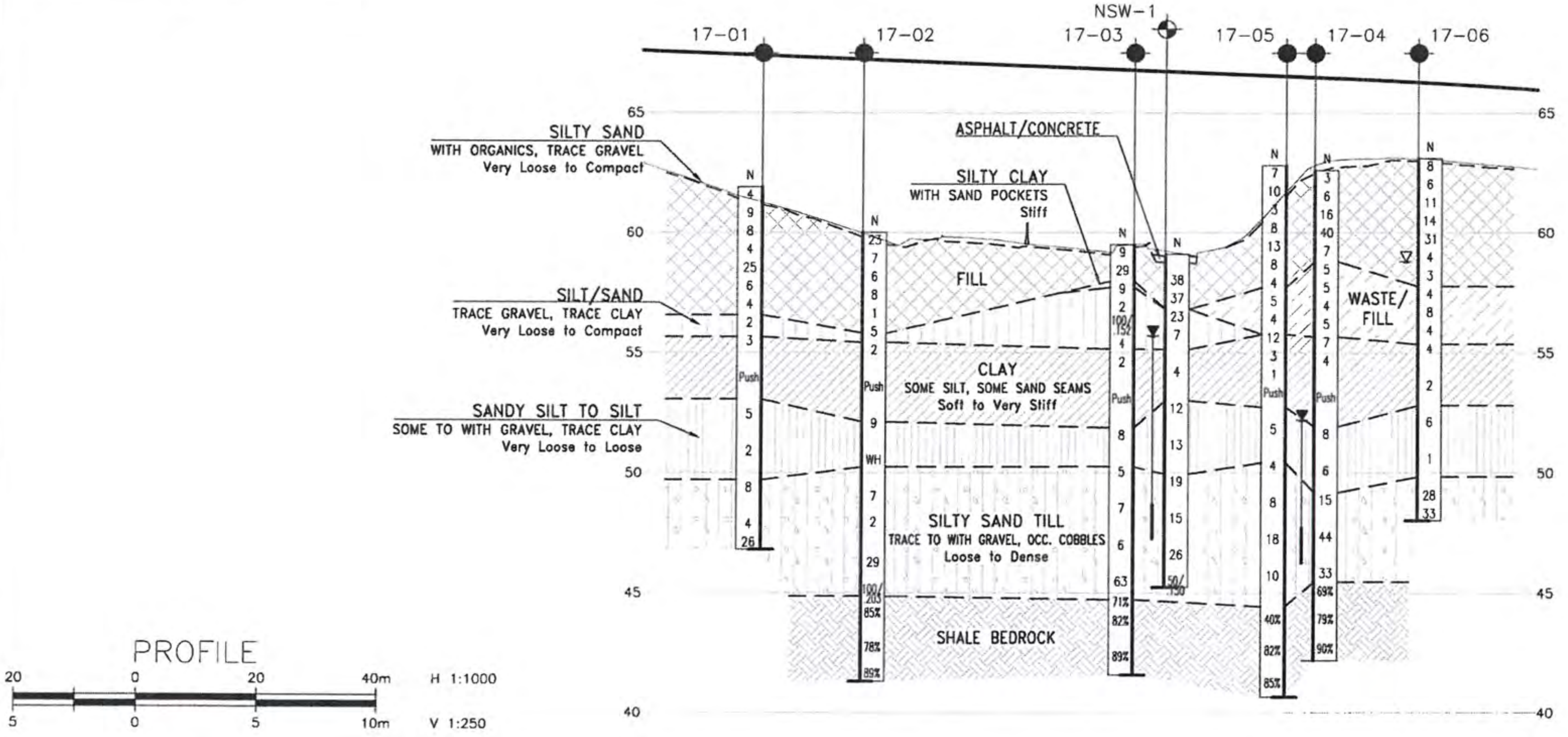
Appendix A.

Borehole Location Plan and Stratigraphic Drawings

MINISTRY OF TRANSPORTATION, ONTARIO



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



LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Mar 9/18
PROVINCE OF ONTARIO

F. J. GRIFFITHS
March 9/18

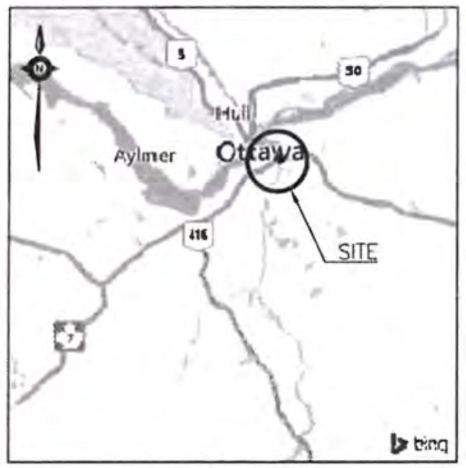
CONT No
GWP No 4048-11-00

HIGHWAY 417
NICHOLAS STREET INTERCHANGE
STRUCTURE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

wsp

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

✦	Borehole (Current Investigation)
⌖	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
│	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-01	61.9	5 031 073.0	369 415.0
17-02	60.0	5 031 050.8	369 410.0
17-03	59.5	5 031 011.3	369 432.6
17-04	62.6	5 030 985.0	369 447.5
17-05	62.8	5 031 002.0	369 467.7
17-06	63.1	5 030 977.7	369 469.8
BH102	60.4	5 031 080.6	369 434.9
BH104	61.7	5 031 033.1	369 464.4
BH3	58.4	5 030 759.7	369 537.4
BH4	61.6	5 031 055.4	369 469.2
NSW-1	59.1	5 031 020.7	369 459.8

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83, Zone 9.

GEOCRES No. 31G5-284

REVISIONS	DATE	BY	DESCRIPTION

DESIGN KE	CHK -	CODE	LOAD	DATE MAR 2018
DRAWN MFA	CHK KE	SITE	STRUCT	DWG 1

FILENAME: H:\Drafting\17000\17532\TED-17532-BHPP.dwg
PLOTDATE: 3/9/2018 10:38 AM

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

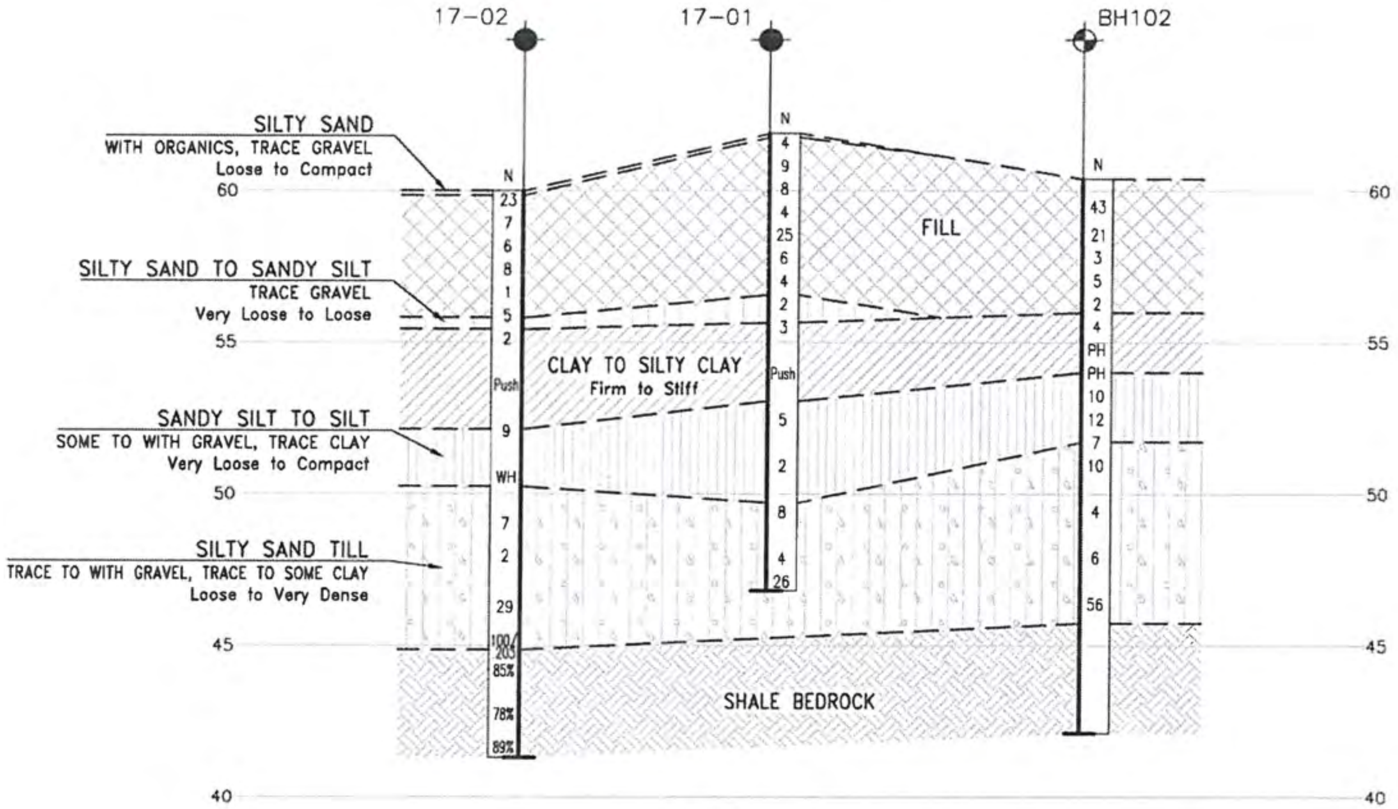
CONT No
GWP No 4048-11-00

HIGHWAY 417
NICHOLAS STREET INTERCHANGE
STRUCTURE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

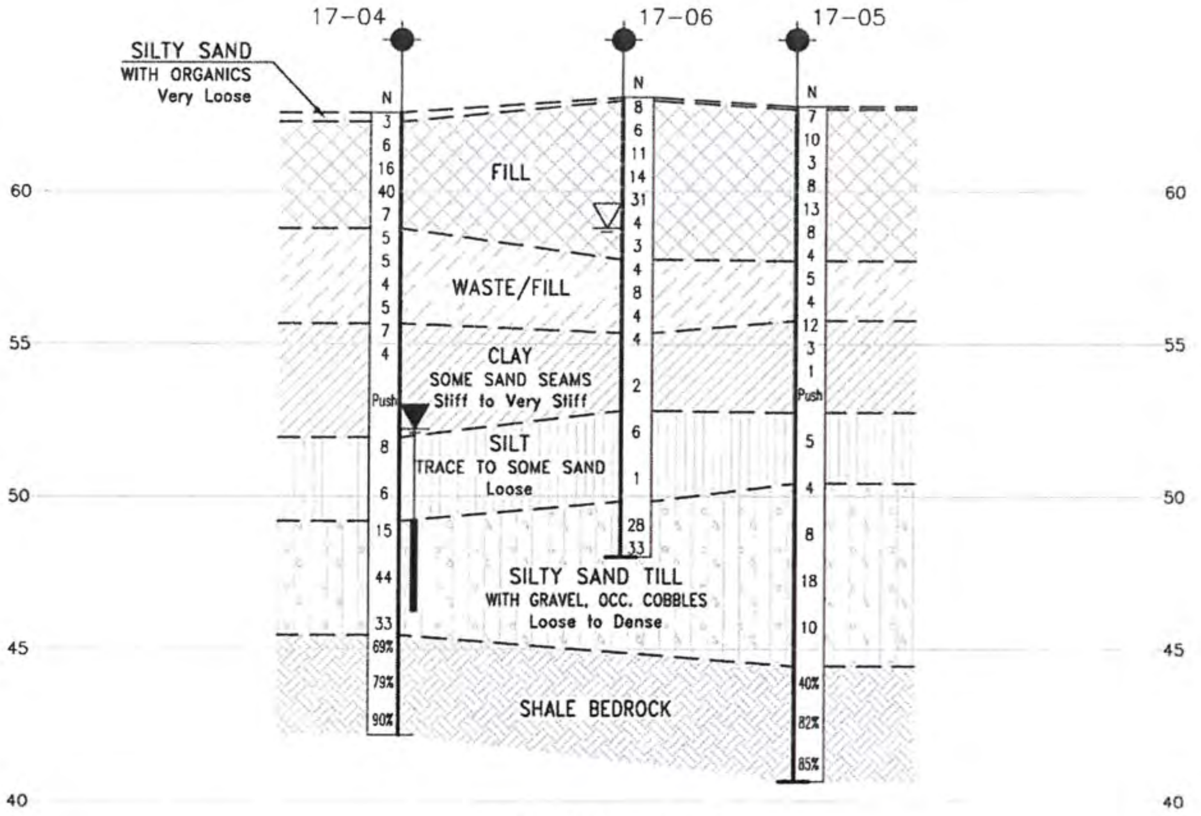
WSP

THURBER ENGINEERING LTD.



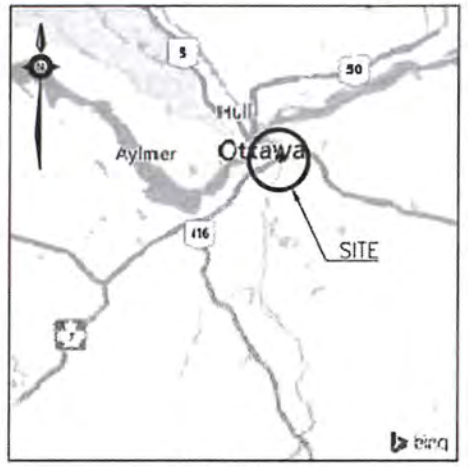
SECTION A-A

10 0 10 20m H 1:500
5 0 5 10m V 1:250



SECTION B-B

10 0 10 20m H 1:500
5 0 5 10m V 1:250



KEYPLAN

LEGEND

⌖	Borehole (Current Investigation)
⌖	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
┃	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-01	61.9	5 031 073.0	369 415.0
17-02	60.0	5 031 050.8	369 410.0
17-03	59.5	5 031 011.3	369 432.6
17-04	62.6	5 030 985.0	369 447.5
17-05	62.8	5 031 002.0	369 467.7
17-06	63.1	5 030 977.7	369 469.8
BH102	60.4	5 031 080.6	369 434.9
BH104	61.7	5 031 033.1	369 464.4
BH3	58.4	5 030 759.7	369 537.4
BH4	61.6	5 031 055.4	369 469.2
NSW-1	59.1	5 031 020.7	369 459.8

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83, Zone 9.

GEOCRES No. 31G5-284

P. K. CHATTERJI
Mar 9/18

F. J. GRIFFITHS
March 9/18

REVISIONS	DATE	BY	DESCRIPTION

DESIGN KE	CHK -	CODE	LOAD	DATE MAR 2018
DRAWN MFA	CHK KE	SITE	STRUCT	DWG 2

FILENAME: H:\Drafting\17000\17532\TED-17532-BHPP.dwg
PLOTDATE: 3/9/2018 10:39 AM

Appendix B.

Record of Borehole Sheets and Field Testing

SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

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

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

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

RECOVERY:

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

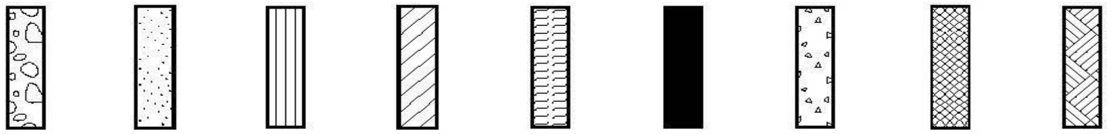
N-VALUE:

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

DYNAMIC CONE PENETRATION TEST (DCPT):

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

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



TEXTURING CLASSIFICATION OF SOILS

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

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

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

SAMPLE TYPES

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

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

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

THURBER

MODIFIED UNIFIED SOIL CLASSIFICATION

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

Note - W_L= Liquid Limit

THURBER

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

TERMS

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

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

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

Ministry of Transportation
Ontario

THURBER

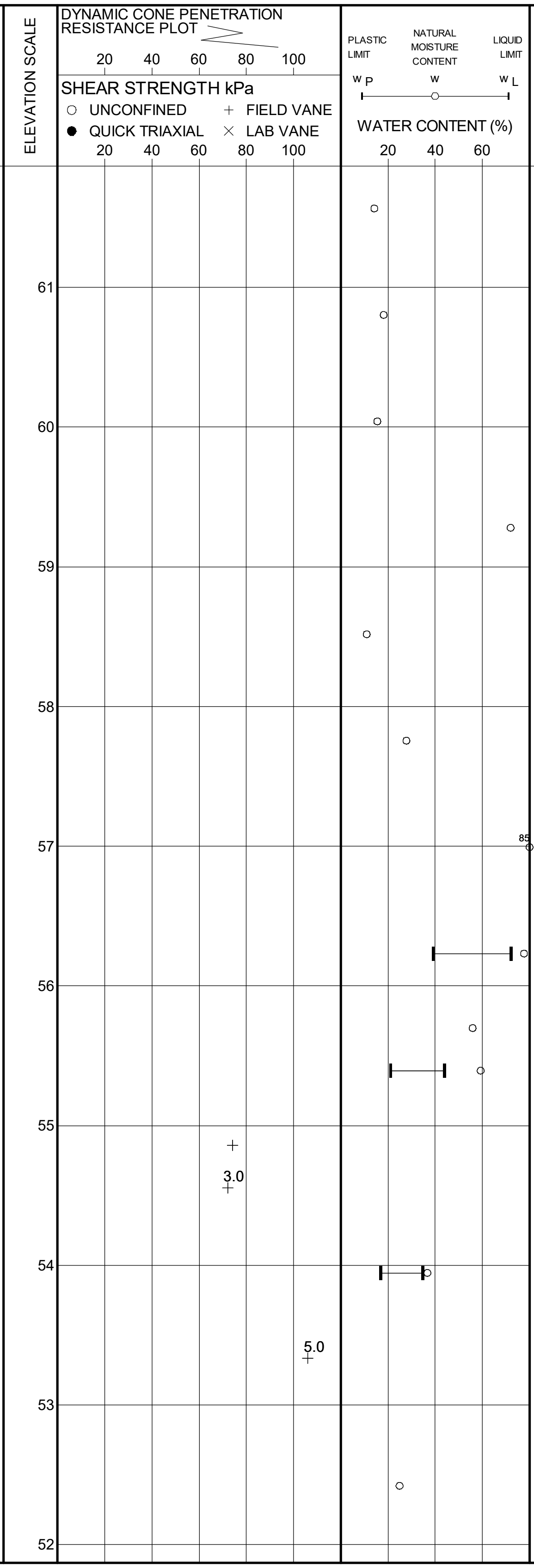
RECORD OF BOREHOLE No 17-01

1 OF 2

METRIC

GWP# 4048-11-00	LOCATION Nicholas Street Interchange - MTM z10: N 369 415.0 E 5 031 073.0	ORIGINATED BY KE
HWY 417	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY KE
DATUM Geodetic	DATE 2017.10.23 - 2017.10.25	CHECKED BY FG

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			GR	SA	SI	CL
61.9										
0.0 0.1	**SILTY SAND** trace gravel, with organics Loose Brown **FILL**	1	SS	4						
	SILTY SAND trace gravel trace WASTE: brick, coal, organics, wood fragments, ash Loose to compact Brown **FILL**	2	SS	9			9	76	15 (SI+CL)	
		3	SS	8						
		4	SS	4						
		5	SS	25						
		6	SS	6						
57.3 4.6	**SAND** with gravel - frequent wood fragments Loose Brown-black **FILL**	7	SS	4						
56.5 5.3	**SILT (MH)** with sand, trace gravel with wood fragments Very loose Grey-brown - 150 mm sand seam at 6.1 m	8	SS	2			0	22	36	42
55.6 6.2	**CLAY (CI to CL)** Stiff Grey	9	SS	3			1	1	45	53
	- Becoming sandy below 7.0 m						0	2	62	36
		10	ST	Push			OED: e_o = 1.015 C_c = 0.33 C_r = 0.032			
53.0 8.8	**SANDY SILT (ML)** some gravel Very loose to loose Grey	11	SS	5						



Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

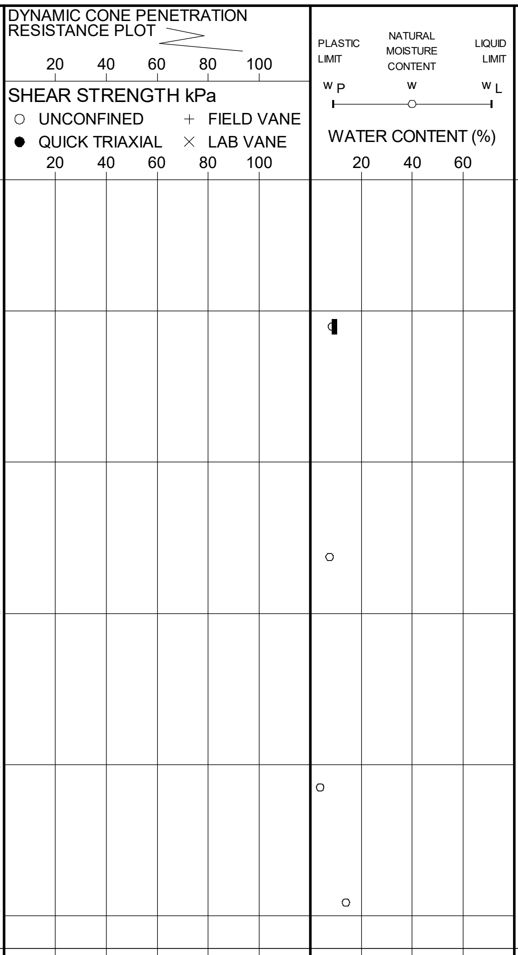
RECORD OF BOREHOLE No 17-01

2 OF 2 **METRIC**

GWP# 4048-11-00
LOCATION Nicholas Street Interchange - MTM z10: N 369 415.0 E 5 031 073.0
ORIGINATED BY KE
HWY 417
BOREHOLE TYPE Hollow Stem Augers
COMPILED BY KE
DATUM Geodetic
DATE 2017.10.23 - 2017.10.25
CHECKED BY FG

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	SANDY SILT (ML) some gravel Very loose Grey								
		12	SS	2	51	14	38	39	9
49.7					50				
12.2	**SILTY SAND (SM)** trace gravel **(Glacial Till)** Loose to compact Grey	13	SS	8	49				
		14	SS	4	48				
	- 100 mm coarse grained sand bed at 14.6 m	15	SS	26	47	6	27	53	14 non-plastic
46.8 15.1	- 100 mm fine grained sand bed at 14.9 m End of Borehole								



GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+³, ×³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

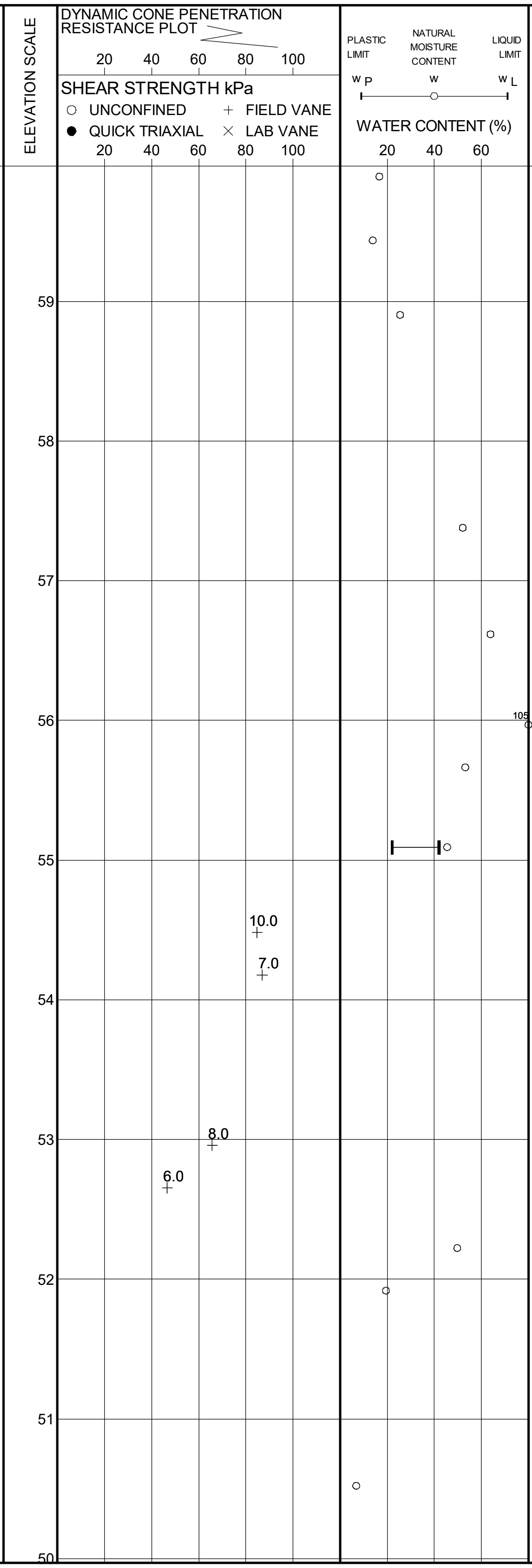
RECORD OF BOREHOLE No 17-02

1 OF 2

METRIC

GWP# 4048-11-00
LOCATION Nicholas Street Interchange - MTM z10: N 369 410.0 E 5 031 050.8
ORIGINATED BY KE
HWY 417
BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core
COMPILED BY KE
DATUM Geodetic
DATE 2017.10.19 - 2017.10.23
CHECKED BY FG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
60.0										
0.0 0.2	**SILTY SAND** with organics Compact Brown **FILL**	1	SS	23			40	52	8 (SI+CL)	
	SAND with silt and gravel with WASTE: brick, coal, organics, wood fragments, ash, glass Very loose to compact Brown **FILL**	2	SS	7						
		3	SS	6						
		4	SS	8						
	becoming brown-black at 3.0 m	5	SS	1			24	64	12 (SI+CL)	
		6	SS	5						
55.8 4.2	**SILTY SAND** trace gravel Loose Dark brown									
55.4 4.6	**CLAY (CI)** Stiff Grey	7	SS	2			0	4	44	52
		8	ST	Push						
52.1 7.9	**SILT** Loose Grey	9	SS	9						
51.3 8.7	**SANDY SILT** with gravel Very loose Grey	10	SS	WH			26	36	30	8 non-plastic
50.2 9.8	**SILTY SAND (SM) (Glacial Till)**									



Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

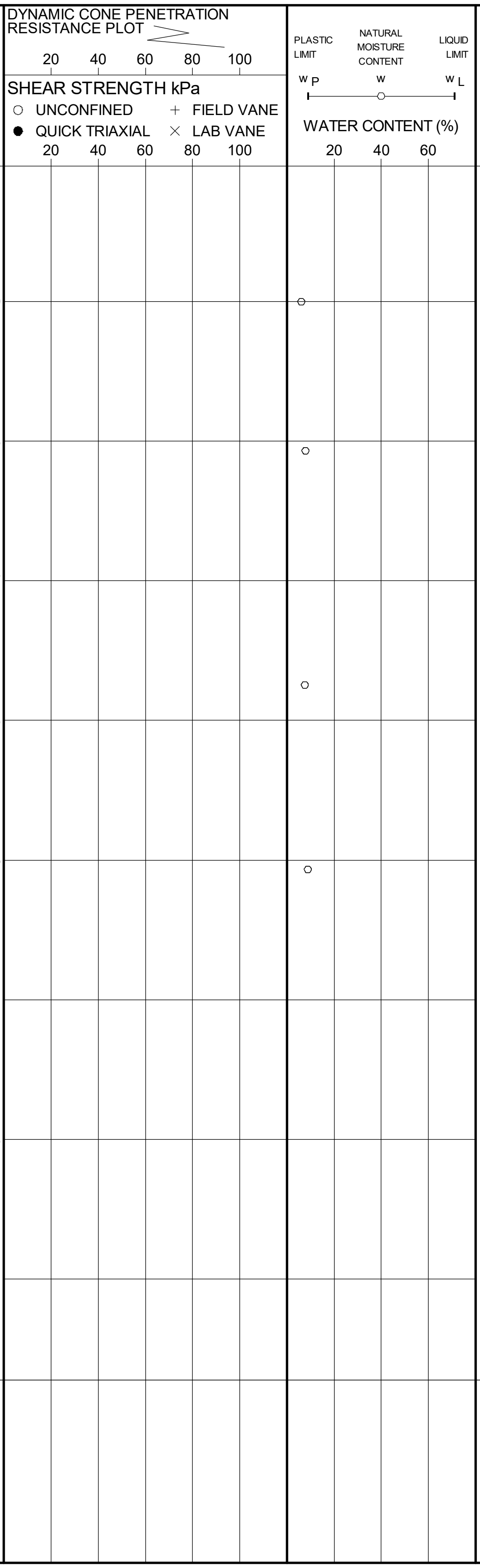
Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-02 2 OF 2 METRIC

GWP# 4048-11-00	LOCATION Nicholas Street Interchange - MTM z10: N 369 410.0 E 5 031 050.8	ORIGINATED BY KE
HWY 417	BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core	COMPILED BY KE
DATUM Geodetic	DATE 2017.10.19 - 2017.10.23	CHECKED BY FG

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page					
	SILTY SAND (SM) with gravel and shale fragments **(Glacial Till)** Loose to compact Grey					
		11	SS	7	49	
	- Frequent sand beds from 11.7 to 12.3 m	12	SS	2	48	
					47	
	- 100 mm sand bed at 13.4 m	13	SS	29		27 54 19 (SI+CL)
					46	
		14	SS	100/ 203mm	45	
44.8 15.1	**BEDROCK** Shale Fresh Laminated to thinnly bedded Strong Fine grained Dark Grey	1	RUN		44	RUN #1 TCR=100% SCR=98% RQD=85%
					43	
		2	RUN			RUN #2 TCR=100% SCR=100% RQD=78%
					42	
		3	RUN			RUN #3 TCR=100% SCR=100% RQD=89%
41.3 18.7	End of Borehole					



UNIT WEIGHT γ kN/m 3

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

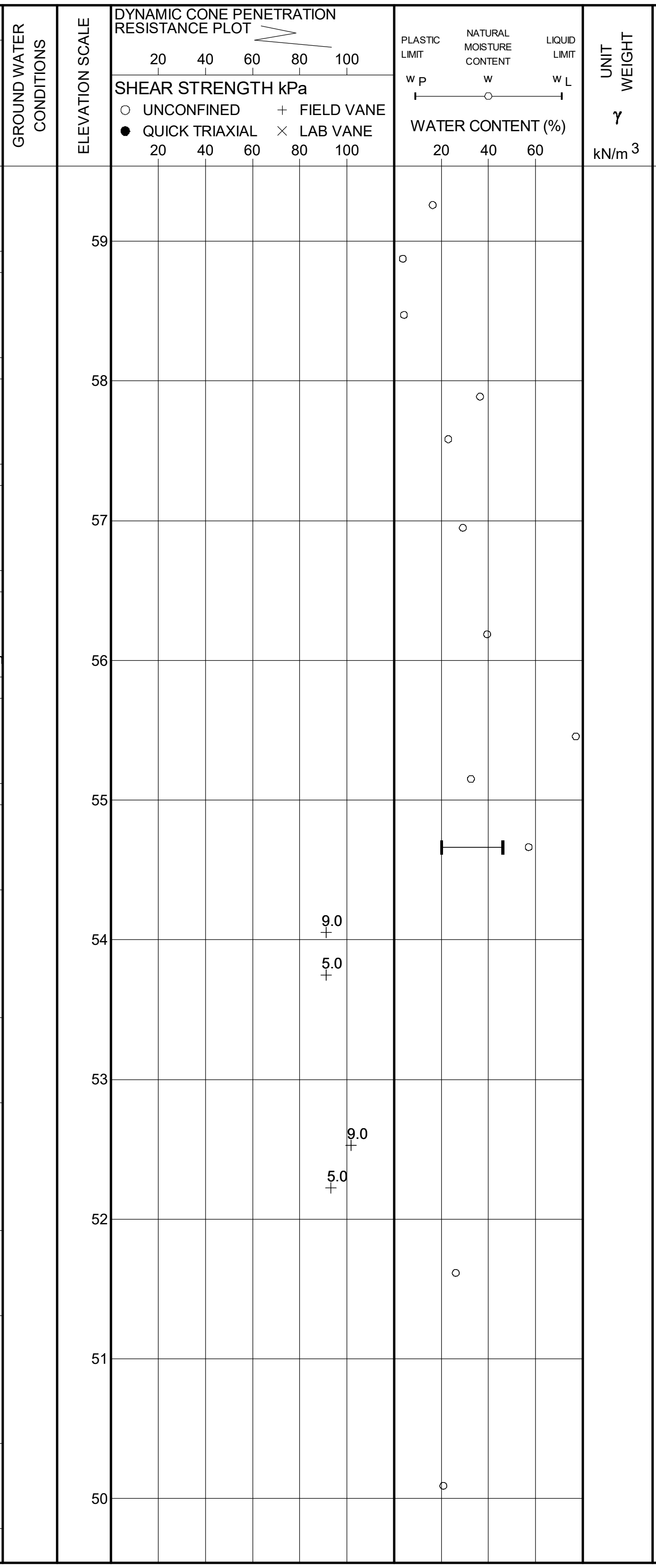
THURBER

RECORD OF BOREHOLE No 17-03

1 OF 2 **METRIC**

GWP#	4048-11-00	LOCATION	Nicholas Street Interchange - MTM z10: N 369 432.6 E 5 031 011.3	ORIGINATED BY	KE
HWY	417	BOREHOLE TYPE	Hollow Stem Augers / NW Casing / NQ Core	COMPILED BY	KE
DATUM	Geodetic	DATE	2017.10.16 - 2017.10.16	CHECKED BY	FG

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
59.5					
0.0 0.1	**SILTY SAND** with organics Loose Brown **FILL**	1	SS	9	
	SAND Loose to compact Brown **FILL** - 200 mm grey sand with gravel layer at 0.8m	2	SS	29	
58.0 1.5	**SILTY CLAY** with sand pockets Stiff Grey-brown	3	SS	9	
57.8 1.8	poorly graded **SAND (SP-SM)** with silt Loose to very loose Brown	4	SS	2	0 89 11 (SI+CL)
	- Very dense oranics and frequent wood fragments below 3.0m	5	SS	100/ 152mm	
		6	SS	4	
55.2 4.3	**CLAY (CI)** Stiff Grey	7	SS	2	0 5 44 51
		8	ST	Push	
51.9 7.6	**SILT** Loose Grey	9	SS	8	0 3 90 7 non-plastic
50.3 9.2	**SILTY SAND (SM)** with gravel **(Glacial Till)** Loose Grey	10	SS	5	



Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 17532_NICHOLASSTINTERCHANGE.GPJ 2012TEMPLATE(MTO).GDT 9/4/18

Ministry of Transportation
Ontario

THURBER

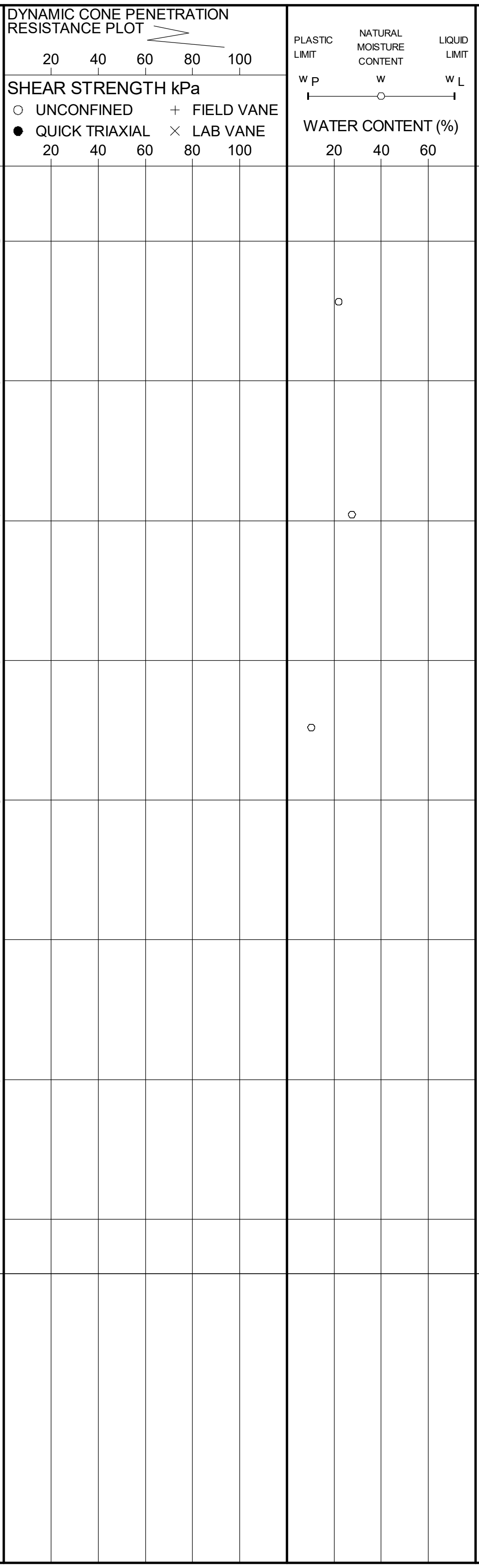
RECORD OF BOREHOLE No 17-03

2 OF 2

METRIC

GWP#	4048-11-00	ORIGINATED BY	KE
HWY	417	COMPILED BY	KE
DATUM	Geodetic	CHECKED BY	FG
LOCATION	Nicholas Street Interchange - MTM z10: N 369 432.6 E 5 031 011.3		
BOREHOLE TYPE	Hollow Stem Augers / NW Casing / NQ Core		
DATE	2017.10.16 - 2017.10.16		

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							
	SILTY SAND (SM) with gravel **(Glacial Till)** Loose to very dense Grey					49		
		11	SS	7				31 40 29 (SI+CL)
						48		
		12	SS	6		47		
						46		
		13	SS	63				
	- occasional cobbles below 14.3 m					45		
44.8 14.8	**BEDROCK** Shale Fresh Laminated to thinly bedded Strong Fine grained Dark grey	1	RUN					RUN #1 TCR=100% SCR=71% RQD=71%
		2	RUN			44		RUN #2 TCR=100% SCR=93% RQD=82%
						43		
		3	RUN			42		RUN #3 TCR=100% SCR=95% RQD=89%
41.6 17.9	End of Borehole							



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-04

1 OF 3 METRIC

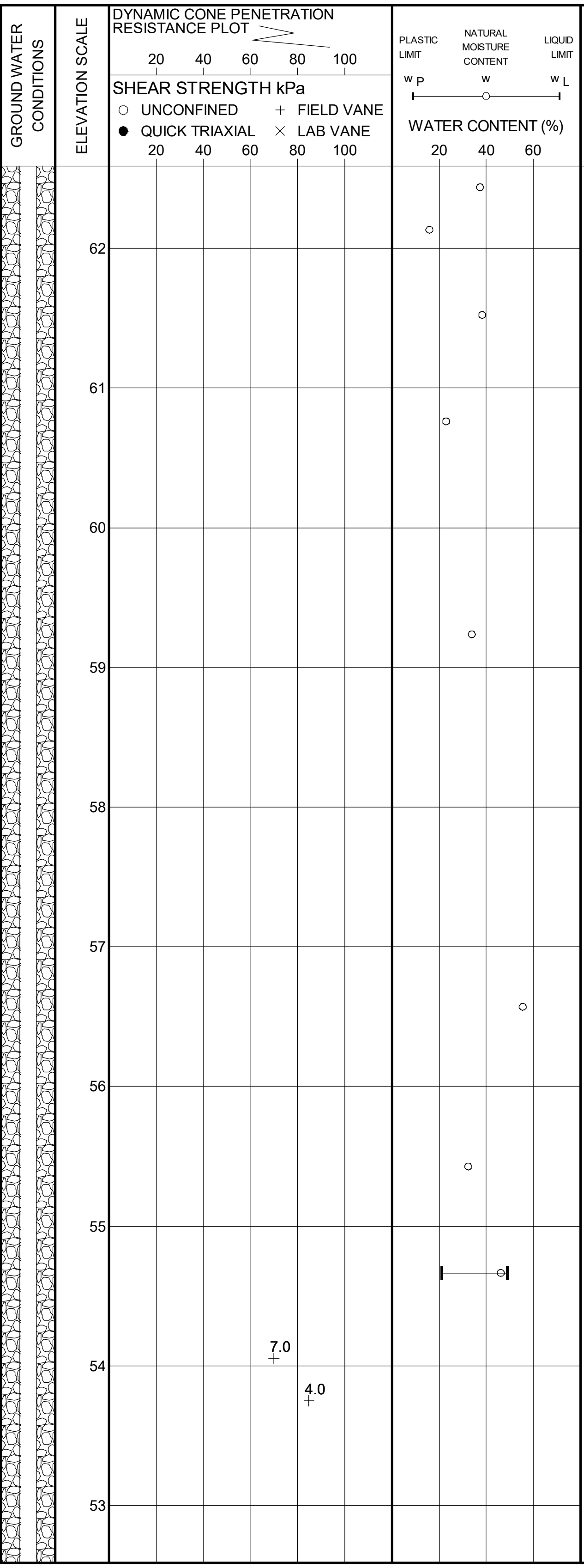
GWP#	4048-11-00	LOCATION	Nicholas Street Interchange - MTM z10: N 369 447.5 E 5 030 985.0	ORIGINATED BY	KE
HWY	417	BOREHOLE TYPE	Hollow Stem Augers / NW Casing / NQ Core	COMPILED BY	KE
DATUM	Geodetic	DATE	2017.10.17 - 2017.10.18	CHECKED BY	FG

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
62.6	
0.0	**SILTY SAND** with organics Very loose Brown **FILL**
62.3 0.3	**SILTY SAND** with gravel with WASTE: brick, coal, organics, wood fragments, ash, metal, glass Loose to dense Brown **FILL** - becoming black at 3.0 m
58.8 3.8	**SILTY SAND** trace gravel with coal, tar, wood fragments Loose Black **WASTE / FILL**
55.7 6.9	**CLAY (CI)** Stiff Grey

SAMPLES

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	3				
2	SS	6				
3	SS	16	21	63	16 (SI+CL)	
4	SS	40				
5	SS	7	18	66	16 (SI+CL)	
6	SS	5				
7	SS	5				
8	SS	4				
			7	65	28 (SI+CL)	
9	SS	5				
10	SS	7				
11	SS	4	0	1	43	56
12	ST	Push				



UNIT WEIGHT γ kN/m3

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-04

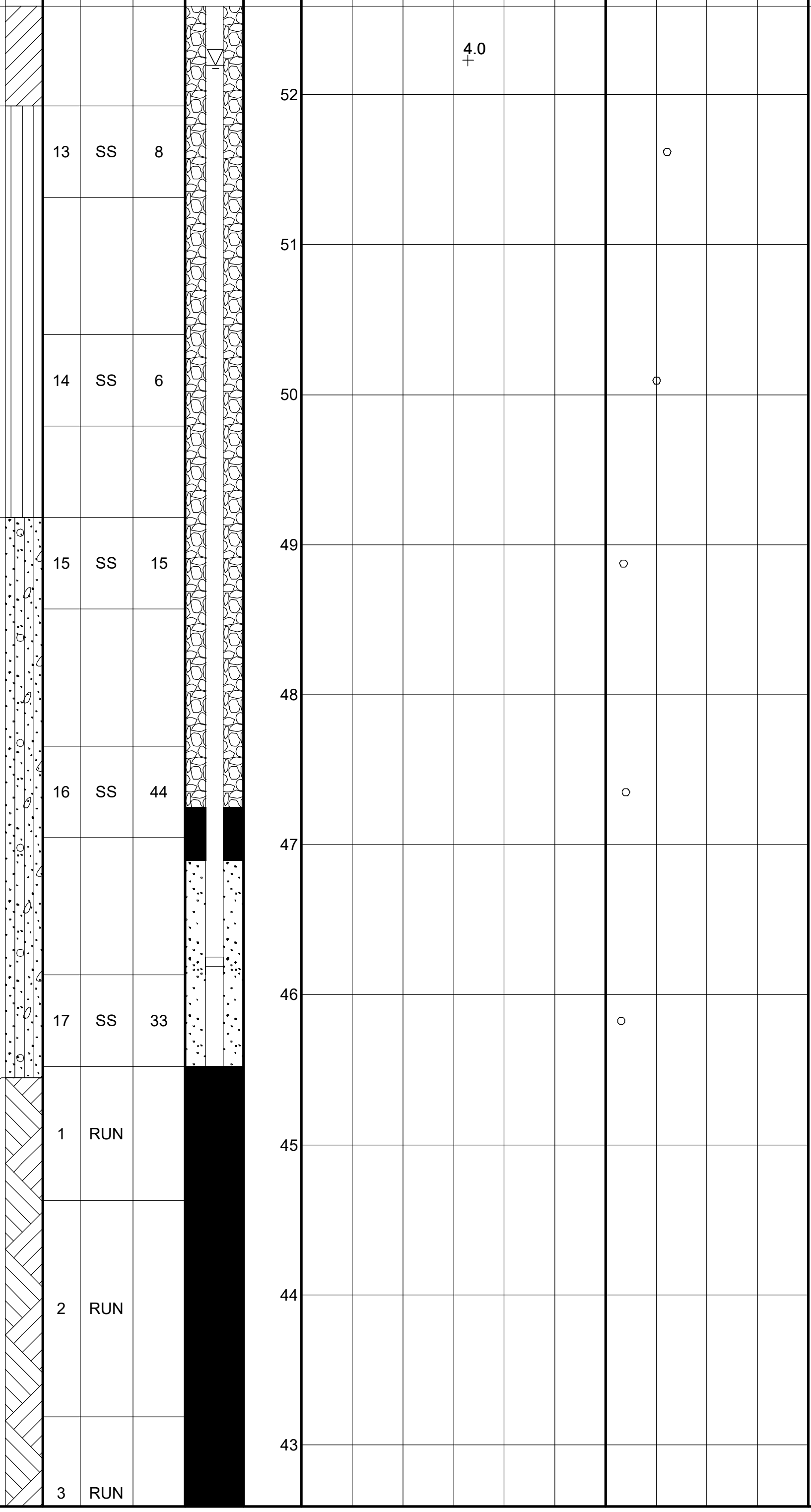
2 OF 3

METRIC

GWP# 4048-11-00
LOCATION Nicholas Street Interchange - MTM z10: N 369 447.5 E 5 030 985.0
ORIGINATED BY KE
HWY 417
BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core
COMPILED BY KE
DATUM Geodetic
DATE 2017.10.17 - 2017.10.18
CHECKED BY FG

Continued From Previous Page

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAY Stiff Grey				
51.9 10.7	**SILT** some sand Loose Grey	13	SS	8	
		14	SS	6	4 11 80 5 non-plastic
49.2 13.4	**SILTY SAND (SM)** with gravel **(Galcial Till)** Compact to dense Grey	15	SS	15	20 46 34 (SI+CL)
		16	SS	44	
		17	SS	33	
45.4 17.1	-occasional cobbles and boulders **BEDROCK** Shale with calcite veins Fresh Strong Laminated to thinly bedded Fine grained Dark grey	1	RUN		RUN #1 TCR=100% SCR=69% RQD=69%
		2	RUN		RUN #2 TCR=100% SCR=79% RQD=79%
		3	RUN		RUN #3 TCR=100% SCR=100% RQD=90%



Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-04

3 OF 3

METRIC

GWP# 4048-11-00
LOCATION Nicholas Street Interchange - MTM z10: N 369 447.5 E 5 030 985.0
ORIGINATED BY KE
HWY 417
BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core
COMPILED BY KE
DATUM Geodetic
DATE 2017.10.17 - 2017.10.18
CHECKED BY FG

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	Continued From Previous Page													
42.2 20.4	**BEDROCK** Shale with calcite veins Fresh Laminated to thinly bedded Strong Fine grained Dark grey	▨				■								
	End of Borehole VWP installed with tip at 16.4 mbgs Water Level on March 22, 2018 Depth 10.4 m Elevation 52.2													

+³, ×³: Numbers refer to Sensitivity

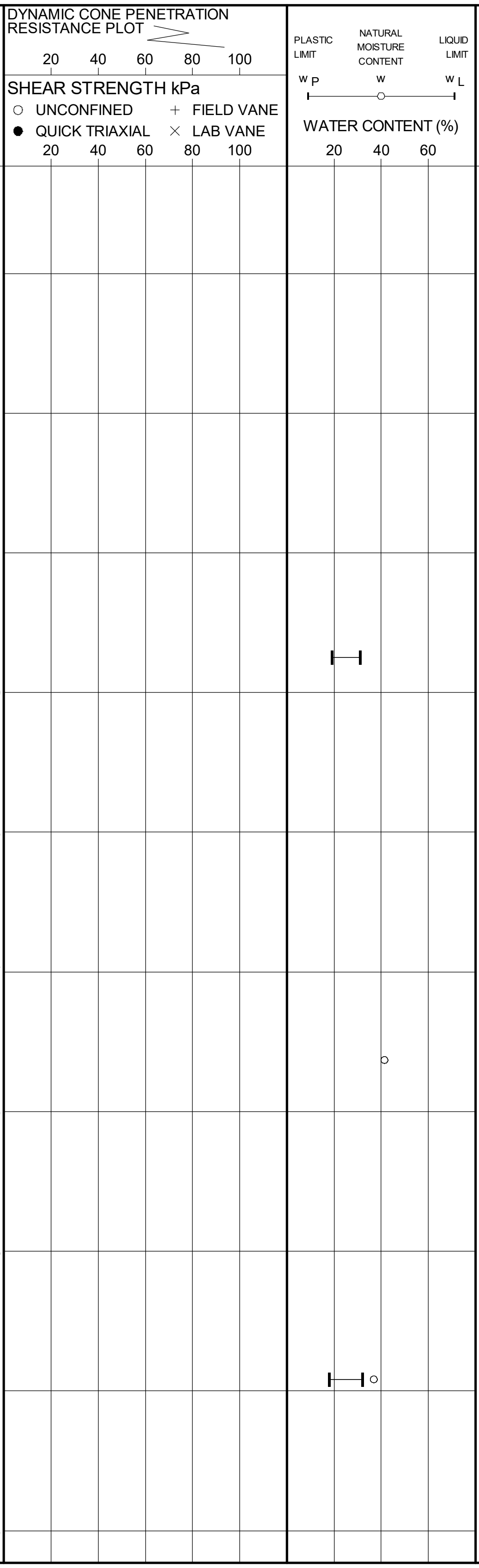
20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-05

1 OF 3 **METRIC**

GWP#	4048-11-00	LOCATION	Nicholas Street Interchange - MTM z10: N 369 467.7 E 5 031 002.0	ORIGINATED BY	KE
HWY	417	BOREHOLE TYPE	Hollow Stem Augers / NW Casing / NQ Core	COMPILED BY	KE
DATUM	Geodetic	DATE	2017.10.12 - 2017.10.13	CHECKED BY	FG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
62.8								
0.0	**SILTY SAND** with organics Very loose Black **FILL**	1	SS	7				
0.1	**SAND** Very loose to compact Brown **FILL**	2	SS	10	1	95	4 (SI+CL)	
		3	SS	3				
		4	SS	8				
59.4 3.4	**CLAY** with silty sand with WASTE: coal, wood fragments, ash, glass Firm to stiff Black **FILL**	5	SS	13	2	44	33	21
		6	SS	8				
		7	SS	4				
57.7 5.1	Intermixed **SAND and SILTY SAND** with gravel and silty clay with WASTE: coal, wood fragments, ash, glass, plastic Loose to compact Black **WASTE / FILL**	8	SS	5				
		9	SS	4	Organic Content 24%			
55.7 7.0	**CLAY (CL)** with sand seams Stiff to very stiff Grey - 100 mm sand bed at 7.2 m	10	SS	12				
		11	SS	3				
		12	SS	1	0	1	67	32
		13	ST	push				



GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m³

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 17532_NICHOLASSTINTERCHANGE.GPJ 2012TEMPLATE(MTO).GDT 9/4/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-05

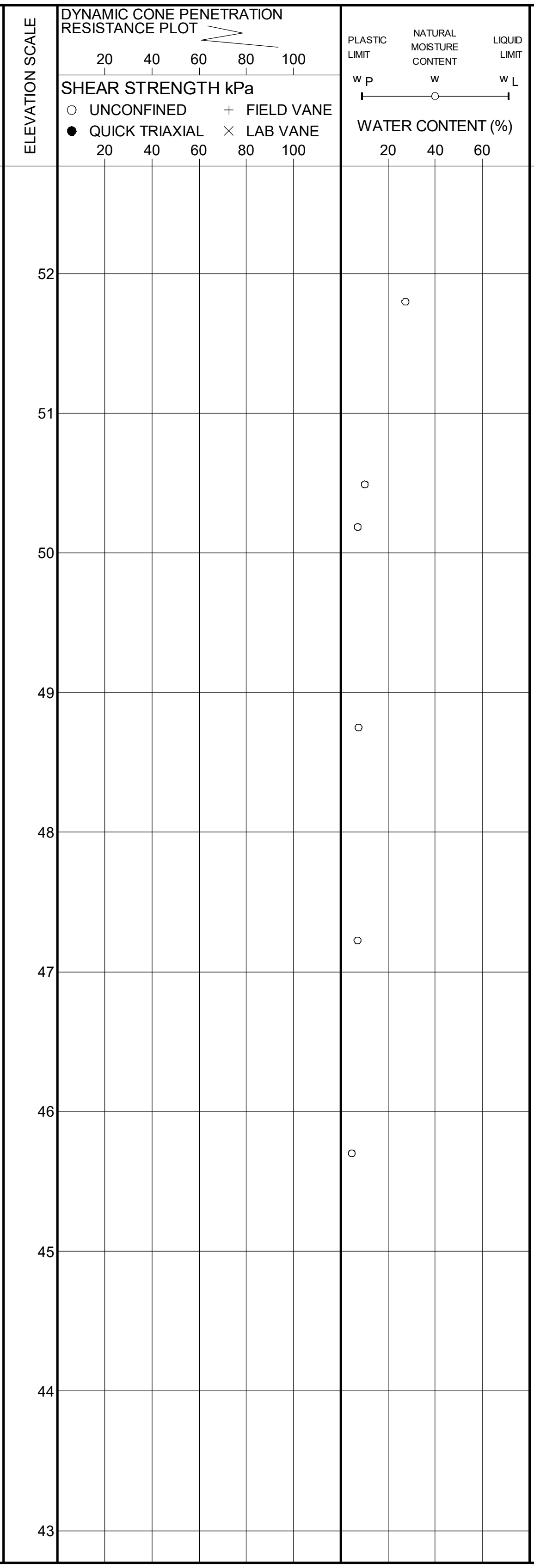
2 OF 3

METRIC

GWP# 4048-11-00	LOCATION Nicholas Street Interchange - MTM z10: N 369 467.7 E 5 031 002.0	ORIGINATED BY KE
HWY 417	BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core	COMPILED BY KE
DATUM Geodetic	DATE 2017.10.12 - 2017.10.13	CHECKED BY FG

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
52.7 10.1	**SILT** Loose Grey				
		14	SS	5	3 1 87 9 non-plastic
50.4 12.4	**SILTY SAND (SM)** with gravel **(Glacial Till)** Loose to compact Grey	15	SS	4	
		16	SS	8	25 44 31 (SI+CL)
		17	SS	18	
		18	SS	10	
	- frequent cobbles below 17.7 m				
44.4 18.4	**BEDROCK** Shale Fresh Strong Laminated to thinly bedded Fine grained Moderately Bedded Black	1	RUN		RUN #1 TCR=100% SCR=90% RQD=40%



UNIT WEIGHT γ kN/m3

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-05

3 OF 3

METRIC

GWP# 4048-11-00	LOCATION Nicholas Street Interchange - MTM z10: N 369 467.7 E 5 031 002.0	ORIGINATED BY KE
HWY 417	BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core	COMPILED BY KE
DATUM Geodetic	DATE 2017.10.12 - 2017.10.13	CHECKED BY FG

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
	BEDROCK Shale Fresh Strong Laminated to thinly bedded Fine grained Moderately Bedded Black	▨	2	RUN			42				RUN #2 TCR=100% SCR=100% RQD=82%
		▨	3	RUN			41				RUN #3 TCR=100% SCR=98% RQD=85%
40.6 22.1	End of Borehole										

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ● 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

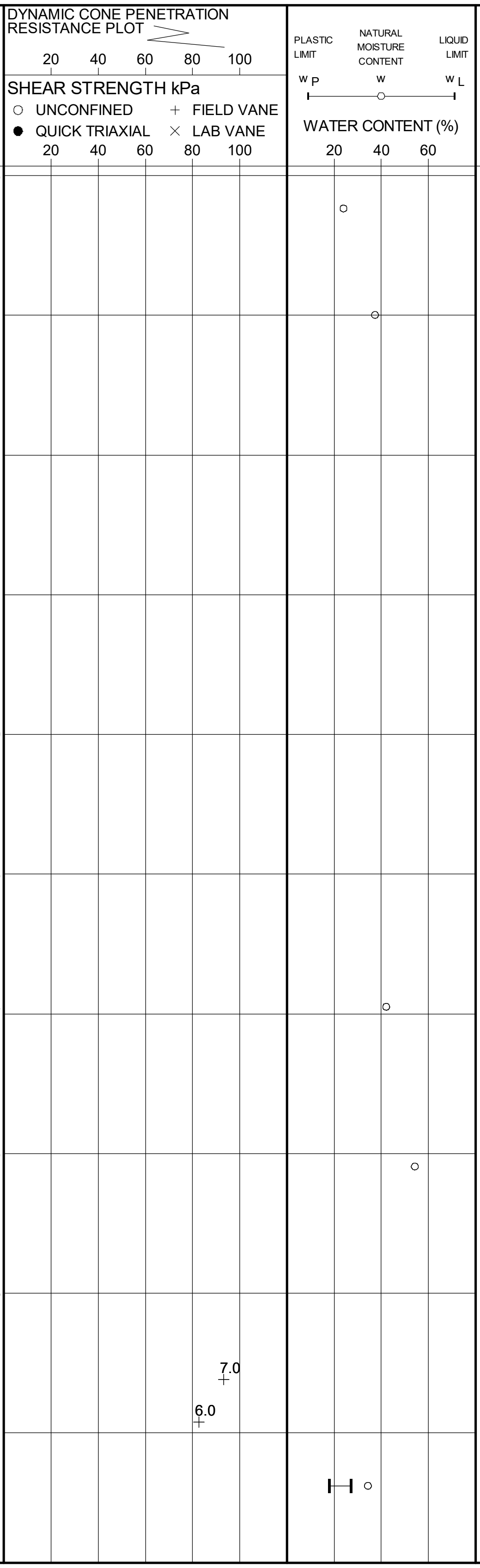
RECORD OF BOREHOLE No 17-06

1 OF 2

METRIC

GWP# 4048-11-00	LOCATION Nicholas Street Interchange - MTM z10: N 369 469.8 E 5 030 977.7	ORIGINATED BY KE
HWY 417	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY KE
DATUM Geodetic	DATE 2017.10.15 - 2017.10.15	CHECKED BY FG

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
63.1						
0.0 0.1	**SILTY SAND** with organics Very loose Black **FILL**	1	SS	8	63	
	SAND with silt with WASTE: coal, organics, ash, glass, brick, tar Loose to dense Brown-black **FILL**	2	SS	6	62	
		3	SS	11	61	4 88 8 (SI+CL)
		4	SS	14	60	
		5	SS	31		
		6	SS	4	59	
		7	SS	3	58	
57.7 5.3	**SILTY SAND** trace gravel with coal, tar, brick, plastic Loose Black **WASTE / FILL**	8	SS	4	57	6 71 23 (SI+CL)
		9	SS	8		
		10	SS	4	56	Organic Content 15%
55.3 7.7	**CLAY (CL)** trace sand seams Stiff Grey	11	SS	4	55	
					54	
		12	SS	2		0 1 67 32



UNIT WEIGHT γ kN/m3

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-06

2 OF 2

METRIC

GWP# 4048-11-00	LOCATION Nicholas Street Interchange - MTM z10: N 369 469.8 E 5 030 977.7	ORIGINATED BY KE
HWY 417	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY KE
DATUM Geodetic	DATE 2017.10.15 - 2017.10.15	CHECKED BY FG

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page								
	CLAY (CL) trace sand seams Stiff Grey					53	+ 7.0		
52.8 10.3	**SILT** trace sand Loose Grey								
		13	SS	6		52			0 3 88 9 non-plastic
						51			
		14	SS	1					0 6 89 5 non-plastic
49.8 13.3	**SILTY SAND (SM)** with gravel **(Glacial Till)** Compact to dense Grey					50			
		15	SS	28		49			
		16	SS	33					25 43 32 (SI+CL)
48.0 15.1	End of Borehole					48			

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

+ 3, × 3: Numbers refer to Sensitivity

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

ONTMT4S 17532_NICHOLASSTINTERCHANGE.GPJ 2012TEMPLATE(MTO).GDT 9/4/18

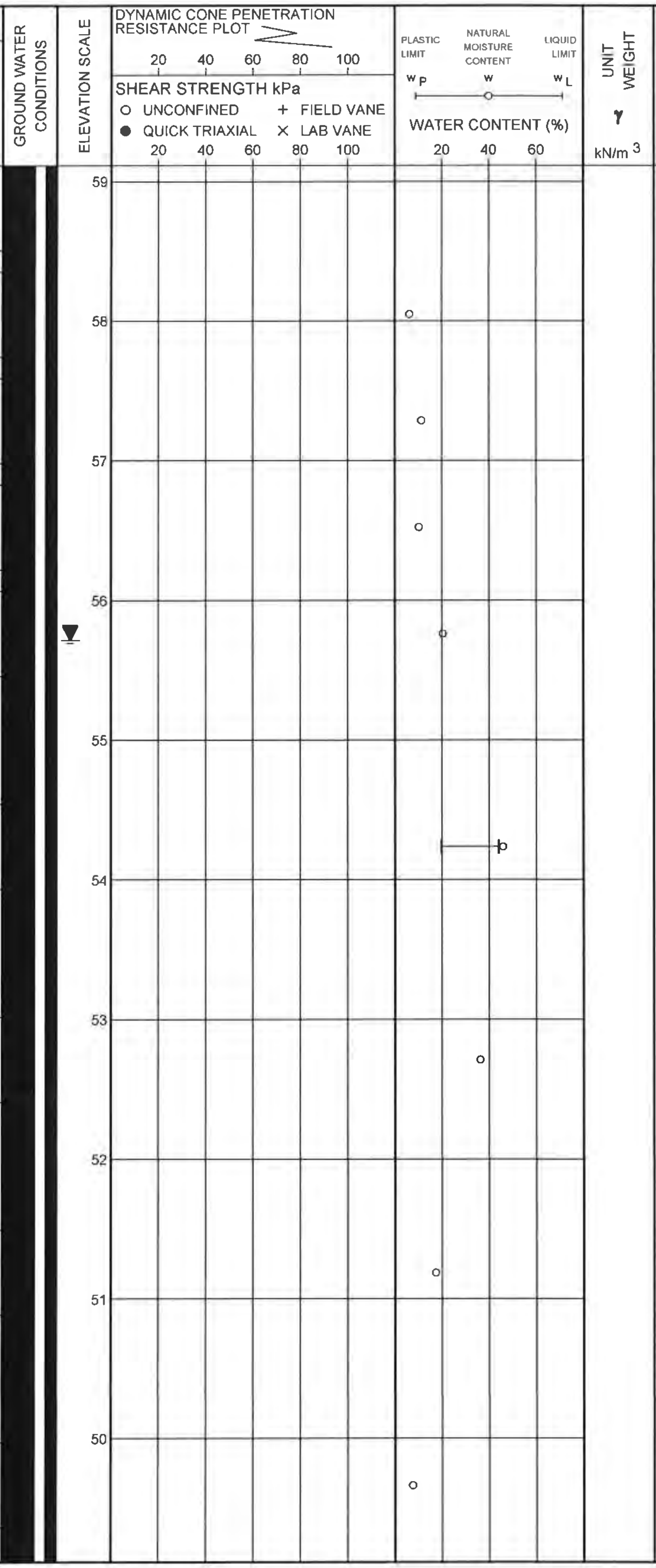
RECORD OF BOREHOLE No NSW-1

1 OF 2

METRIC

W.P.	4091-07-00	LOCATION	N 5 031 020.7 E 369 459.8	ORIGINATED BY	GA
HWY	417	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012 04 30 - 2012 05 01	CHECKED BY	LRB

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
59.1					
0.0 0.1	**ASPHALT:** (75mm)				
58.7 0.4	**CONCRETE:** (350mm)	1	GS		
	SAND, trace to some gravel, trace silt Dense Brown Dry (FILL)	2	SS	38	
		3	SS	37	
56.8 2.3	**SAND**, some silt, trace gravel, trace clay Compact Brown Dry	4	SS	23	
56.1 3.0	**SAND**, medium to coarse grained Loose Grey Wet	5	SS	7	
55.1 4.0	Silty **CLAY**, trace sand Soft Grey	6	SS	4	0 2 48 50
53.0 6.1	**SILT**, trace to some sand, trace clay Compact Grey Wet	7	SS	12	
		8	SS	13	0 6 88 6
50.0 9.1	Silty **SAND**, trace to some gravel, trace to some clay Compact Grey Wet (TILL)	9	SS	19	



Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20
15-⊕-5
10
(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NSW-1

2 OF 2

METRIC

W P 4091-07-00
LOCATION N 5 031 020 7 E 369 459 8
ORIGINATED BY GA
HWY 417
BOREHOLE TYPE Hollow Stem Augers
COMPILED BY AN
DATUM Geodetic
DATE 2012 04 30 - 2012 05 01
CHECKED BY LRB

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	Silty **SAND**, trace to some gravel, trace to some clay Compact Grey Wet (TILL)							
		10	SS	15	10	53	27	10
		11	SS	26				
45 2		12	SS	50/				
13 9	END OF BOREHOLE AT 13 9m UPON AUGER REFUSAL ON PROBABLE BEDROCK BOREHOLE OPEN TO 13 9m AND WATER LEVEL AT 3 3m UPON COMPLETION Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1 52m slotted screen			0 150				

ELEVATION SCALE: 49, 48, 47, 46

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV (m)
May 02/12	3 4	55 7
May 03/12	3 4	55 7

ONTMT4S 1201A GPJ 5/9/12

+³, ×³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

PROJECT No. 6339

RECORD OF BOREHOLE 3

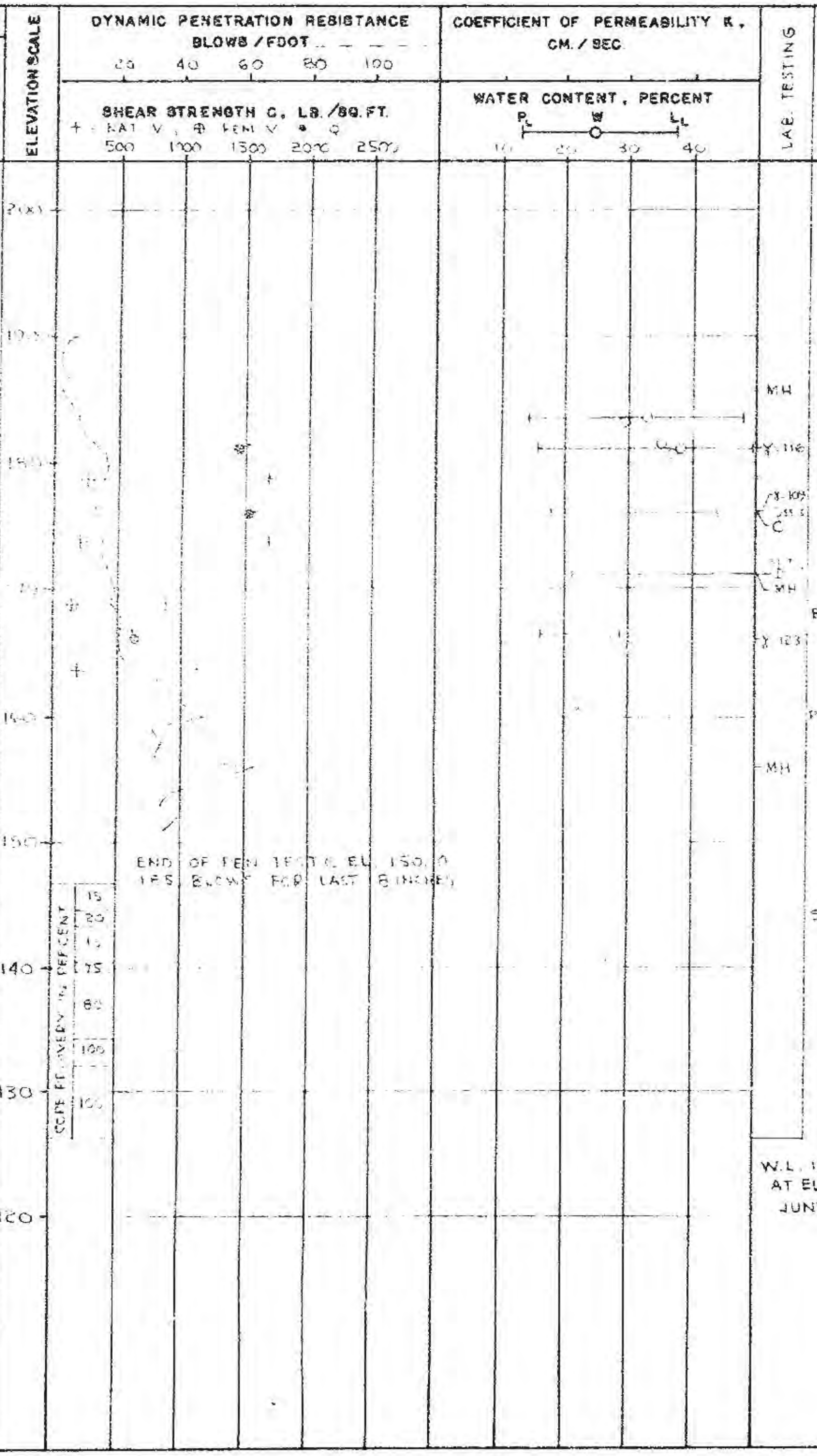
LOCATION SEE FIGURE 1 BORING DATE MAY 25 - 28, 1963 DATUM GEODETIC

BOREHOLE TYPE POWER AUGER & WASH BORING BOREHOLE DIAMETER 4.5" BX & AX CASING

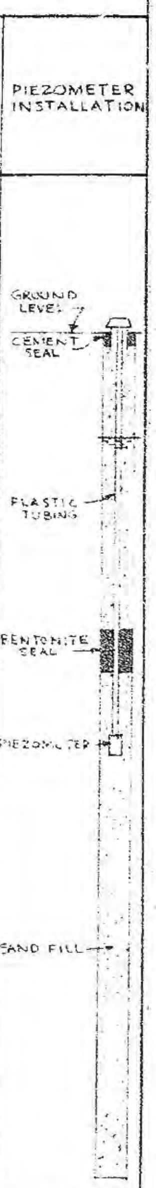
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

ELEVN / DEPTH	SOIL PROFILE – DESCRIPTION
191.6 0.0	GROUND LEVEL
	LOOSE DARK BROWN SILTY SAND TO CLAYEY SILT, GLASS AND WOOD FRAGMENTS (FILL)
185.3 6.3	STIFF TO FIRM GREY BROWN, GREY BELOW ELEV 180, SILTY CLAY, TRACE OF FINE SAND AND OCCASIONAL FINE GRAVEL
162.5 29.1	COMPACT GREY SANDY SILT TO SILTY FINE SAND, TRACE OF CLAY
151.6 40.0	DENSE TO VERY DENSE GRAVEL, COBBLES AND BOULDERS IN SANDY SILT MATRIX (TILL)
140.3 51.3	SOUND DARK GREY SHALE BEDROCK, OCCASIONAL THIN LIMESTONE SEAMS
126.3 65.3	END OF HOLE

SAMPLES NUMBER	TYPE	BLOWS / FT.
1	2" S.S.	2
2	"	6
3	"	13
4	[illegible]	[illegible]
5	[illegible]	[illegible]
6	2" S.S.	[illegible]
7	[illegible]	[illegible]
8	[illegible]	9
9	"	12
10		60
11	AXT RC	—
12		—
13	"	—
14	"	—
15	"	—
16	"	—
17	"	—



END OF PEN TEST @ EL. 150.0 165 BLOWS FOR LAST 8 INCHES



W.L. IN PIEZOMETER AT ELEV. 153.6 JUNE 15, 1963

VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED

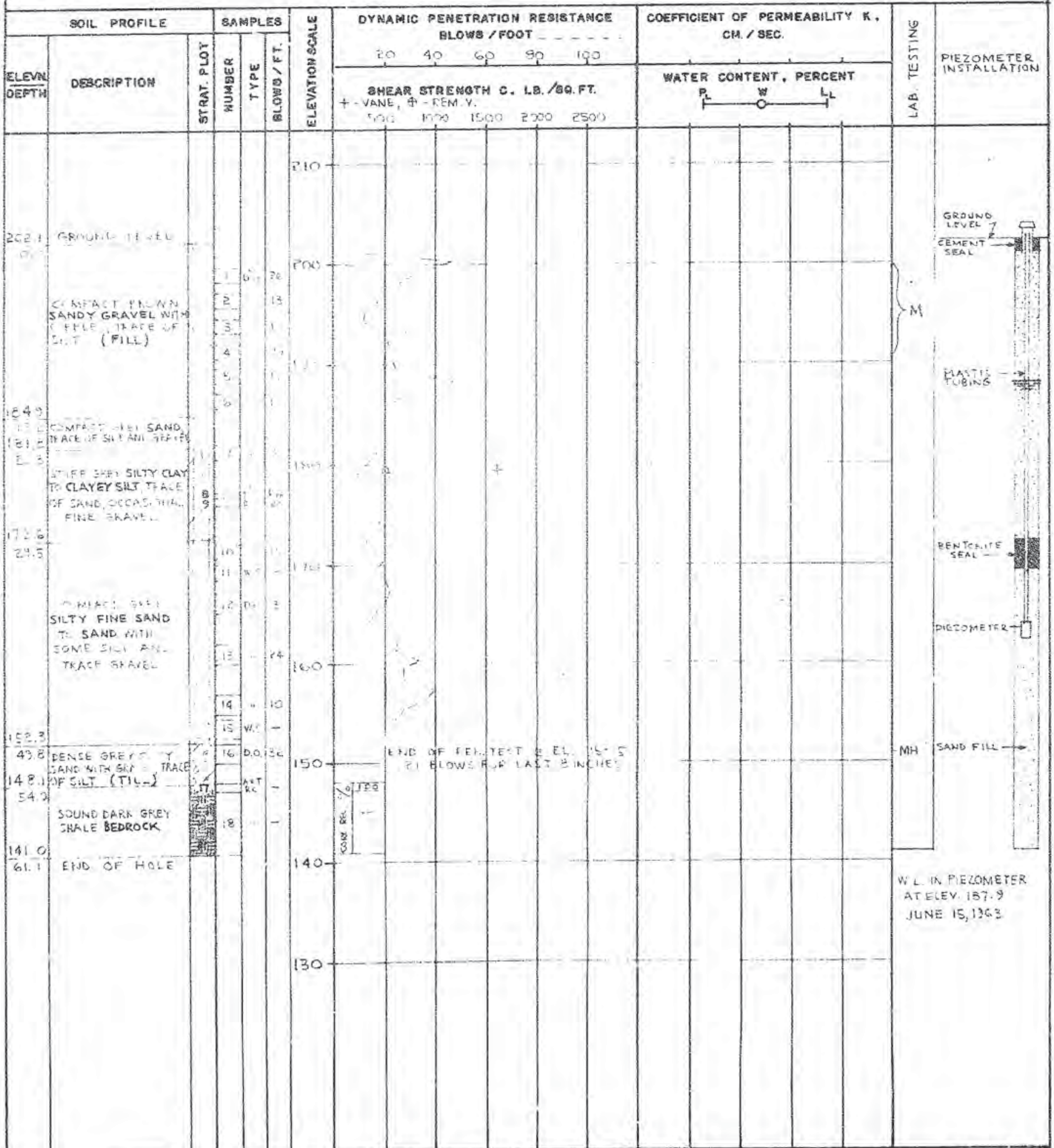
PROJECT No. 6339

RECORD OF BOREHOLE 4

LOCATION SEE FIGURE 1 **BORING DATE** JUNE 3 - 5, 1963 **DATUM** GEODETIC

BOREHOLE TYPE WASH BORING **BOREHOLE DIAMETER** NX, EX, AX CASING

SAMPLER HAMMER WEIGHT 140 **LB. DROP** 30 **INCHES** **PEN. TEST HAMMER WEIGHT** 140 **LB. DROP** 30 **INCHES**



ELEVN. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FT.
202.1 0.0	GROUND LEVEL				
	COMPACT BROWN SANDY GRAVEL WITH COBBLES, TRACE OF SILT (FILL)		1	D.O.	26
			2		13
			3		[illegible]
			4		[illegible]
			5		[illegible]
			6		[illegible]
184.9 17.2	COMPACT GREY SAND, TRACE OF SILT AND GRAVEL		7		[illegible]
181.8 20.3	STIFF GREY SILTY CLAY TO CLAYEY SILT, TRACE OF SAND, OCCASIONAL FINE GRAVEL		8 9		[illegible]
172.6 29.5	COMPACT GREY SILTY FINE SAND TO SAND WITH SOME SILT AND TRACE GRAVEL		10		[illegible]
			11	W.S.	–
			12	D.O.	3
			13	"	24
			14	"	10
			15	W.S.	–
158.3 43.8	DENSE GREY SILTY SAND WITH GRAVEL, TRACE OF SILT (TILL)		16	D.O.	36
148.1 54.0	SOUND DARK GREY SHALE BEDROCK		17	AXT RC	–
			18		–
141.0 61.1	END OF HOLE				

END OF PEN. TEST @ EL. [illegible]
21 BLOWS FOR LAST 8 INCHES

W.L. IN PIEZOMETER AT ELEV. 187.9 JUNE 15, 1963

VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED ЯМ

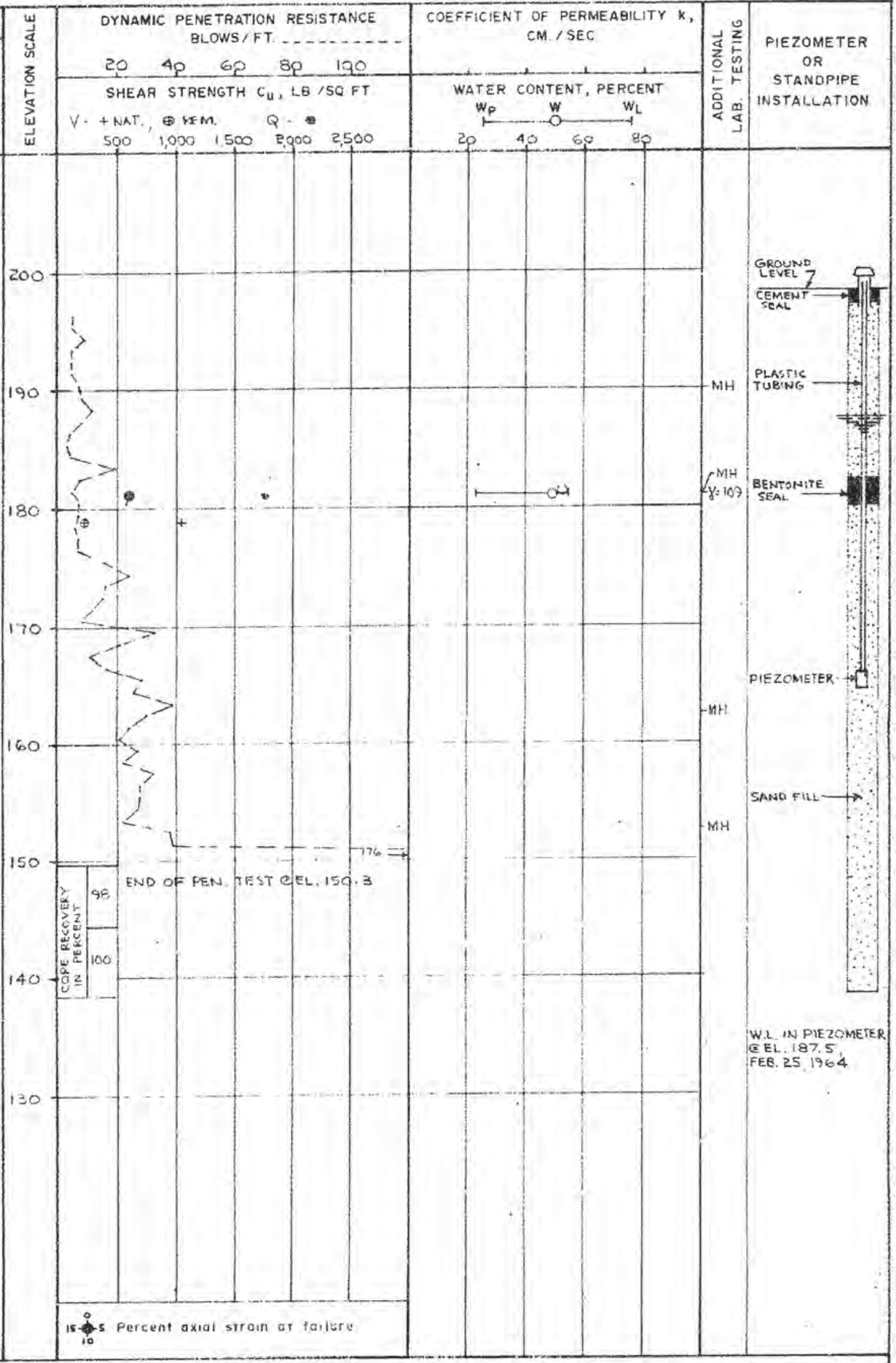
RECORD OF BOREHOLE 102

LOCATION See Figure 1 BORING DATE JAN. 27-30, 1964 DATUM GEODETIC

BOREHOLE TYPE POWER AUGER & WASH BORING BOREHOLE DIAMETER 4.5" & BX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE		SAMPLES		
ELEVN. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FT.
198.3	GROUND LEVEL			
0.0	VERY LOOSE TO LOOSE BLACK ORGANIC SILT TO SILTY SAND WITH GRAVEL, TRACE TO SOME CLAY, CINDERS, PIECES OF WOOD, STEEL GLASS, BRICK ETC. (FILL)	1	2" D.O.	43
		2	"	21
		3	"	3
		4	"	5
		5	"	2
183.8 14.5	FIRM TO STIFF GREY-BROWN TO GREY SENSITIVE **SILTY CLAY**	6	"	4
		7	T.O.	PH
		8	"	PH
177.3 21.0	COMPACT GREY **SILT** TRACE OF CLAY AND FINE SAND, OCCASIONAL THIN CLAYEY SILT SEAMS	9	D.O.	10
		10	"	12
		11	"	7
169.8 28.5	LOOSE TO COMPACT (VERY DENSE BELOW EL 154 APPROX.) DARK GREY SILTY SAND WITH GRAVEL, TRACE TO SOME CLAY (TILL)	12	"	10
		13	"	4
		14	"	6
		15	"	56
150.2 48.1	SOUND DARK GREY SHALE **BEDROCK**	16	AXT R.C.	—
		17	"	—
138.3 60.0	END OF HOLE			



VERTICAL SCALE 1 INCH TO 10'-0"

GOLDER & ASSOCIATES

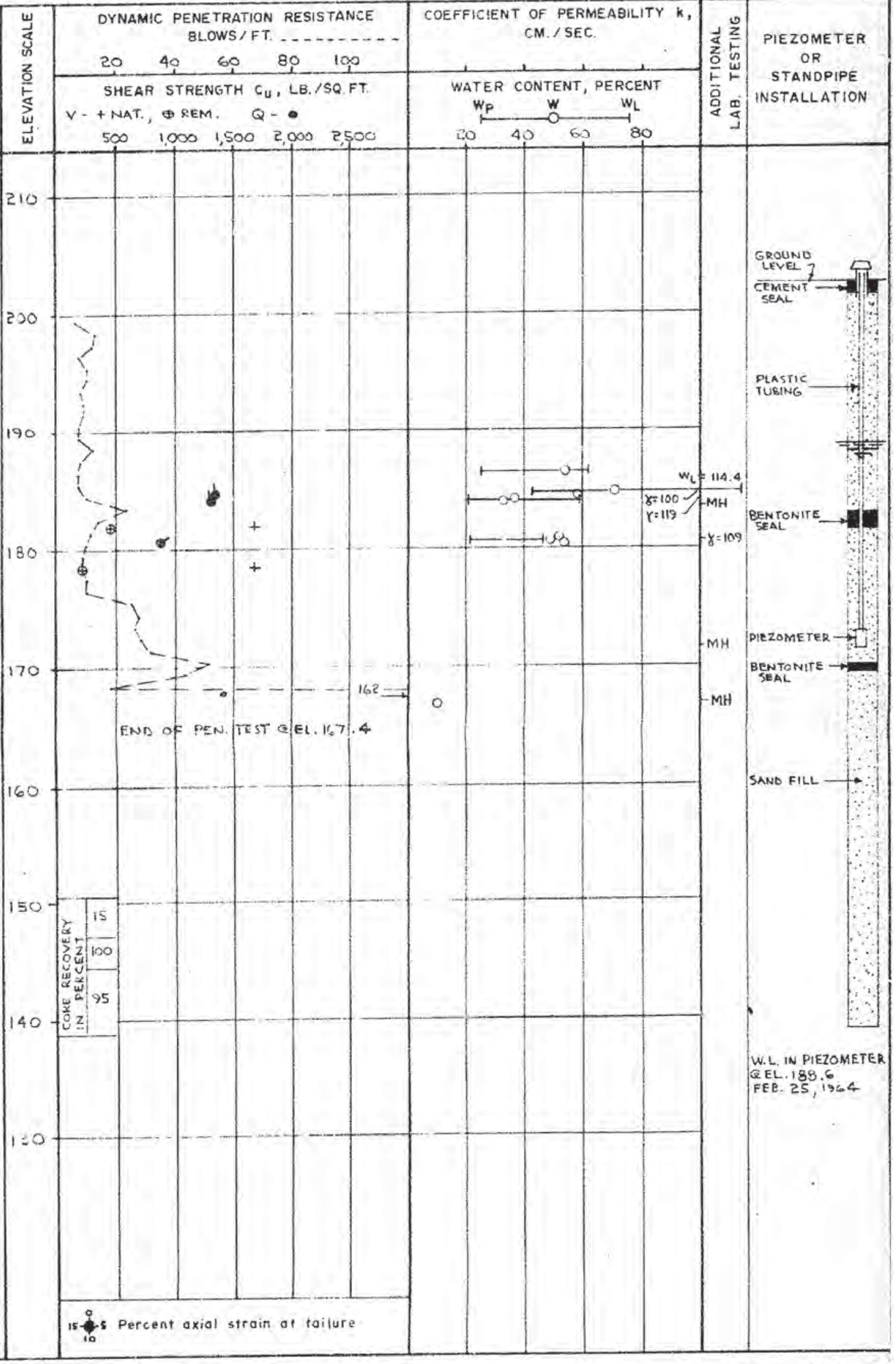
DRAWN J.A.

CHECKED DW

RECORD OF BOREHOLE 104

LOCATION See Figure 1
BORING DATE JAN. 29-31, 1964
DATUM GEODETIC
BOREHOLE TYPE POWER AUGER & WASH BORING
BOREHOLE DIAMETER 4.5" & BX CASING
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES
PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE ELEVN. DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FT.
202.4	GROUND LEVEL			
0.0	LOOSE BLACK CINDERS TRACE OF SAND (FILL)			
200.2 2.2	LOOSE BROWN SAND, TRACE OF SILT WITH POCKETS OF FIRM GREY FISSURED AND SENSITIVE SILTY CLAY SCATTERED THROUGHOUT (FILL)	1	2" D.O.	24
		2	"	15
		3	"	9
		4	"	7
		5	"	6
187.9 14.5	SOFT TO STIFF CHUNKY SENSITIVE BROWN - GREY SILTY CLAY WITH ORGANIC MATTER AND SAND POCKETS (FILL)	6 7	T.O D.O.	PH
		8	T.O.	PH
183.4 19.0	FIRM TO STIFF GREY SENSITIVE **SILTY CLAY TO CLAYEY SILT**	9	"	PH
		10	"	PH
176.4 26.0	COMPACT GREY **SILT** TRACE OF CLAY AND FINE SAND	11	D.O.	7
		12	"	18
169.9 32.5	LOOSE TO COMPACT (DENSE TO VERY DENSE BELOW EL. 154 APPROX) DARK GREY SANDY TO CLAYEY SILT WITH GRAVEL, OCCASIONAL COBBLES (TILL)	13	"	4
		14	"	WH
		15	"	2
		16	"	42
		17	AXT RC	—
147.4 55.0	SOUND DARK GREY SHALE **BEDROCK**	18	"	—
138.6 63.8	END OF HOLE			



W.L. IN PIEZOMETER @ EL. 188.6 FEB. 25, 1964

VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED

GEOPHYSICS GPR INTERNATIONAL INC.

100 – 2545 Delorimier Street
Longueuil (Québec)
Canada J4K 3P7

Tel. : (450) 679-2400
Fax : (514) 521-4128
info@geophysicsgpr.com
www.geophysicsgpr.com

November 10th, 2017

Transmitted by email: CMurray@thurber.ca
Our Ref.: GPR-17-00157

Mr. Christopher Murray, M.Sc.
Geotechnical Engineer in Training
Thurber Engineering Ltd.
104, 2460 Lancaster Road
Ottawa (ON) K1B 4S5

Subject: **Shear-Wave Velocity Sounding, Nicholas Street, Ottawa (ON)**

Dear Sir,

Geophysics GPR International Inc. has been requested by Thurber Engineering Ltd. to carry out seismic shear wave surveys at the Highway 417 Nicholas Street underpass, in Ottawa (ON). The geophysical investigations used the Multi-channel Analysis of Surface Waves (MASW) and the Extended SPatial AutoCorrelation (ESPAC). From the subsequent results, the $\overline{V}_{S30}$ value was calculated to identify the Site Class.

The surveys were carried out in the evening of October 30th, by Mr. Sofiane Boulila and Mr. André Beaudoin, Sr. Tech. The Figure 1 shows the regional location of the site and the Figure 2 illustrates the location of the seismic spreads. Both figures are presented in Appendix.

The following paragraphs briefly describe the survey design, the principles of the test methods, and the results in graphic and table format.

MASW PRINCIPLE

The ***Multi-channel Analysis of Surface Waves*** (MASW) and the ***Extended SPatial AutoCorrelation*** (ESPAC or MAM for ***Microtremors Array Method***) are seismic methods used to evaluate the shear wave velocities of subsurface materials through the analysis of the dispersion properties of the Rayleigh surface waves ("ground roll"). The MASW is considered an "active" method, as the seismic signal is induced at known location and time in the geophones spread axis. Conversely, the ESPAC is considered a "passive" method, using the low frequency "noises" produced far away. The method can also be used with "active" seismic source records. The ESPAC method allows deeper Vs soundings, but generally with a lower resolution for the surface portion. Its dispersion curve can then be merged with the higher frequency one from the MASW to calculate a more complete inversion. The dispersion properties are measured as a change in phase velocity with frequency. Surface wave energy will decay exponentially with depth. Lower frequency surface waves will travel deeper and thus be more influenced by deeper velocity layering than the shallow higher frequency waves. The inversion of the Rayleigh wave dispersion curve yields a shear wave (V_S) velocity depth profile (sounding). Figure 3 outlines the basic field operating procedure for the MASW method.

Figure 4 illustrates an example of one of the MASW/ESPAC records, the corresponding spectrogram analysis and resulting 1D V_S model.

More detailed descriptions of the methods are presented in ***Shear Wave Velocity Measurement Guidelines for Canadian Seismic Site Characterization in Soil and Rock***, Hunter, J.A., Crow, H.L., et al., Geological Surveys of Canada, General Information Product 110, 2015.

INTERPRETATION METHOD

The main processing sequence involved data inspection; spectral analysis ("phase shift" for MASW, and cross-correlation for ESPAC); picking the fundamental mode of the dispersion curves; and 1D modelling and inversion of the MASW and ESPAC shot records using the SeisImagerSW™ software. The data modeling and inversions used a non-linear least square algorithm.

In theory, all the shot records for a given seismic spread should produce a similar shear-wave velocity profile. In practice, however, differences can arise due to energy dissipation, localized surface seismic velocities variations, and/or dipping of overburden layers or rock. In general the precision of the calculated seismic shear wave velocities (V_S) is of the order of 15% or better.

SURVEY DESIGN

The seismic sounding was carried out on the North side of the Highway 417 Nicholas Street underpass. The geophone spacing for the main spread was of 3 metres, which means that the total length of a 24 geophones spread was 69 metres. A second shorter seismic spread, with geophone spacing of 1 metre, was dedicated to the near surface materials.

The shear wave depth soundings can be considered as the average of the bulk area within the geophone spread, especially for its central half-length.

The seismic records were realized with a seismograph Terraloc MK6 (from ABEM Instrument), and the geophones were 4.5 Hz. An 18 pounds sledgehammer was used as the energy source with impacts being recorded off both ends of the seismic spreads.

The seismic records counted 4096 data, sampled at 1000 μs for the MASW, and 50 μs for the seismic refraction method. The records included a pre-trig portion of 10 ms. A stacking procedure was also used to improve the Signal / Noise ratio for the seismic records.

RESULTS

The calculated V_S results from MASW are illustrated at Figure 5, and they are also presented at the Table 1.

The $\overline{V}_{S30}$ value results from the harmonic mean of the shear wave velocities, from the surface to 30 metres deep. It is calculated by dividing the total depth of interest (30 metres) by the sum of the time spent in each velocity layer from the surface up to 30 metres. This value reflects an equivalent homogeneous single layer response.

The calculated $\overline{V}_{S30}$ value for the actual site is 389.8 m/s, corresponding to the Site Class “C”. However, low seismic velocities were calculated for the unconsolidated materials, from the surface to approximately 5 metres deep.

CONCLUSION

Seismic surveys were carried out with the MASW and ESPAC analysis methods to calculate the $\overline{V}_{S30}$ value for the Site Class determination. The surveyed site was located on the North side of the Highway 417 Nicholas Street underpass, in Ottawa (ON).

