



THURBER ENGINEERING LTD.

**PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 17 TWINNING, RENFREW AREA
BONNECHERE RIVER BRIDGE
STA. 20+200, HORTON TOWNSHIP
EASTBOUND STRUCTURE - SITE NO. 29X-0192/B1
WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009**

Geocres No.: 31F-236

Report to:

Ministry of Transportation Ontario

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

Thurber Engineering Ltd. (Thurber) has been engaged by the Ministry of Transportation Ontario (MTO) to carry out Foundation Investigations to support the design of the Highway 17 Twinning Project which extends from Scheel Drive westerly to 3 km west of Bruce Street in the Renfrew area. Thurber carried out the investigation under MTO Assignment No. 4018-E-0009.

This report addresses the proposed eastbound Highway 17 bridge over the Bonnechere River (Site No. 29X-0192/B1) near Renfrew, Ontario. The existing Highway 17 alignment at this site will become the future Highway 17 westbound lanes and new eastbound lanes will be constructed to the south of the existing alignment.

Previous foundation investigation information from boreholes completed in 2003 for the proposed eastbound bridge structure was available under Geocres 31F-136. The original investigation for the existing Highway 17 six-span bridge was available under Geocres 31F-018.

This section of the report presents the factual findings obtained from the available historical foundation investigation reports and from the foundation investigation completed as part of the current study.

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 of the proposed