The $\overline{V}_{S30}$ value of the actual site is 390 m/s. Considering this value (determined through the MASW and the ESPAC methods), Table 4.1.8.4.A of the CNBC, and the Building Code, O. Reg. 332/12, the investigated site presents a Site Class “C” ($360 < \overline{V}_{S30} \leqslant 760$ m/s). Nevertheless, some low seismic velocities were calculated for the unconsolidated materials, from the surface to approximately 5 metres deep. A geotechnical assessment for the potential of liquefaction could be required for these low seismic velocities unconsolidated materials.

It must be noted that other geotechnical information gleaned on site; including the presence of liquefiable soils, soft clays, high moisture content etc. can supersede the Site Classification provided in this report based on the $\overline{V}_{S30}$ value.

The V_S values calculated are representative of the in situ materials, and were not corrected for the total and effective stresses.

Jean-Luc Arsenault, M.A.Sc., P.Eng.
Project Manager

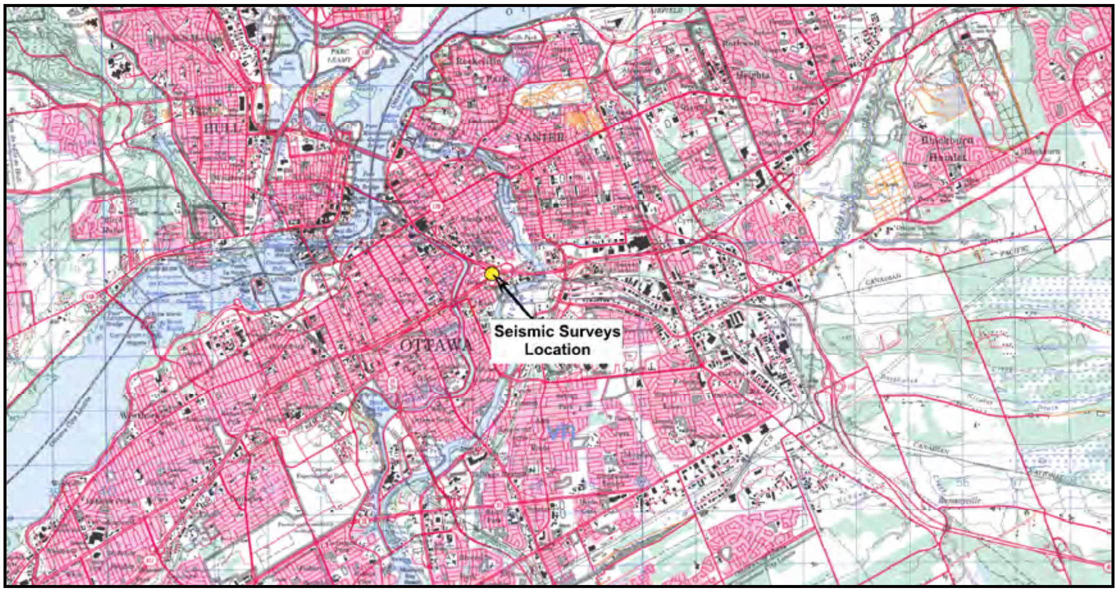


Figure 1: Regional location of the Site
(source: topographic map 31 G/05)

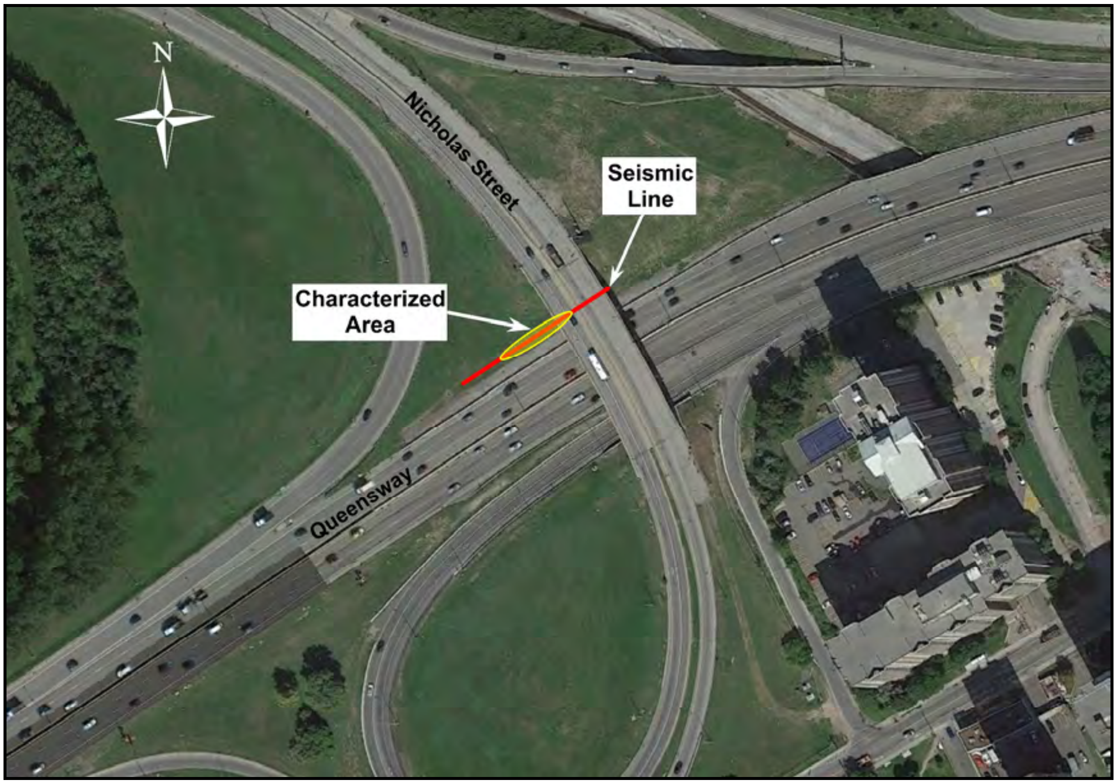


Figure 2: Location of the seismic spreads
(source : ***Google Earth***™)

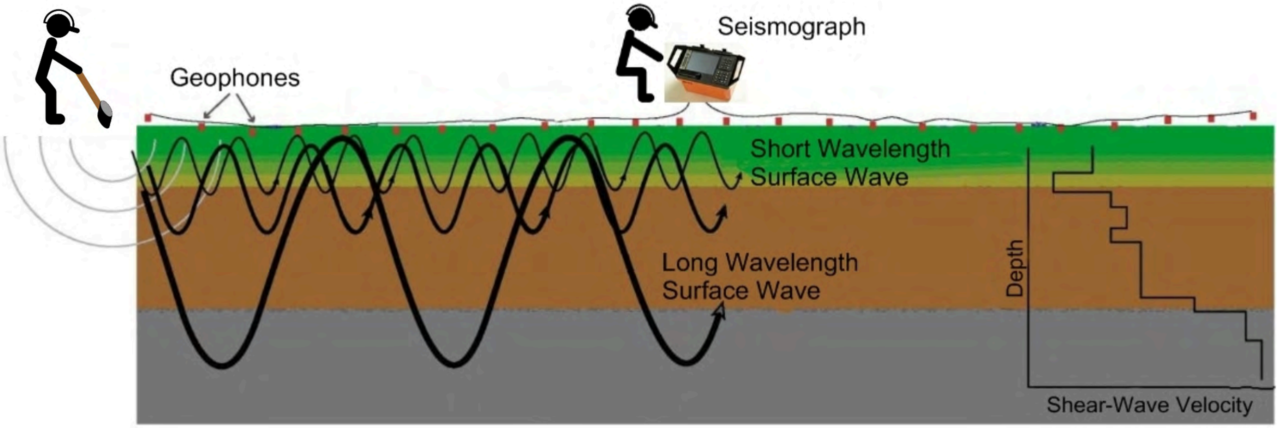
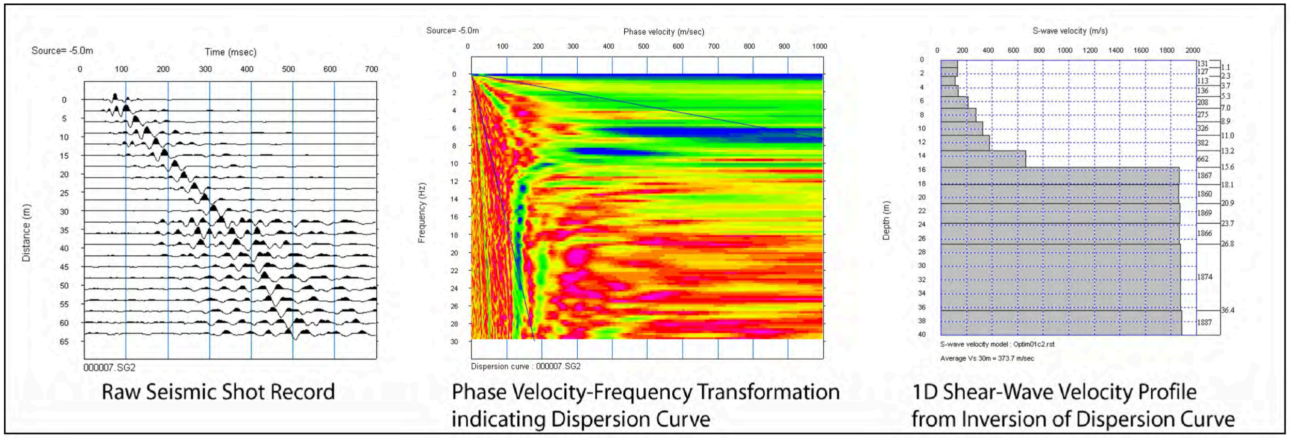


Figure 3: MASW Field Operating Principle



Raw Seismic Shot Record

Phase Velocity-Frequency Transformation indicating Dispersion Curve

1D Shear-Wave Velocity Profile from Inversion of Dispersion Curve

Figure 4: Example of a MASW/ESPAC Record, Phase Velocity - Frequency Curve and resulting 1D Shear Wave Velocity Model

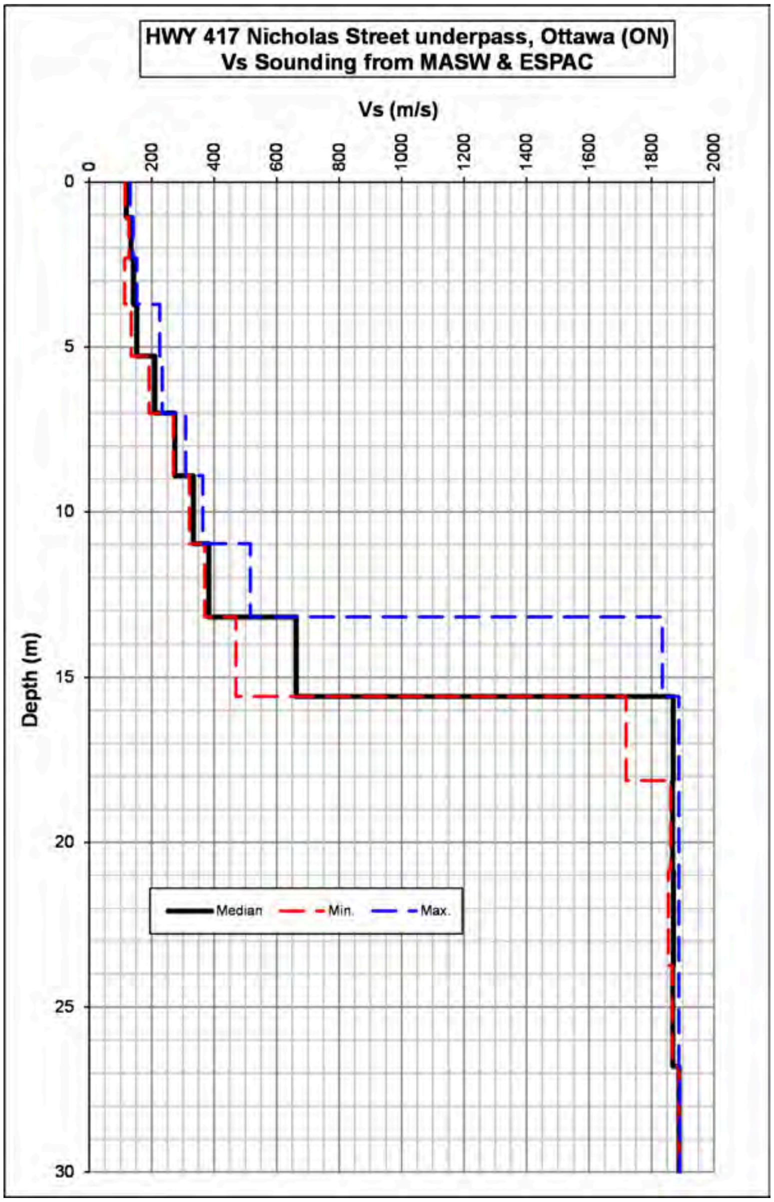


Figure 5: Vs Sounding from MASW and ESPAC

TABLE 1

V_{S30} Calculation for the Site Class

Depth	Vs			Thickness	Cumulative Thickness	Delay for Med. Vs	Cumulative Delay	Avg. Vs at given Depth
	Min.	Median	Max.					
(m)	(m/s)	(m/s)	(m/s)	(m)	(m)	(s)	(s)	(m/s)
0	**114.7**	**118.3**	**131.2**					
1.07	**126.7**	**133.6**	**140.6**	1.07	1.07	0.009049	0.009049	118.3
2.31	**113.2**	**141.7**	**152.6**	1.24	2.31	0.009255	0.018304	126.0
3.71	**134.5**	**152.3**	225.7	1.40	3.71	0.009886	0.028190	131.5
5.27	**191.4**	209.8	233.3	1.57	5.27	0.010285	0.038475	137.1
7.01	268.9	273.9	309.0	1.73	7.01	0.008249	0.046725	149.9
8.90	320.4	333.3	363.2	1.90	8.90	0.006921	0.053646	165.9
10.96	369.3	383.1	516.1	2.06	10.96	0.006181	0.059827	183.2
13.19	469.5	662.7	1834.7	2.23	13.19	0.005808	0.065635	200.9
15.58	1718.6	1869.1	1887.5	2.39	15.58	0.003606	0.069242	225.0
18.13	1861.0	1867.5	1887.5	2.56	18.13	0.001367	0.070609	256.8
20.85	1853.7	1869.9	1887.5	2.72	20.85	0.001457	0.072065	289.3
23.74	1866.5	1867.8	1887.5	2.89	23.74	0.001543	0.073608	322.5
26.79	1873.8	1874.8	1887.5	3.05	26.79	0.001632	0.075241	356.0
30	1873.8	1874.8	1887.5	3.21	30.00	0.001715	0.076955	389.8

V_{S30} (m/s)	**389.8**
Site Class	**C** (1)

(1) : Conditional to geotechnical assessment results for the low seismic velocities materials.

Appendix C.

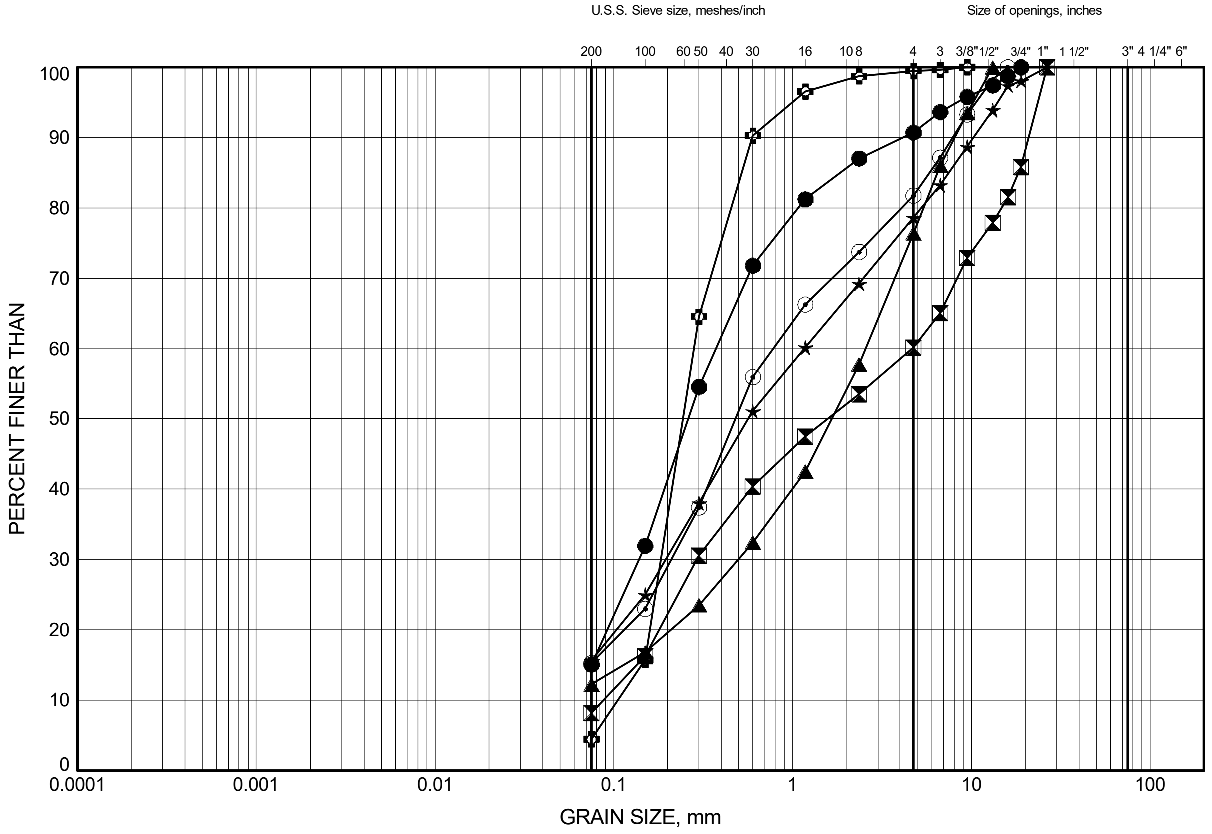
Laboratory Testing

Nicholas Street Interchange Structure Replacement

GRAIN SIZE DISTRIBUTION

FIGURE C1

Silty Sand to Sand Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-01	1.07	60.80
⧗	17-02	0.53	59.44
▲	17-02	3.35	56.62
★	17-04	1.83	60.76
⊙	17-04	3.35	59.24
✤	17-05	1.07	61.70

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

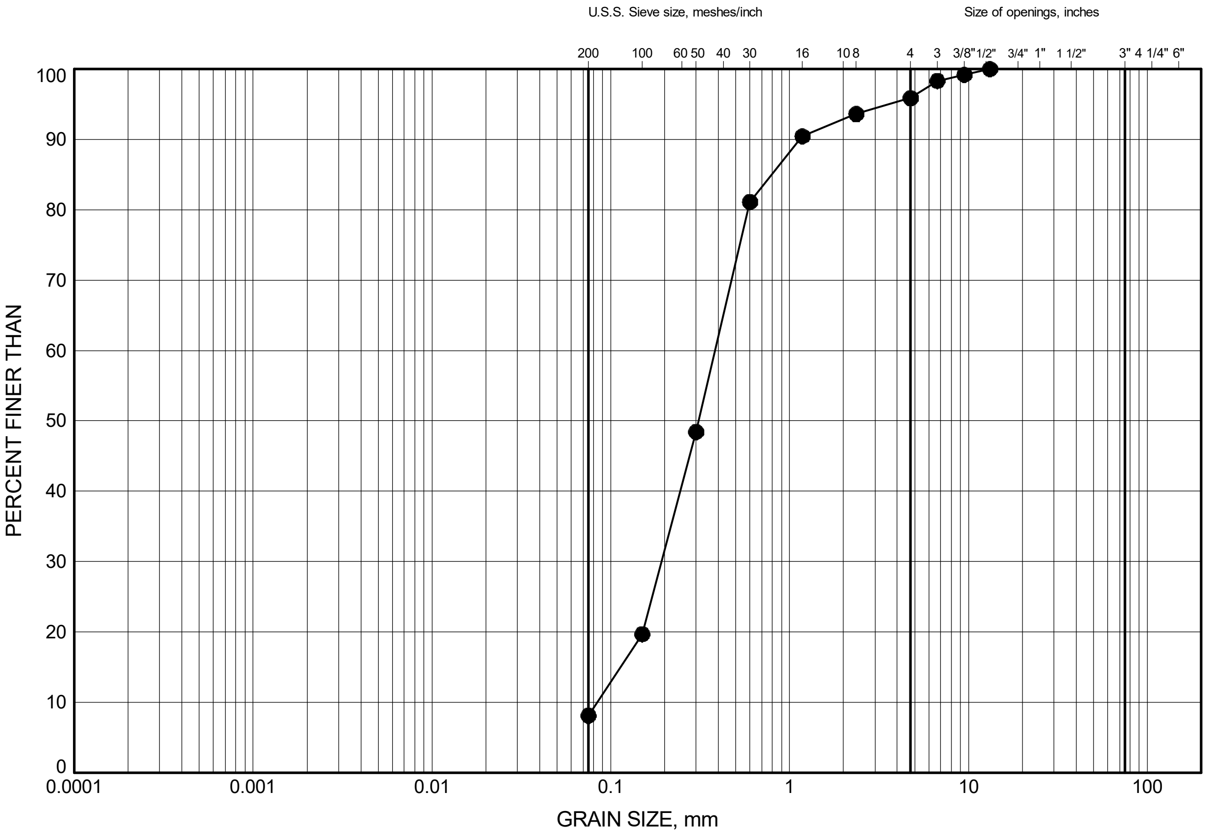
Chkd. FG

Nicholas Street Interchange Structure Replacement

GRAIN SIZE DISTRIBUTION

FIGURE C2

Silty Sand to Sand Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-06	1.83	61.24

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

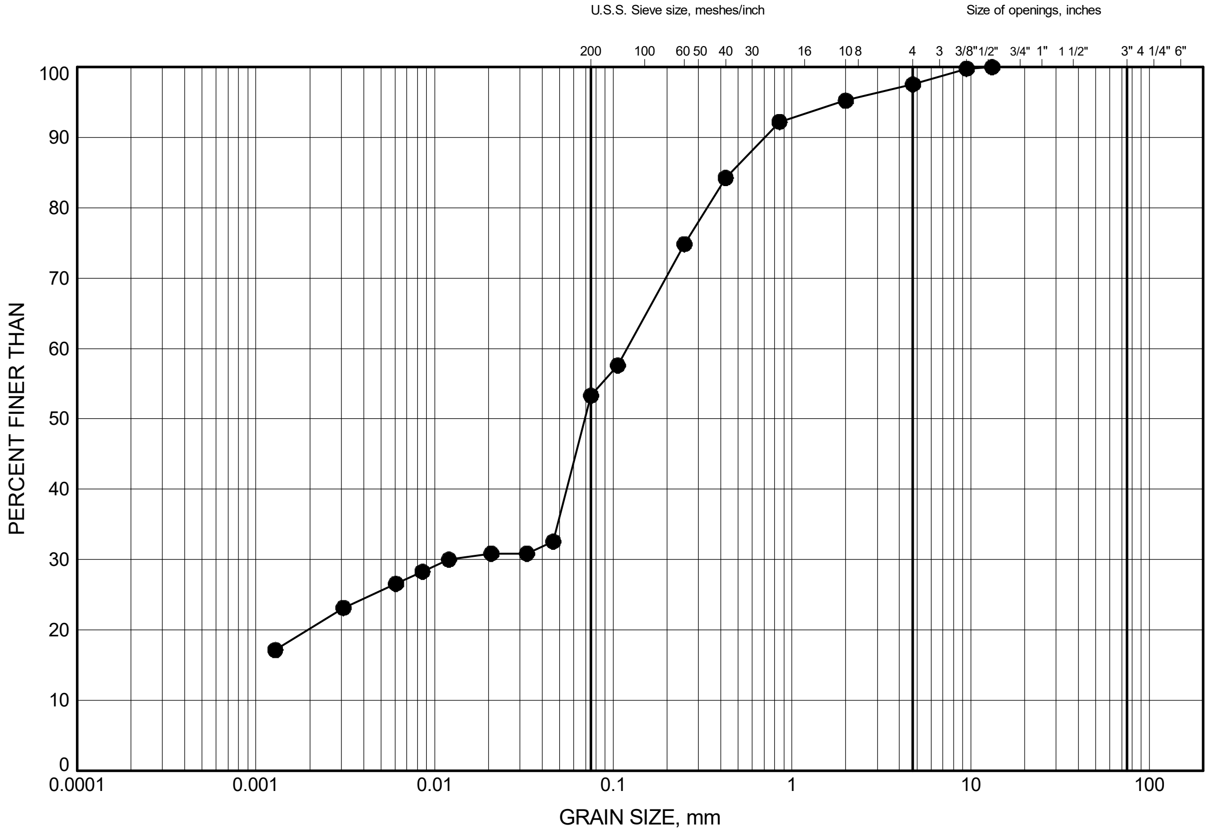
Chkd. FG

Nicholas Street Interchange Structure Replacement

GRAIN SIZE DISTRIBUTION

FIGURE C3

Clay Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-05	3.52	59.25

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

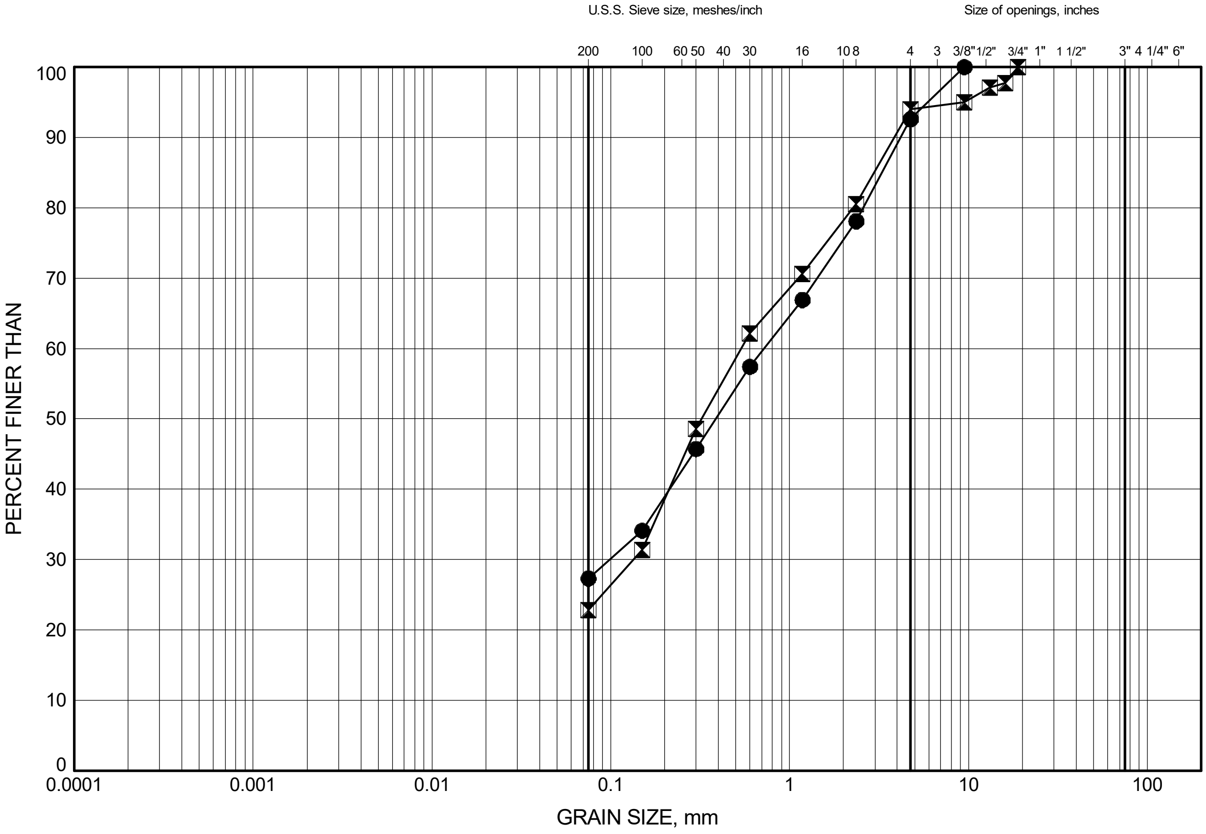
Chkd. FG

Nicholas Street Interchange Structure Replacement

GRAIN SIZE DISTRIBUTION

FIGURE C4

Waste Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-04	6.02	56.57
⧗	17-06	6.02	57.05

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

Chkd. FG

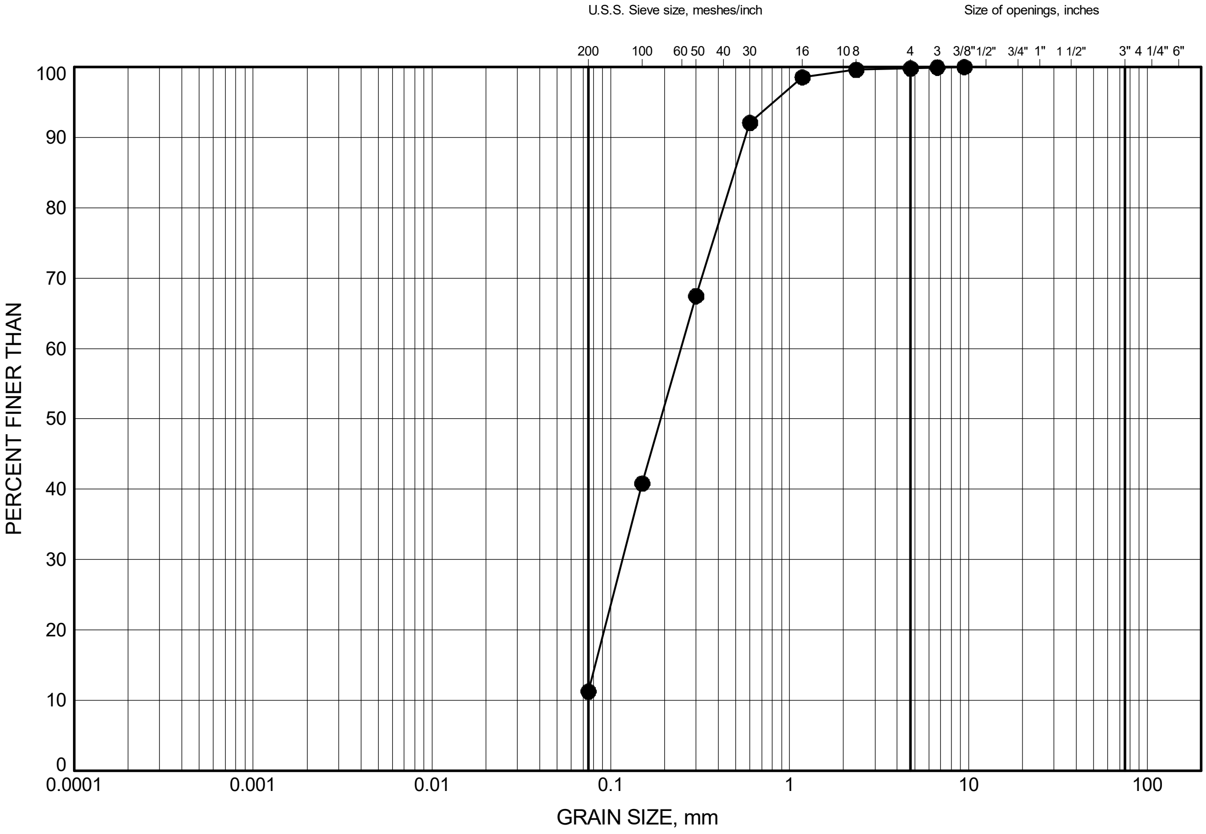
GRAIN SIZE DISTRIBUTION - THURBER 17532_NICHOLASSTINTERCHANGE.GPJ 28/3/18

Nicholas Street Interchange Structure Replacement

GRAIN SIZE DISTRIBUTION

FIGURE C5

Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-03	2.59	56.95

Date March 2018

GWP# 4048-11-00

Prep'd KE

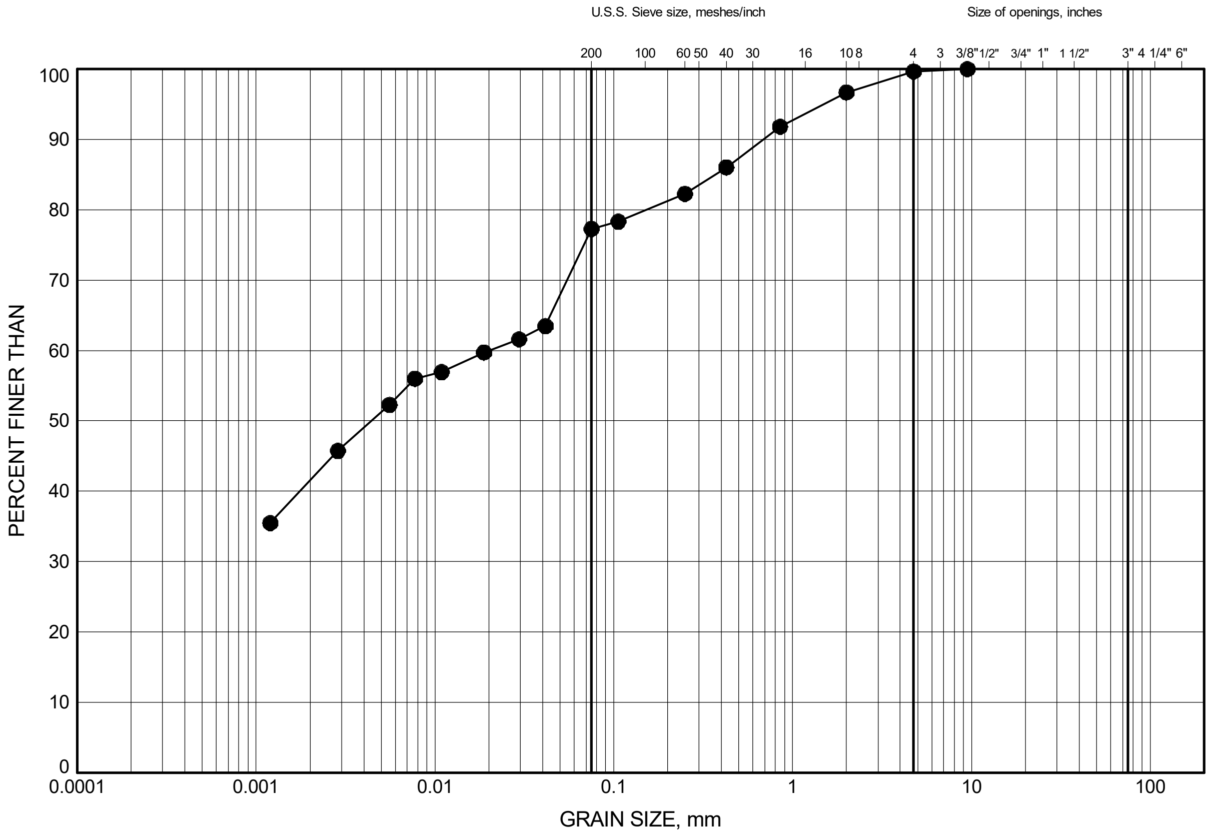
Chkd. FG

Nicholas Street Interchange Structure Replacement

GRAIN SIZE DISTRIBUTION

FIGURE C6

Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-01	5.64	56.23

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

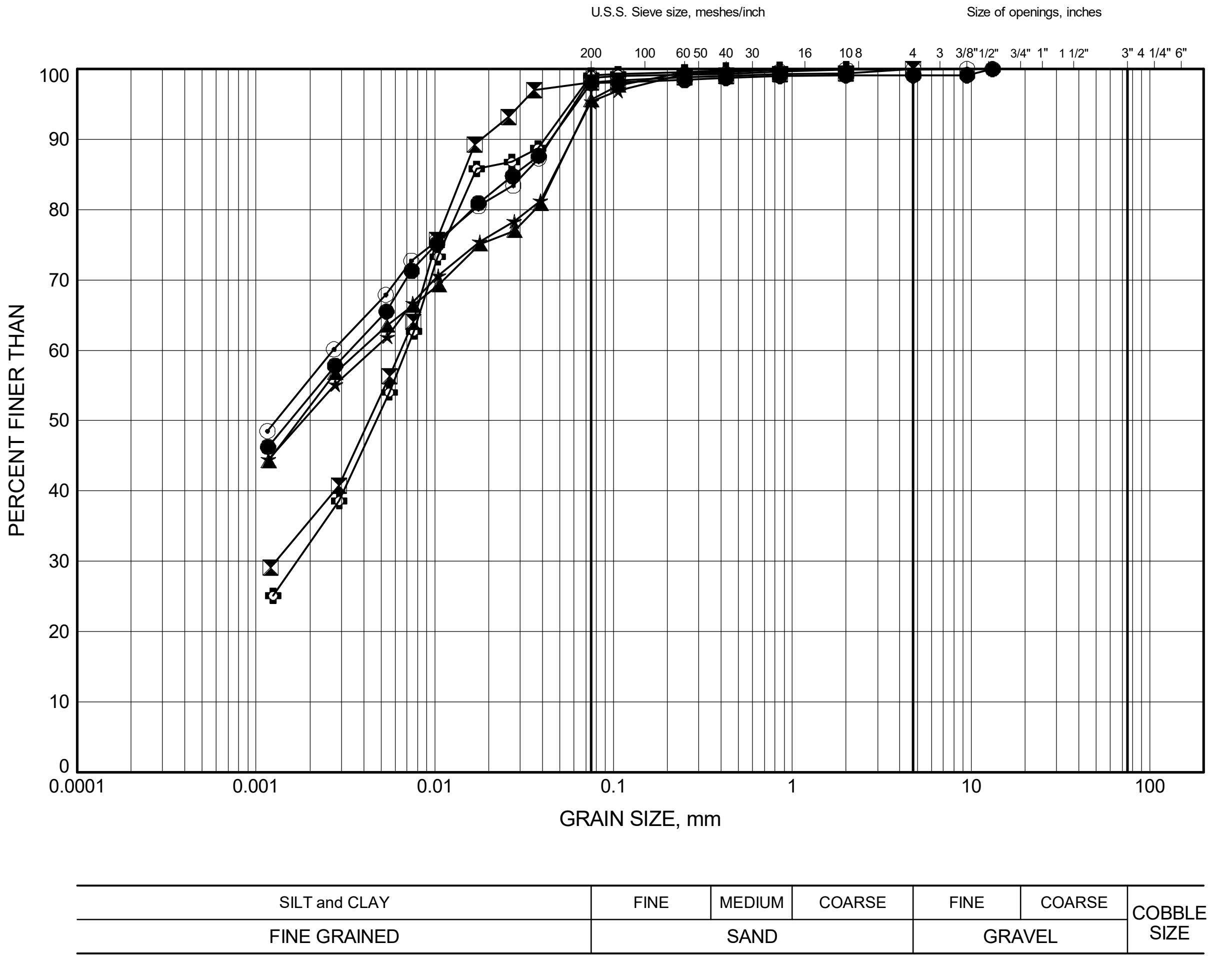
Chkd. FG

Nicholas Street Interchange Structure Replacement

GRAIN SIZE DISTRIBUTION

FIGURE C7

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-01	6.48	55.39
⧗	17-01	7.62	54.25
▲	17-02	4.88	55.09
★	17-03	4.88	54.66
⊙	17-04	7.92	54.67
✤	17-05	8.69	54.08

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

Chkd. FG

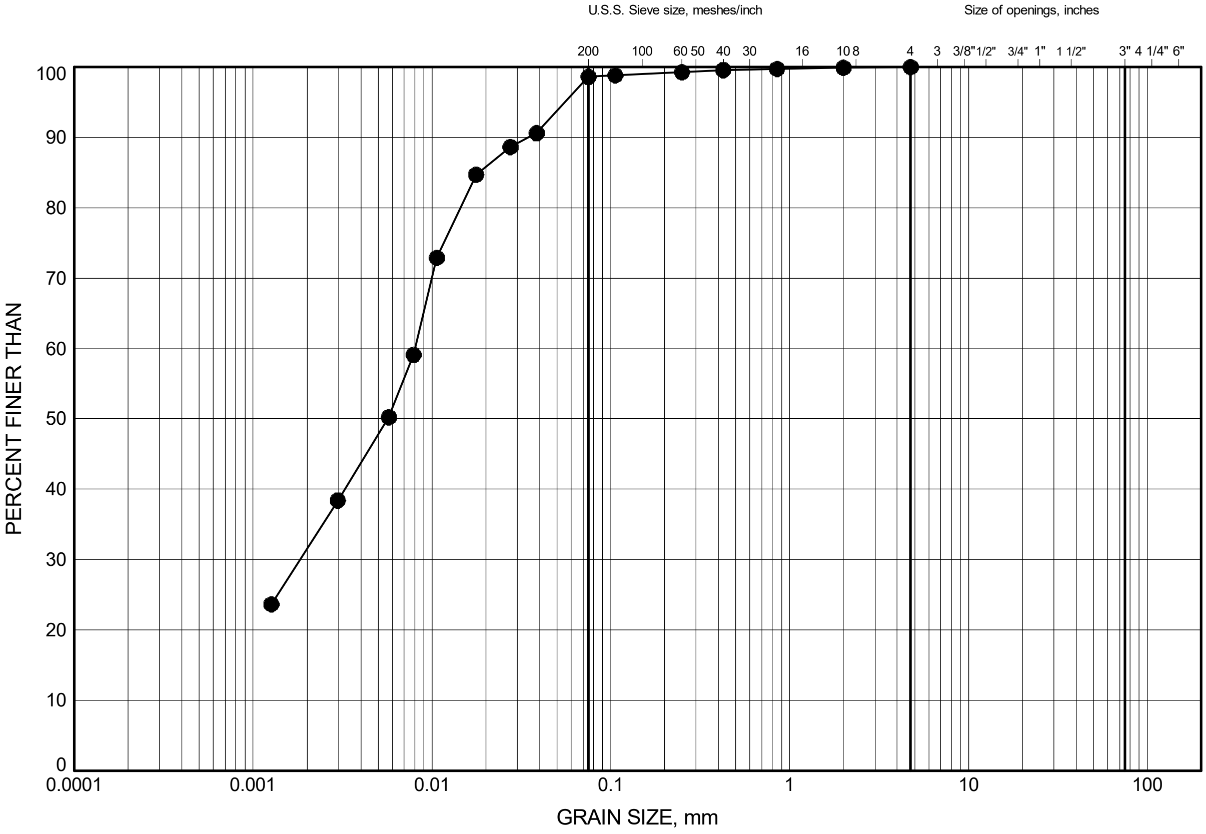
GRAIN SIZE DISTRIBUTION - THURBER 17532_NICHOLASSTINTERCHANGE.GPJ 28/3/18

Nicholas Street Interchange Structure Replacement

GRAIN SIZE DISTRIBUTION

FIGURE C8

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-06	9.45	53.62

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

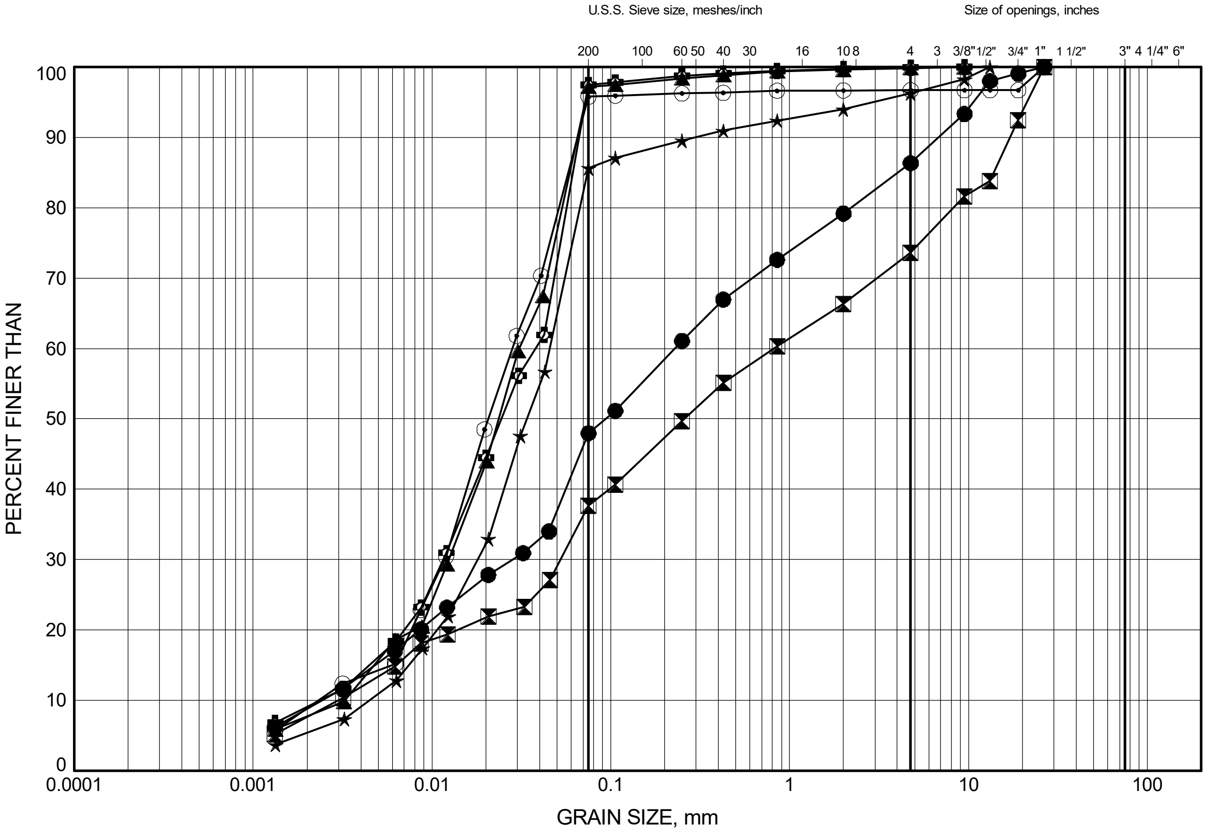
Chkd. FG

Nicholas Street Interchange Structure Replacement

GRAIN SIZE DISTRIBUTION

FIGURE C9

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)
●	17-01	10.97	50.90
⧗	17-02	9.45	50.52
▲	17-03	7.92	51.62
★	17-04	12.50	50.09
⊙	17-05	10.97	51.80
✣	17-06	10.97	52.10

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

Chkd. FG

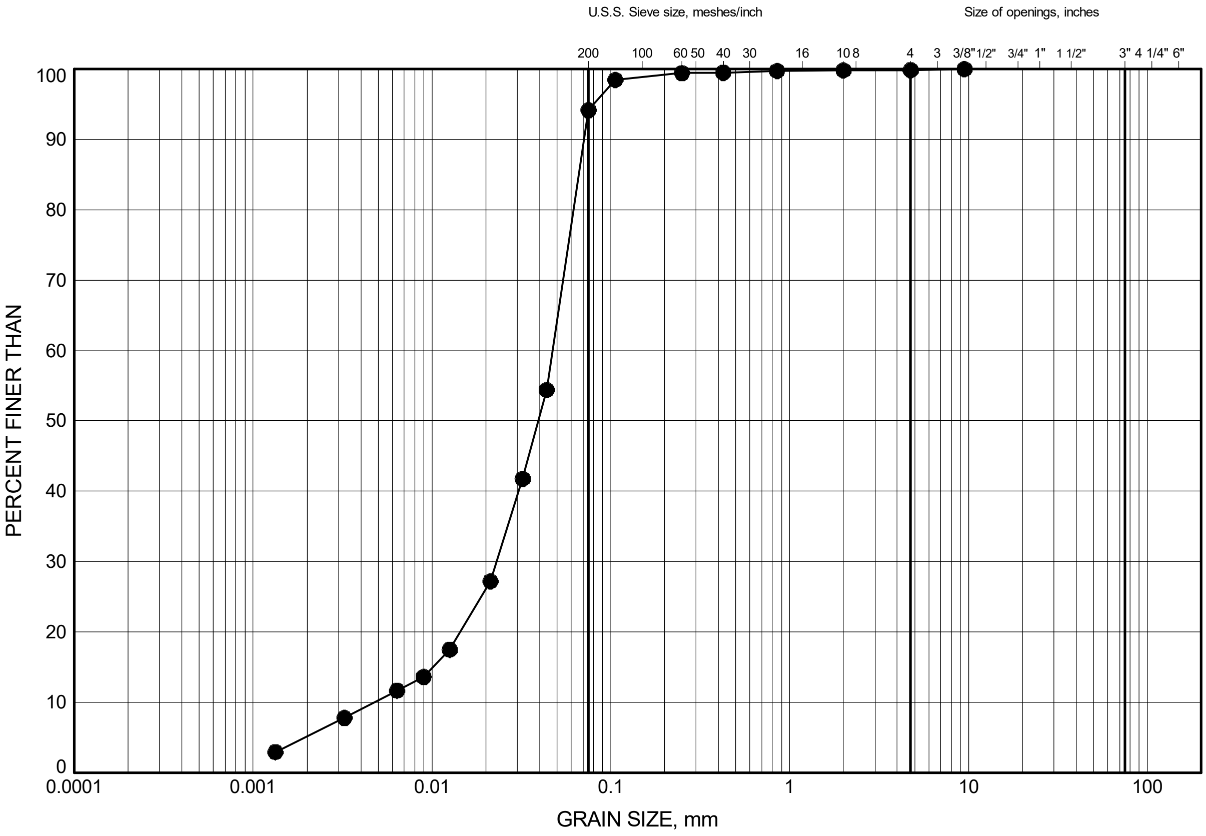
GRAIN SIZE DISTRIBUTION - THURBER 17532_NICHOLASSTINTERCHANGE.GPJ 28/3/18

Nicholas Street Interchange Structure Replacement

GRAIN SIZE DISTRIBUTION

FIGURE C10

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)
●	17-06	12.50	50.57

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

Chkd. FG

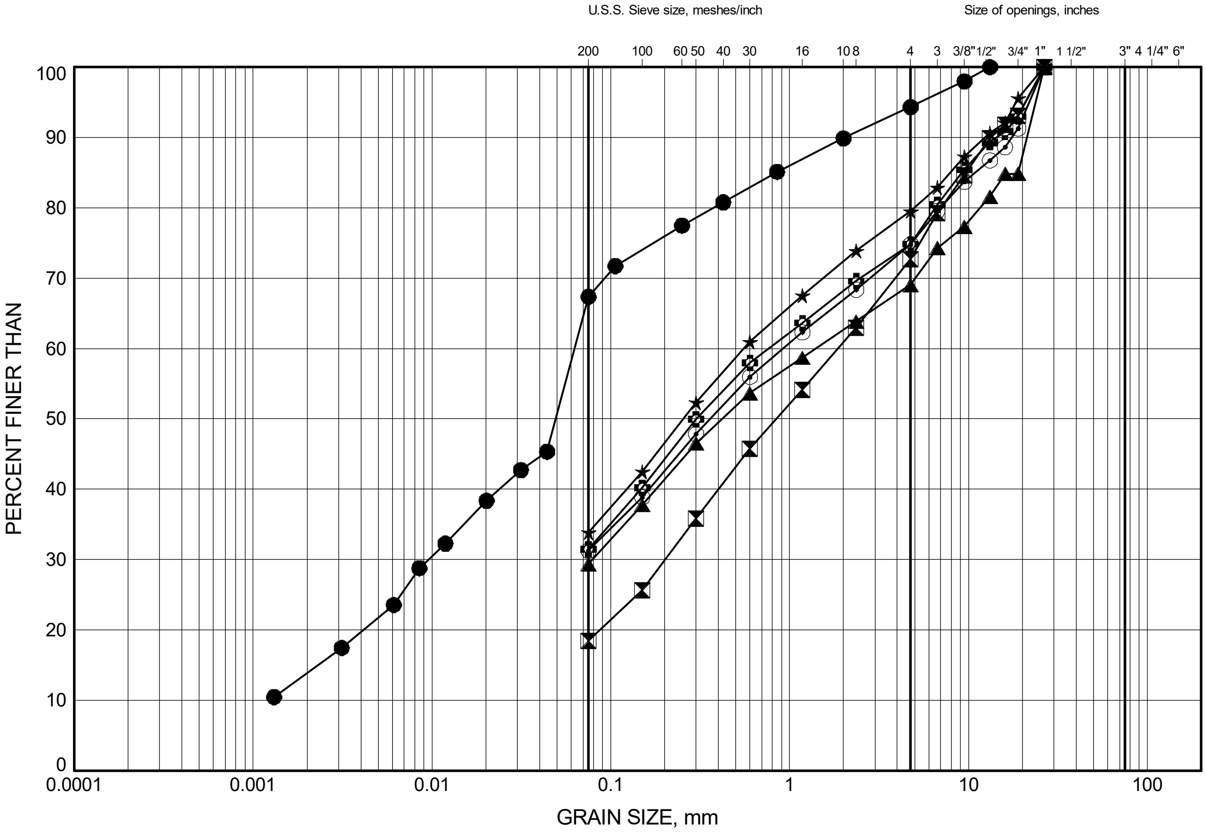
GRAIN SIZE DISTRIBUTION - THURBER 17532_NICHOLASSTINTERCHANGE.GPJ 28/3/18

Nicholas Street Interchange Structure Replacement

GRAIN SIZE DISTRIBUTION

FIGURE C11

Silty Sand Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-01	14.78	47.09
⧗	17-02	13.72	46.25
▲	17-03	10.97	48.57
★	17-04	13.72	48.87
⊙	17-05	14.02	48.75
✿	17-06	14.78	48.29

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

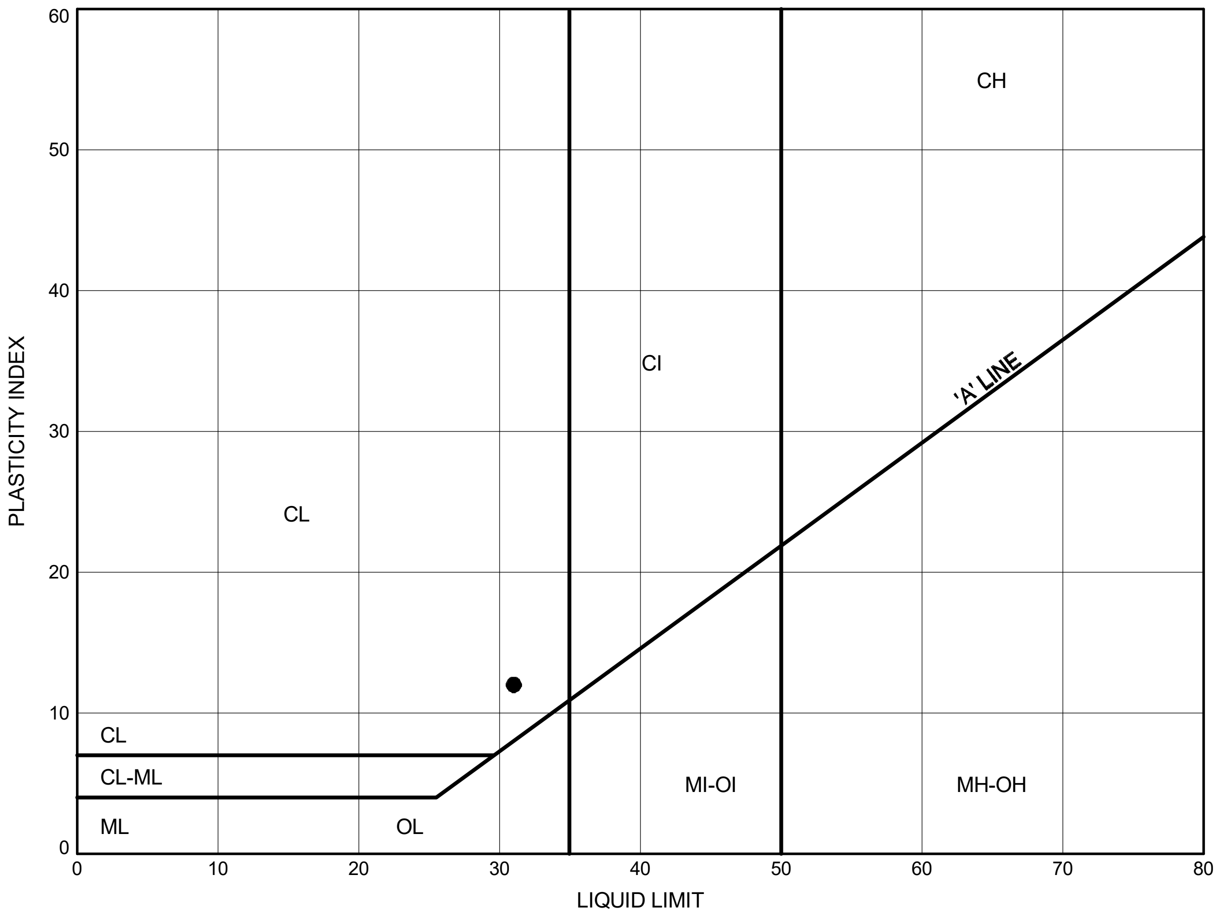
Chkd. FG

Nicholas Street Interchange Structure Replacement

ATTERBERG LIMITS TEST RESULTS

FIGURE C12

Clay Fill



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-05	3.52	59.25

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

Chkd. FG

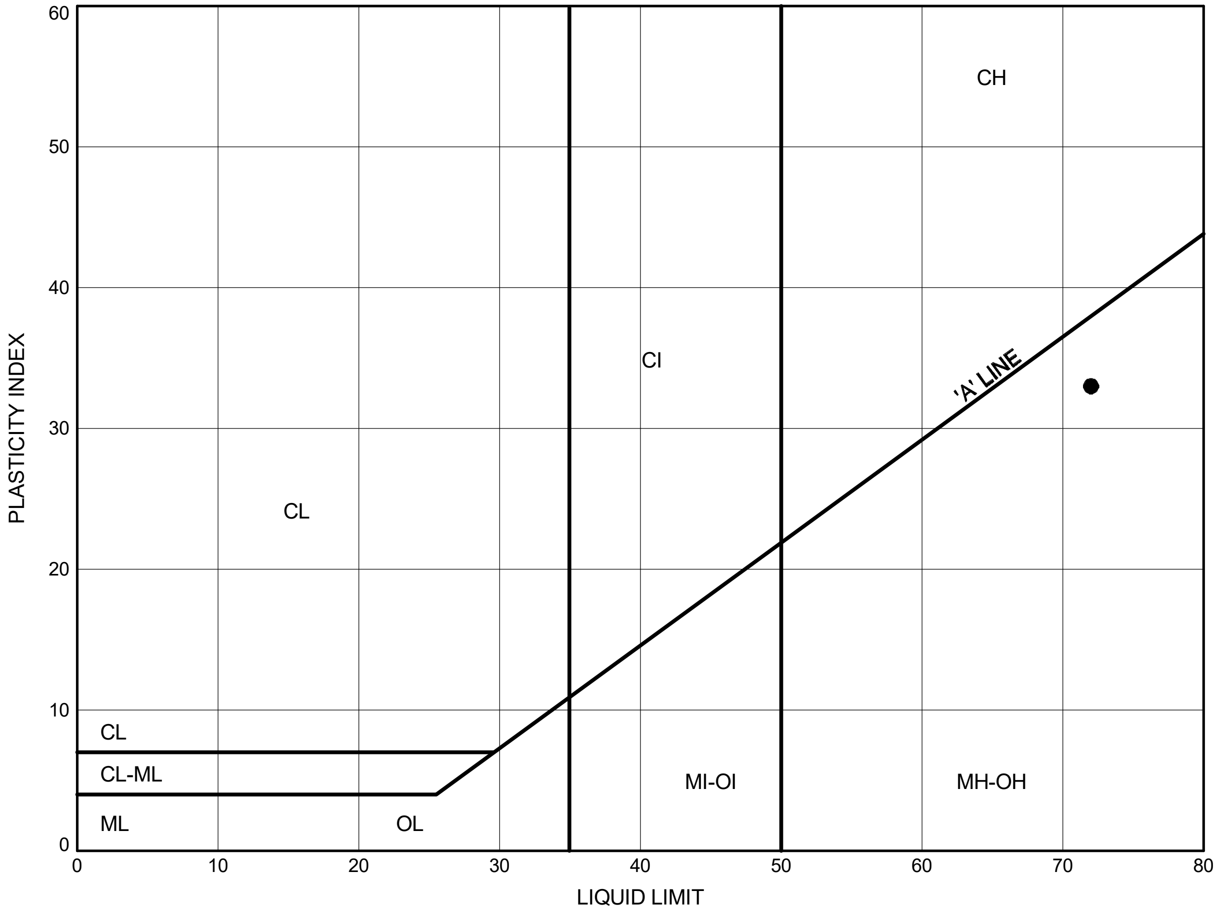
THURBALT 17532_NICHOLASSTINTERCHANGE.GPJ 28/3/18

Nicholas Street Interchange Structure Replacement

ATTERBERG LIMITS TEST RESULTS

FIGURE C13

Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-01	5.64	56.23

THURBALT 17532_NICHOLASSTINTERCHANGE.GPJ 28/3/18

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

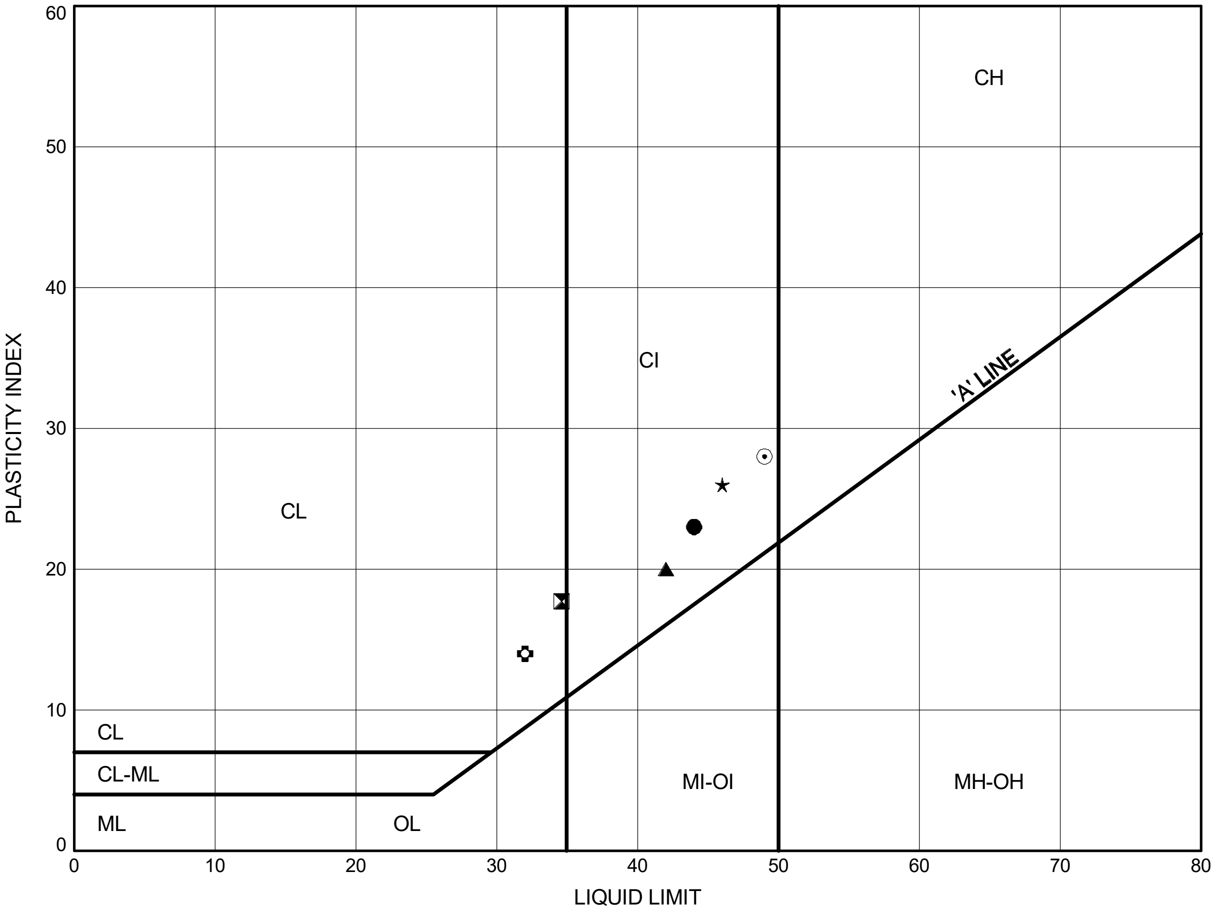
Chkd. FG

Nicholas Street Interchange Structure Replacement

ATTERBERG LIMITS TEST RESULTS

FIGURE C14

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-01	6.48	55.39
⧗	17-01	7.92	53.95
▲	17-02	4.88	55.09
★	17-03	4.88	54.66
⊙	17-04	7.92	54.67
✿	17-05	8.69	54.08

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

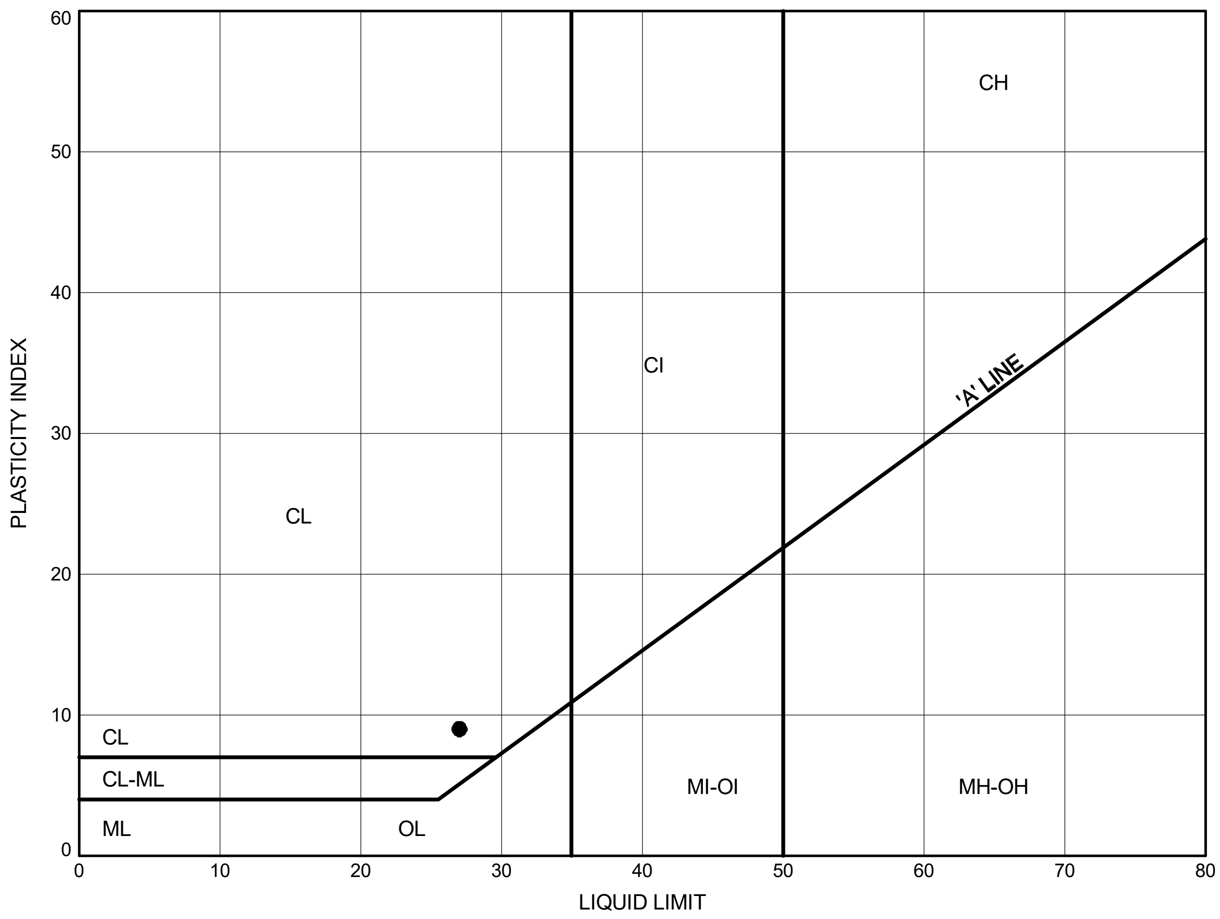
Chkd. FG

Nicholas Street Interchange Structure Replacement

ATTERBERG LIMITS TEST RESULTS

FIGURE C15

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-06	9.45	53.62

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

Chkd. FG

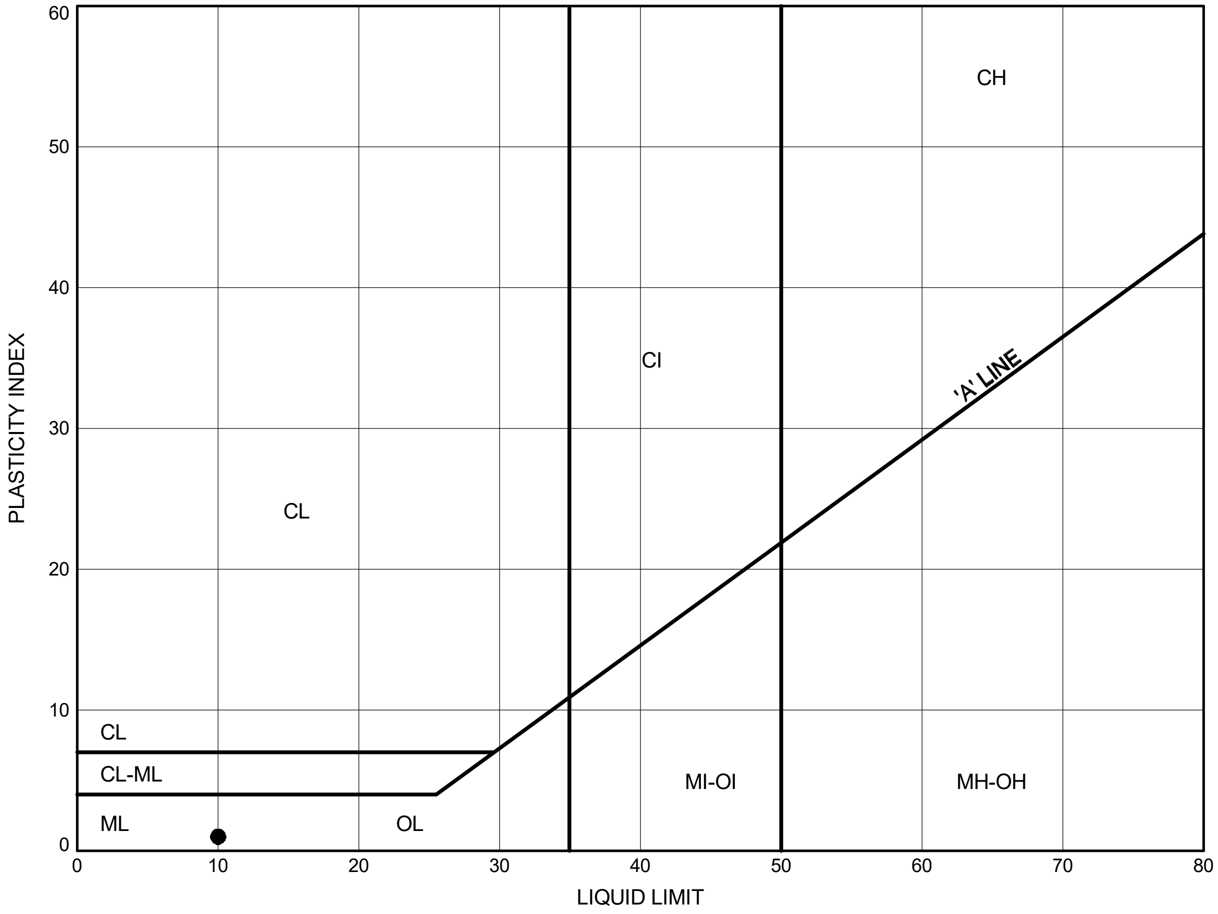
THURBALT 17532_NICHOLASSTINTERCHANGE.GPJ 28/3/18

Nicholas Street Interchange Structure Replacement

ATTERBERG LIMITS TEST RESULTS

FIGURE C16

Silt to Sandy Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-01	10.97	50.90

THURBALT 17532_NICHOLASSTINTERCHANGE.GPJ 28/3/18

Date March 2018

GWP# 4048-11-00

THURBER

Prep'd KE

Chkd. FG

Borehole 17-02

Runs 1 to 3

Elevation 41.3 to 44.8 m

THURBER ENGINEERING LTD.

Foundation Investigation
Highway 417 Nicholas St. Underpass
(Site #3-224)
Ottawa, Ontario

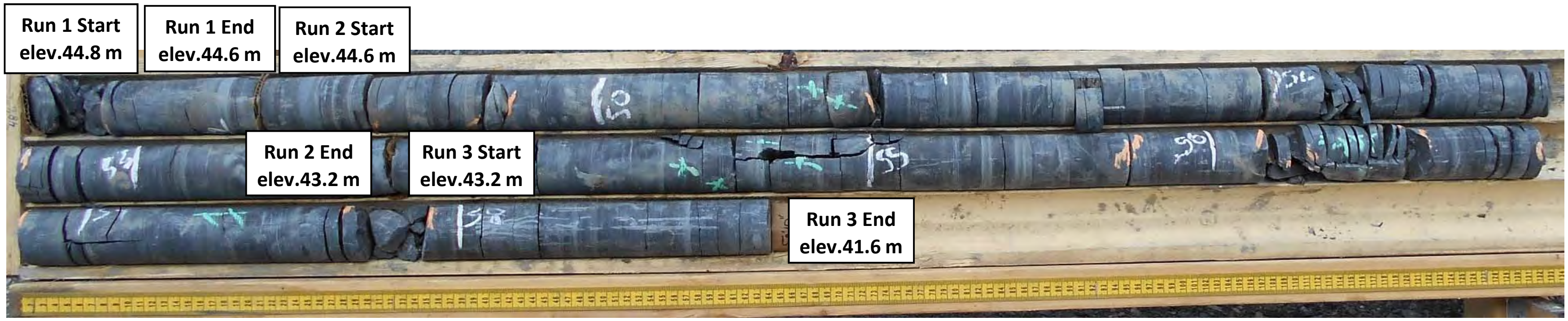
GWP: 4048-11-00

Project No.: 17532

Borehole 17-03

Runs 1 to 3

Elevation 41.6 to 44.8 m



THURBER ENGINEERING LTD.

Foundation Investigation
Highway 417 Nicholas St. Underpass
(Site #3-224)
Ottawa, Ontario

GWP: 4048-11-00

Project No.: 17532

Borehole 17-04

Runs 1 to 3

Elevation 42.2 to 45.5 m

THURBER ENGINEERING LTD.

Foundation Investigation
Highway 417 Nicholas St. Underpass
(Site #3-224)
Ottawa, Ontario

GWP: 4048-11-00

Project No.: 17532

Borehole 17-05

Runs 1 to 3

Elevation 40.6 to 44.4 m

THURBER ENGINEERING LTD.

Foundation Investigation
Highway 417 Nicholas St. Underpass
(Site #3-224)
Ottawa, Ontario

GWP: 4048-11-00

Project No.: 17532

Stantec

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

November 10, 2017
File: 122410864

Attention: **Thurber Engineering Ltd., File #17532**

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

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

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
BH17-04	64'5"-64'11"	54.7	No well-formed cones, vertical cracks through core (SHALE)

Sincerely,

Stantec Consulting Ltd

Brian Prevost

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
brian.prevost@stantec.com

Stantec Consulting Ltd.
400 - 1331 Clyde Avenue, Ottawa ON K2C 3G4

November 8, 2017
File: 122410864

Attention: Katya Edney, P. Eng.
Thurber Engineering Ltd.
104 – 2460 Lancaster Road
Ottawa, Ontario, Canada, K1B 4S5
Tel: 613-274-2121
E-mail: kedney@thurber.ca

Dear Mrs. Edney,

**Reference: Consolidation Test Results for HWY 417 Project, Thurber Consulting Ltd.,
File #17532: BH 17-01, ST 10, sampled on October 25, 2017**

This letter presents the results of one-dimensional consolidation test carried out on the above referenced sample in accordance with ASTM D2435/D2435M - 11. The test results are provided in the attached tables and figures.

This letter provides test results only and does not constitute any interpretation or engineering recommendations with respect to material suitability or specification compliance.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Regards,

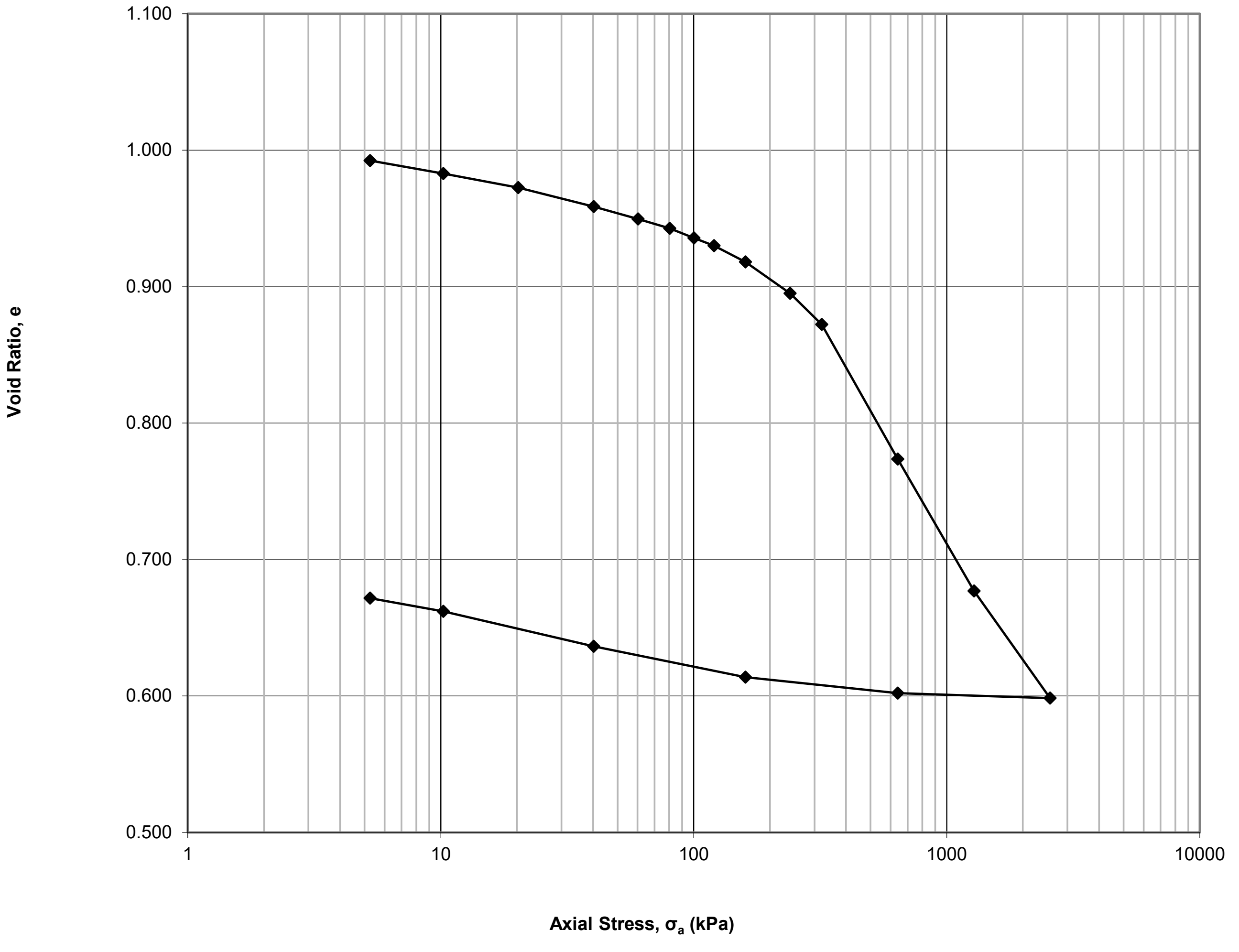
STANTEC CONSULTING LTD.

Ramy Saadeldin, Ph.D., P.Eng.
Geotechnical Engineering
Phone: (613) 738-6047
Fax: (613) 722-2799
Ramy.Saadeldin@stantec.com

One-Dimensional Consolidation Properties of Soils Using Incremental Loading

ASTM D2435/D2435M - 11

Project	**Thurber Engineering, File# 17532**
Project No.	**122410864**
Borehole No.	**BH 17-01**
Sample No.	**ST 10**
Sample Depth	**25-27 ft.**



Filename: V:\01216\active\laboratory_standing_offers\2017 L
Checked by: D. Boateng Date: 7-Nov-17
Approved by: R. Hache Date: 7-Nov-17

Stantec

Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11

Specimen Details

Project Name	Thurber Engineering, File# 17532
Project Location	HWY 417, Ottawa-Ontario
Borehole	BH 17-01
Sample No.	ST 10
Depth	25-27 ft.
Sample Date	October 25, 2017
Test Number	One
Technician Name	Daniel Boateng

Soil Description & Classification

CL- Silt and Clay, Trace Sand, Grey, Fissured, Moist

Specific Gravity of Solids		2.755
Liquid Limit	%	35
Plastic Limit	%	17
Plasticity Index	%	18
Average water content of trimmings	%	37

Additional Notes (information source, occurence and size of large isolated particles etc.)

A piece of gravel retained on 13.2mm sieve and trace sand observed in upper two inches of extruded sample

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm^2	1963
Volume	mm^3	39270
Mass	g	73.39
Dry Mass	g	53.68
Density	Mg/m^3	1.869
Dry Density	Mg/m^3	1.367
Water Content	%	36.72
Degree of Saturation	%	99.6
Height of Solids	mm	9.92
Initial Void Ratio		1.015

Final Specimen Conditions

Water Content	%	26.64
Final Void Ratio		0.672

Filename: V:\01216\active\laboratory_standing_offers\2017 Laboratory Standing Offers\122

Checked by: D. Boateng Date: 7-Nov-17

Approved by: R. Hache Date: 7-Nov-17

Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Specimen Details

Project Name	Thurber Engineering, File# 17532
Project Location	HWY 417, Ottawa-Ontario
Borehole	BH 17-01
Sample No.	ST 10
Depth	25-27 ft.
Sample Date	October 25, 2017
Test Number	One
Technician Name	Daniel Boateng

Test Procedure

Date Started	November 3, 2017
Date Finished	November 5, 2017
Machine Number	Frame D
Cell Number	D
Ring Number	D
Trimming Procedure	Turntable
Moisture Condition	Inundated
Axial Stress at Inundation kPa	5
Water Used	Distilled
Test Method	B
Interpretation Procedure for c_v	2

All Departures from Outlined ASTM D2435/D2435M-11 Procedure

Calculations

Load Increment	Increment Duration min	Axial Stress σ_a kPa	Corrected Deformation ΔH mm	Specimen Height H mm	Axial Strain ε_a %	Void Ratio e
Seating	0.0	5	0.0000	20.0000	0.00	1.015
1	9.8	5	0.2287	19.7713	1.14	0.992
2	14.8	10	0.3242	19.6758	1.62	0.983
3	16.5	20	0.4252	19.5748	2.13	0.973
4	16.5	40	0.5632	19.4368	2.82	0.959
5	23.3	60	0.6534	19.3466	3.27	0.950
6	19.8	80	0.7223	19.2777	3.61	0.943
7	28.3	100	0.7925	19.2075	3.96	0.936
8	19.8	120	0.8476	19.1524	4.24	0.930
9	29.8	160	0.9656	19.0344	4.83	0.918
10	46.3	240	1.1937	18.8063	5.97	0.895
11	53.0	320	1.4210	18.5790	7.11	0.872
12	86.3	640	2.4002	17.5998	12.00	0.774
13	61.3	1280	3.3595	16.6405	16.80	0.677
14	53.0	2560	4.1381	15.8619	20.69	0.598
15	10.0	640	4.1008	15.8992	20.50	0.602
16	14.8	160	3.9859	16.0141	19.93	0.614
17	24.8	40	3.7604	16.2396	18.80	0.636
18	49.8	10	3.5061	16.4939	17.53	0.662
19	41.5	5	3.4109	16.5891	17.05	0.672

Filename: V:\01216\active\laboratory_standing_offers\2017 Laboratory Standing Offers\12:

Checked by: D. Boateng Date: 7-Nov-17

Approved by: R. Hache Date: 7-Nov-17

One-Dimensional Consolidation Test using Incremental Loading

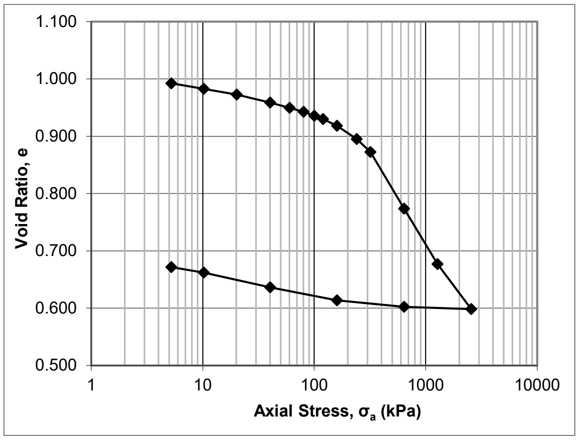
ASTM D2435/D2435M - 11

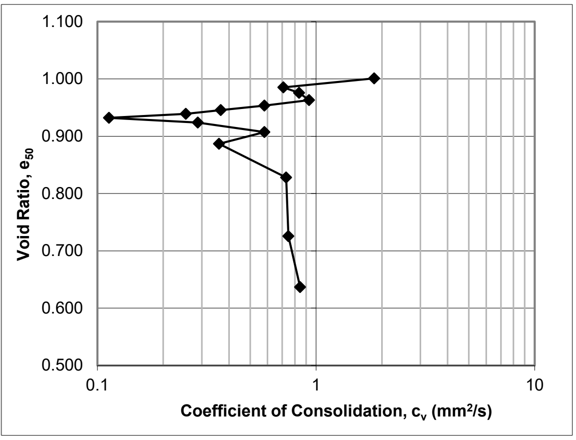
Specimen Details

Project Name	Thurber Engineering, File# 17532
Project Location	HWY 417, Ottawa-Ontario
Borehole	BH 17-01
Sample No.	ST 10
Depth	25-27 ft.
Sample Date	October 25, 2017
Test Number	One
Technician Name	Daniel Boateng

Calculations

		Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
Load Increment	Axial Stress $\sigma_{a,\ average}$ kPa	Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\varepsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm^2/s	Time t_{90} sec	Coeff. Consol. c_v mm^2/s
Seating	3								
1	5	0.1428	19.8572	0.71	1.001			45	1.85E+00
2	8	0.2983	19.7017	1.49	0.985			116	7.10E-01
3	15	0.3950	19.6050	1.98	0.976			97	8.38E-01
4	30	0.5216	19.4784	2.61	0.963			87	9.29E-01
5	50	0.6165	19.3835	3.08	0.953			137	5.80E-01
6	70	0.6920	19.3080	3.46	0.946			216	3.66E-01
7	90	0.7575	19.2425	3.79	0.939			310	2.54E-01
8	110	0.8248	19.1752	4.12	0.932			690	1.13E-01
9	140	0.9102	19.0898	4.55	0.924			268	2.88E-01
10	200	1.0715	18.9285	5.36	0.907			131	5.81E-01
11	280	1.2768	18.7232	6.38	0.887			207	3.60E-01
12	480	1.8618	18.1382	9.31	0.828			95	7.31E-01
13	960	2.8737	17.1263	14.37	0.726			83	7.48E-01
14	1920	3.7584	16.2416	18.79	0.637			66	8.46E-01
15	1600	4.1060	15.8940	20.53	0.602				
16	400	4.0097	15.9903	20.05	0.611				
17	100	3.8266	16.1734	19.13	0.630				
18	25	3.6067	16.3933	18.03	0.652				
19	8	3.5020	16.4980	17.51	0.663				





Stantec	Project No.: 122410864	Photo Log
	Project Name: Thurber Eng., File# 17532	

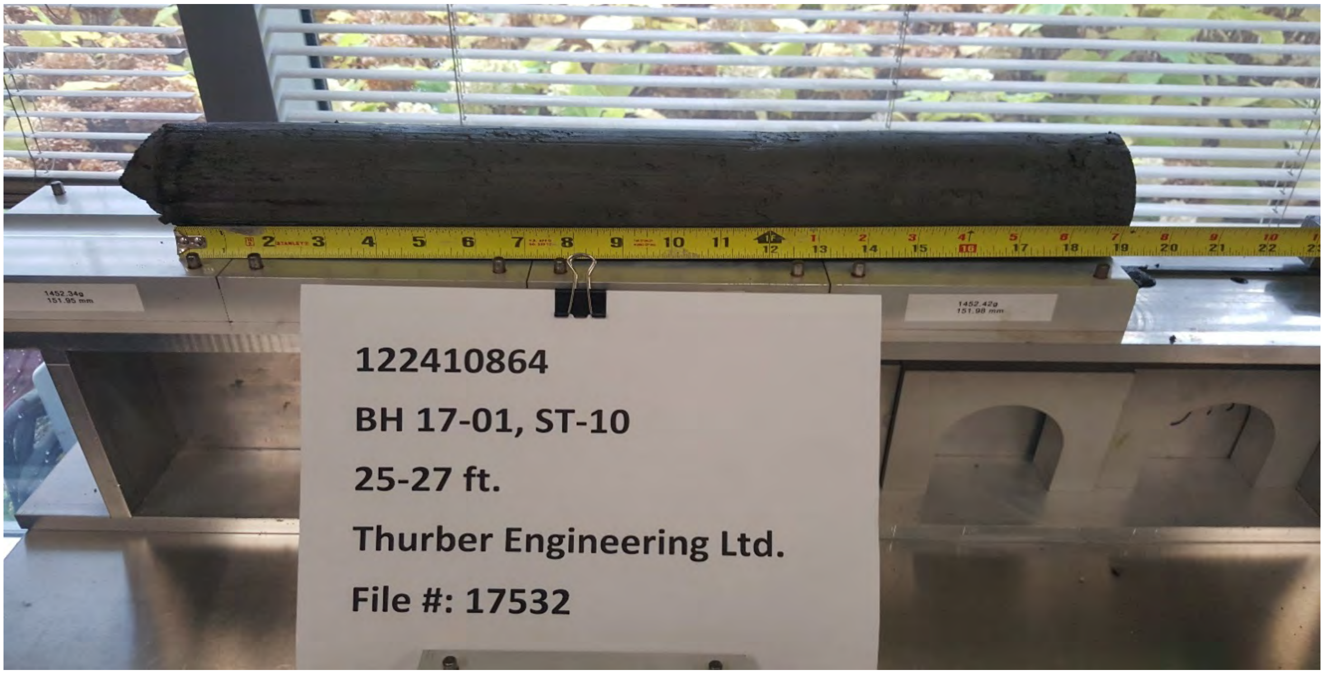


Photo No.:	1	Borehole:	BH 17-01, ST 10	Depth:	25 – 27 ft.

Photo No.:	2	Borehole:	BH 17-01, ST 10	Depth:	25 – 27 ft.

Stantec	Project No.: 122410864	Photo Log
	Project Name: Thurber Eng., File# 17532	

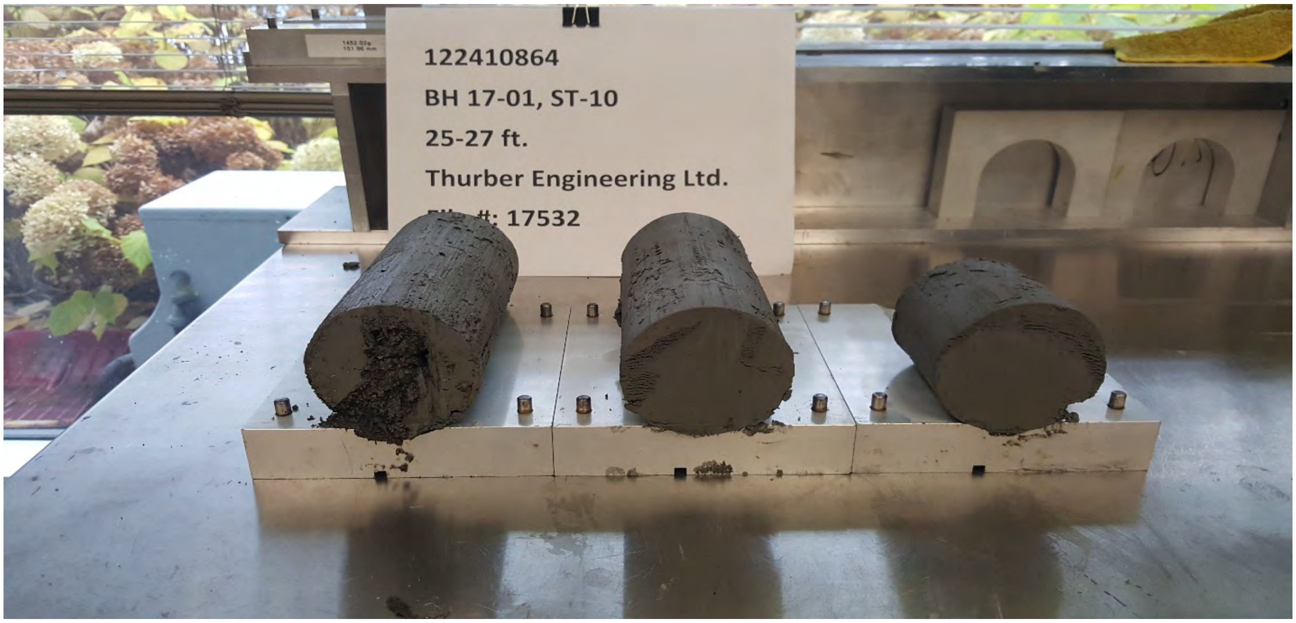


Photo No.: 3	Borehole: BH 17-01, ST 10	Depth: 25 – 27 ft.

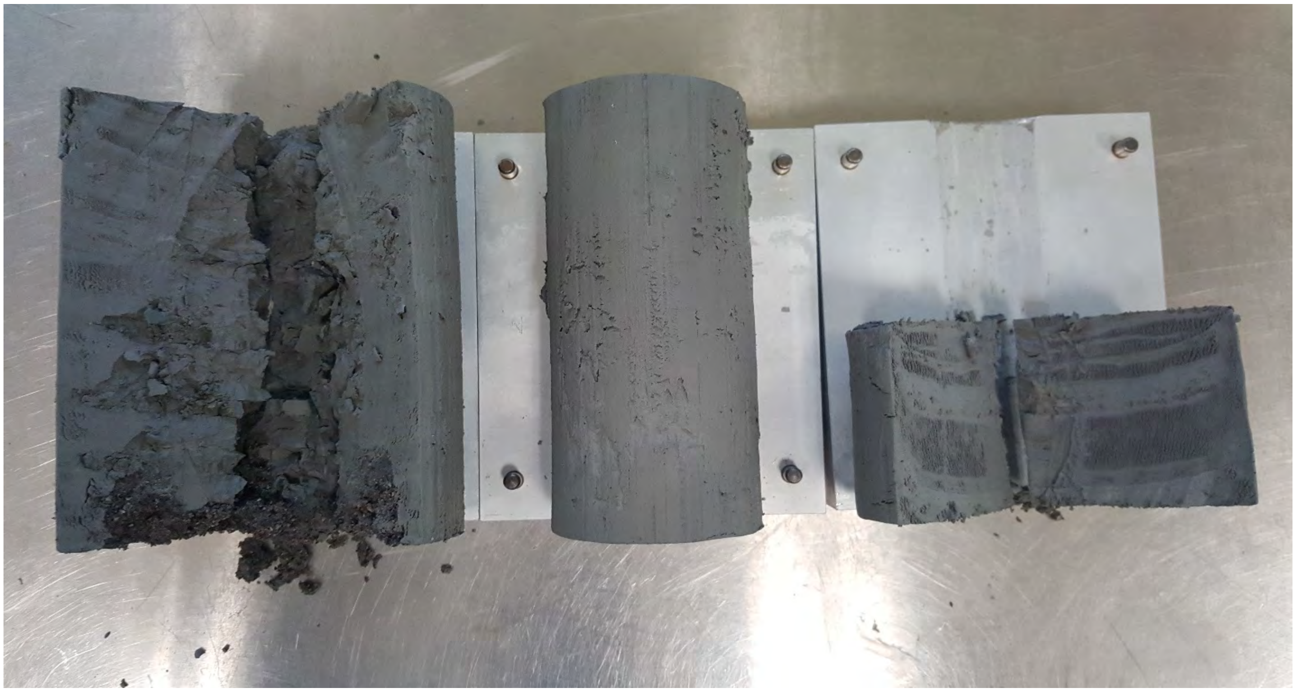


Photo No.: 4	Borehole: BH 17-01, ST 10	Depth: 25 – 27 ft.

PARACEL LABORATORIES LTD. TRUSTED. RESPONSIVE. RELIABLE.

300 - 2319 St. Laurent Blvd
Ottawa, ON, K1G 4J8
1-800-749-1947
www.paracellabs.com

Certificate of Analysis

Thurber Engineering Ltd.
2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Stephen Peters

Client PO: 17532
Project: Hwy 417 Nicholas St. Interchange
Custody: 38411

Report Date: 24-Oct-2017
Order Date: 23-Oct-2017

Order #: 1743104

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

Paracel ID	Client ID
1743104-01	17-02 SS#3 (5-7')
1743104-02	17-03 SS#3B (5.83-7')
1743104-03	17-05 SS#3 (5-7')

Approved By: Mark Foto

Mark Foto, M.Sc.
Lab Supervisor

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO: 17532

Report Date: 24-Oct-2017

Order Date: 23-Oct-2017

Project Description: Hwy 417 Nicholas St. Interchange

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	24-Oct-17	24-Oct-17
Conductivity	MOE E3138 - probe @25 °C, water ext	24-Oct-17	24-Oct-17
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	23-Oct-17	24-Oct-17
Resistivity	EPA 120.1 - probe, water extraction	24-Oct-17	24-Oct-17
Solids, %	Gravimetric, calculation	24-Oct-17	24-Oct-17

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO: 17532

Report Date: 24-Oct-2017

Order Date: 23-Oct-2017

Project Description: Hwy 417 Nicholas St. Interchange

	Client ID:	17-02 SS#3 (5-7')	17-03 SS#3B (5.83-7')	17-05 SS#3 (5-7')	-
	Sample Date:	19-Oct-17	15-Oct-17	12-Oct-17	-
	Sample ID:	1743104-01	1743104-02	1743104-03	-
	MDL/Units	Soil	Soil	Soil	-
Physical Characteristics					
% Solids	0.1 % by Wt.	82.0	82.8	95.0	-
General Inorganics					
Conductivity	5 uS/cm	518	1330	62	-
pH	0.05 pH Units	7.46	7.60	7.55	-
Resistivity	0.10 Ohm.m	19.3	7.50	162	-
Anions					
Chloride	5 ug/g dry	23	838	<5	-
Sulphate	5 ug/g dry	487	87	<5	-

Method Quality Control: Blank

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

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
General Inorganics									
Conductivity	173	5	uS/cm	177			2.1	6.2	
pH	8.13	0.05	pH Units	8.13			0.0	10	
Resistivity	57.7	0.10	Ohm.m	56.5			2.1	20	
Physical Characteristics									
% Solids	75.2	0.1	% by Wt.	75.5			0.3	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	104	5	ug/g		104	78-113			
Sulphate	108	5	ug/g		108	78-111			

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

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

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

Appendix D.

Site Photographs

Photo 1. Looking east along Highway 417 at southern proposed abutment.

Photo 2. Looking west along Highway 417.

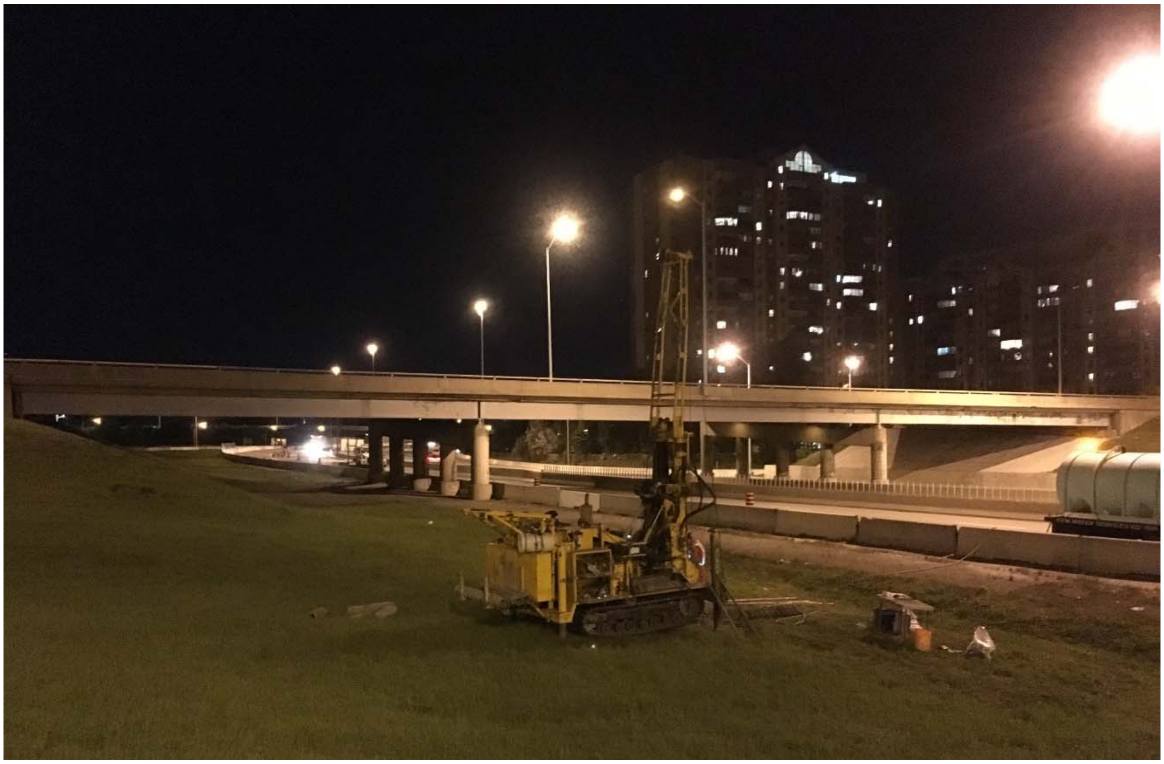


Photo 3. Looking east along Highway 417 at existing Nicholas St. Underpass.

Photo 4. Looking north at northern proposed approach.

Appendix E.
Foundation Comparison

Comparison of Deep Foundation Alternatives

Comment	Steel Piles (H-Piles, Pipe Piles)	Caissons (Socketed into Bedrock)
Advantages	- Higher geotechnical capacity then spread footings - Quick installation procedure - Likely requires less concrete than spread footings or caissons - Can provide frost protection by insulation	- High axial and lateral resistance - Construction can continue in winter weather conditions - Reduces magnitude of excavations and limits dewatering requirements
Disadvantages	- Higher unit cost than spread footings - has potential to encounter obstructions in the existing fill and glacial till material	- Higher unit cost than spread footings - Requires local availability of concrete - Specialized installation measures such as equipment, liners and drilling mud will be required - Potential difficulty in cleaning and inspecting base - has potential to encounter obstructions in the existing fill and glacial till material
Risks / Consequences	- Difficulty advancing through obstructions	- Difficulty in advancing through obstructions - Waste fill to dispose of. Possibility of impacted groundwater
Relative Cost	Moderate to High	High
	Recommended for Abutments (H-Piles)	**Recommended for Pier**

Appendix F.

GSC Seismic Hazard Calculation, Preliminary Site-Specific Response Spectra, Liquefaction Triggering Analysis, Seismic Limit Equilibrium Analyses, Lateral Displacement Profile

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

November 15, 2017

Site: 45.4164 N, 75.6738 W   User File Reference: HWY 417 - Ottawa, ON

Requested by: Nicholas Street Underpass, Thurber Engineering Ltd.

National Building Code ground motions: 2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.05)	Sa(0.1)	**Sa(0.2)**	Sa(0.3)	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**Sa(5.0)**	**Sa(10.0)**	**PGA (g)**	**PGV (m/s)**
0.447	0.523	**0.439**	0.334	**0.237**	**0.118**	**0.056**	**0.015**	**0.0054**	**0.281**	**0.197**

Notes. Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC 2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are specified in **bold** font. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. ***These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.05)	0.044	0.149	0.247
Sa(0.1)	0.061	0.187	0.300
Sa(0.2)	0.055	0.161	0.255
Sa(0.3)	0.044	0.124	0.195
Sa(0.5)	0.031	0.088	0.139
Sa(1.0)	0.015	0.044	0.070
Sa(2.0)	0.0061	0.021	0.033
Sa(5.0)	0.0012	0.0047	0.0081
Sa(10.0)	0.0006	0.0019	0.0032
PGA	0.033	0.102	0.163
PGV	0.021	0.068	0.111

References

National Building Code of Canada 2015 NRCC no. 56190;
Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

User's Guide - NBC 2015, Structural Commentaries NRCC no. xxxxxx (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français

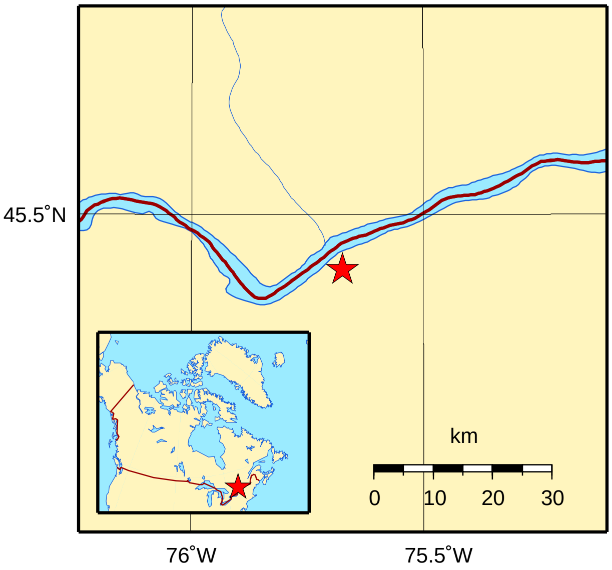
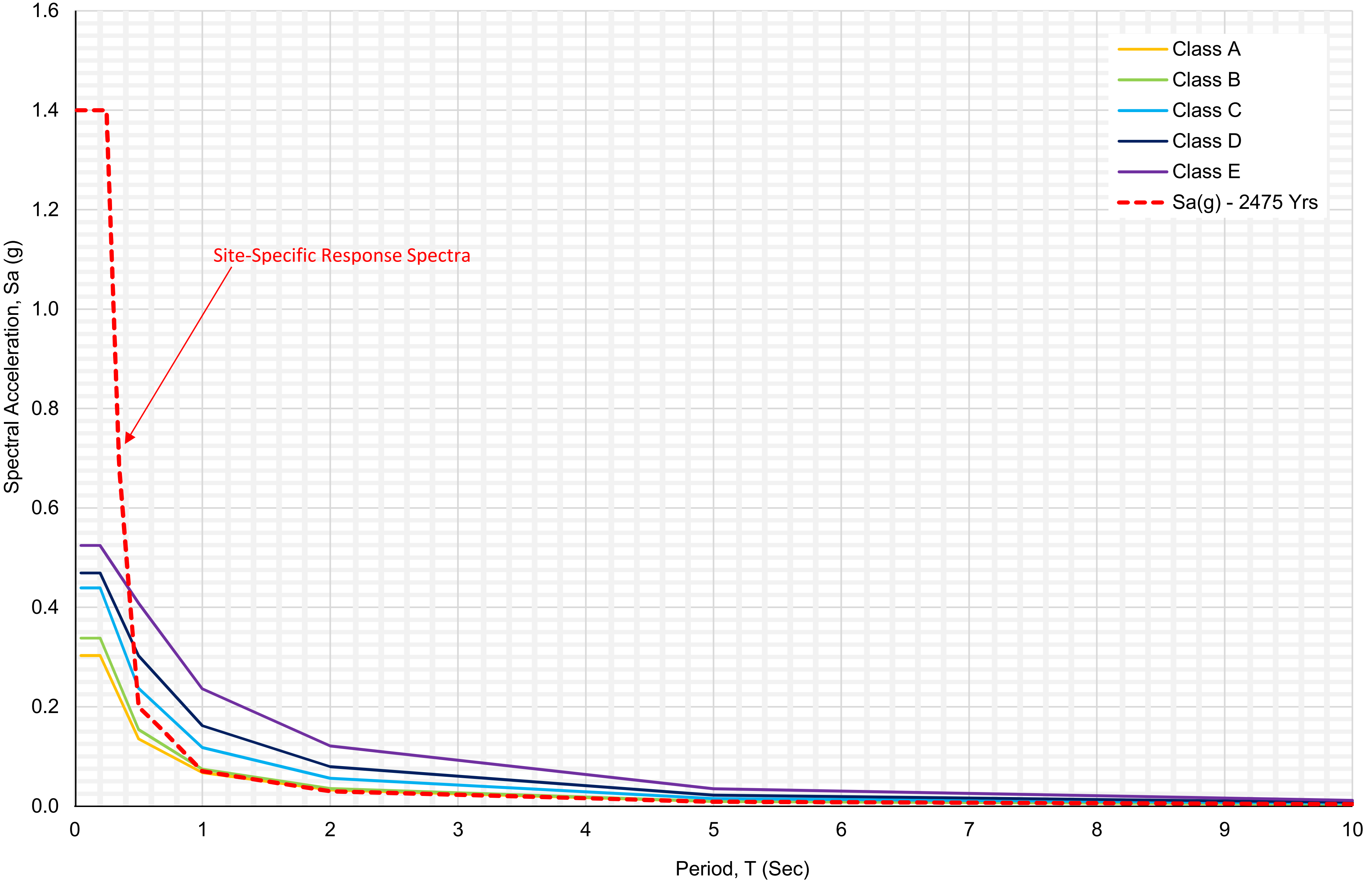


Figure 1: Preliminary Site-Specific Response Spectra Without Removing the Waste
Highway 417 Nicholas Street Underpass - Site #3-224 (1:2475 year)



THURBER

Figure 2: Preliminary Site-Specific Response Spectra Without Removing the Waste
Highway 417 Nicholas Street Underpass - Site #3-224 (1:975 year)

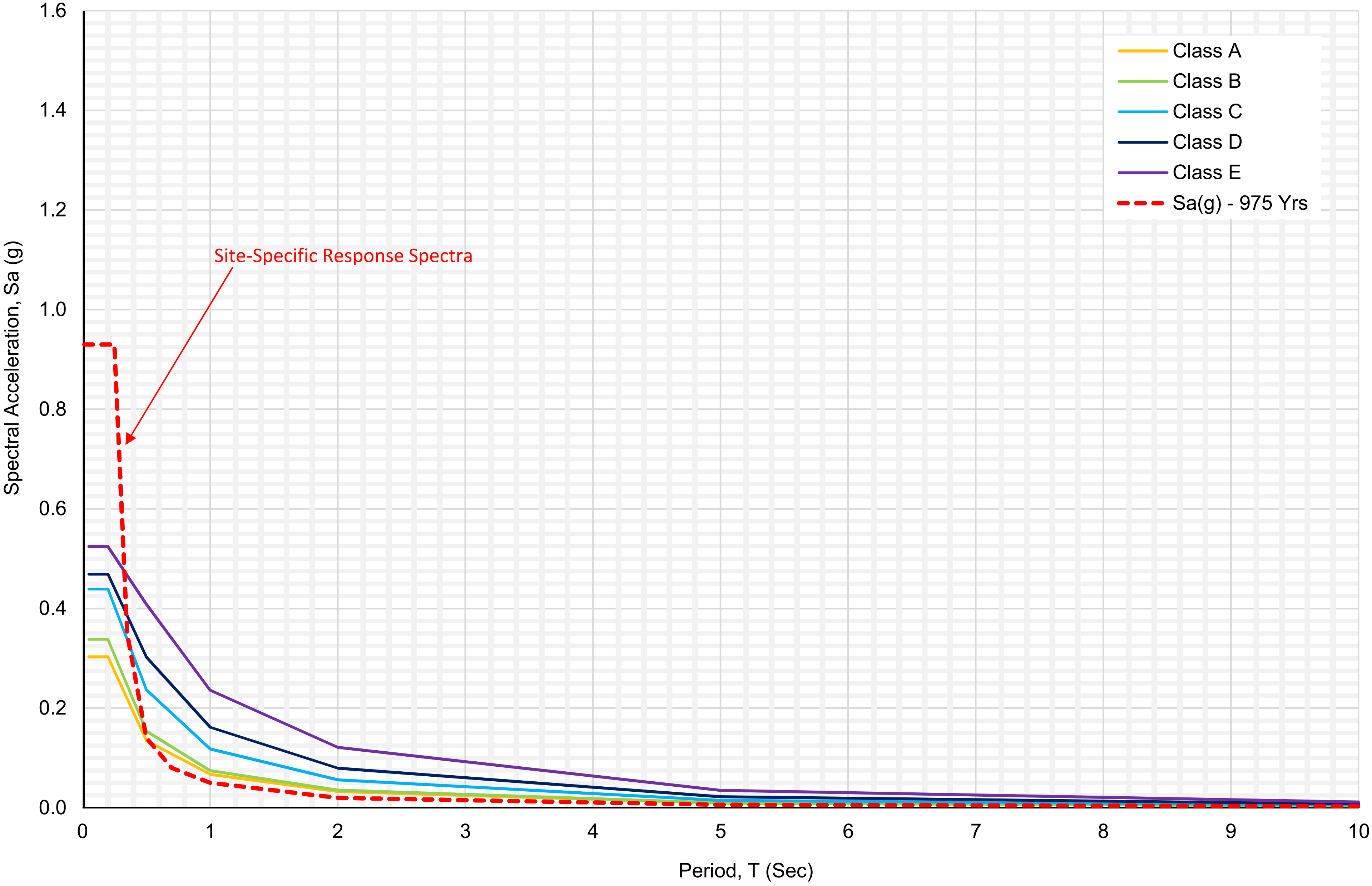
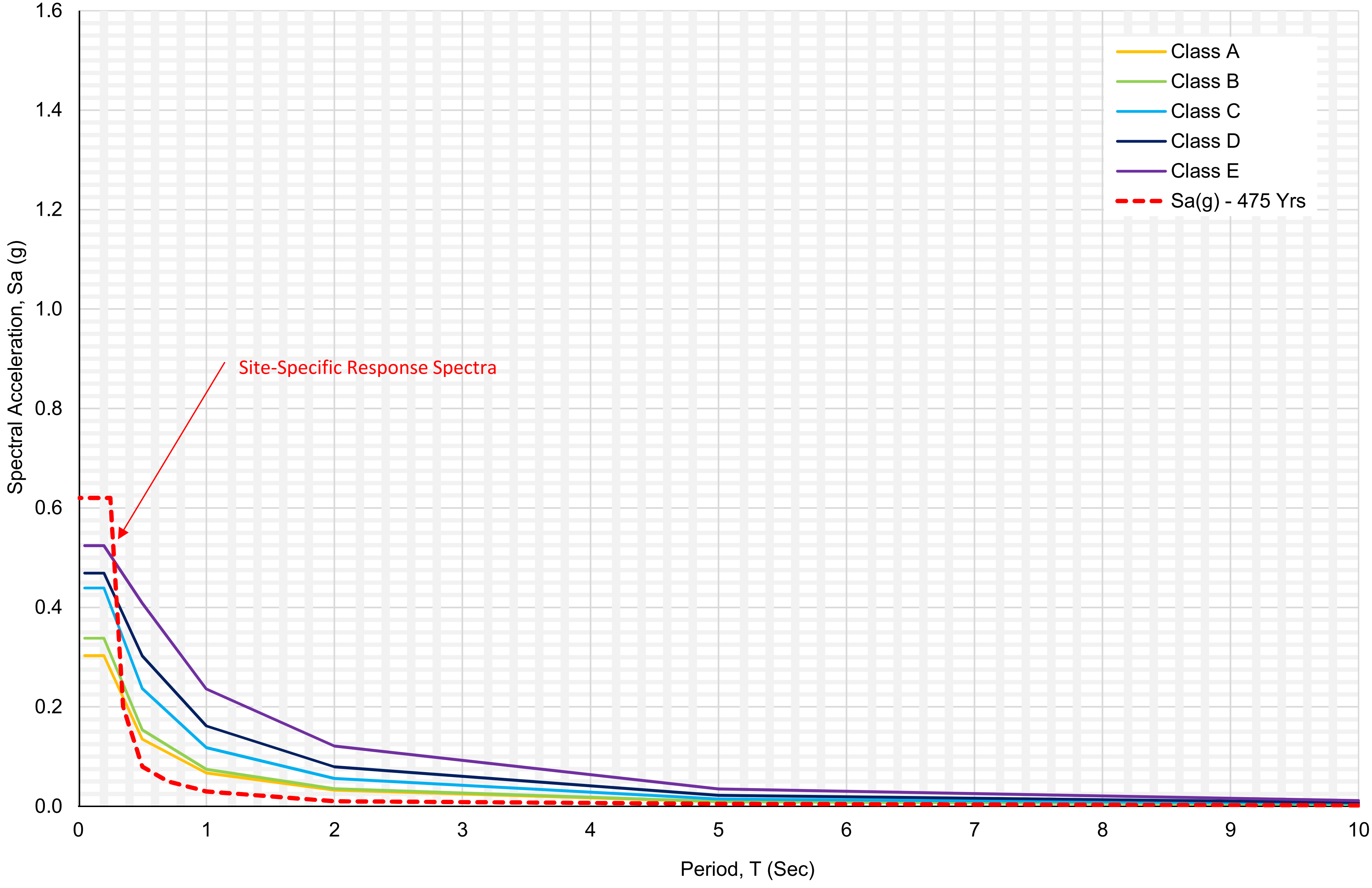


Figure 3: Preliminary Site-Specific Response Spectra Without Removing Waste
Highway 417 Nicholas Street Underpass - Site #3-224 (1:475 year)



THURBER

Figure 4: Preliminary Site-Specific Response Spectra after Replacement of Waste at South Abutment Highway 417 Nicholas Street Underpass - Site #3-224 (1:2475 year)

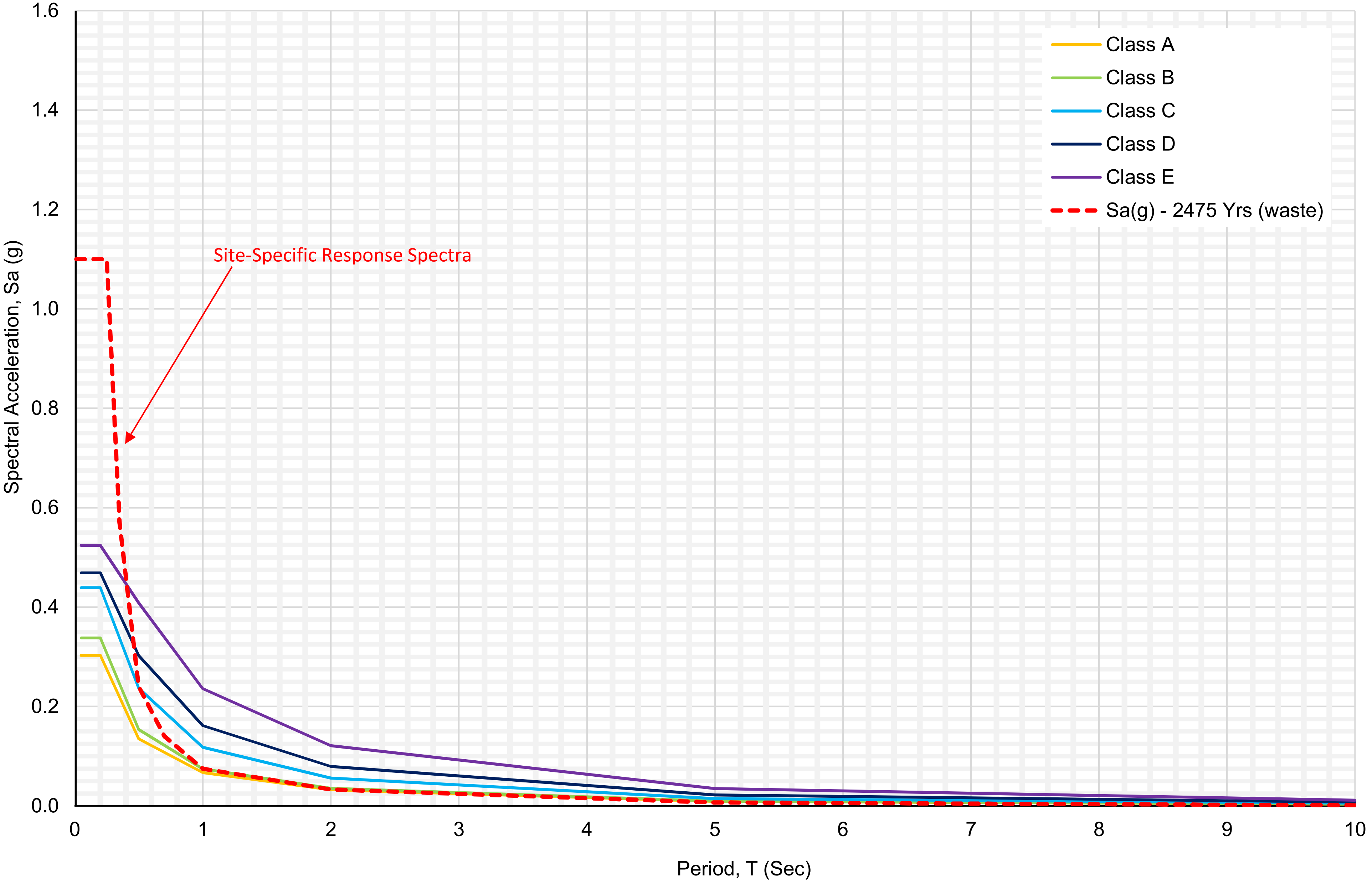
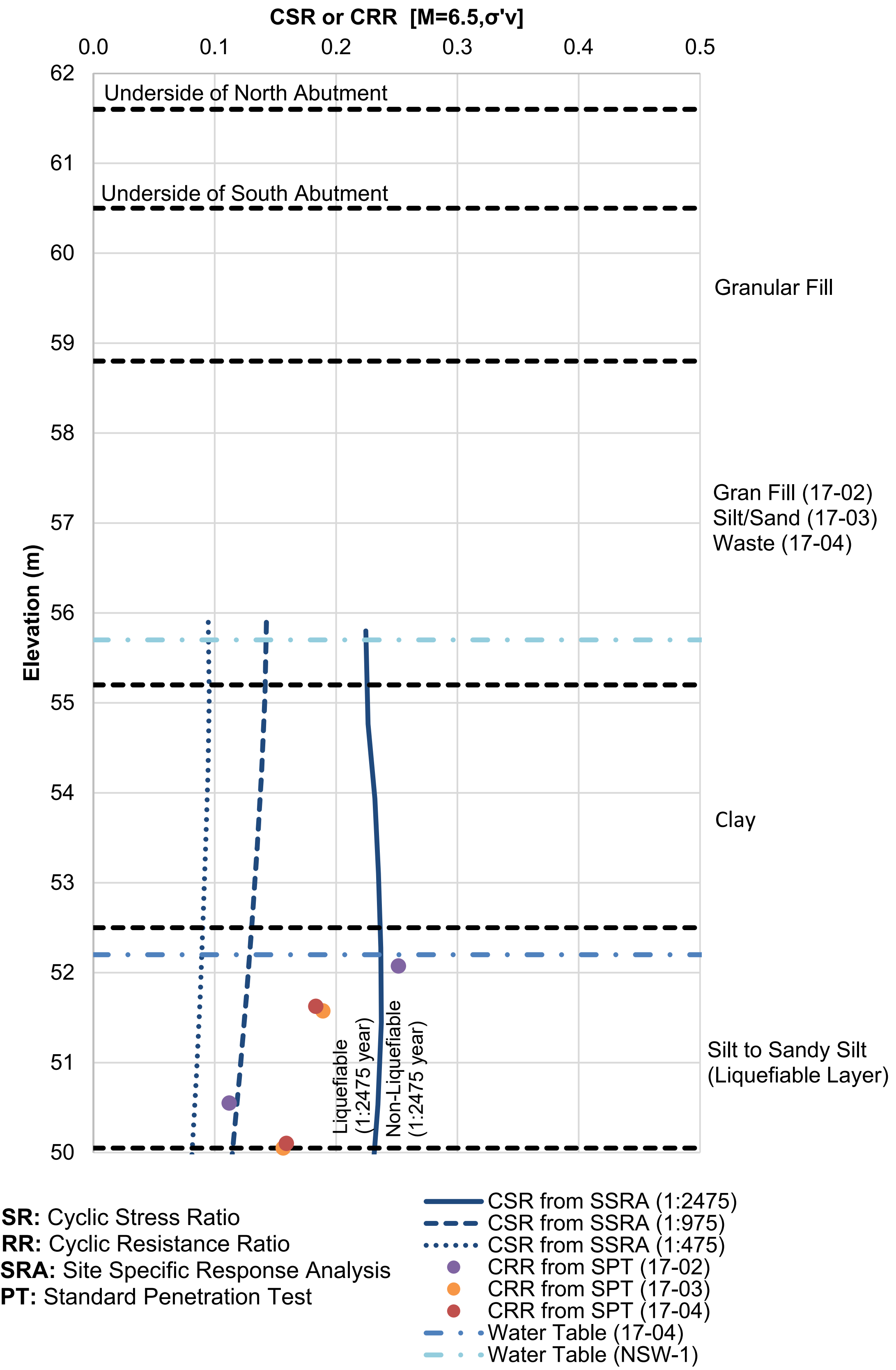


FIGURE 5
Liquefaction Triggering Analysis
Highway 417 Nicholas Street Underpass
Ottawa, ON

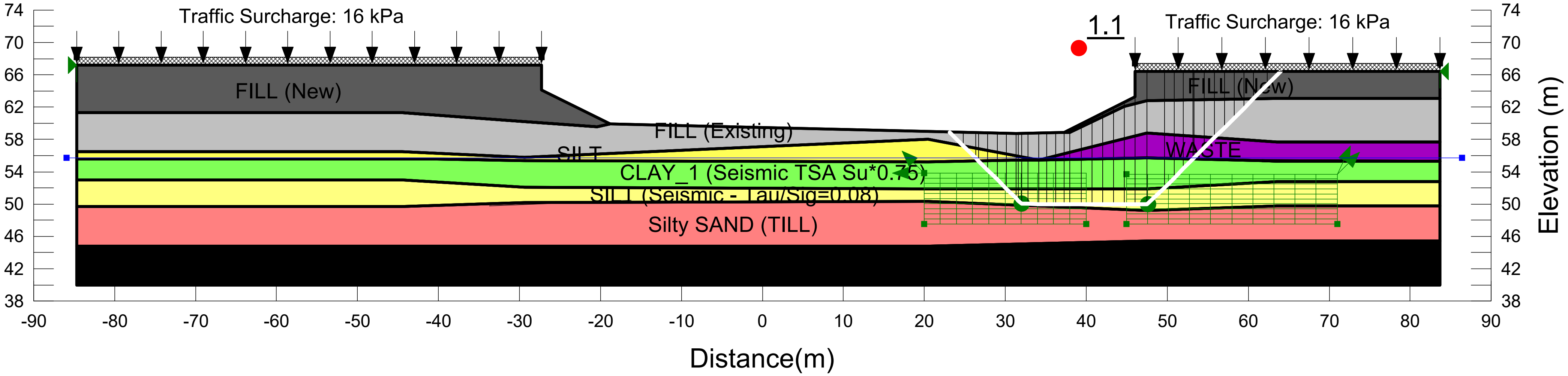


CSR: Cyclic Stress Ratio
CRR: Cyclic Resistance Ratio
SSRA: Site Specific Response Analysis
SPT: Standard Penetration Test

Title: HWY 417 - Nicholas St. Underpass
Comments: Embankment Stability Assessment
Name: SA1.41 - South Abutment - Seismic (kx=0) - Flow Slide

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
PWP Conditions Source: Piezometric Line
Seismic: H\ 0 V\ 0
Slip Surface Center: (42.539354, 68.276043) w/ Radius: 20.479894 m
FoS Contours: 1.1 to 2.1, ++0.1

FILL (New)	21.2 kN/m³	0 kPa	34 °		
FILL (Existing)	20 kN/m³	0 kPa	30 °		
SILT	18 kN/m³	0 kPa	28 °	0 kPa	0 °
Silty SAND (TILL)	21 kN/m³	0 kPa	38 °		
WASTE	19 kN/m³	0 kPa	29 °		
BEDROCK					
SILT (Seismic - Tau/Sig=0.08)	18 kN/m³	0.08	0 kPa		
CLAY_1 (Seismic TSA Su*0.75)	18.34 kN/m³	56 kPa	0 °		



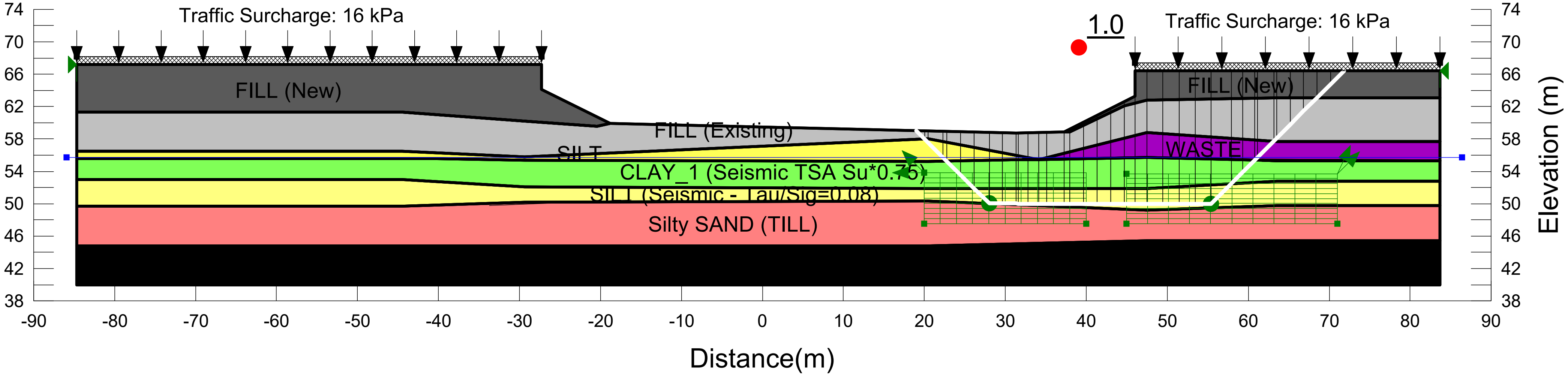
Reviewed By: ________________
Tool Version: 8.15.6.13446
Last Solved Date: 2018-03-28, 11:11:14 AM
Directory: \\ott-pserver1\Project Data\Projects\10000 to 20000\17532 - Hwy 417 Nicholas\Reports & Memos\Foundations\18-01-17\From Oakville\20171116_NicholasStUP_Seismic_djp_for memo.gsz

Figure 6

Title: HWY 417 - Nicholas St. Underpass
Comments: Embankment Stability Assessment
Name: SA1.51 - South Abutment - Seismic (kx=ay) - Yield

FILL (New)	21.2 kN/m³	0 kPa	34 °		
FILL (Existing)	20 kN/m³	0 kPa	30 °		
SILT	18 kN/m³	0 kPa	28 °	0 kPa	0 °
Silty SAND (TILL)	21 kN/m³	0 kPa	38 °		
WASTE	19 kN/m³	0 kPa	29 °		
BEDROCK					
SILT (Seismic - Tau/Sig=0.08)	18 kN/m³	0.08	0 kPa		
CLAY_1 (Seismic TSA Su*0.75)	18.34 kN/m³	56 kPa	0 °		

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
PWP Conditions Source: Piezometric Line
Seismic: H\ 0.07 V\ 0
Slip Surface Center: (44.643812, 68.251503) w/ Radius: 24.250643 m
FoS Contours: 1.0 to 2.0, ++0.1

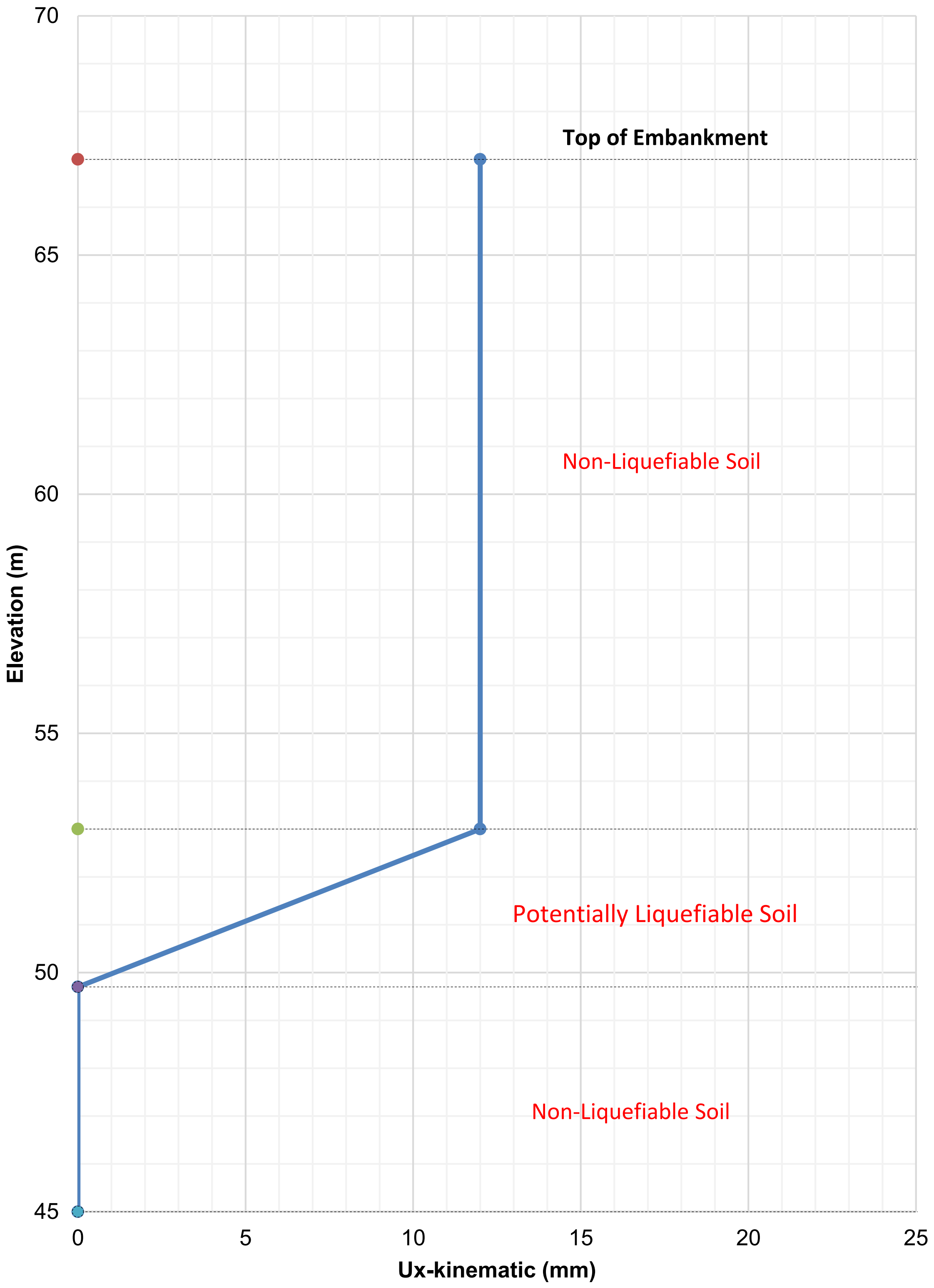


Reviewed By: ______________
Tool Version: 8.15.6.13446
Last Solved Date: 2018-03-28, 11:11:22 AM
Directory: \\ott-pserver1\Project Data\Projects\10000 to 20000\17532 - Hwy 417 Nicholas\Reports & Memos\Foundations\18-01-17\From Oakville\20171116_NicholasStUP_Seismic_djp_for memo.gsz

Figure 7

FIGURE 8
Lateral Displacement Profile from Newmark Analysis
Highway 417 Nicholas Street Underpass
Ottawa, ON

Liquefaction Induced Soil Displacement Profile for Both Abutments



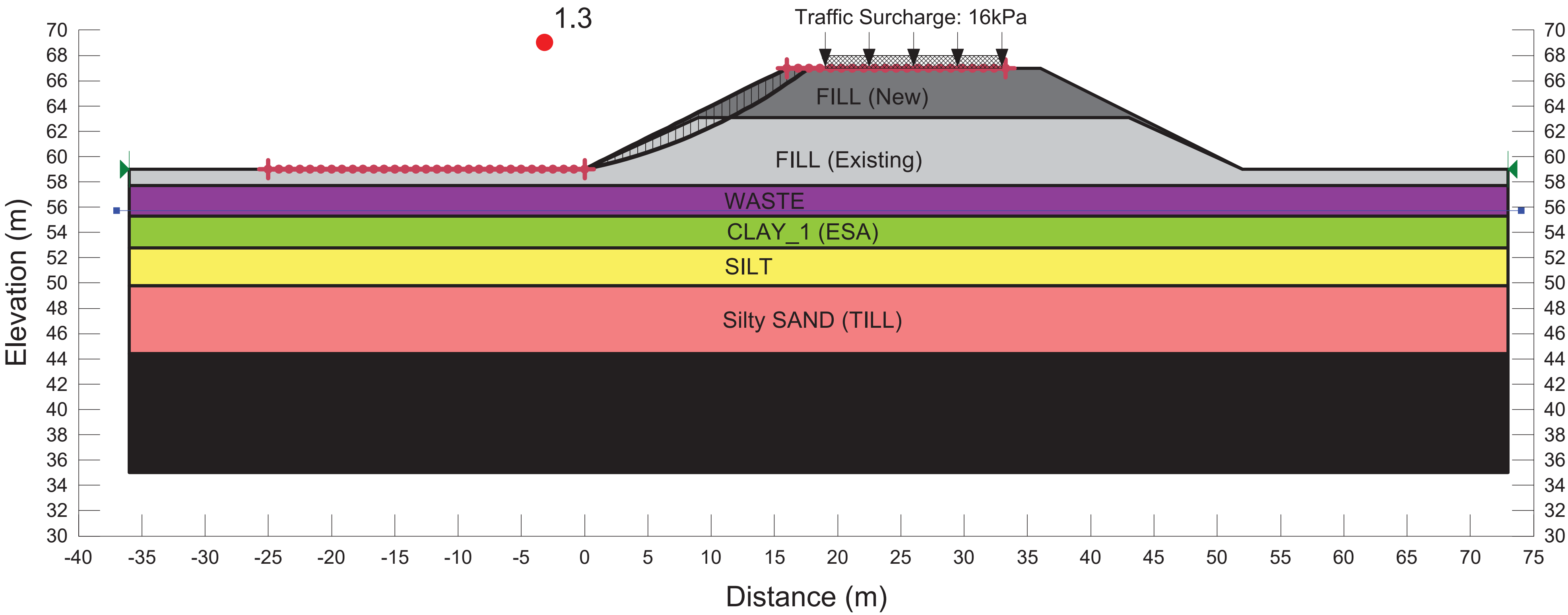
Appendix G.

Slope Stability Analysis

Title: HWY 417 - Nicholas St. Underpass
Comments: Embankment Stability Assessment
Name: South - Drained Static

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
PWP Conditions Source: Piezometric Line
Seismic: H\ 0 V\ 0
Slip Surface Center: (-9.1356888, 102.87581) w/ Radius: 44.816823 m
FoS Contours: 1.2 to 2.2, ++0.1

FILL (New)	21.2 kN/m³	0 kPa	32 °		
FILL (Existing)	20 kN/m³	0 kPa	30 °		
SILT	18 kN/m³	0 kPa	28 °	0 kPa	0 °
CLAY_1 (ESA)	18.34 kN/m³	0 kPa	27 °		
Silty SAND (TILL)	21 kN/m³	0 kPa	38 °		
WASTE	19 kN/m³	0 kPa	29 °		
BEDROCK					



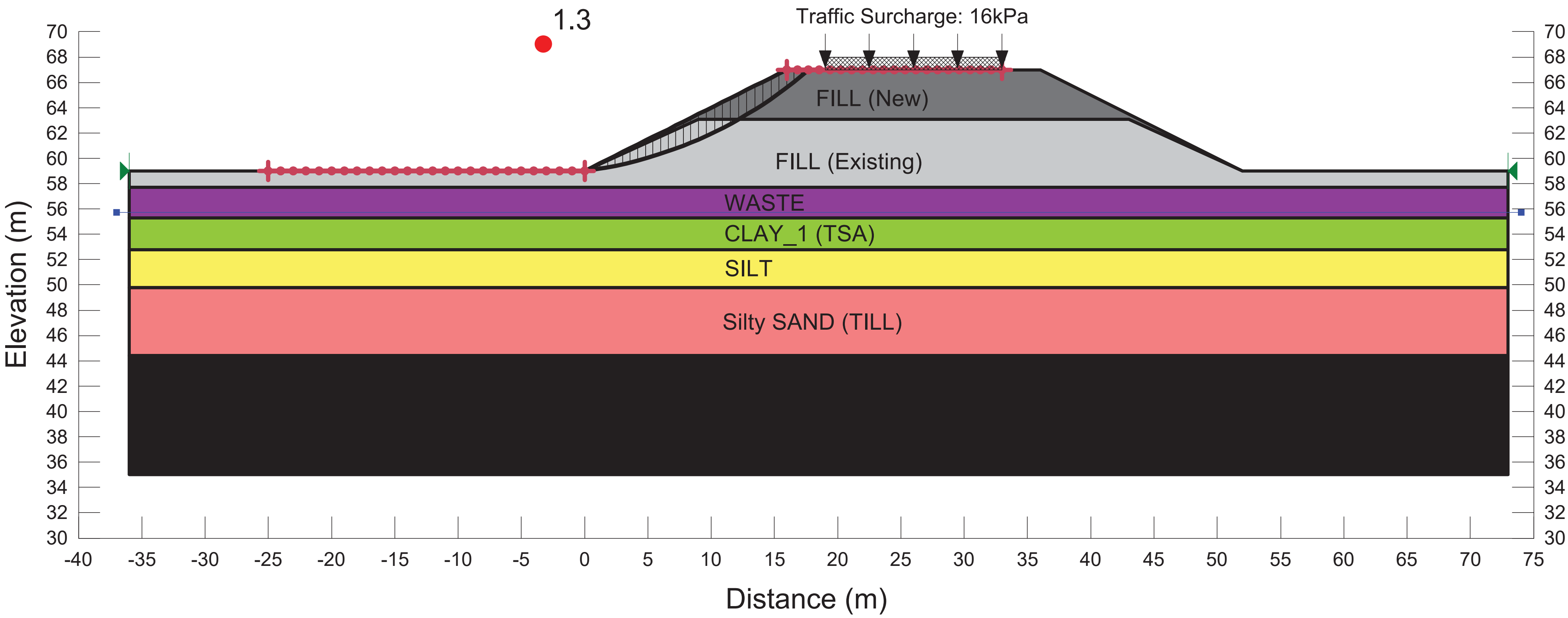
Reviewed By: _______________
Tool Version: 8.15.6.13446
Last Solved Date: 2018-04-02, 3:53:25 PM
Directory: \\ott-pserver1\Project Data\Projects\10000 to 20000\17532 - Hwy 417 Nicholas\Analysis\20171116_NicholasStUP_SOUTH_V2.gsz

FIGURE G-1

Title: HWY 417 - Nicholas St. Underpass
Comments: Embankment Stability Assessment
Name: South - Undrained Static

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
PWP Conditions Source: Piezometric Line
Seismic: H\ 0 V\ 0
Slip Surface Center: (-4.3263216, 92.151333) w/ Radius: 33.432438 m
FoS Contours: 1.2 to 2.2, ++0.1

FILL (New)	21.2 kN/m³	0 kPa	32 °		
FILL (Existing)	20 kN/m³	0 kPa	30 °		
SILT	18 kN/m³	0 kPa	28 °	0 kPa	0 °
CLAY_1 (TSA)	18.34 kN/m³	75 kPa	0 °		
Silty SAND (TILL)	21 kN/m³	0 kPa	38 °		
WASTE	19 kN/m³	0 kPa	29 °		
BEDROCK					



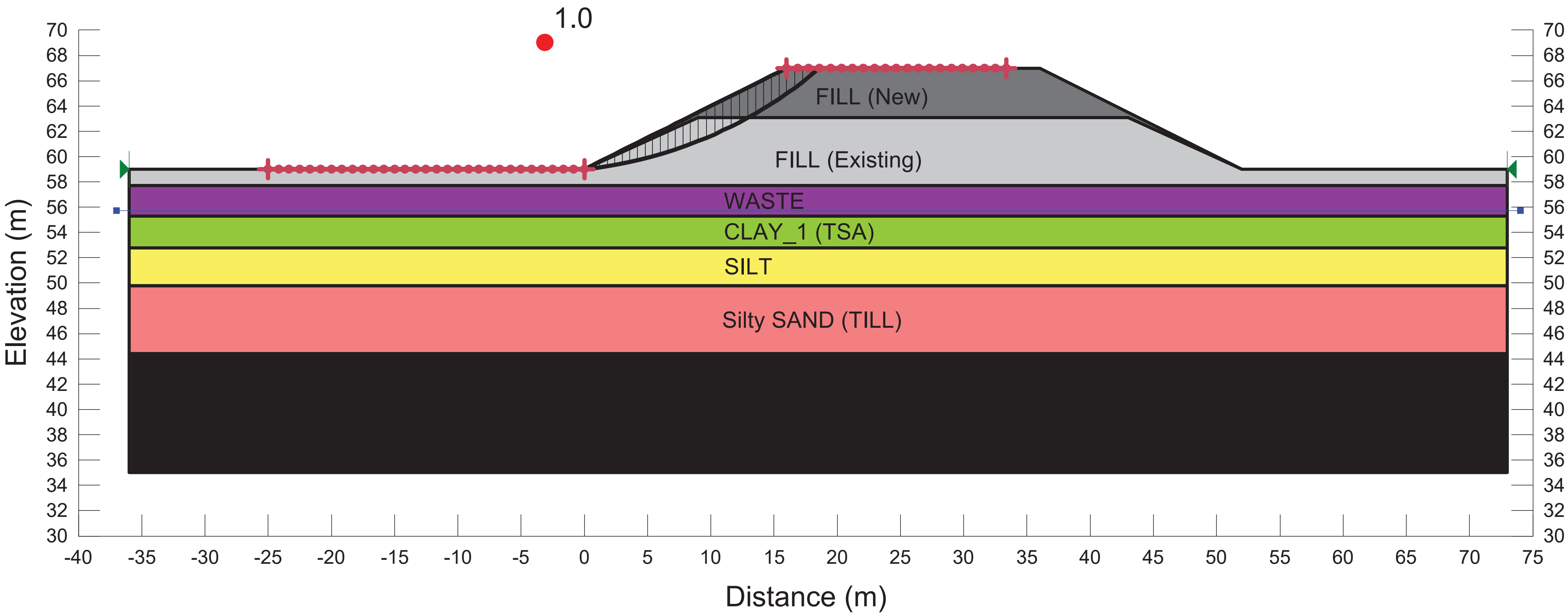
Reviewed By: _______________
Tool Version: 8.15.6.13446
Last Solved Date: 2018-04-02, 3:53:33 PM
Directory: \\ott-pserver1\Project Data\Projects\10000 to 20000\17532 - Hwy 417 Nicholas\Analysis\20171116_NicholasStUP_SOUTH_V2.gsz

FIGURE G-2

Title: HWY 417 - Nicholas St. Underpass
Comments: Embankment Stability Assessment
Name: South - Undrained Dynamic

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
PWP Conditions Source: Piezometric Line
Seismic: H\ 0.141 V\ 0
Slip Surface Center: (-3.5985588, 93.004913) w/ Radius: 34.194791 m
FoS Contours: 0.9 to 1.9, ++0.1

FILL (New)	21.2 kN/m³	0 kPa	32 °		
FILL (Existing)	20 kN/m³	0 kPa	30 °		
SILT	18 kN/m³	0 kPa	28 °	0 kPa	0 °
CLAY_1 (TSA)	18.34 kN/m³	75 kPa	0 °		
Silty SAND (TILL)	21 kN/m³	0 kPa	38 °		
WASTE	19 kN/m³	0 kPa	29 °		
BEDROCK					



Reviewed By: _______________
Tool Version: 8.15.6.13446
Last Solved Date: 2018-04-02, 3:53:37 PM
Directory: \\ott-pserver1\Project Data\Projects\10000 to 20000\17532 - Hwy 417 Nicholas\Analysis\20171116_NicholasStUP_SOUTH_V2.gsz

FIGURE G-3

Appendix H.

Pile Analysis – P-Y Curves

Project No.: Thurber - 17532
Project: Highway 417 - Nicholas
Date: January 10, 2018

HP 310x110 Pile
North Abutment
Depth Below Elevation 61.6m (underside of abutment)

	Depth (m)																																															
	Top 3 m		3		3.5		4		4.5		5		5.5		6		6.5		7		7.5		8		8.5		9		9.5		10		10.5		11		11.5		12		13		14		15		16	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
STATIC	Disregard p-y in location of CSP		0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
			0.0003	1.21	0.0001	4.08	0.0000	1.45	0.0001	3.30	0.0002	8.37	0.0003	17.73	0.0050	113.61	0.0010	42.02	0.0010	42.02	0.0010	42.02	0.0010	42.02	0.0010	42.02	0.0010	42.02	0.0024	84.85	0.0036	135.64	0.0052	208.10	0.0073	305.42	0.0004	71.65	0.0006	103.73	0.0010	201.82	0.0017	357.10	0.0020	446.66	0.0020	482.44
			0.0007	1.64	0.0006	7.35	0.0005	6.48	0.0005	10.69	0.0006	18.05	0.0008	29.23	0.0050	113.84	0.0020	59.43	0.0020	59.43	0.0020	59.43	0.0020	59.43	0.0020	59.43	0.0020	59.43	0.0026	90.35	0.0037	138.96	0.0057	220.10	0.0076	319.29	0.0009	110.10	0.0010	143.99	0.0014	243.06	0.0020	395.35	0.0023	484.47	0.0023	522.47
			0.0012	1.90	0.0010	9.17	0.0010	9.48	0.0010	15.57	0.0011	25.08	0.0012	38.31	0.0050	114.07	0.0031	69.24	0.0031	69.24	0.0031	69.24	0.0031	69.24	0.0031	69.24	0.0031	69.24	0.0029	95.64	0.0039	142.24	0.0062	232.10	0.0080	329.03	0.0013	141.26	0.0014	177.96	0.0018	280.20	0.0023	431.34	0.0026	520.47	0.0026	560.61
			0.0016	2.10	0.0015	10.54	0.0014	11.92	0.0015	19.61	0.0015	31.01	0.0017	46.17	0.0050	114.30	0.0041	75.61	0.0041	75.61	0.0041	75.61	0.0041	75.61	0.0041	75.61	0.0041	75.61	0.0031	100.75	0.0040	145.46	0.0067	244.10	0.0083	338.69	0.0017	168.48	0.0018	208.17	0.0022	314.40	0.0027	465.49	0.0029	554.92	0.0029	597.15
			0.0020	2.26	0.0020	11.67	0.0019	14.04	0.0019	23.17	0.0020	36.28	0.0021	53.24	0.0051	114.52	0.0051	79.96	0.0051	79.96	0.0051	79.96	0.0051	79.96	0.0051	79.96	0.0051	79.96	0.0034	105.70	0.0042	148.64	0.0072	256.10	0.0086	348.35	0.0021	193.12	0.0023	235.78	0.0025	346.35	0.0030	498.09	0.0032	588.05	0.0032	632.30
			0.0025	2.40	0.0024	12.65	0.0024	15.95	0.0024	26.40	0.0024	41.10	0.0025	59.76	0.0051	114.75	0.0061	82.86	0.0061	82.86	0.0061	82.86	0.0061	82.86	0.0061	82.86	0.0061	82.86	0.0036	110.50	0.0043	151.78	0.0077	268.09	0.0090	358.01	0.0026	215.88	0.0027	261.45	0.0029	376.50	0.0033	529.38	0.0034	620.02	0.0035	666.23
			0.0029	2.52	0.0029	13.51	0.0028	17.71	0.0029	29.40	0.0029	45.57	0.0030	65.84	0.0051	114.98	0.0072	84.65	0.0072	84.65	0.0072	84.65	0.0072	84.65	0.0072	84.65	0.0072	84.65	0.0039	115.18	0.0044	154.87	0.0082	280.09	0.0093	367.67	0.0030	237.18	0.0031	285.58	0.0033	405.17	0.0036	559.51	0.0037	650.95	0.0037	699.08
			0.0034	2.63	0.0033	14.30	0.0033	19.35	0.0033	32.21	0.0034	49.78	0.0034	71.58	0.0051	115.21	0.0082	85.54	0.0082	85.54	0.0082	85.54	0.0082	85.54	0.0082	85.54	0.0082	85.54	0.0041	119.73	0.0046	157.93	0.0087	292.09	0.0096	377.33	0.0034	257.31	0.0035	308.46	0.0037	432.58	0.0039	588.63	0.0040	680.97	0.0040	730.96
			0.0038	2.73	0.0038	15.02	0.0038	20.89	0.0038	34.87	0.0038	53.78	0.0039	77.04	0.0051	115.43	0.0092	85.67	0.0092	85.67	0.0092	85.67	0.0092	85.67	0.0092	85.67	0.0092	85.67	0.0044	124.17	0.0047	160.95	0.0092	304.08	0.0100	386.99	0.0039	276.47	0.0039	330.29	0.0040	458.92	0.0042	616.85	0.0043	710.16	0.0043	761.97
			0.0043	2.82	0.0043	15.69	0.0042	22.36	0.0042	37.41	0.0043	57.58	0.0043	82.26	0.0051	115.66	0.0102	85.15	0.0102	85.15	0.0102	85.15	0.0102	85.15	0.0102	85.15	0.0102	85.15	0.0047	128.52	0.0049	163.93	0.0097	316.08	0.0103	396.65	0.0043	294.82	0.0043	351.23	0.0044	484.32	0.0045	644.26	0.0046	738.59	0.0046	792.19
			0.0047	2.91	0.0047	16.31	0.0047	23.77	0.0047	39.84	0.0047	61.24	0.0047	87.27	0.0052	115.88	0.0113	84.06	0.0113	84.06	0.0113	84.06	0.0113	84.06	0.0113	84.06	0.0113	84.06	0.0049	132.77	0.0050	166.88	0.0101	328.08	0.0106	406.32	0.0047	312.45	0.0048	371.40	0.0048	508.88	0.0049	670.94	0.0049	766.33	0.0049	821.68
			0.0052	2.99	0.0052	16.90	0.0052	25.11	0.0052	42.18	0.0052	64.76	0.0052	92.11	0.0052	116.11	0.0123	82.47	0.0123	82.47	0.0123	82.47	0.0123	82.47	0.0123	82.47	0.0123	82.47	0.0052	136.93	0.0052	169.79	0.0106	340.08	0.0110	415.98	0.0052	329.47	0.0052	390.88	0.0052	532.70	0.0052	696.95	0.0052	793.44	0.0052	850.50
			0.0084	3.55	0.0084	20.93	0.0084	34.26	0.0084	58.21	0.0084	89.36	0.0084	127.11	0.0084	160.23	0.0205	59.49	0.0205	59.49	0.0205	59.49	0.0205	59.49	0.0205	59.49	0.0205	59.49	0.0084	188.97	0.0084	234.32	0.0111	352.07	0.0113	425.64	0.0084	454.66	0.0084	539.42	0.0084	735.13	0.0084	961.79	0.0084	1094.95	0.0084	1173.70
			0.0116	4.12	0.0116	24.96	0.0116	43.40	0.0116	74.24	0.0116	113.97	0.0116	162.11	0.0116	204.35	0.0286	36.47	0.0286	36.47	0.0286	36.47	0.0286	36.47	0.0286	36.47	0.0286	36.47	0.0116	241.00	0.0116	298.84	0.0116	364.07	0.0116	435.30	0.0116	579.86	0.0116	687.95	0.0116	937.56	0.0116	1226.63	0.0116	1396.46	0.0116	1496.89
			0.0140	4.12	0.0140	24.96	0.0140	43.40	0.0140	74.24	0.0140	113.97	0.0140	162.11	0.0140	204.35	0.0368	13.46	0.0368	13.46	0.0368	13.46	0.0368	13.46	0.0368	13.46	0.0368	13.46	0.0140	241.00	0.0140	298.84	0.0140	364.07	0.0140	435.30	0.0140	579.86	0.0140	687.95	0.0140	937.56	0.0140	1226.63	0.0140	1396.46	0.0140	1496.89
			0.0163	4.12	0.0163	24.96	0.0163	43.40	0.0163	74.24	0.0163	113.97	0.0163	162.11	0.0163	204.35	0.0389	13.46	0.0389	13.46	0.0389	13.46	0.0389	13.46	0.0389	13.46	0.0389	13.46	0.0163	241.00	0.0163	298.84	0.0163	364.07	0.0163	435.30	0.0163	579.86	0.0163	687.95	0.0163	937.56	0.0163	1226.63	0.0163	1396.46	0.0163	1496.89

HP 310x110 Pile
South Abutment
Depth Below Elevation 60.1m (underside of abutment)

	Depth (m)																																															
	Top 3 m		3		3.5		4		4.5		5		5.5		6		6.5		7		7.5		8		8.5		9		9.5		10		10.5		11		11.5		12		12.5		13		14		15	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
STATIC	Disregard p-y in location of CSP		0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
			0.0002	0.92	0.0004	3.91	0.0003	2.58	0.0006	6.45	0.0012	15.05	0.0010	42.02	0.0010	42.02	0.0010	42.02	0.0010	42.02	0.0010	42.02	0.0010	42.02	0.0010	42.02	0.0004	14.13	0.0008	27.45	0.0013	48.71	0.0020	80.64	0.0030	126.35	0.0043	189.34	0.0003	46.03	0.0004	67.59	0.0005	97.63	0.0009	187.21	0.0015	328.54
			0.0007	1.28	0.0009	5.13	0.0007	4.67	0.0010	9.00	0.0016	17.65	0.0020	59.43	0.0020	59.43	0.0020	59.43	0.0020	59.43	0.0020	59.43	0.0020	59.43	0.0020	59.43	0.0008	21.83	0.0012	35.50	0.0016	56.48	0.0023	87.39	0.0032	131.24	0.0044	191.34	0.0007	84.67	0.0008	109.08	0.0009	141.29	0.0013	232.68	0.0018	372.07
			0.0011	1.50	0.0013	6.02	0.0012	6.25	0.0014	11.15	0.0019	20.03	0.0031	69.24	0.0031	69.24	0.0031	69.24	0.0031	69.24	0.0031	69.24	0.0031	69.24	0.0031	69.24	0.0013	28.06	0.0016	42.51	0.0020	63.60	0.0026	93.82	0.0034	136.01	0.0045	193.33	0.0012	114.08	0.0012	142.10	0.0014	177.51	0.0017	273.01	0.0021	412.53
			0.0016	1.66	0.0017	6.74	0.0016	7.58	0.0018	13.06	0.0023	22.24	0.0041	75.61	0.0041	75.61	0.0041	75.61	0.0041	75.61	0.0041	75.61	0.0041	75.61	0.0041	75.61	0.0017	33.50	0.0020	48.84	0.0023	70.25	0.0029	99.98	0.0036	140.68	0.0046	195.31	0.0016	139.22	0.0017	170.75	0.0018	209.46	0.0021	309.81	0.0025	450.58
			0.0020	1.79	0.0022	7.37	0.0020	8.77	0.0022	14.80	0.0026	24.31	0.0051	79.96	0.0051	79.96	0.0051	79.96	0.0051	79.96	0.0051	79.96	0.0051	79.96	0.0051	79.96	0.0021	38.42	0.0024	54.68	0.0027	76.51	0.0032	105.91	0.0038	145.25	0.0046	197.27	0.0020	161.72	0.0021	196.58	0.0022	238.54	0.0025	343.98	0.0028	486.66
			0.0025	1.90	0.0026	7.92	0.0025	9.86	0.0027	16.42	0.0030	26.27	0.0061	82.86	0.0061	82.86	0.0061	82.86	0.0061	82.86	0.0061	82.86	0.0061	82.86	0.0061	82.86	0.0026	42.96	0.0028	60.14	0.0030	82.46	0.0035	111.62	0.0040	149.73	0.0047	199.22	0.0025	182.35	0.0025	220.38	0.0026	265.48	0.0028	376.08	0.0032	521.09
			0.0029	2.00	0.0030	8.42	0.0029	10.86	0.0031	17.94	0.0034	28.15	0.0072	84.65	0.0072	84.65	0.0072	84.65	0.0072	84.65	0.0072	84.65	0.0072	84.65	0.0072	84.65	0.0030	47.21	0.0032	65.30	0.0034	88.14	0.0037	117.16	0.0042	154.12	0.0048	201.16	0.0029	201.58	0.0030	242.63	0.0030	290.77	0.0032	406.51	0.0035	554.11
			0.0034	2.09	0.0035	8.88	0.0034	11.81	0.0035	19.39	0.0037	29.95	0.0082	85.54	0.0082	85.54	0.0082	85.54	0.0082	85.54	0.0082	85.54	0.0082	85.54	0.0082	85.54	0.0034	51.23	0.0036	70.21	0.0038	93.60	0.0040	122.53	0.0044	158.44	0.0049	203.08	0.0034	219.68	0.0034	263.63	0.0035	314.71	0.0036	435.53	0.0038	585.91
			0.0038	2.17	0.0039	9.31	0.0038	12.71	0.0039	20.76	0.0041	31.68	0.0092	85.67	0.0092	85.67	0.0092	85.67	0.0092	85.67	0.0092	85.67	0.0092	85.67	0.0092	85.67	0.0039	55.06	0.0040	74.90	0.0041	98.85	0.0043	127.75	0.0046	162.68	0.0049	205.00	0.0038	236.88	0.0039	283.60	0.0039	337.53	0.0040	463.36	0.0042	616.63
			0.0043	2.25	0.0043	9.71	0.0043	13.56	0.0043	22.08	0.0044	33.35	0.0102	85.15	0.0102	85.15	0.0102	85.15	0.0102	85.15	0.0102	85.15	0.0102	85.15	0.0102	85.15	0.0043	58.71	0.0044	79.42	0.0045	103.94	0.0046	132.84	0.0048	166.85	0.0050	206.90	0.0043	253.30	0.0043	302.71	0.0043	359.39	0.0044	490.14	0.0045	646.40
			0.0047	2.32	0.0047	10.09	0.0047	14.38	0.0047	23.36	0.0048	34.97	0.0113	84.06	0.0113	84.06	0.0113	84.06	0.0113	84.06	0.0113	84.06	0.0113	84.06	0.0113	84.06	0.0047	62.23	0.0048	83.77	0.0048	108.87	0.0049	137.80	0.0050	170.95	0.0051	208.79	0.0047	269.06	0.0047	321.06	0.0047	380.43	0.0048	516.02	0.0048	675.31
			0.0052	2.38	0.0052	10.44	0.0052	15.17	0.0052	24.58	0.0052	36.54	0.0123	82.47	0.0123	82.47	0.0123	82.47	0.0123	82.47	0.0123	82.47	0.0123	82.47	0.0123	82.47	0.0052	65.63	0.0052	87.98	0.0052	113.65	0.0052	142.65	0.0052	174.99	0.0052	210.67	0.0052	284.25	0.0052	338.77	0.0052	400.74	0.0052	541.08	0.0052	703.44
			0.0084	2.84	0.0084	13.06	0.0084	20.77	0.0084	33.93	0.0084	50.42	0.0205	59.49	0.0205	59.49	0.0205	59.49	0.0205	59.49	0.0205	59.49	0.0205	59.49	0.0205	59.49	0.0084	90.56	0.0084	121.41	0.0084	156.84	0.0084	196.86	0.0084	241.49	0.0084	290.73	0.0084	392.26	0.0084	467.50	0.0084	553.02	0.0084	746.69	0.0084	970.74
			0.0116	3.30	0.0116	15.67	0.0116	26.38	0.0116	43.27	0.0116	64.31	0.0286	36.47	0.0286	36.47	0.0286	36.47	0.0286	36.47	0.0286	36.47	0.0286	36.47	0.0286	36.47	0.0116	115.50	0.0116	154.85	0.0116	200.03	0.0116	251.07	0.0116	307.98	0.0116	370.79	0.0116	500.28	0.0116	596.23	0.0116	705.30	0.0116	952.30	0.0116	1238.05
			0.0140	3.30	0.0140	15.67	0.0140	26.38	0.0140	43.27	0.0140	64.31	0.0368	13.46	0.0368	13.46	0.0368	13.46	0.0368	13.46	0.0368	13.46	0.0368	13.46	0.0368	13.46	0.0140	115.50	0.0140	154.85	0.0140	200.03	0.0140	251.07	0.0140	307.98	0.0140	370.79	0.0140	500.28	0.0140	596.23	0.0140	705.30	0.0140	952.30	0.0140	1238.05
			0.0163	3.30	0.0163	15.67	0.0163	26.38	0.0163	43.27	0.0163	64.31	0.0389	13.46	0.0389	13.46	0.0389	13.46	0.0389	13.46	0.0389	13.46	0.0389	13.46	0.0389	13.46	0.0163	115.50	0.0163	154.85	0.0163	200.03	0.0163	251.07	0.0163	307.98	0.0163	370.79	0.0163	500.28	0.0163	596.23	0.0163	705.30	0.0163	952.30	0.0163	1238.05

HP 310x110 Pile
North Abutment
Depth Below Elevation 61.6m (underside of abutment)

	Depth (m)																																															
	Top 3 m		3		3.5		4		4.5		5		5.5		6		6.5		7		7.5		8		8.5		9		9.5		10		10.5		11		11.5		12		13		14		15		16	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
SEISMIC	Disregard p-y in location of CSP		0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
			0.0003	1.21	0.0001	4.08	0.0000	1.45	0.0001	3.30	0.0002	8.37	0.0003	17.73	0.0050	113.61	0.0010	30.82	0.0010	30.82	0.0010	30.82	0.0010	30.82	0.0010	30.82	0.0010	28.02	0.0001	2.79	0.0001	2.79	0.0001	0.93	0.0001	0.93	0.0001	2.33	0.0001	13.73	0.0002	37.40	0.0004	84.13	0.0007	165.79	0.0013	296.71
			0.0007	1.64	0.0006	7.35	0.0005	6.48	0.0005	10.69	0.0006	18.05	0.0008	29.23	0.0050	113.84	0.0020	43.58	0.0020	43.58	0.0020	43.58	0.0020	43.58	0.0020	43.58	0.0020	39.62	0.0007	5.58	0.0007	5.58	0.0007	1.86	0.0007	1.86	0.0006	4.65	0.0005	44.80	0.0006	77.72	0.0008	130.86	0.0011	215.50	0.0016	345.52
			0.0012	1.90	0.0010	9.17	0.0010	9.48	0.0010	15.57	0.0011	25.08	0.0012	38.31	0.0050	114.07	0.0031	50.78	0.0031	50.78	0.0031	50.78	0.0031	50.78	0.0031	50.78	0.0031	46.16	0.0025	8.37	0.0025	8.37	0.0025	2.79	0.0025	2.79	0.0021	6.98	0.0010	65.28	0.0011	107.30	0.0013	168.56	0.0015	258.68	0.0020	390.24
			0.0016	2.10	0.0015	10.54	0.0014	11.92	0.0015	19.61	0.0015	31.01	0.0017	46.17	0.0050	114.30	0.0041	55.45	0.0041	55.45	0.0041	55.45	0.0041	55.45	0.0041	55.45	0.0041	50.41	0.0059	11.16	0.0059	11.16	0.0059	3.72	0.0059	3.72	0.0049	9.30	0.0015	82.22	0.0016	132.33	0.0017	201.44	0.0020	297.62	0.0023	431.86
			0.0020	2.26	0.0020	11.67	0.0019	14.04	0.0019	23.17	0.0020	36.28	0.0021	53.24	0.0051	114.52	0.0051	58.64	0.0051	58.64	0.0051	58.64	0.0051	58.64	0.0051	58.64	0.0051	53.31	0.0115	13.95	0.0115	13.95	0.0115	4.65	0.0115	4.65	0.0096	11.63	0.0019	97.15	0.0020	154.60	0.0021	231.17	0.0024	333.52	0.0027	471.04
			0.0025	2.40	0.0024	12.65	0.0024	15.95	0.0024	26.40	0.0024	41.10	0.0025	59.76	0.0051	114.75	0.0061	60.77	0.0061	60.77	0.0061	60.77	0.0061	60.77	0.0061	60.77	0.0061	55.24	0.0198	16.74	0.0198	16.74	0.0198	5.58	0.0198	5.58	0.0165	13.95	0.0024	110.72	0.0025	174.97	0.0026	258.61	0.0028	367.08	0.0030	508.23
			0.0029	2.52	0.0029	13.51	0.0028	17.71	0.0029	29.40	0.0029	45.57	0.0030	65.84	0.0051	114.98	0.0072	62.08	0.0072	62.08	0.0072	62.08	0.0072	62.08	0.0072	62.08	0.0072	56.44	0.0315	19.53	0.0315	19.53	0.0315	6.51	0.0315	6.51	0.0263	16.28	0.0029	123.29	0.0029	193.91	0.0030	284.28	0.0032	398.77	0.0034	543.73
			0.0034	2.63	0.0033	14.30	0.0033	19.35	0.0033	32.21	0.0034	49.78	0.0034	71.58	0.0051	115.21	0.0082	62.73	0.0082	62.73	0.0082	62.73	0.0082	62.73	0.0082	62.73	0.0082	57.03	0.0470	22.32	0.0470	22.32	0.0470	7.44	0.0470	7.44	0.0392	18.60	0.0033	135.09	0.0034	211.73	0.0034	308.54	0.0036	428.91	0.0037	577.80
			0.0038	2.73	0.0038	15.02	0.0038	20.89	0.0038	34.87	0.0038	53.78	0.0039	77.04	0.0051	115.43	0.0092	62.82	0.0092	62.82	0.0092	62.82	0.0092	62.82	0.0092	62.82	0.0092	57.11	0.0670	25.11	0.0670	25.11	0.0670	8.37	0.0670	8.37	0.0558	20.93	0.0038	146.26	0.0038	228.62	0.0039	331.63	0.0040	457.74	0.0041	610.62
			0.0043	2.82	0.0043	15.69	0.0042	22.36	0.0042	37.41	0.0043	57.58	0.0043	82.26	0.0051	115.66	0.0102	62.44	0.0102	62.44	0.0102	62.44	0.0102	62.44	0.0102	62.44	0.0102	56.77	0.0919	27.90	0.0919	27.90	0.0919	9.30	0.0919	9.30	0.0765	23.25	0.0042	156.90	0.0043	244.75	0.0043	353.72	0.0044	485.44	0.0045	642.34
			0.0047	2.91	0.0047	16.31	0.0047	23.77	0.0047	39.84	0.0047	61.24	0.0047	87.27	0.0052	115.88	0.0113	61.65	0.0113	61.65	0.0113	61.65	0.0113	61.65	0.0113	61.65	0.0113	56.04	0.1223	30.69	0.1223	30.69	0.1223	10.23	0.1223	10.23	0.1019	25.58	0.0047	167.09	0.0047	260.22	0.0047	374.96	0.0048	512.17	0.0048	673.08
			0.0052	2.99	0.0052	16.90	0.0052	25.11	0.0052	42.18	0.0052	64.76	0.0052	92.11	0.0052	116.11	0.0123	60.48	0.0123	60.48	0.0123	60.48	0.0123	60.48	0.0123	60.48	0.0123	54.98	0.1587	33.48	0.1587	33.48	0.1587	11.16	0.1587	11.16	0.1323	27.90	0.0052	176.90	0.0052	275.12	0.0052	395.44	0.0052	538.02	0.0052	702.94
			0.0084	3.55	0.0084	20.93	0.0084	34.26	0.0084	58.21	0.0084	89.36	0.0084	127.11	0.0084	160.23	0.0205	43.63	0.0205	43.63	0.0205	43.63	0.0205	43.63	0.0205	43.63	0.0205	39.66	0.2018	36.27	0.2018	36.27	0.2018	12.09	0.2018	12.09	0.1682	30.23	0.0084	244.12	0.0084	379.66	0.0084	545.71	0.0084	742.46	0.0084	970.06
			0.0116	4.12	0.0116	24.96	0.0116	43.40	0.0116	74.24	0.0116	113.97	0.0116	162.11	0.0116	204.35	0.0286	26.75	0.0286	26.75	0.0286	26.75	0.0286	26.75	0.0286	26.75	0.0286	24.32	0.2520	39.06	0.2520	39.06	0.2520	13.02	0.2520	13.02	0.2100	32.55	0.0116	311.34	0.0116	484.21	0.0116	695.98	0.0116	946.91	0.0116	1237.18
			0.0140	4.12	0.0140	24.96	0.0140	43.40	0.0140	74.24	0.0140	113.97	0.0140	162.11	0.0140	204.35	0.0368	9.87	0.0368	9.87	0.0368	9.87	0.0368	9.87	0.0368	9.87	0.0368	8.97	0.3100	41.85	0.3100	41.85	0.3100	13.95	0.3100	13.95	0.2583	34.88	0.0140	311.34	0.0140	484.21	0.0140	695.98	0.0140	946.91	0.0140	1237.18
			0.0163	4.12	0.0163	24.96	0.0163	43.40	0.0163	74.24	0.0163	113.97	0.0163	162.11	0.0163	204.35	0.0389	9.87	0.0389	9.87	0.0389	9.87	0.0389	9.87	0.0389	9.87	0.0389	8.97	0.3294	41.85	0.3294	41.85	0.3294	13.95	0.3294	13.95	0.2745	34.88	0.0163	311.34	0.0163	484.21	0.0163	695.98	0.0163	946.91	0.0163	1237.18

HP 310x110 Pile
South Abutment
Depth Below Elevation 60.1m (underside of abutment)

	Depth (m)																																															
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
SEISMIC	Disregard p-y in location of CSP		0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
			0.0002	0.92	0.0004	3.91	0.0003	2.58	0.0006	6.45	0.0012	15.05	0.0010	30.82	0.0010	30.82	0.0010	30.82	0.0010	30.82	0.0010	30.82	0.0010	30.82	0.0010	28.02	0.0001	2.79	0.0001	2.79	0.0001	2.79	0.0001	2.79	0.0001	2.79	0.0001	2.79	0.0000	6.05	0.0000	7.28	0.0001	12.97	0.0002	34.21	0.0003	75.65
			0.0007	1.28	0.0009	5.13	0.0007	4.67	0.0010	9.00	0.0016	17.65	0.0020	43.58	0.0020	43.58	0.0020	43.58	0.0020	43.58	0.0020	43.58	0.0020	43.58	0.0020	39.62	0.0007	5.58	0.0007	5.58	0.0007	5.58	0.0007	5.58	0.0007	5.58	0.0007	5.58	0.0004	12.09	0.0005	34.41	0.0005	45.54	0.0006	76.53	0.0008	125.20
			0.0011	1.50	0.0013	6.02	0.0012	6.25	0.0014	11.15	0.0019	20.03	0.0031	50.78	0.0031	50.78	0.0031	50.78	0.0031	50.78	0.0031	50.78	0.0031	50.78	0.0031	46.16	0.0025	8.37	0.0025	8.37	0.0025	8.37	0.0025	8.37	0.0025	8.37	0.0025	8.37	0.0012	18.14	0.0010	51.20	0.0010	66.70	0.0011	106.95	0.0012	164.28
			0.0016	1.66	0.0017	6.74	0.0016	7.58	0.0018	13.06	0.0023	22.24	0.0041	55.45	0.0041	55.45	0.0041	55.45	0.0041	55.45	0.0041	55.45	0.0041	55.45	0.0041	50.41	0.0059	11.16	0.0059	11.16	0.0059	11.16	0.0059	11.16	0.0059	11.16	0.0059	11.16	0.0029	24.18	0.0014	64.97	0.0015	84.17	0.0015	132.55	0.0017	198.09
			0.0020	1.79	0.0022	7.37	0.0020	8.77	0.0022	14.80	0.0026	24.31	0.0051	58.64	0.0051	58.64	0.0051	58.64	0.0051	58.64	0.0051	58.64	0.0051	58.64	0.0051	53.31	0.0115	13.95	0.0115	13.95	0.0115	13.95	0.0115	13.95	0.0115	13.95	0.0115	13.95	0.0057	30.23	0.0019	77.07	0.0019	99.55	0.0020	155.29	0.0021	228.51
			0.0025	1.90	0.0026	7.92	0.0025	9.86	0.0027	16.42	0.0030	26.27	0.0061	60.77	0.0061	60.77	0.0061	60.77	0.0061	60.77	0.0061	60.77	0.0061	60.77	0.0061	55.24	0.0198	16.74	0.0198	16.74	0.0198	16.74	0.0198	16.74	0.0198	16.74	0.0198	16.74	0.0099	36.27	0.0024	88.05	0.0024	113.53	0.0024	176.05	0.0025	256.51
			0.0029	2.00	0.0030	8.42	0.0029	10.86	0.0031	17.94	0.0034	28.15	0.0072	62.08	0.0072	62.08	0.0072	62.08	0.0072	62.08	0.0072	62.08	0.0072	62.08	0.0072	56.44	0.0315	19.53	0.0315	19.53	0.0315	19.53	0.0315	19.53	0.0315	19.53	0.0315	19.53	0.0158	42.32	0.0028	98.21	0.0028	126.48	0.0029	195.33	0.0030	282.67
			0.0034	2.09	0.0035	8.88	0.0034	11.81	0.0035	19.39	0.0037	29.95	0.0082	62.73	0.0082	62.73	0.0082	62.73	0.0082	62.73	0.0082	62.73	0.0082	62.73	0.0082	57.03	0.0470	22.32	0.0470	22.32	0.0470	22.32	0.0470	22.32	0.0470	22.32	0.0470	22.32	0.0235	48.36	0.0033	107.72	0.0033	138.62	0.0033	213.46	0.0034	307.35
			0.0038	2.17	0.0039	9.31	0.0038	12.71	0.0039	20.76	0.0041	31.68	0.0092	62.82	0.0092	62.82	0.0092	62.82	0.0092	62.82	0.0092	62.82	0.0092	62.82	0.0092	57.11	0.0670	25.11	0.0670	25.11	0.0670	25.11	0.0670	25.11	0.0670	25.11	0.0670	25.11	0.0335	54.41	0.0038	116.73	0.0038	150.11	0.0038	230.65	0.0039	330.81
			0.0043	2.25	0.0043	9.71	0.0043	13.56	0.0043	22.08	0.0044	33.35	0.0102	62.44	0.0102	62.44	0.0102	62.44	0.0102	62.44	0.0102	62.44	0.0102	62.44	0.0102	56.77	0.0919	27.90	0.0919	27.90	0.0919	27.90	0.0919	27.90	0.0919	27.90	0.0919	27.90	0.0459	60.45	0.0042	125.31	0.0042	161.06	0.0043	247.05	0.0043	353.24
			0.0047	2.32	0.0047	10.09	0.0047	14.38	0.0047	23.36	0.0048	34.97	0.0113	61.65	0.0113	61.65	0.0113	61.65	0.0113	61.65	0.0113	61.65	0.0113	61.65	0.0113	56.04	0.1223	30.69	0.1223	30.69	0.1223	30.69	0.1223	30.69	0.1223	30.69	0.1223	30.69	0.0611	66.50	0.0047	133.52	0.0047	171.55	0.0047	262.77	0.0047	374.79
			0.0052	2.38	0.0052	10.44	0.0052	15.17	0.0052	24.58	0.0052	36.54	0.0123	60.48	0.0123	60.48	0.0123	60.48	0.0123	60.48	0.0123	60.48	0.0123	60.48	0.0123	54.98	0.1587	33.48	0.1587	33.48	0.1587	33.48	0.1587	33.48	0.1587	33.48	0.1587	33.48	0.0794	72.54	0.0052	141.42	0.0052	181.64	0.0052	277.91	0.0052	395.57
			0.0084	2.84	0.0084	13.06	0.0084	20.77	0.0084	33.93	0.0084	50.42	0.0205	43.63	0.0205	43.63	0.0205	43.63	0.0205	43.63	0.0205	43.63	0.0205	43.63	0.0205	39.66	0.2018	36.27	0.2018	36.27	0.2018	36.27	0.2018	36.27	0.2018	36.27	0.2018	36.27	0.1009	78.59	0.0084	195.16	0.0084	250.66	0.0084	383.51	0.0084	545.89
			0.0116	3.30	0.0116	15.67	0.0116	26.38	0.0116	43.27	0.0116	64.31	0.0286	26.75	0.0286	26.75	0.0286	26.75	0.0286	26.75	0.0286	26.75	0.0286	26.75	0.0286	24.32	0.2520	39.06	0.2520	39.06	0.2520	39.06	0.2520	39.06	0.2520	39.06	0.2520	39.06	0.1260	84.63	0.0116	248.90	0.0116	319.69	0.0116	489.12	0.0116	696.20
			0.0140	3.30	0.0140	15.67	0.0140	26.38	0.0140	43.27	0.0140	64.31	0.0368	9.87	0.0368	9.87	0.0368	9.87	0.0368	9.87	0.0368	9.87	0.0368	9.87	0.0368	8.97	0.3100	41.85	0.3100	41.85	0.3100	41.85	0.3100	41.85	0.3100	41.85	0.3100	41.85	0.1550	90.68	0.0140	248.90	0.0140	319.69	0.0140	489.12	0.0140	696.20
			0.0163	3.30	0.0163	15.67	0.0163	26.38	0.0163	43.27	0.0163	64.31	0.0389	9.87	0.0389	9.87	0.0389	9.87	0.0389	9.87	0.0389	9.87	0.0389	9.87	0.0389	8.97	0.3294	41.85	0.3294	41.85	0.3294	41.85	0.3294	41.85	0.3294	41.85	0.3294	41.85	0.1647	90.68	0.0163	248.90	0.0163	319.69	0.0163	489.12	0.0163	696.20

THURBER

Project No.: Thurber - 17532
Project: Highway 417 - Nicholas
Date: February 9, 2018

HP 360x132
North Abutment
Depth Below Elevation 61.6m (underside of abutment)

	Depth (m)																																																									
	0.1		0.5		1		1.5		2		2.5		3		3.5		4		4.5		5		5.5		6		6.5		7		7.5		8		8.5		9		9.5		10		10.5		11		11.5		12		13		14		15		16	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
STATIC	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
	0.0018	1.67	0.0020	9.36	0.0015	14.01	0.0006	8.10	0.0007	12.24	0.0010	24.27	0.0015	43.04	0.0021	70.47	0.0029	108.61	0.0038	159.68	0.0048	226.05	0.0050	258.92	0.0014	31.58	0.0012	50.56	0.0012	50.56	0.0012	50.56	0.0012	50.56	0.0012	50.56	0.0012	50.56	0.0013	45.59	0.0013	47.84	0.0013	50.13	0.0013	52.51	0.0017	286.82	0.0023	403.28	0.0023	451.52	0.0024	494.44	0.0024	537.43	0.0024	580.49
	0.0022	1.76	0.0024	9.88	0.0019	15.35	0.0011	11.57	0.0012	17.35	0.0015	30.48	0.0020	49.98	0.0025	77.62	0.0032	115.36	0.0040	165.29	0.0049	229.65	0.0051	262.32	0.0028	63.15	0.0025	71.51	0.0025	71.51	0.0025	71.51	0.0025	71.51	0.0025	71.51	0.0025	71.51	0.0025	91.19	0.0025	95.68	0.0025	100.27	0.0025	105.02	0.0021	327.72	0.0026	441.01	0.0027	491.66	0.0027	537.26	0.0028	582.93	0.0028	628.65
	0.0026	1.85	0.0028	10.34	0.0024	16.50	0.0016	14.36	0.0017	21.62	0.0020	35.97	0.0024	56.34	0.0029	84.37	0.0035	121.87	0.0042	170.78	0.0051	233.21	0.0052	265.69	0.0042	94.73	0.0037	83.31	0.0037	83.31	0.0037	83.31	0.0037	83.31	0.0037	83.31	0.0037	83.31	0.0038	136.78	0.0038	143.51	0.0038	150.40	0.0038	157.53	0.0025	365.55	0.0030	476.76	0.0030	529.79	0.0031	577.98	0.0031	626.24	0.0031	674.54
	0.0030	1.92	0.0031	10.75	0.0028	17.53	0.0021	16.77	0.0022	25.41	0.0024	40.96	0.0028	62.27	0.0033	90.79	0.0038	128.16	0.0044	176.16	0.0052	236.73	0.0053	269.03	0.0055	126.30	0.0049	90.97	0.0049	90.97	0.0049	90.97	0.0049	90.97	0.0049	90.97	0.0049	90.97	0.0051	182.38	0.0050	191.35	0.0050	200.54	0.0050	210.04	0.0029	401.01	0.0033	510.86	0.0034	566.23	0.0034	616.94	0.0035	667.70	0.0035	718.50
	0.0034	1.99	0.0035	11.14	0.0032	18.46	0.0026	18.94	0.0027	28.86	0.0029	45.58	0.0032	67.85	0.0036	96.93	0.0041	134.25	0.0047	181.43	0.0053	240.23	0.0055	272.34	0.0069	157.88	0.0062	96.21	0.0062	96.21	0.0062	96.21	0.0062	96.21	0.0062	96.21	0.0062	96.21	0.0063	227.97	0.0063	239.19	0.0063	250.67	0.0063	262.55	0.0033	434.55	0.0037	543.55	0.0038	601.21	0.0038	654.36	0.0038	707.56	0.0038	760.79
	0.0038	2.05	0.0039	11.49	0.0036	19.31	0.0031	20.93	0.0032	32.06	0.0034	49.92	0.0037	73.15	0.0040	102.82	0.0044	140.17	0.0049	186.61	0.0055	243.69	0.0056	275.63	0.0083	189.45	0.0074	99.70	0.0074	99.70	0.0074	99.70	0.0074	99.70	0.0074	99.70	0.0074	99.70	0.0076	273.56	0.0076	287.03	0.0075	300.81	0.0075	315.06	0.0037	466.50	0.0041	575.02	0.0041	634.93	0.0041	690.45	0.0041	746.02	0.0042	801.62
	0.0042	2.10	0.0043	11.82	0.0041	20.10	0.0037	22.78	0.0037	35.07	0.0039	54.03	0.0041	78.22	0.0044	108.51	0.0047	145.94	0.0051	191.70	0.0056	247.12	0.0057	278.89	0.0097	221.03	0.0086	101.86	0.0086	101.86	0.0086	101.86	0.0086	101.86	0.0086	101.86	0.0086	101.86	0.0088	319.16	0.0088	334.86	0.0088	350.94	0.0088	367.58	0.0042	497.09	0.0044	605.41	0.0045	667.53	0.0045	725.37	0.0045	783.24	0.0045	841.15
	0.0046	2.16	0.0047	12.13	0.0045	20.84	0.0042	24.51	0.0042	37.92	0.0043	57.95	0.0045	83.08	0.0047	114.01	0.0050	151.56	0.0053	196.70	0.0057	250.52	0.0058	282.13	0.0111	252.60	0.0098	102.92	0.0098	102.92	0.0098	102.92	0.0098	102.92	0.0098	102.92	0.0098	102.92	0.0101	364.75	0.0101	382.70	0.0101	401.08	0.0101	420.09	0.0046	526.52	0.0048	634.85	0.0048	699.13	0.0048	759.23	0.0048	819.36	0.0048	879.51
	0.0050	2.21	0.0051	12.43	0.0049	21.54	0.0047	26.16	0.0047	40.64	0.0048	61.70	0.0049	87.76	0.0051	119.34	0.0053	157.05	0.0056	201.62	0.0058	253.89	0.0059	285.35	0.0125	284.18	0.0111	103.08	0.0111	103.08	0.0111	103.08	0.0111	103.08	0.0111	103.08	0.0111	103.08	0.0114	410.34	0.0113	430.54	0.0113	451.21	0.0113	472.60	0.0050	554.92	0.0051	663.44	0.0052	729.84	0.0052	792.15	0.0052	854.48	0.0052	916.82
	0.0054	2.25	0.0054	12.71	0.0054	22.20	0.0052	27.72	0.0052	43.25	0.0053	65.31	0.0054	92.29	0.0055	124.52	0.0056	162.42	0.0058	206.46	0.0060	257.23	0.0060	288.54	0.0139	315.75	0.0123	102.45	0.0123	102.45	0.0123	102.45	0.0123	102.45	0.0123	102.45	0.0123	102.45	0.0126	455.94	0.0126	478.38	0.0126	501.35	0.0126	525.11	0.0054	582.41	0.0055	691.25	0.0055	759.74	0.0055	824.21	0.0055	888.69	0.0055	953.18
	0.0058	2.30	0.0058	12.97	0.0058	22.82	0.0057	29.23	0.0057	45.76	0.0057	68.80	0.0058	96.68	0.0058	129.57	0.0059	167.68	0.0060	211.24	0.0061	260.54	0.0061	291.71	0.0152	347.33	0.0135	101.15	0.0135	101.15	0.0135	101.15	0.0135	101.15	0.0135	101.15	0.0135	101.15	0.0139	501.53	0.0139	526.22	0.0138	551.48	0.0138	577.62	0.0058	609.09	0.0059	718.36	0.0059	788.90	0.0059	855.48	0.0059	922.07	0.0059	988.67
	0.0062	2.34	0.0062	13.23	0.0062	23.42	0.0062	30.67	0.0062	48.18	0.0062	72.17	0.0062	100.95	0.0062	134.50	0.0062	172.83	0.0062	215.94	0.0062	263.83	0.0062	294.85	0.0166	378.90	0.0148	99.23	0.0148	99.23	0.0148	99.23	0.0148	99.23	0.0148	99.23	0.0148	99.23	0.0152	547.13	0.0151	574.05	0.0151	601.62	0.0151	630.13	0.0062	635.04	0.0062	744.82	0.0062	817.37	0.0062	886.03	0.0062	954.69	0.0062	1023.35
	0.0101	2.74	0.0101	15.74	0.0101	28.69	0.0101	41.39	0.0101	66.49	0.0101	99.60	0.0101	139.31	0.0101	185.61	0.0101	238.50	0.0101	298.00	0.0101	364.08	0.0101	406.90	0.0180	410.48	0.0246	71.58	0.0246	71.58	0.0246	71.58	0.0246	71.58	0.0246	71.58	0.0246	71.58	0.0164	592.72	0.0164	621.89	0.0163	651.75	0.0163	682.64	0.0101	876.36	0.0101	1027.86	0.0101	1127.98	0.0101	1222.73	0.0101	1317.47	0.0101	1412.22
	0.0140	3.13	0.0140	18.25	0.0140	33.96	0.0140	52.12	0.0140	84.80	0.0140	127.03	0.0140	177.66	0.0140	236.72	0.0140	304.18	0.0140	380.05	0.0140	464.34	0.0140	518.94	0.0194	442.05	0.0345	43.88	0.0345	43.88	0.0345	43.88	0.0345	43.88	0.0345	43.88	0.0345	43.88	0.0177	638.31	0.0176	669.73	0.0176	701.89	0.0176	735.15	0.0140	1117.67	0.0140	1310.89	0.0140	1438.58	0.0140	1559.42	0.0140	1680.26	0.0140	1801.09
	0.0168	3.13	0.0168	18.25	0.0168	33.96	0.0168	52.12	0.0168	84.80	0.0168	127.03	0.0168	177.66	0.0168	236.72	0.0168	304.18	0.0168	380.05	0.0168	464.34	0.0168	518.94	0.0233	442.05	0.0443	16.19	0.0443	16.19	0.0443	16.19	0.0443	16.19	0.0443	16.19	0.0443	16.19	0.0212	638.31	0.0212	669.73	0.0211	701.89	0.0211	735.15	0.0168	1117.67	0.0168	1310.89	0.0168	1438.58	0.0168	1559.42	0.0168	1680.26	0.0168	1801.09
	0.0196	3.13	0.0196	18.25	0.0196	33.96	0.0196	52.12	0.0196	84.80	0.0196	127.03	0.0196	177.66	0.0196	236.72	0.0196	304.18	0.0196	380.05	0.0196	464.34	0.0196	518.94	0.0272	442.05	0.0468	16.19	0.0468	16.19	0.0468	16.19	0.0468	16.19	0.0468	16.19	0.0468	16.19	0.0248	638.31	0.0247	669.73	0.0246	701.89	0.0246	735.15	0.0196	1117.67	0.0196	1310.89	0.0196	1438.58	0.0196	1559.42	0.0196	1680.26	0.0196	1801.09

HP 360x132
South Abutment
Depth Below Elevation 60.1m (underside of abutment)

	Depth (m)																																																									
	0.1		0.5		1		1.5		2		2.5		3		3.5		4		4.5		5		5.5		6		6.5		7		7.5		8		8.5		9		9.5		10		10.5		11		11.5		12		12.5		13		14		15	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
STATIC	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
	0.0018	1.67	0.0020	9.36	0.0015	14.01	0.0006	8.10	0.0007	12.24	0.0012	7.29	0.0013	9.78	0.0013	11.33	0.0013	12.61	0.0012	13.90	0.0012	15.19	0.0012	50.56	0.0012	50.56	0.0012	50.56	0.0012	50.56	0.0012	50.56	0.0012	50.56	0.0012	50.56	0.0049	167.77	0.0067	242.40	0.0089	339.18	0.0116	461.93	0.0011	45.77	0.0011	48.81	0.0009	168.28	0.0012	222.57	0.0015	291.10	0.0019	386.30	0.0019	427.77
	0.0022	1.76	0.0024	9.88	0.0019	15.35	0.0011	11.57	0.0012	17.35	0.0023	14.58	0.0026	19.55	0.0026	22.65	0.0025	25.23	0.0025	27.80	0.0024	30.38	0.0025	71.51	0.0025	71.51	0.0025	71.51	0.0025	71.51	0.0025	71.51	0.0025	71.51	0.0025	71.51	0.0050	170.23	0.0073	255.22	0.0093	353.96	0.0118	469.31	0.0022	91.54	0.0022	97.63	0.0014	215.91	0.0017	270.69	0.0019	338.78	0.0023	434.38	0.0023	478.63
	0.0026	1.85	0.0028	10.34	0.0024	16.50	0.0016	14.36	0.0017	21.62	0.0035	21.87	0.0039	29.33	0.0039	33.98	0.0038	37.84	0.0037	41.70	0.0036	45.56	0.0037	83.31	0.0037	83.31	0.0037	83.31	0.0037	83.31	0.0037	83.31	0.0037	83.31	0.0037	83.31	0.0051	172.67	0.0078	267.86	0.0097	365.07	0.0120	476.69	0.0033	137.31	0.0034	146.44	0.0019	257.53	0.0021	313.81	0.0024	382.46	0.0027	479.25	0.0027	526.22
	0.0030	1.92	0.0031	10.75	0.0028	17.53	0.0021	16.77	0.0022	25.41	0.0047	29.16	0.0052	39.11	0.0052	45.31	0.0050	50.45	0.0049	55.60	0.0048	60.75	0.0049	90.97	0.0049	90.97	0.0049	90.97	0.0049	90.97	0.0049	90.97	0.0049	90.97	0.0049	90.97	0.0053	175.09	0.0084	280.51	0.0101	375.43	0.0121	484.07	0.0044	183.08	0.0045	195.26	0.0024	295.19	0.0026	353.40	0.0028	423.14	0.0030	521.55	0.0031	571.18
	0.0034	1.99	0.0035	11.14	0.0032	18.46	0.0026	18.94	0.0027	28.86	0.0058	36.45	0.0065	48.89	0.0065	56.63	0.0063	63.07	0.0062	69.50	0.0061	75.94	0.0062	96.21	0.0062	96.21	0.0062	96.21	0.0062	96.21	0.0062	96.21	0.0062	96.21	0.0062	96.21	0.0054	177.48	0.0090	293.16	0.0105	385.78	0.0123	491.45	0.0055	228.85	0.0056	244.07	0.0029	329.97	0.0030	390.32	0.0032	461.44	0.0034	561.75	0.0035	613.96
	0.0038	2.05	0.0039	11.49	0.0036	19.31	0.0031	20.93	0.0032	32.06	0.0070	43.74	0.0078	58.66	0.0077	67.96	0.0076	75.68	0.0074	83.40	0.0073	91.13	0.0074	99.70	0.0074	99.70	0.0074	99.70	0.0074	99.70	0.0074	99.70	0.0074	99.70	0.0074	99.70	0.0055	179.86	0.0095	305.81	0.0109	396.14	0.0125	498.83	0.0066	274.62	0.0067	292.89	0.0033	362.53	0.0035	425.11	0.0036	497.79	0.0038	600.17	0.0039	654.90
	0.0042	2.10	0.0043	11.82	0.0041	20.10	0.0037	22.78	0.0037	35.07	0.0081	51.03	0.0091	68.44	0.0090	79.28	0.0088	88.29	0.0086	97.30	0.0085	106.31	0.0086	101.86	0.0086	101.86	0.0086	101.86	0.0086	101.86	0.0086	101.86	0.0086	101.86	0.0086	101.86	0.0056	182.21	0.0101	318.45	0.0113	406.49	0.0127	506.21	0.0077	320.40	0.0078	341.70	0.0038	393.30	0.0039	458.15	0.0041	532.50	0.0042	637.07	0.0043	694.26
	0.0046	2.16	0.0047	12.13	0.0045	20.84	0.0042	24.51	0.0042	37.92	0.0093	58.32	0.0104	78.22	0.0103	90.61	0.0101	100.91	0.0099	111.20	0.0097	121.50	0.0098	102.92	0.0098	102.92	0.0098	102.92	0.0098	102.92	0.0098	102.92	0.0098	102.92	0.0098	102.92	0.0057	184.55	0.0106	331.10	0.0117	416.85	0.0129	513.59	0.0088	366.17	0.0089	390.52	0.0043	422.60	0.0044	489.71	0.0045	565.81	0.0046	672.63	0.0047	732.22
	0.0050	2.21	0.0051	12.43	0.0049	21.54	0.0047	26.16	0.0047	40.64	0.0105	65.61	0.0117	87.99	0.0116	101.94	0.0113	113.52	0.0111	125.10	0.0109	136.69	0.0111	103.08	0.0111	103.08	0.0111	103.08	0.0111	103.08	0.0111	103.08	0.0111	103.08	0.0111	103.08	0.0059	186.86	0.0112	343.75	0.0120	427.20	0.0131	520.97	0.0099	411.94	0.0101	439.33	0.0048	450.63	0.0048	520.02	0.0049	597.89	0.0050	707.03	0.0050	768.96
	0.0054	2.25	0.0054	12.71	0.0054	22.20	0.0052	27.72	0.0052	43.25	0.0116	72.90	0.0130	97.77	0.0129	113.26	0.0126	126.13	0.0123	139.00	0.0121	151.88	0.0123	102.45	0.0123	102.45	0.0123	102.45	0.0123	102.45	0.0123	102.45	0.0123	102.45	0.0123	102.45	0.0060	189.16	0.0118	356.40	0.0124	437.56	0.0132	528.34	0.0110	457.71	0.0112	488.15	0.0053	477.59	0.0053	549.23	0.0054	628.91	0.0054	740.37	0.0054	804.59
	0.0058	2.30	0.0058	12.97	0.0058	22.82	0.0057	29.23	0.0057	45.76	0.0128	80.20	0.0143	107.55	0.0142	124.59	0.0138	138.75	0.0136	152.90	0.0133	167.06	0.0135	101.15	0.0135	101.15	0.0135	101.15	0.0135	101.15	0.0135	101.15	0.0135	101.15	0.0135	101.15	0.0061	191.44	0.0123	369.04	0.0128	447.91	0.0134	535.72	0.0121	503.48	0.0123	536.96	0.0057	503.60	0.0058	577.47	0.0058	658.97	0.0058	772.78	0.0058	839.24
	0.0062	2.34	0.0062	13.23	0.0062	23.42	0.0062	30.67	0.0062	48.18	0.0140	87.49	0.0156	117.33	0.0155	135.92	0.0151	151.36	0.0148	166.81	0.0145	182.25	0.0148	99.23	0.0148	99.23	0.0148	99.23	0.0148	99.23	0.0148	99.23	0.0148	99.23	0.0148	99.23	0.0062	193.71	0.0129	381.69	0.0132	458.27	0.0136	543.10	0.0131	549.25	0.0134	585.78	0.0062	528.76	0.0062	604.85	0.0062	688.17	0.0062	804.33	0.0062	872.99
	0.0101	2.74	0.0101	15.74	0.0101	28.69	0.0101	41.39	0.0101	66.49	0.0151	94.78	0.0169	127.10	0.0168	147.24	0.0164	163.97	0.0160	180.71	0.0158	197.44	0.0246	71.58	0.0246	71.58	0.0246	71.58	0.0246	71.58	0.0246	71.58	0.0246	71.58	0.0246	71.58	0.0101	267.31	0.0134	394.34	0.0136	468.63	0.0138	550.48	0.0142	595.02	0.0145	634.59	0.0101	729.70	0.0101	834.69	0.0101	949.67	0.0101	1109.98	0.0101	1204.72
	0.0140	3.13	0.0140	18.25	0.0140	33.96	0.0140	52.12	0.0140	84.80	0.0163	102.07	0.0182	136.88	0.0181	158.57	0.0176	176.59	0.0173	194.61	0.0170	212.63	0.0345	43.88	0.0345	43.88	0.0345	43.88	0.0345	43.88	0.0345	43.88	0.0345	43.88	0.0345	43.88	0.0140	340.92	0.0140	406.99	0.0140	478.98	0.0140	556.91	0.0153	640.79	0.0156	683.41	0.0140	930.63	0.0140	1064.53	0.0140	1211.17	0.0140	1415.62	0.0140	1536.46
	0.0168	3.13	0.0168	18.25	0.0168	33.96	0.0168	52.12	0.0168	84.80	0.0196	102.07	0.0219	136.88	0.0217	158.57	0.0211	176.59	0.0207	194.61	0.0204	212.63	0.0443	16.19	0.0443	16.19	0.0443	16.19	0.0443	16.19	0.0443	16.19	0.0443	16.19	0.0443	16.19	0.0168	340.92	0.0168	406.99	0.0168	478.98	0.0168	556.91	0.0184	640.79	0.0188	683.41	0.0168	930.63	0.0168	1064.53	0.0168	1211.17	0.0168	1415.62	0.0168	1536.46
	0.0196	3.13	0.0196	18.25	0.0196	33.96	0.0196	52.12	0.0196	84.80	0.0228	102.07	0.0255	136.88	0.0253	158.57	0.0247	176.59	0.0242	194.61	0.0238	212.63	0.0468	16.19	0.0468	16.19	0.0468	16.19	0.0468	16.19	0.0468	16.19	0.0468	16.19	0.0468	16.19	0.0196	340.92	0.0196	406.99	0.0196	478.98	0.0196	556.91	0.0215	640.79	0.0219	683.41	0.0196	930.63	0.0196	1064.53	0.0196	1211.17	0.0196	1415.62	0.0196	1536.46

HP 360x132
North Abutment
Depth Below Elevation 61.6m (underside of abutment)

	Depth (m)																																																									
	0.1		0.5		1		1.5		2		2.5		3		3.5		4		4.5		5		5.5		6		6.5		7		7.5		8		8.5		9		9.5		10		10.5		11		11.5		12		13		14		15		16	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
SEISMIC	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
	0.0018	1.67	0.0020	9.36	0.0015	14.01	0.0006	8.10	0.0007	12.24	0.0010	24.27	0.0015	43.04	0.0021	70.47	0.0029	108.61	0.0038	159.68	0.0048	226.05	0.0050	258.92	0.0014	31.58	0.0012	39.33	0.0012	39.33	0.0012	39.33	0.0012	39.33	0.0012	31.84	0.0012	24.35	0.0001	3.36	0.0001	3.36	0.0001	1.12	0.0001	1.12	0.0001	1.79	0.0001	5.15	0.0005	96.17	0.0009	180.37	0.0014	310.62	0.0021	500.96
	0.0022	1.76	0.0024	9.88	0.0019	15.35	0.0011	11.57	0.0012	17.35	0.0015	30.48	0.0020	49.98	0.0025	77.62	0.0032	115.36	0.0040	165.29	0.0049	229.65	0.0051	262.32	0.0028	63.15	0.0025	55.62	0.0025	55.62	0.0025	55.62	0.0025	55.62	0.0025	45.02	0.0025	34.43	0.0009	6.71	0.0009	6.71	0.0009	2.24	0.0009	2.24	0.0008	3.58	0.0005	10.29	0.0010	148.44	0.0014	236.32	0.0018	366.68	0.0025	553.07
	0.0026	1.85	0.0028	10.34	0.0024	16.50	0.0016	14.36	0.0017	21.62	0.0020	35.97	0.0024	56.34	0.0029	84.37	0.0035	121.87	0.0042	170.78	0.0051	233.21	0.0052	265.69	0.0042	94.73	0.0037	64.80	0.0037	64.80	0.0037	64.80	0.0037	64.80	0.0037	52.45	0.0037	40.11	0.0030	10.07	0.0030	10.07	0.0030	3.36	0.0030	3.36	0.0028	5.37	0.0018	15.44	0.0015	190.73	0.0018	284.75	0.0023	417.68	0.0029	602.18
	0.0030	1.92	0.0031	10.75	0.0028	17.53	0.0021	16.77	0.0022	25.41	0.0024	40.96	0.0028	62.27	0.0033	90.79	0.0038	128.16	0.0044	176.16	0.0052	236.73	0.0053	269.03	0.0055	126.30	0.0049	70.76	0.0049	70.76	0.0049	70.76	0.0049	70.76	0.0049	57.28	0.0049	43.80	0.0071	13.43	0.0071	13.43	0.0071	4.48	0.0071	4.48	0.0066	7.16	0.0042	20.59	0.0021	227.65	0.0023	328.35	0.0027	464.94	0.0032	648.84
	0.0034	1.99	0.0035	11.14	0.0032	18.46	0.0026	18.94	0.0027	28.86	0.0029	45.58	0.0032	67.85	0.0036	96.93	0.0041	134.25	0.0047	181.43	0.0053	240.23	0.0055	272.34	0.0069	157.88	0.0062	74.83	0.0062	74.83	0.0062	74.83	0.0062	74.83	0.0062	60.58	0.0062	46.32	0.0138	16.79	0.0138	16.79	0.0138	5.60	0.0138	5.60	0.0129	8.95	0.0083	25.74	0.0026	261.05	0.0028	368.49	0.0031	509.28	0.0036	693.43
	0.0038	2.05	0.0039	11.49	0.0036	19.31	0.0031	20.93	0.0032	32.06	0.0034	49.92	0.0037	73.15	0.0040	102.82	0.0044	140.17	0.0049	186.61	0.0055	243.69	0.0056	275.63	0.0083	189.45	0.0074	77.55	0.0074	77.55	0.0074	77.55	0.0074	77.55	0.0074	62.78	0.0074	48.01	0.0239	20.14	0.0239	20.14	0.0239	6.71	0.0239	6.71	0.0223	10.74	0.0143	30.88	0.0031	291.90	0.0033	405.99	0.0036	551.26	0.0040	736.24
	0.0042	2.10	0.0043	11.82	0.0041	20.10	0.0037	22.78	0.0037	35.07	0.0039	54.03	0.0041	78.22	0.0044	108.51	0.0047	145.94	0.0051	191.70	0.0056	247.12	0.0057	278.89	0.0097	221.03	0.0086	79.22	0.0086	79.22	0.0086	79.22	0.0086	79.22	0.0086	64.13	0.0086	49.04	0.0379	23.50	0.0379	23.50	0.0379	7.83	0.0379	7.83	0.0354	12.53	0.0227	36.03	0.0036	320.76	0.0038	441.38	0.0040	591.27	0.0044	777.50
	0.0046	2.16	0.0047	12.13	0.0045	20.84	0.0042	24.51	0.0042	37.92	0.0043	57.95	0.0045	83.08	0.0047	114.01	0.0050	151.56	0.0053	196.70	0.0057	250.52	0.0058	282.13	0.0111	252.60	0.0098	80.05	0.0098	80.05	0.0098	80.05	0.0098	80.05	0.0098	64.80	0.0098	49.56	0.0566	26.86	0.0566	26.86	0.0566	8.95	0.0566	8.95	0.0528	14.32	0.0340	41.18	0.0041	348.05	0.0043	475.02	0.0045	629.61	0.0047	817.39
	0.0050	2.21	0.0051	12.43	0.0049	21.54	0.0047	26.16	0.0047	40.64	0.0048	61.70	0.0049	87.76	0.0051	119.34	0.0053	157.05	0.0056	201.62	0.0058	253.89	0.0059	285.35	0.0125	284.18	0.0111	80.17	0.0111	80.17	0.0111	80.17	0.0111	80.17	0.0111	64.90	0.0111	49.63	0.0806	30.21	0.0806	30.21	0.0806	10.07	0.0806	10.07	0.0752	16.11	0.0483	46.33	0.0047	374.01	0.0048	507.19	0.0049	666.49	0.0051	856.07
	0.0054	2.25	0.0054	12.71	0.0054	22.20	0.0052	27.72	0.0052	43.25	0.0053	65.31	0.0054	92.29	0.0055	124.52	0.0056	162.42	0.0058	206.46	0.0060	257.23	0.0060	288.54	0.0139	315.75	0.0123	79.69	0.0123	79.69	0.0123	79.69	0.0123	79.69	0.0123	64.51	0.0123	49.33	0.1105	33.57	0.1105	33.57	0.1105	11.19	0.1105	11.19	0.1032	17.90	0.0663	51.47	0.0052	398.86	0.0052	538.09	0.0053	702.11	0.0055	893.65
	0.0058	2.30	0.0058	12.97	0.0058	22.82	0.0057	29.23	0.0057	45.76	0.0057	68.80	0.0058	96.68	0.0058	129.57	0.0059	167.68	0.0060	211.24	0.0061	260.54	0.0061	291.71	0.0152	347.33	0.0135	78.67	0.0135	78.67	0.0135	78.67	0.0135	78.67	0.0135	63.68	0.0135	48.70	0.1471	36.93	0.1471	36.93	0.1471	12.31	0.1471	12.31	0.1373	19.69	0.0883	56.62	0.0057	422.75	0.0057	567.89	0.0058	736.59	0.0058	930.23
	0.0062	2.34	0.0062	13.23	0.0062	23.42	0.0062	30.67	0.0062	48.18	0.0062	72.17	0.0062	100.95	0.0062	134.50	0.0062	172.83	0.0062	215.94	0.0062	263.83	0.0062	294.85	0.0166	378.90	0.0148	77.18	0.0148	77.18	0.0148	77.18	0.0148	77.18	0.0148	62.48	0.0148	47.78	0.1910	40.28	0.1910	40.28	0.1910	13.43	0.1910	13.43	0.1782	21.48	0.1146	61.77	0.0062	445.80	0.0062	596.72	0.0062	770.07	0.0062	965.92
	0.0101	2.74	0.0101	15.74	0.0101	28.69	0.0101	41.39	0.0101	66.49	0.0101	99.60	0.0101	139.31	0.0101	185.61	0.0101	238.50	0.0101	298.00	0.0101	364.08	0.0101	406.90	0.0180	410.48	0.0246	55.67	0.0246	55.67	0.0246	55.67	0.0246	55.67	0.0246	45.07	0.0246	34.46	0.2428	43.64	0.2428	43.64	0.2428	14.55	0.2428	14.55	0.2266	23.28	0.1457	66.92	0.0101	615.21	0.0101	823.47	0.0101	1062.69	0.0101	1332.97
	0.0140	3.13	0.0140	18.25	0.0140	33.96	0.0140	52.12	0.0140	84.80	0.0140	127.03	0.0140	177.66	0.0140	236.72	0.0140	304.18	0.0140	380.05	0.0140	464.34	0.0140	518.94	0.0194	442.05	0.0345	34.13	0.0345	34.13	0.0345	34.13	0.0345	34.13	0.0345	27.63	0.0345	21.13	0.3033	47.00	0.3033	47.00	0.3033	15.67	0.3033	15.67	0.2830	25.07	0.1820	72.06	0.0140	784.61	0.0140	1050.23	0.0140	1355.32	0.0140	1700.01
	0.0168	3.13	0.0168	18.25	0.0168	33.96	0.0168	52.12	0.0168	84.80	0.0168	127.03	0.0168	177.66	0.0168	236.72	0.0168	304.18	0.0168	380.05	0.0168	464.34	0.0168	518.94	0.0233	442.05	0.0443	12.59	0.0443	12.59	0.0443	12.59	0.0443	12.59	0.0443	10.19	0.0443	7.79	0.3730	50.36	0.3730	50.36	0.3730	16.79	0.3730	16.79	0.3481	26.86	0.2238	77.21	0.0168	784.61	0.0168	1050.23	0.0168	1355.32	0.0168	1700.01
	0.0196	3.13	0.0196	18.25	0.0196	33.96	0.0196	52.12	0.0196	84.80	0.0196	127.03	0.0196	177.66	0.0196	236.72	0.0196	304.18	0.0196	380.05	0.0196	464.34	0.0196	518.94	0.0272	442.05	0.0468	12.59	0.0468	12.59	0.0468	12.59	0.0468	12.59	0.0468	10.19	0.0468	7.79	0.3963	50.36	0.3963	50.36	0.3963	16.79	0.3963	16.79	0.3699	26.86	0.2378	77.21	0.0196	784.61	0.0196	1050.23	0.0196	1355.32	0.0196	1700.01

HP 360x132
South Abutment
Depth Below Elevation 60.1m (underside of abutment)

	Depth (m)																																																									
	0.1		0.5		1		1.5		2		2.5		3		3.5		4		4.5		5		5.5		6		6.5		7		7.5		8		8.5		9		9.5		10		10.5		11		11.5		12		12.5		13		14		15	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
SEISMIC	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
	0.0018	1.67	0.0020	9.36	0.0015	14.01	0.0006	8.10	0.0007	12.24	0.0012	7.29	0.0013	9.78	0.0013	11.33	0.0013	12.61	0.0012	13.90	0.0012	15.19	0.0012	39.33	0.0012	39.33	0.0012	39.33	0.0012	39.33	0.0012	39.33	0.0012	31.84	0.0012	24.35	0.0001	3.36	0.0001	3.36	0.0001	3.36	0.0001	3.36	0.0001	3.36	0.0001	3.36	0.0001	4.92	0.0001	7.53	0.0000	10.15	0.0003	55.23	0.0005	109.12
	0.0022	1.76	0.0024	9.88	0.0019	15.35	0.0011	11.57	0.0012	17.35	0.0023	14.58	0.0026	19.55	0.0026	22.65	0.0025	25.23	0.0025	27.80	0.0024	30.38	0.0025	55.62	0.0025	55.62	0.0025	55.62	0.0025	55.62	0.0025	55.62	0.0025	45.02	0.0025	34.43	0.0009	6.71	0.0009	6.71	0.0009	6.71	0.0009	6.71	0.0009	6.71	0.0009	6.71	0.0007	9.85	0.0004	15.07	0.0001	20.29	0.0008	108.44	0.0010	169.38
	0.0026	1.85	0.0028	10.34	0.0024	16.50	0.0016	14.36	0.0017	21.62	0.0035	21.87	0.0039	29.33	0.0039	33.98	0.0038	37.84	0.0037	41.70	0.0036	45.56	0.0037	64.80	0.0037	64.80	0.0037	64.80	0.0037	64.80	0.0037	64.80	0.0037	52.45	0.0037	40.11	0.0030	10.07	0.0030	10.07	0.0030	10.07	0.0030	10.07	0.0030	10.07	0.0030	10.07	0.0024	14.77	0.0014	22.60	0.0004	30.44	0.0013	148.13	0.0015	218.04
	0.0030	1.92	0.0031	10.75	0.0028	17.53	0.0021	16.77	0.0022	25.41	0.0047	29.16	0.0052	39.11	0.0052	45.31	0.0050	50.45	0.0049	55.60	0.0048	60.75	0.0049	70.76	0.0049	70.76	0.0049	70.76	0.0049	70.76	0.0049	70.76	0.0049	57.28	0.0049	43.80	0.0071	13.43	0.0071	13.43	0.0071	13.43	0.0071	13.43	0.0071	13.43	0.0071	13.43	0.0057	19.69	0.0033	30.14	0.0009	40.58	0.0019	181.86	0.0021	260.48
	0.0034	1.99	0.0035	11.14	0.0032	18.46	0.0026	18.94	0.0027	28.86	0.0058	36.45	0.0065	48.89	0.0065	56.63	0.0063	63.07	0.0062	69.50	0.0061	75.94	0.0062	74.83	0.0062	74.83	0.0062	74.83	0.0062	74.83	0.0062	74.83	0.0062	60.58	0.0062	46.32	0.0138	16.79	0.0138	16.79	0.0138	16.79	0.0138	16.79	0.0138	16.79	0.0138	16.79	0.0111	24.62	0.0064	37.67	0.0018	50.73	0.0024	211.95	0.0026	298.86
	0.0038	2.05	0.0039	11.49	0.0036	19.31	0.0031	20.93	0.0032	32.06	0.0070	43.74	0.0078	58.66	0.0077	67.96	0.0076	75.68	0.0074	83.40	0.0073	91.13	0.0074	77.55	0.0074	77.55	0.0074	77.55	0.0074	77.55	0.0074	77.55	0.0074	62.78	0.0074	48.01	0.0239	20.14	0.0239	20.14	0.0239	20.14	0.0239	20.14	0.0239	20.14	0.0239	20.14	0.0191	29.54	0.0111	45.21	0.0032	60.87	0.0030	239.51	0.0031	334.29
	0.0042	2.10	0.0043	11.82	0.0041	20.10	0.0037	22.78	0.0037	35.07	0.0081	51.03	0.0091	68.44	0.0090	79.28	0.0088	88.29	0.0086	97.30	0.0085	106.31	0.0086	79.22	0.0086	79.22	0.0086	79.22	0.0086	79.22	0.0086	79.22	0.0086	64.13	0.0086	49.04	0.0379	23.50	0.0379	23.50	0.0379	23.50	0.0379	23.50	0.0379	23.50	0.0379	23.50	0.0303	34.47	0.0177	52.74	0.0051	71.02	0.0035	265.15	0.0036	367.45
	0.0046	2.16	0.0047	12.13	0.0045	20.84	0.0042	24.51	0.0042	37.92	0.0093	58.32	0.0104	78.22	0.0103	90.61	0.0101	100.91	0.0099	111.20	0.0097	121.50	0.0098	80.05	0.0098	80.05	0.0098	80.05	0.0098	80.05	0.0098	80.05	0.0098	64.80	0.0098	49.56	0.0566	26.86	0.0566	26.86	0.0566	26.86	0.0566	26.86	0.0566	26.86	0.0566	26.86	0.0453	39.39	0.0264	60.28	0.0075	81.16	0.0041	289.28	0.0041	398.78
	0.0050	2.21	0.0051	12.43	0.0049	21.54	0.0047	26.16	0.0047	40.64	0.0105	65.61	0.0117	87.99	0.0116	101.94	0.0113	113.52	0.0111	125.10	0.0109	136.69	0.0111	80.17	0.0111	80.17	0.0111	80.17	0.0111	80.17	0.0111	80.17	0.0111	64.90	0.0111	49.63	0.0806	30.21	0.0806	30.21	0.0806	30.21	0.0806	30.21	0.0806	30.21	0.0806	30.21	0.0645	44.31	0.0376	67.81	0.0107	91.31	0.0046	312.18	0.0047	428.59
	0.0054	2.25	0.0054	12.71	0.0054	22.20	0.0052	27.72	0.0052	43.25	0.0116	72.90	0.0130	97.77	0.0129	113.26	0.0126	126.13	0.0123	139.00	0.0121	151.88	0.0123	79.69	0.0123	79.69	0.0123	79.69	0.0123	79.69	0.0123	79.69	0.0123	64.51	0.0123	49.33	0.1105	33.57	0.1105	33.57	0.1105	33.57	0.1105	33.57	0.1105	33.57	0.1105	33.57	0.0884	49.24	0.0516	75.35	0.0147	101.46	0.0051	334.04	0.0052	457.12
	0.0058	2.30	0.0058	12.97	0.0058	22.82	0.0057	29.23	0.0057	45.76	0.0128	80.20	0.0143	107.55	0.0142	124.59	0.0138	138.75	0.0136	152.90	0.0133	167.06	0.0135	78.67	0.0135	78.67	0.0135	78.67	0.0135	78.67	0.0135	78.67	0.0135	63.68	0.0135	48.70	0.1471	36.93	0.1471	36.93	0.1471	36.93	0.1471	36.93	0.1471	36.93	0.1471	36.93	0.1177	54.16	0.0686	82.88	0.0196	111.60	0.0057	355.02	0.0057	484.55
	0.0062	2.34	0.0062	13.23	0.0062	23.42	0.0062	30.67	0.0062	48.18	0.0140	87.49	0.0156	117.33	0.0155	135.92	0.0151	151.36	0.0148	166.81	0.0145	182.25	0.0148	77.18	0.0148	77.18	0.0148	77.18	0.0148	77.18	0.0148	77.18	0.0148	62.48	0.0148	47.78	0.1910	40.28	0.1910	40.28	0.1910	40.28	0.1910	40.28	0.1910	40.28	0.1910	40.28	0.1528	59.08	0.0891	90.42	0.0255	121.75	0.0062	375.22	0.0062	511.01
	0.0101	2.74	0.0101	15.74	0.0101	28.69	0.0101	41.39	0.0101	66.49	0.0151	94.78	0.0169	127.10	0.0168	147.24	0.0164	163.97	0.0160	180.71	0.0158	197.44	0.0246	55.67	0.0246	55.67	0.0246	55.67	0.0246	55.67	0.0246	55.67	0.0246	45.07	0.0246	34.46	0.2428	43.64	0.2428	43.64	0.2428	43.64	0.2428	43.64	0.2428	43.64	0.2428	43.64	0.1942	64.01	0.1133	97.95	0.0324	131.89	0.0101	517.81	0.0101	705.19
	0.0140	3.13	0.0140	18.25	0.0140	33.96	0.0140	52.12	0.0140	84.80	0.0163	102.07	0.0182	136.88	0.0181	158.57	0.0176	176.59	0.0173	194.61	0.0170	212.63	0.0345	34.13	0.0345	34.13	0.0345	34.13	0.0345	34.13	0.0345	34.13	0.0345	27.63	0.0345	21.13	0.3033	47.00	0.3033	47.00	0.3033	47.00	0.3033	47.00	0.3033	47.00	0.3033	47.00	0.2426	68.93	0.1415	105.48	0.0404	142.04	0.0140	660.39	0.0140	899.38
	0.0168	3.13	0.0168	18.25	0.0168	33.96	0.0168	52.12	0.0168	84.80	0.0196	102.07	0.0219	136.88	0.0217	158.57	0.0211	176.59	0.0207	194.61	0.0204	212.63	0.0443	12.59	0.0443	12.59	0.0443	12.59	0.0443	12.59	0.0443	12.59	0.0443	10.19	0.0443	7.79	0.3730	50.36	0.3730	50.36	0.3730	50.36	0.3730	50.36	0.3730	50.36	0.3730	50.36	0.2984	73.85	0.1741	113.02	0.0497	152.18	0.0168	660.39	0.0168	899.38
	0.0196	3.13	0.0196	18.25	0.0196	33.96	0.0196	52.12	0.0196	84.80	0.0228	102.07	0.0255	136.88	0.0253	158.57	0.0247	176.59	0.0242	194.61	0.0238	212.63	0.0468	12.59	0.0468	12.59	0.0468	12.59	0.0468	12.59	0.0468	12.59	0.0468	10.19	0.0468	7.79	0.3963	50.36	0.3963	50.36	0.3963	50.36	0.3963	50.36	0.3963	50.36	0.3963	50.36	0.3171	73.85	0.1849	113.02	0.0528	152.18	0.0196	660.39	0.0196	899.38

Project No.: Thurber - 17532
Project: Highway 417 - Nicholas
Date: January 10, 2018

1.5 m Diameter Caisson
North Abutment
Depth Below Elevation 61.6m (underside of abutment)

	Depth (m)																																																									
	0.1		0.5		1		1.5		2		2.5		3		3.5		4		4.5		5		5.5		6		6.5		7		7.5		8		8.5		9		9.5		10		10.5		11		11.5		12		13		14		15		16	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
STATIC	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
	0.0066	6.22	0.0073	34.15	0.0078	73.36	0.0081	113.50	0.0080	150.72	0.0078	181.83	0.0073	204.65	0.0068	222.20	0.0060	226.72	0.0051	215.06	0.0044	204.95	0.0034	177.14	0.0157	357.16	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0058	209.55	0.0064	242.66	0.0075	300.35	0.0088	365.69	0.0004	68.46	0.0005	84.61	0.0007	127.10	0.0009	183.31	0.0012	255.69	0.0015	346.84
	0.0083	6.60	0.0089	36.07	0.0094	77.30	0.0096	119.52	0.0096	158.98	0.0093	192.66	0.0089	218.51	0.0084	239.26	0.0078	248.08	0.0069	242.43	0.0062	239.72	0.0054	221.28	0.0165	368.10	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0076	245.19	0.0081	279.93	0.0091	337.41	0.0102	402.06	0.0026	215.04	0.0027	243.49	0.0029	310.97	0.0031	391.46	0.0033	487.07	0.0036	600.10
	0.0100	6.92	0.0105	37.76	0.0109	80.80	0.0111	124.90	0.0111	166.36	0.0109	202.30	0.0105	230.77	0.0101	254.22	0.0095	266.57	0.0087	265.74	0.0081	269.00	0.0074	257.78	0.0174	378.81	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0093	277.63	0.0098	314.23	0.0107	372.00	0.0117	436.42	0.0049	312.35	0.0049	350.92	0.0051	440.10	0.0053	542.99	0.0055	661.27	0.0057	796.81
	0.0116	7.21	0.0121	39.27	0.0125	83.96	0.0127	129.77	0.0127	173.06	0.0125	211.03	0.0121	241.83	0.0117	267.63	0.0112	283.02	0.0105	286.26	0.0100	294.69	0.0093	289.61	0.0182	389.30	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0110	307.69	0.0115	346.26	0.0123	404.64	0.0132	469.12	0.0071	392.97	0.0072	440.20	0.0073	548.21	0.0075	670.93	0.0077	809.70	0.0079	966.05
	0.0133	7.46	0.0137	40.64	0.0141	86.85	0.0142	134.25	0.0142	179.21	0.0140	219.03	0.0137	251.93	0.0134	279.85	0.0129	297.91	0.0123	304.74	0.0119	317.79	0.0113	318.18	0.0191	399.58	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0128	335.89	0.0132	376.49	0.0139	435.65	0.0147	500.40	0.0093	464.05	0.0094	519.04	0.0095	643.98	0.0097	784.71	0.0098	942.29	0.0100	1117.95
	0.0150	7.70	0.0153	41.89	0.0156	89.52	0.0158	138.40	0.0157	184.91	0.0156	226.45	0.0153	261.27	0.0151	291.09	0.0147	311.58	0.0141	321.64	0.0137	338.92	0.0132	344.32	0.0199	409.66	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0145	362.59	0.0148	405.23	0.0155	465.31	0.0161	530.48	0.0116	528.70	0.0116	590.79	0.0117	731.32	0.0118	888.70	0.0120	1063.78	0.0122	1257.55
	0.0167	7.91	0.0169	43.06	0.0172	92.01	0.0173	142.27	0.0173	190.23	0.0172	233.37	0.0169	269.96	0.0167	301.55	0.0164	324.26	0.0160	337.28	0.0156	358.49	0.0152	368.57	0.0208	419.57	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0163	388.02	0.0165	432.70	0.0171	493.79	0.0176	559.49	0.0138	588.60	0.0139	657.31	0.0139	812.39	0.0140	985.36	0.0142	1176.90	0.0143	1387.79
	0.0183	8.11	0.0186	44.14	0.0188	94.34	0.0188	145.90	0.0188	195.24	0.0187	239.86	0.0186	278.12	0.0184	311.34	0.0181	336.11	0.0178	351.88	0.0175	376.78	0.0172	391.27	0.0216	429.30	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0180	412.37	0.0182	459.10	0.0186	521.25	0.0191	587.56	0.0161	644.80	0.0161	719.74	0.0161	888.54	0.0162	1076.26	0.0163	1283.41	0.0164	1510.58
	0.0200	8.30	0.0202	45.16	0.0203	96.53	0.0204	149.33	0.0204	199.97	0.0203	246.00	0.0202	285.81	0.0200	320.56	0.0198	347.26	0.0196	365.60	0.0194	394.00	0.0191	412.69	0.0225	438.87	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0198	435.79	0.0199	484.55	0.0202	547.81	0.0206	614.80	0.0183	698.01	0.0183	778.85	0.0184	960.70	0.0184	1162.45	0.0185	1384.49	0.0186	1627.24
	0.0217	8.47	0.0218	46.13	0.0219	98.61	0.0219	152.59	0.0219	204.45	0.0219	251.82	0.0218	293.10	0.0217	329.28	0.0216	357.80	0.0214	378.58	0.0212	410.30	0.0211	433.02	0.0233	448.29	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0215	458.40	0.0216	509.17	0.0218	573.56	0.0220	641.27	0.0205	748.71	0.0205	835.20	0.0206	1029.51	0.0206	1244.70	0.0207	1481.02	0.0207	1738.74
	0.0233	8.64	0.0234	47.04	0.0234	100.59	0.0235	155.68	0.0235	208.72	0.0234	257.36	0.0234	300.03	0.0233	337.58	0.0233	367.81	0.0232	390.90	0.0231	425.82	0.0230	452.42	0.0242	457.56	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0233	480.28	0.0233	533.04	0.0234	598.58	0.0235	667.06	0.0228	797.30	0.0228	889.20	0.0228	1095.48	0.0228	1323.59	0.0228	1573.65	0.0229	1845.80
	0.0250	8.80	0.0250	47.91	0.0250	102.47	0.0250	158.64	0.0250	212.80	0.0250	262.65	0.0250	306.66	0.0250	345.50	0.0250	377.36	0.0250	402.66	0.0250	440.65	0.0250	470.99	0.0250	466.70	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0250	501.50	0.0250	556.24	0.0250	622.95	0.0250	692.23	0.0250	844.04	0.0250	941.17	0.0250	1158.98	0.0250	1399.55	0.0250	1662.89	0.0250	1949.00
	0.0406	10.23	0.0406	56.13	0.0406	120.89	0.0406	188.00	0.0406	253.22	0.0406	314.22	0.0406	369.45	0.0406	418.46	0.0406	461.99	0.0406	501.90	0.0406	561.55	0.0406	616.01	0.0406	633.78	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0406	688.88	0.0406	767.62	0.0406	859.67	0.0406	955.27	0.0406	1164.78	0.0406	1298.81	0.0406	1599.39	0.0406	1931.38	0.0406	2294.78	0.0406	2689.62
	0.0563	11.67	0.0563	64.34	0.0563	139.32	0.0563	217.36	0.0563	293.64	0.0563	365.80	0.0563	432.24	0.0563	491.43	0.0563	546.62	0.0563	601.15	0.0563	682.45	0.0563	761.04	0.0563	800.85	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.0563	876.25	0.0563	978.99	0.0563	1096.40	0.0563	1218.32	0.0563	1485.51	0.0563	1656.45	0.0563	2039.80	0.0563	2463.21	0.0563	2926.68	0.0563	3430.24
	0.0675	11.67	0.0675	64.34	0.0675	139.32	0.0675	217.36	0.0675	293.64	0.0675	365.80	0.0675	432.24	0.0675	491.43	0.0675	546.62	0.0675	601.15	0.0675	682.45	0.0675	761.04	0.0675	800.85	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.0675	876.25	0.0675	978.99	0.0675	1096.40	0.0675	1218.32	0.0675	1485.51	0.0675	1656.45	0.0675	2039.80	0.0675	2463.21	0.0675	2926.68	0.0675	3430.24
	0.0788	11.67	0.0788	64.34	0.0788	139.32	0.0788	217.36	0.0788	293.64	0.0788	365.80	0.0788	432.24	0.0788	491.43	0.0788	546.62	0.0788	601.15	0.0788	682.45	0.0788	761.04	0.0788	800.85	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.0788	876.25	0.0788	978.99	0.0788	1096.40	0.0788	1218.32	0.0788	1485.51	0.0788	1656.45	0.0788	2039.80	0.0788	2463.21	0.0788	2926.68	0.0788	3430.24

1.5 m Diameter Caisson
South Abutment
Depth Below Elevation 60.1m (underside of abutment)

	Depth (m)																																																									
	0.1		0.5		1		1.5		2		2.5		3		3.5		4		4.5		5		5.5		6		6.5		7		7.5		8		8.5		9		9.5		10		10.5		11		11.5		12		12.5		13		14		15	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
STATIC	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
	0.0066	6.22	0.0073	34.15	0.0078	73.36	0.0081	113.50	0.0080	150.72	0.0348	217.96	0.0309	232.03	0.0264	231.24	0.0224	224.93	0.0203	228.36	0.0176	220.76	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0032	109.02	0.0030	108.59	0.0032	123.14	0.0034	137.39	0.0040	165.90	0.0047	206.45	0.0002	39.05	0.0003	49.03	0.0003	61.97	0.0005	95.18	0.0006	139.95
	0.0083	6.60	0.0089	36.07	0.0094	77.30	0.0096	119.52	0.0096	158.98	0.0364	224.86	0.0328	238.91	0.0287	238.80	0.0227	225.85	0.0207	230.48	0.0183	224.86	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0052	141.27	0.0050	145.12	0.0052	162.75	0.0054	180.21	0.0059	210.69	0.0066	252.21	0.0025	170.25	0.0025	192.74	0.0026	219.06	0.0027	279.06	0.0028	350.24
	0.0100	6.92	0.0105	37.76	0.0109	80.80	0.0111	124.90	0.0111	166.36	0.0381	229.05	0.0348	244.62	0.0310	246.28	0.0229	226.76	0.0211	232.58	0.0190	228.88	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0072	168.11	0.0070	175.70	0.0072	196.44	0.0074	217.14	0.0078	250.00	0.0084	293.13	0.0047	252.42	0.0048	284.26	0.0048	320.99	0.0049	402.91	0.0051	497.11
	0.0116	7.21	0.0121	39.27	0.0125	83.96	0.0127	129.77	0.0127	173.06	0.0397	233.24	0.0367	250.32	0.0333	253.76	0.0231	227.66	0.0215	234.65	0.0196	232.83	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0091	191.66	0.0090	202.68	0.0092	226.45	0.0093	250.30	0.0097	285.67	0.0103	330.65	0.0070	319.94	0.0070	359.62	0.0071	405.14	0.0072	505.76	0.0073	619.92
	0.0133	7.46	0.0137	40.64	0.0141	86.85	0.0142	134.25	0.0142	179.21	0.0414	237.42	0.0387	256.02	0.0356	261.24	0.0234	228.56	0.0220	236.70	0.0203	236.72	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0111	212.94	0.0110	227.18	0.0112	253.87	0.0113	280.79	0.0116	318.67	0.0121	365.61	0.0092	379.27	0.0093	425.89	0.0093	479.23	0.0094	596.54	0.0095	728.66
	0.0150	7.70	0.0153	41.89	0.0156	89.52	0.0158	138.40	0.0157	184.91	0.0430	241.61	0.0406	261.72	0.0379	268.73	0.0236	229.45	0.0224	238.73	0.0210	240.54	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0131	232.51	0.0130	249.82	0.0131	279.33	0.0132	309.23	0.0135	349.59	0.0139	398.52	0.0115	433.12	0.0115	486.08	0.0115	546.55	0.0116	679.15	0.0117	827.80
	0.0167	7.91	0.0169	43.06	0.0172	92.01	0.0173	142.27	0.0173	190.23	0.0447	245.80	0.0426	267.42	0.0402	276.21	0.0238	230.34	0.0228	240.74	0.0216	244.30	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0151	250.75	0.0150	271.01	0.0151	303.25	0.0152	336.03	0.0154	378.85	0.0158	429.77	0.0137	482.96	0.0138	541.80	0.0138	608.90	0.0138	755.73	0.0139	919.79
	0.0183	8.11	0.0186	44.14	0.0188	94.34	0.0188	145.90	0.0188	195.24	0.0463	249.99	0.0445	273.13	0.0425	283.69	0.0241	231.23	0.0233	242.73	0.0223	248.00	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0171	267.91	0.0170	291.01	0.0171	325.90	0.0172	361.50	0.0174	406.71	0.0176	459.62	0.0160	529.68	0.0160	594.04	0.0160	667.37	0.0161	827.59	0.0161	1006.20
	0.0200	8.30	0.0202	45.16	0.0203	96.53	0.0204	149.33	0.0204	199.97	0.0480	254.17	0.0465	278.83	0.0448	291.18	0.0243	232.11	0.0237	244.69	0.0230	251.64	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0191	284.16	0.0190	310.02	0.0191	347.49	0.0191	385.83	0.0193	433.39	0.0195	488.27	0.0182	573.87	0.0183	643.47	0.0183	722.71	0.0183	895.64	0.0184	1088.06
	0.0217	8.47	0.0218	46.13	0.0219	98.61	0.0219	152.59	0.0219	204.45	0.0496	258.36	0.0484	284.53	0.0471	298.66	0.0245	232.98	0.0241	246.64	0.0237	255.23	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0210	299.65	0.0210	328.18	0.0210	368.16	0.0211	409.19	0.0212	459.05	0.0213	515.87	0.0205	615.98	0.0205	690.57	0.0205	775.44	0.0205	960.50	0.0206	1166.13
	0.0233	8.64	0.0234	47.04	0.0234	100.59	0.0235	155.68	0.0235	208.72	0.0513	262.55	0.0504	290.23	0.0494	306.14	0.0248	233.85	0.0246	248.56	0.0243	258.77	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0230	314.47	0.0230	345.61	0.0230	388.05	0.0230	431.70	0.0231	483.82	0.0232	542.55	0.0227	656.30	0.0228	735.67	0.0228	825.95	0.0228	1022.65	0.0228	1240.96
	0.0250	8.80	0.0250	47.91	0.0250	102.47	0.0250	158.64	0.0250	212.80	0.0529	266.73	0.0523	295.93	0.0517	313.63	0.0250	234.71	0.0250	250.47	0.0250	262.26	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0250	328.71	0.0250	362.41	0.0250	407.23	0.0250	453.46	0.0250	507.80	0.0250	568.40	0.0250	695.08	0.0250	779.06	0.0250	874.55	0.0250	1082.46	0.0250	1312.99
	0.0406	10.23	0.0406	56.13	0.0406	120.89	0.0406	188.00	0.0406	253.22	0.0546	270.92	0.0543	301.64	0.0540	321.11	0.0406	292.54	0.0406	319.16	0.0406	342.97	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0406	438.82	0.0406	491.34	0.0406	556.26	0.0406	624.20	0.0406	700.76	0.0406	784.40	0.0406	959.21	0.0406	1075.11	0.0406	1206.88	0.0406	1493.79	0.0406	1811.92
	0.0563	11.67	0.0563	64.34	0.0563	139.32	0.0563	217.36	0.0563	293.64	0.0563	275.11	0.0563	307.34	0.0563	328.59	0.0563	350.36	0.0563	387.84	0.0563	423.68	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.0563	548.93	0.0563	620.28	0.0563	705.29	0.0563	794.95	0.0563	893.73	0.0563	1000.39	0.0563	1223.34	0.0563	1371.15	0.0563	1539.20	0.0563	1905.12	0.0563	2310.86
	0.0675	11.67	0.0675	64.34	0.0675	139.32	0.0675	217.36	0.0675	293.64	0.0675	275.11	0.0675	307.34	0.0675	328.59	0.0675	350.36	0.0675	387.84	0.0675	423.68	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.0675	548.93	0.0675	620.28	0.0675	705.29	0.0675	794.95	0.0675	893.73	0.0675	1000.39	0.0675	1223.34	0.0675	1371.15	0.0675	1539.20	0.0675	1905.12	0.0675	2310.86
	0.0788	11.67	0.0788	64.34	0.0788	139.32	0.0788	217.36	0.0788	293.64	0.0788	275.11	0.0788	307.34	0.0788	328.59	0.0788	350.36	0.0788	387.84	0.0788	423.68	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.0788	548.93	0.0788	620.28	0.0788	705.29	0.0788	794.95	0.0788	893.73	0.0788	1000.39	0.0788	1223.34	0.0788	1371.15	0.0788	1539.20	0.0788	1905.12	0.0788	2310.86

1.5 m Diameter Caisson
North Abutment
Depth Below Elevation 61.6m (underside of abutment)

	Depth (m)																																																									
	0.1		0.5		1		1.5		2		2.5		3		3.5		4		4.5		5		5.5		6		6.5		7		7.5		8		8.5		9		9.5		10		10.5		11		11.5		12		13		14		15		16	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
SEISMIC	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
	0.0066	6.22	0.0073	34.15	0.0078	73.36	0.0081	113.50	0.0080	150.72	0.0078	181.83	0.0073	204.65	0.0068	222.20	0.0060	226.72	0.0051	215.06	0.0044	204.95	0.0034	177.14	0.0157	357.16	0.0050	158.15	0.0050	158.15	0.0050	158.15	0.0050	158.15	0.0050	128.03	0.0050	97.91	0.0004	13.50	0.0004	13.50	0.0004	4.50	0.0004	4.50	0.0004	7.20	0.0003	20.70	0.0002	38.52	0.0002	50.49	0.0004	79.17	0.0005	118.37
	0.0083	6.60	0.0089	36.07	0.0094	77.30	0.0096	119.52	0.0096	158.98	0.0093	192.66	0.0089	218.51	0.0084	239.26	0.0078	248.08	0.0069	242.43	0.0062	239.72	0.0054	221.28	0.0165	368.10	0.0099	223.66	0.0099	223.66	0.0099	223.66	0.0099	223.66	0.0099	181.06	0.0099	138.46	0.0036	27.00	0.0036	27.00	0.0036	9.00	0.0036	9.00	0.0033	14.40	0.0021	41.40	0.0025	170.18	0.0025	207.88	0.0026	265.00	0.0027	332.41
	0.0100	6.92	0.0105	37.76	0.0109	80.80	0.0111	124.90	0.0111	166.36	0.0109	202.30	0.0105	230.77	0.0101	254.22	0.0095	266.57	0.0087	265.74	0.0081	269.00	0.0074	257.78	0.0174	378.81	0.0149	260.58	0.0149	260.58	0.0149	260.58	0.0149	260.58	0.0149	210.94	0.0149	161.31	0.0120	40.50	0.0120	40.50	0.0120	13.50	0.0120	13.50	0.0112	21.60	0.0072	62.10	0.0047	250.34	0.0047	307.35	0.0048	386.83	0.0050	477.93
	0.0116	7.21	0.0121	39.27	0.0125	83.96	0.0127	129.77	0.0127	173.06	0.0125	211.03	0.0121	241.83	0.0117	267.63	0.0112	283.02	0.0105	286.26	0.0100	294.69	0.0093	289.61	0.0182	389.30	0.0198	284.55	0.0198	284.55	0.0198	284.55	0.0198	284.55	0.0198	230.35	0.0198	176.15	0.0284	54.00	0.0284	54.00	0.0284	18.00	0.0284	18.00	0.0265	28.80	0.0171	82.80	0.0070	315.62	0.0070	389.18	0.0071	487.56	0.0072	598.98
	0.0133	7.46	0.0137	40.64	0.0141	86.85	0.0142	134.25	0.0142	179.21	0.0140	219.03	0.0137	251.93	0.0134	279.85	0.0129	297.91	0.0123	304.74	0.0119	317.79	0.0113	318.18	0.0191	399.58	0.0248	300.92	0.0248	300.92	0.0248	300.92	0.0248	300.92	0.0248	243.60	0.0248	186.28	0.0556	67.50	0.0556	67.50	0.0556	22.50	0.0556	22.50	0.0519	36.00	0.0333	103.50	0.0092	372.66	0.0092	461.11	0.0093	576.30	0.0094	705.90
	0.0150	7.70	0.0153	41.89	0.0156	89.52	0.0158	138.40	0.0157	184.91	0.0156	226.45	0.0153	261.27	0.0151	291.09	0.0147	311.58	0.0141	321.64	0.0137	338.92	0.0132	344.32	0.0199	409.66	0.0297	311.85	0.0297	311.85	0.0297	311.85	0.0297	311.85	0.0297	252.45	0.0297	193.05	0.0960	81.00	0.0960	81.00	0.0960	27.00	0.0960	27.00	0.0896	43.20	0.0576	124.20	0.0115	424.23	0.0115	526.42	0.0116	656.97	0.0116	803.25
	0.0167	7.91	0.0169	43.06	0.0172	92.01	0.0173	142.27	0.0173	190.23	0.0172	233.37	0.0169	269.96	0.0167	301.55	0.0164	324.26	0.0160	337.28	0.0156	358.49	0.0152	368.57	0.0208	419.57	0.0347	318.59	0.0347	318.59	0.0347	318.59	0.0347	318.59	0.0347	257.91	0.0347	197.22	0.1524	94.50	0.1524	94.50	0.1524	31.50	0.1524	31.50	0.1423	50.40	0.0915	144.90	0.0137	471.80	0.0137	586.87	0.0138	731.70	0.0139	893.51
	0.0183	8.11	0.0186	44.14	0.0188	94.34	0.0188	145.90	0.0188	195.24	0.0187	239.86	0.0186	278.12	0.0184	311.34	0.0181	336.11	0.0178	351.88	0.0175	376.78	0.0172	391.27	0.0216	429.30	0.0396	321.92	0.0396	321.92	0.0396	321.92	0.0396	321.92	0.0396	260.61	0.0396	199.29	0.2276	108.00	0.2276	108.00	0.2276	36.00	0.2276	36.00	0.2124	57.60	0.1365	165.60	0.0160	516.27	0.0160	643.55	0.0160	801.79	0.0161	978.23
	0.0200	8.30	0.0202	45.16	0.0203	96.53	0.0204	149.33	0.0204	199.97	0.0203	246.00	0.0202	285.81	0.0200	320.56	0.0198	347.26	0.0196	365.60	0.0194	394.00	0.0191	412.69	0.0225	438.87	0.0446	322.41	0.0446	322.41	0.0446	322.41	0.0446	322.41	0.0446	261.00	0.0446	199.59	0.3240	121.50	0.3240	121.50	0.3240	40.50	0.3240	40.50	0.3024	64.80	0.1944	186.30	0.0182	558.24	0.0182	697.17	0.0183	868.13	0.0183	1058.47
	0.0217	8.47	0.0218	46.13	0.0219	98.61	0.0219	152.59	0.0219	204.45	0.0219	251.82	0.0218	293.10	0.0217	329.28	0.0216	357.80	0.0214	378.58	0.0212	410.30	0.0211	433.02	0.0233	448.29	0.0495	320.45	0.0495	320.45	0.0495	320.45	0.0495	320.45	0.0495	259.42	0.0495	198.38	0.4444	135.00	0.4444	135.00	0.4444	45.00	0.4444	45.00	0.4148	72.00	0.2667	207.00	0.0205	598.15	0.0205	748.25	0.0205	931.35	0.0205	1134.95
	0.0233	8.64	0.0234	47.04	0.0234	100.59	0.0235	155.68	0.0235	208.72	0.0234	257.36	0.0234	300.03	0.0233	337.58	0.0233	367.81	0.0232	390.90	0.0231	425.82	0.0230	452.42	0.0242	457.56	0.0545	316.36	0.0545	316.36	0.0545	316.36	0.0545	316.36	0.0545	256.10	0.0545	195.84	0.5916	148.50	0.5916	148.50	0.5916	49.50	0.5916	49.50	0.5521	79.20	0.3549	227.70	0.0227	636.30	0.0227	797.18	0.0228	991.92	0.0228	1208.25
	0.0250	8.80	0.0250	47.91	0.0250	102.47	0.0250	158.64	0.0250	212.80	0.0250	262.65	0.0250	306.66	0.0250	345.50	0.0250	377.36	0.0250	402.66	0.0250	440.65	0.0250	470.99	0.0250	466.70	0.0594	310.51	0.0594	310.51	0.0594	310.51	0.0594	310.51	0.0594	251.37	0.0594	192.22	0.7680	162.00	0.7680	162.00	0.7680	54.00	0.7680	54.00	0.7168	86.40	0.4608	248.40	0.0250	672.94	0.0250	844.24	0.0250	1050.19	0.0250	1278.78
	0.0406	10.23	0.0406	56.13	0.0406	120.89	0.0406	188.00	0.0406	253.22	0.0406	314.22	0.0406	369.45	0.0406	418.46	0.0406	461.99	0.0406	501.90	0.0406	561.55	0.0406	616.01	0.0406	633.78	0.0990	223.89	0.0990	223.89	0.0990	223.89	0.0990	223.89	0.0990	181.24	0.0990	138.60	0.9764	175.50	0.9764	175.50	0.9764	58.50	0.9764	58.50	0.9113	93.60	0.5859	269.10	0.0406	922.06	0.0406	1165.05	0.0406	1449.26	0.0406	1764.72
	0.0563	11.67	0.0563	64.34	0.0563	139.32	0.0563	217.36	0.0563	293.64	0.0563	365.80	0.0563	432.24	0.0563	491.43	0.0563	546.62	0.0563	601.15	0.0563	682.45	0.0563	761.04	0.0563	800.85	0.1386	137.26	0.1386	137.26	0.1386	137.26	0.1386	137.26	0.1386	111.12	0.1386	84.97	1.2196	189.00	1.2196	189.00	1.2196	63.00	1.2196	63.00	1.1383	100.80	0.7317	289.80	0.0563	1171.18	0.0563	1485.86	0.0563	1848.34	0.0563	2250.65
	0.0675	11.67	0.0675	64.34	0.0675	139.32	0.0675	217.36	0.0675	293.64	0.0675	365.80	0.0675	432.24	0.0675	491.43	0.0675	546.62	0.0675	601.15	0.0675	682.45	0.0675	761.04	0.0675	800.85	0.1782	50.64	0.1782	50.64	0.1782	50.64	0.1782	50.64	0.1782	40.99	0.1782	31.35	1.5000	202.50	1.5000	202.50	1.5000	67.50	1.5000	67.50	1.4000	108.00	0.9000	310.50	0.0675	1171.18	0.0675	1485.86	0.0675	1848.34	0.0675	2250.65
	0.0788	11.67	0.0788	64.34	0.0788	139.32	0.0788	217.36	0.0788	293.64	0.0788	365.80	0.0788	432.24	0.0788	491.43	0.0788	546.62	0.0788	601.15	0.0788	682.45	0.0788	761.04	0.0788	800.85	0.1881	50.64	0.1881	50.64	0.1881	50.64	0.1881	50.64	0.1881	40.99	0.1881	31.35	1.5938	202.50	1.5938	202.50	1.5938	67.50	1.5938	67.50	1.4875	108.00	0.9563	310.50	0.0788	1171.18	0.0788	1485.86	0.0788	1848.34	0.0788	2250.65

1.5 m Diameter Caisson
South Abutment
Depth Below Elevation 60.1m (underside of abutment)

	Depth (m)																																																									
	0.1		0.5		1		1.5		2		2.5		3		3.5		4		4.5		5		5.5		6		6.5		7		7.5		8		8.5		9		9.5		10		10.5		11		11.5		12		12.5		13		14		15	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
SEISMIC	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
	0.0066	6.22	0.0073	34.15	0.0078	73.36	0.0081	113.50	0.0080	150.72	0.0348	217.96	0.0309	232.03	0.0264	231.24	0.0224	224.93	0.0203	228.36	0.0176	220.76	0.0050	158.15	0.0050	158.15	0.0050	158.15	0.0050	158.15	0.0050	158.15	0.0050	128.03	0.0050	97.91	0.0004	13.50	0.0004	13.50	0.0004	13.50	0.0004	13.50	0.0004	13.50	0.0004	13.50	0.0004	19.80	0.0002	30.30	0.0001	40.80	0.0001	27.95	0.0002	40.70
	0.0083	6.60	0.0089	36.07	0.0094	77.30	0.0096	119.52	0.0096	158.98	0.0364	224.86	0.0328	238.91	0.0287	238.80	0.0227	225.85	0.0207	230.48	0.0183	224.86	0.0099	223.66	0.0099	223.66	0.0099	223.66	0.0099	223.66	0.0099	223.66	0.0099	181.06	0.0099	138.46	0.0036	27.00	0.0036	27.00	0.0036	27.00	0.0036	27.00	0.0036	27.00	0.0036	27.00	0.0028	39.60	0.0017	60.60	0.0005	81.60	0.0024	156.82	0.0024	196.56
	0.0100	6.92	0.0105	37.76	0.0109	80.80	0.0111	124.90	0.0111	166.36	0.0381	229.05	0.0348	244.62	0.0310	246.28	0.0229	226.76	0.0211	232.58	0.0190	228.88	0.0149	260.58	0.0149	260.58	0.0149	260.58	0.0149	260.58	0.0149	260.58	0.0149	210.94	0.0149	161.31	0.0120	40.50	0.0120	40.50	0.0120	40.50	0.0120	40.50	0.0120	40.50	0.0120	40.50	0.0096	59.40	0.0056	90.90	0.0016	122.40	0.0047	233.52	0.0047	292.70
	0.0116	7.21	0.0121	39.27	0.0125	83.96	0.0127	129.77	0.0127	173.06	0.0397	233.24	0.0367	250.32	0.0333	253.76	0.0231	227.66	0.0215	234.65	0.0196	232.83	0.0198	284.55	0.0198	284.55	0.0198	284.55	0.0198	284.55	0.0198	284.55	0.0198	230.35	0.0198	176.15	0.0284	54.00	0.0284	54.00	0.0284	54.00	0.0284	54.00	0.0284	54.00	0.0284	54.00	0.0228	79.20	0.0133	121.20	0.0038	163.20	0.0069	296.01	0.0070	371.56
	0.0133	7.46	0.0137	40.64	0.0141	86.85	0.0142	134.25	0.0142	179.21	0.0414	237.42	0.0387	256.02	0.0356	261.24	0.0234	228.56	0.0220	236.70	0.0203	236.72	0.0248	300.92	0.0248	300.92	0.0248	300.92	0.0248	300.92	0.0248	300.92	0.0248	243.60	0.0248	186.28	0.0556	67.50	0.0556	67.50	0.0556	67.50	0.0556	67.50	0.0556	67.50	0.0556	67.50	0.0444	99.00	0.0259	151.50	0.0074	204.00	0.0092	350.66	0.0092	440.81
	0.0150	7.70	0.0153	41.89	0.0156	89.52	0.0158	138.40	0.0157	184.91	0.0430	241.61	0.0406	261.72	0.0379	268.73	0.0236	229.45	0.0224	238.73	0.0210	240.54	0.0297	311.85	0.0297	311.85	0.0297	311.85	0.0297	311.85	0.0297	311.85	0.0297	252.45	0.0297	193.05	0.0960	81.00	0.0960	81.00	0.0960	81.00	0.0960	81.00	0.0960	81.00	0.0960	81.00	0.0768	118.80	0.0448	181.80	0.0128	244.80	0.0114	400.11	0.0115	503.64
	0.0167	7.91	0.0169	43.06	0.0172	92.01	0.0173	142.27	0.0173	190.23	0.0447	245.80	0.0426	267.42	0.0402	276.21	0.0238	230.34	0.0228	240.74	0.0216	244.30	0.0347	318.59	0.0347	318.59	0.0347	318.59	0.0347	318.59	0.0347	318.59	0.0347	257.91	0.0347	197.22	0.1524	94.50	0.1524	94.50	0.1524	94.50	0.1524	94.50	0.1524	94.50	0.1524	94.50	0.1220	138.60	0.0711	212.10	0.0203	285.60	0.0137	445.77	0.0137	561.77
	0.0183	8.11	0.0186	44.14	0.0188	94.34	0.0188	145.90	0.0188	195.24	0.0463	249.99	0.0445	273.13	0.0425	283.69	0.0241	231.23	0.0233	242.73	0.0223	248.00	0.0396	321.92	0.0396	321.92	0.0396	321.92	0.0396	321.92	0.0396	321.92	0.0396	260.61	0.0396	199.29	0.2276	108.00	0.2276	108.00	0.2276	108.00	0.2276	108.00	0.2276	108.00	0.2276	108.00	0.1820	158.40	0.1062	242.40	0.0303	326.40	0.0160	488.49	0.0160	616.25
	0.0200	8.30	0.0202	45.16	0.0203	96.53	0.0204	149.33	0.0204	199.97	0.0480	254.17	0.0465	278.83	0.0448	291.18	0.0243	232.11	0.0237	244.69	0.0230	251.64	0.0446	322.41	0.0446	322.41	0.0446	322.41	0.0446	322.41	0.0446	322.41	0.0446	261.00	0.0446	199.59	0.3240	121.50	0.3240	121.50	0.3240	121.50	0.3240	121.50	0.3240	121.50	0.3240	121.50	0.2592	178.20	0.1512	272.70	0.0432	367.20	0.0182	528.84	0.0182	667.79
	0.0217	8.47	0.0218	46.13	0.0219	98.61	0.0219	152.59	0.0219	204.45	0.0496	258.36	0.0484	284.53	0.0471	298.66	0.0245	232.98	0.0241	246.64	0.0237	255.23	0.0495	320.45	0.0495	320.45	0.0495	320.45	0.0495	320.45	0.0495	320.45	0.0495	259.42	0.0495	198.38	0.4444	135.00	0.4444	135.00	0.4444	135.00	0.4444	135.00	0.4444	135.00	0.4444	135.00	0.3556	198.00	0.2074	303.00	0.0593	408.00	0.0205	567.22	0.0205	716.88
	0.0233	8.64	0.0234	47.04	0.0234	100.59	0.0235	155.68	0.0235	208.72	0.0513	262.55	0.0504	290.23	0.0494	306.14	0.0248	233.85	0.0246	248.56	0.0243	258.77	0.0545	316.36	0.0545	316.36	0.0545	316.36	0.0545	316.36	0.0545	316.36	0.0545	256.10	0.0545	195.84	0.5916	148.50	0.5916	148.50	0.5916	148.50	0.5916	148.50	0.5916	148.50	0.5916	148.50	0.4732	217.80	0.2761	333.30	0.0789	448.80	0.0227	603.95	0.0227	763.89
	0.0250	8.80	0.0250	47.91	0.0250	102.47	0.0250	158.64	0.0250	212.80	0.0529	266.73	0.0523	295.93	0.0517	313.63	0.0250	234.71	0.0250	250.47	0.0250	262.26	0.0594	310.51	0.0594	310.51	0.0594	310.51	0.0594	310.51	0.0594	310.51	0.0594	251.37	0.0594	192.22	0.7680	162.00	0.7680	162.00	0.7680	162.00	0.7680	162.00	0.7680	162.00	0.7680	162.00	0.6144	237.60	0.3584	363.60	0.1024	489.60	0.0250	639.23	0.0250	809.11
	0.0406	10.23	0.0406	56.13	0.0406	120.89	0.0406	188.00	0.0406	253.22	0.0546	270.92	0.0543	301.64	0.0540	321.11	0.0406	292.54	0.0406	319.16	0.0406	342.97	0.0990	223.89	0.0990	223.89	0.0990	223.89	0.0990	223.89	0.0990	223.89	0.0990	181.24	0.0990	138.60	0.9764	175.50	0.9764	175.50	0.9764	175.50	0.9764	175.50	0.9764	175.50	0.9764	175.50	0.7812	257.40	0.4557	393.90	0.1302	530.40	0.0406	878.59	0.0406	1116.57
	0.0563	11.67	0.0563	64.34	0.0563	139.32	0.0563	217.36	0.0563	293.64	0.0563	275.11	0.0563	307.34	0.0563	328.59	0.0563	350.36	0.0563	387.84	0.0563	423.68	0.1386	137.26	0.1386	137.26	0.1386	137.26	0.1386	137.26	0.1386	137.26	0.1386	111.12	0.1386	84.97	1.2196	189.00	1.2196	189.00	1.2196	189.00	1.2196	189.00	1.2196	189.00	1.2196	189.00	0.9756	277.20	0.5691	424.20	0.1626	571.20	0.0563	1117.94	0.0563	1424.03
	0.0675	11.67	0.0675	64.34	0.0675	139.32	0.0675	217.36	0.0675	293.64	0.0675	275.11	0.0675	307.34	0.0675	328.59	0.0675	350.36	0.0675	387.84	0.0675	423.68	0.1782	50.64	0.1782	50.64	0.1782	50.64	0.1782	50.64	0.1782	50.64	0.1782	40.99	0.1782	31.35	1.5000	202.50	1.5000	202.50	1.5000	202.50	1.5000	202.50	1.5000	202.50	1.5000	202.50	1.2000	297.00	0.7000	454.50	0.2000	612.00	0.0675	1117.94	0.0675	1424.03
	0.0788	11.67	0.0788	64.34	0.0788	139.32	0.0788	217.36	0.0788	293.64	0.0788	275.11	0.0788	307.34	0.0788	328.59	0.0788	350.36	0.0788	387.84	0.0788	423.68	0.1881	50.64	0.1881	50.64	0.1881	50.64	0.1881	50.64	0.1881	50.64	0.1881	40.99	0.1881	31.35	1.5938	202.50	1.5938	202.50	1.5938	202.50	1.5938	202.50	1.5938	202.50	1.5938	202.50	1.2750	297.00	0.7438	454.50	0.2125	612.00	0.0788	1117.94	0.0788	1424.03

THURBER

Project No.: Thurber - 17532
Project: Highway 417 - Nicholas
Date: January 10, 2018

1.5 m Diameter Caisson
Central Pier
Depth Below Elevation 57.5 m (underside of footing)

	Depth (m)																																													
	0.1		0.5		1		1.5		2		2.5		3		3.5		4		4.5		5		5.5		6		6.5		7		7.5		8		8.5		9		9.5		10		10.5		11		11.5		12		13		14	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
STATIC	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
	0.0066	6.22	0.0073	34.15	0.0078	73.36	0.0081	113.50	0.0078	145.34	0.0073	171.32	0.0067	189.62	0.0062	203.30	0.0055	205.01	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0050	203.34	0.0050	150.81	0.0045	144.19	0.0048	163.76	0.0003	45.12	0.0003	47.61	0.0003	48.86	0.0003	55.87	0.0004	70.53	0.0005	87.82	0.0007	131.38	0.0009	188.85
	0.0083	6.60	0.0089	36.07	0.0094	77.30	0.0096	119.52	0.0093	153.71	0.0089	182.37	0.0084	203.80	0.0079	220.75	0.0072	226.79	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0099	287.57	0.0068	177.75	0.0063	175.75	0.0066	197.88	0.0026	147.46	0.0026	160.76	0.0026	172.99	0.0026	190.89	0.0026	218.13	0.0027	247.98	0.0029	316.37	0.0031	397.95
	0.0100	6.92	0.0105	37.76	0.0109	80.80	0.0111	124.90	0.0109	161.15	0.0105	192.13	0.0101	216.20	0.0096	235.85	0.0090	245.36	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0149	335.03	0.0086	201.42	0.0082	203.47	0.0085	228.22	0.0048	210.91	0.0048	232.28	0.0048	252.84	0.0048	279.06	0.0049	316.43	0.0049	356.73	0.0051	446.81	0.0053	550.76
	0.0116	7.21	0.0121	39.27	0.0125	83.96	0.0127	129.77	0.0125	167.88	0.0121	200.91	0.0117	227.29	0.0113	249.26	0.0108	261.71	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0198	365.85	0.0104	222.81	0.0101	228.55	0.0103	255.91	0.0071	262.31	0.0071	290.68	0.0070	318.56	0.0071	351.91	0.0071	397.90	0.0072	447.18	0.0073	556.11	0.0075	679.88
	0.0133	7.46	0.0137	40.64	0.0141	86.85	0.0142	134.25	0.0140	174.04	0.0137	208.92	0.0134	237.37	0.0130	261.39	0.0126	276.41	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0248	386.90	0.0122	242.49	0.0119	251.69	0.0121	281.60	0.0093	306.99	0.0093	341.72	0.0093	376.32	0.0093	416.08	0.0094	469.76	0.0094	527.06	0.0095	652.99	0.0097	794.78
	0.0150	7.70	0.0153	41.89	0.0156	89.52	0.0158	138.40	0.0156	179.74	0.0154	216.31	0.0150	246.65	0.0147	272.51	0.0143	289.84	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0297	400.96	0.0141	260.83	0.0138	273.30	0.0140	305.72	0.0115	347.20	0.0115	387.85	0.0115	428.72	0.0116	474.41	0.0116	535.12	0.0116	599.79	0.0117	741.34	0.0119	899.81
	0.0167	7.91	0.0169	43.06	0.0172	92.01	0.0173	142.27	0.0172	185.05	0.0170	223.19	0.0167	255.25	0.0165	282.80	0.0161	302.23	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0347	409.62	0.0159	278.07	0.0157	293.68	0.0158	328.54	0.0138	384.16	0.0138	430.38	0.0138	477.20	0.0138	528.43	0.0138	595.68	0.0139	667.22	0.0139	823.37	0.0141	997.46
	0.0183	8.11	0.0186	44.14	0.0188	94.34	0.0188	145.90	0.0187	190.04	0.0186	229.64	0.0184	263.30	0.0182	292.41	0.0179	313.78	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0396	413.90	0.0177	294.39	0.0175	313.03	0.0177	350.29	0.0160	418.61	0.0160	470.12	0.0160	522.62	0.0160	579.09	0.0161	652.51	0.0161	730.50	0.0162	900.42	0.0162	1089.29
	0.0200	8.30	0.0202	45.16	0.0203	96.53	0.0204	149.33	0.0203	194.74	0.0202	235.71	0.0200	270.87	0.0199	301.44	0.0197	324.62	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0446	414.53	0.0195	309.94	0.0194	331.51	0.0195	371.10	0.0183	451.03	0.0183	507.62	0.0183	565.57	0.0183	627.05	0.0183	706.31	0.0183	790.44	0.0184	973.44	0.0184	1176.38
	0.0217	8.47	0.0218	46.13	0.0219	98.61	0.0219	152.59	0.0219	199.19	0.0218	241.46	0.0217	278.04	0.0216	309.96	0.0214	334.84	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0495	412.01	0.0214	324.81	0.0213	349.23	0.0213	391.11	0.0205	481.78	0.0205	543.25	0.0205	606.47	0.0205	672.75	0.0205	757.59	0.0205	847.57	0.0206	1043.09	0.0206	1259.50
	0.0233	8.64	0.0234	47.04	0.0234	100.59	0.0235	155.68	0.0234	203.43	0.0234	246.93	0.0233	284.84	0.0233	318.05	0.0232	344.54	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0545	406.75	0.0232	339.09	0.0231	366.28	0.0232	410.42	0.0228	511.11	0.0228	577.29	0.0228	645.63	0.0228	716.53	0.0228	806.71	0.0228	902.32	0.0228	1109.85	0.0228	1339.22
	0.0250	8.80	0.0250	47.91	0.0250	102.47	0.0250	158.64	0.0250	207.48	0.0250	252.14	0.0250	291.32	0.0250	325.75	0.0250	353.77	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0594	399.23	0.0250	352.85	0.0250	382.76	0.0250	429.10	0.0250	539.22	0.0250	609.97	0.0250	683.27	0.0250	758.64	0.0250	853.98	0.0250	955.01	0.0250	1174.12	0.0250	1415.98
	0.0406	10.23	0.0406	56.13	0.0406	120.89	0.0406	188.00	0.0406	246.89	0.0406	301.66	0.0406	350.98	0.0406	394.55	0.0406	433.12	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0990	287.85	0.0406	468.79	0.0406	518.35	0.0406	585.45	0.0406	731.09	0.0406	833.23	0.0406	940.60	0.0406	1046.93	0.0406	1178.50	0.0406	1317.91	0.0406	1620.28	0.0406	1954.06
	0.0563	11.67	0.0563	64.34	0.0563	139.32	0.0563	217.36	0.0563	286.30	0.0563	351.17	0.0563	410.63	0.0563	463.35	0.0563	512.46	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.1386	176.48	0.0563	584.72	0.0563	653.94	0.0563	741.80	0.0563	922.96	0.0563	1056.49	0.0563	1197.92	0.0563	1335.21	0.0563	1503.01	0.0563	1680.82	0.0563	2066.45	0.0563	2492.13
	0.0675	11.67	0.0675	64.34	0.0675	139.32	0.0675	217.36	0.0675	286.30	0.0675	351.17	0.0675	410.63	0.0675	463.35	0.0675	512.46	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.1782	65.10	0.0675	584.72	0.0675	653.94	0.0675	741.80	0.0675	922.96	0.0675	1056.49	0.0675	1197.92	0.0675	1335.21	0.0675	1503.01	0.0675	1680.82	0.0675	2066.45	0.0675	2492.13
	0.0788	11.67	0.0788	64.34	0.0788	139.32	0.0788	217.36	0.0788	286.30	0.0788	351.17	0.0788	410.63	0.0788	463.35	0.0788	512.46	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.1881	65.10	0.0788	584.72	0.0788	653.94	0.0788	741.80	0.0788	922.96	0.0788	1056.49	0.0788	1197.92	0.0788	1335.21	0.0788	1503.01	0.0788	1680.82	0.0788	2066.45	0.0788	2492.13

1.5 m Diameter Caisson
Central Pier
Depth Below Elevation 57.5 m (underside of footing)

	Depth (m)																																													
	0.1		0.5		1		1.5		2		2.5		3		3.5		4		4.5		5		5.5		6		6.5		7		7.5		8		8.5		9		9.5		10		10.5		11		11.5		12		13		14	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
SEISMIC	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
	0.0066	6.22	0.0073	34.15	0.0078	73.36	0.0081	113.50	0.0078	145.34	0.0073	171.32	0.0067	189.62	0.0062	203.30	0.0055	205.01	0.0050	158.15	0.0050	158.15	0.0050	158.15	0.0050	158.15	0.0050	132.85	0.0050	101.22	0.0050	69.59	0.0004	12.60	0.0004	12.60	0.0004	12.60	0.0003	21.24	0.0002	32.04	0.0000	42.84	0.0002	37.55	0.0002	39.65	0.0002	40.70	0.0003	57.34	0.0004	89.03
	0.0083	6.60	0.0089	36.07	0.0094	77.30	0.0096	119.52	0.0093	153.71	0.0089	182.37	0.0084	203.80	0.0079	220.75	0.0072	226.79	0.0099	223.66	0.0099	223.66	0.0099	223.66	0.0099	223.66	0.0099	187.88	0.0099	143.15	0.0099	98.41	0.0036	25.20	0.0036	25.20	0.0036	25.20	0.0026	42.48	0.0014	64.08	0.0002	85.68	0.0025	143.82	0.0025	156.96	0.0025	169.15	0.0025	211.39	0.0027	270.20
	0.0100	6.92	0.0105	37.76	0.0109	80.80	0.0111	124.90	0.0109	161.15	0.0105	192.13	0.0101	216.20	0.0096	235.85	0.0090	245.36	0.0149	260.58	0.0149	260.58	0.0149	260.58	0.0149	260.58	0.0149	218.89	0.0149	166.77	0.0149	114.65	0.0120	37.80	0.0120	37.80	0.0120	37.80	0.0088	63.72	0.0048	96.12	0.0008	128.52	0.0047	207.10	0.0047	228.33	0.0047	248.85	0.0048	310.60	0.0049	391.32
	0.0116	7.21	0.0121	39.27	0.0125	83.96	0.0127	129.77	0.0125	167.88	0.0121	200.91	0.0117	227.29	0.0113	249.26	0.0108	261.71	0.0198	284.55	0.0198	284.55	0.0198	284.55	0.0198	284.55	0.0198	239.02	0.0198	182.11	0.0198	125.20	0.0284	50.40	0.0284	50.40	0.0284	50.40	0.0209	84.96	0.0114	128.16	0.0019	171.36	0.0070	258.00	0.0070	286.21	0.0070	314.01	0.0070	392.41	0.0071	491.78
	0.0133	7.46	0.0137	40.64	0.0141	86.85	0.0142	134.25	0.0140	174.04	0.0137	208.92	0.0134	237.37	0.0130	261.39	0.0126	276.41	0.0248	300.92	0.0248	300.92	0.0248	300.92	0.0248	300.92	0.0248	252.77	0.0248	192.59	0.0248	132.40	0.0556	63.00	0.0556	63.00	0.0556	63.00	0.0407	106.20	0.0222	160.20	0.0037	214.20	0.0092	302.10	0.0092	336.62	0.0092	371.09	0.0093	464.41	0.0094	580.41
	0.0150	7.70	0.0153	41.89	0.0156	89.52	0.0158	138.40	0.0156	179.74	0.0154	216.31	0.0150	246.65	0.0147	272.51	0.0143	289.84	0.0297	311.85	0.0297	311.85	0.0297	311.85	0.0297	311.85	0.0297	261.96	0.0297	199.59	0.0297	137.22	0.0960	75.60	0.0960	75.60	0.0960	75.60	0.0704	127.44	0.0384	192.24	0.0064	257.04	0.0115	341.71	0.0115	382.09	0.0115	422.77	0.0115	529.81	0.0116	661.04
	0.0167	7.91	0.0169	43.06	0.0172	92.01	0.0173	142.27	0.0172	185.05	0.0170	223.19	0.0167	255.25	0.0165	282.80	0.0161	302.23	0.0347	318.59	0.0347	318.59	0.0347	318.59	0.0347	318.59	0.0347	267.62	0.0347	203.90	0.0347	140.18	0.1524	88.20	0.1524	88.20	0.1524	88.20	0.1118	148.68	0.0610	224.28	0.0102	299.88	0.0137	378.05	0.0137	423.94	0.0137	470.50	0.0138	590.37	0.0138	735.76
	0.0183	8.11	0.0186	44.14	0.0188	94.34	0.0188	145.90	0.0187	190.04	0.0186	229.64	0.0184	263.30	0.0182	292.41	0.0179	313.78	0.0396	321.92	0.0396	321.92	0.0396	321.92	0.0396	321.92	0.0396	270.42	0.0396	206.03	0.0396	141.65	0.2276	100.80	0.2276	100.80	0.2276	100.80	0.1669	169.92	0.0910	256.32	0.0152	342.72	0.0160	411.88	0.0160	463.00	0.0160	515.16	0.0160	647.16	0.0161	805.88
	0.0200	8.30	0.0202	45.16	0.0203	96.53	0.0204	149.33	0.0203	194.74	0.0202	235.71	0.0200	270.87	0.0199	301.44	0.0197	324.62	0.0446	322.41	0.0446	322.41	0.0446	322.41	0.0446	322.41	0.0446	270.82	0.0446	206.34	0.0446	141.86	0.3240	113.40	0.3240	113.40	0.3240	113.40	0.2376	191.16	0.1296	288.36	0.0216	385.56	0.0182	443.69	0.0182	499.81	0.0182	557.36	0.0183	700.90	0.0183	872.26
	0.0217	8.47	0.0218	46.13	0.0219	98.61	0.0219	152.59	0.0219	199.19	0.0218	241.46	0.0217	278.04	0.0216	309.96	0.0214	334.84	0.0495	320.45	0.0495	320.45	0.0495	320.45	0.0495	320.45	0.0495	269.18	0.0495	205.09	0.0495	141.00	0.4444	126.00	0.4444	126.00	0.4444	126.00	0.3259	212.40	0.1778	320.40	0.0296	428.40	0.0205	473.83	0.0205	534.76	0.0205	597.51	0.0205	752.11	0.0205	935.53
	0.0233	8.64	0.0234	47.04	0.0234	100.59	0.0235	155.68	0.0234	203.43	0.0234	246.93	0.0233	284.84	0.0233	318.05	0.0232	344.54	0.0545	316.36	0.0545	316.36	0.0545	316.36	0.0545	316.36	0.0545	265.75	0.0545	202.47	0.0545	139.20	0.5916	138.60	0.5916	138.60	0.5916	138.60	0.4338	233.64	0.2366	352.44	0.0394	471.24	0.0227	502.56	0.0227	568.13	0.0227	635.91	0.0228	801.16	0.0228	996.15
	0.0250	8.80	0.0250	47.91	0.0250	102.47	0.0250	158.64	0.0250	207.48	0.0250	252.14	0.0250	291.32	0.0250	325.75	0.0250	353.77	0.0594	310.51	0.0594	310.51	0.0594	310.51	0.0594	310.51	0.0594	260.83	0.0594	198.73	0.0594	136.63	0.7680	151.20	0.7680	151.20	0.7680	151.20	0.5632	254.88	0.3072	384.48	0.0512	514.08	0.0250	530.07	0.0250	600.15	0.0250	672.82	0.0250	848.34	0.0250	1054.49
	0.0406	10.23	0.0406	56.13	0.0406	120.89	0.0406	188.00	0.0406	246.89	0.0406	301.66	0.0406	350.98	0.0406	394.55	0.0406	433.12	0.0990	223.89	0.0990	223.89	0.0990	223.89	0.0990	223.89	0.0990	188.07	0.0990	143.29	0.0990	98.51	0.9764	163.80	0.9764	163.80	0.9764	163.80	0.7161	276.12	0.3906	416.52	0.0651	556.92	0.0406	717.17	0.0406	818.02	0.0406	924.12	0.0406	1170.71	0.0406	1455.19
	0.0563	11.67	0.0563	64.34	0.0563	139.32	0.0563	217.36	0.0563	286.30	0.0563	351.17	0.0563	410.63	0.0563	463.35	0.0563	512.46	0.1386	137.26	0.1386	137.26	0.1386	137.26	0.1386	137.26	0.1386	115.30	0.1386	87.85	0.1386	60.40	1.2196	176.40	1.2196	176.40	1.2196	176.40	0.8943	297.36	0.4878	448.56	0.0813	599.76	0.0563	904.27	0.0563	1035.90	0.0563	1175.41	0.0563	1493.08	0.0563	1855.89
	0.0675	11.67	0.0675	64.34	0.0675	139.32	0.0675	217.36	0.0675	286.30	0.0675	351.17	0.0675	410.63	0.0675	463.35	0.0675	512.46	0.1782	50.64	0.1782	50.64	0.1782	50.64	0.1782	50.64	0.1782	42.54	0.1782	32.41	0.1782	22.28	1.5000	189.00	1.5000	189.00	1.5000	189.00	1.1000	318.60	0.6000	480.60	0.1000	642.60	0.0675	904.27	0.0675	1035.90	0.0675	1175.41	0.0675	1493.08	0.0675	1855.89
	0.0788	11.67	0.0788	64.34	0.0788	139.32	0.0788	217.36	0.0788	286.30	0.0788	351.17	0.0788	410.63	0.0788	463.35	0.0788	512.46	0.1881	50.64	0.1881	50.64	0.1881	50.64	0.1881	50.64	0.1881	42.54	0.1881	32.41	0.1881	22.28	1.5938	189.00	1.5938	189.00	1.5938	189.00	1.1688	318.60	0.6375	480.60	0.1063	642.60	0.0788	904.27	0.0788	1035.90	0.0788	1175.41	0.0788	1493.08	0.0788	1855.89

Appendix I.

List of Special Provisions and OPSS Documents Referenced in this Report

1. The following Special Provisions and OPSS Documents are referenced in this report:

OPSS.PROV 206	Construction Specification for Grading
OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering of Pipeline, Utility and Associated Structure Excavation
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS 805	Construction Specification for Temporary erosion and Sediment Control Measures
OPSS 902	Construction Specification for Excavating and Backfilling Structures
OPSS 903	Construction Specification for Deep Foundations
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
OPSS.PROV 1205	Material Specification for Clay Seal
OPSS 1860	Material Specification for Geotextile
OPSD 208.010	Benching of Earth Slopes

Special Provision 109S12	Amendment to OPSS 902, March 2018
Special Provision 517F01	Amendment to OPSS 517, July 2017
Special Provision Foun0003	Dewatering Structure Excavations, March 2018

2. Suggested text for a NSSP on **“**Integral Abutment CSP Sand Backfill”

   The sand backfill used within the CSP to provide the required flexibility for the piles in the integral abutment design shall meet the following gradation envelope.

   Note piles should be driven first before placing the sand backfill in the CSP.

Integral Abutment Sand Backfill Grading

MTO Sieve Designation	Percent Passing (%)
#10	100
#30	80 – 100
#40	40 – 80
#60	5 – 25
#100	0 – 6

3. Suggested text for an NSSP on “Construction of Caissons”

   The bedrock consists of shale bedrock with very hard interbeds. The strength and hardness of this rock must be taken into account when selecting equipment to advance the caisson into rock. Equipment supplied to construct rock sockets must be capable of excavating the bedrock to the specified socket dimensions without disturbing or fracturing the bedrock forming the sidewalls and base of the socket. Blasting to facilitate the removal of bedrock is not permitted.

4. Suggested text for a NSSP on “Pile Obstructions”

   Pile driving at the site may be impeded by obstructions within the existing fill and glacial till (i.e. cobbles, boulders and/or hard layers).

5. Suggested text for a NSSP on “Installation of Temporary Protection System”

   Vibratory equipment is not permitted for installation or removal of temporary protection systems

6. Suggested text for a NSSP on “Use of Heavy Construction Equipment"

   The use of heavy construction equipment and in particular heavy lift cranes may be required during removal of the existing and erection of the new bridge. The impact of the heavy equipment loads on the existing embankment, the expanded polystyrene, the native soft to firm soils clay underlying the embankment and the existing bridge foundations must be considered during selection of the methodology and equipment employed for construction.

   Prior to commencement of construction, the Contractor shall retain a Geotechnical Consultant to assess the impact of the proposed equipment loads and methodology, and determine requirements and/or restrictions necessary to safely support the loads. All Foundation Engineering services required for this project shall be performed by consultant(s) listed as accepted under the MTO's RAQS for providing services under the specialty of Geotechnical (Structures and Embankments) - High Complexity.

   The assessment shall include, but not be limited to, the following:

   - Determining appropriate setbacks for heavy equipment from the bridge abutments and existing foundations;
   - Determining the permissible ground pressure that may be applied to the foundation soils by the equipment; and
   - Providing recommendations for crane pad design to distribute the crane loads without causing foundation failure.

   The Contractor shall submit the findings of the geotechnical assessment and details of the proposed equipment and construction methodology to the Contract Administrator for information purposes a minimum of two weeks prior to the start of construction.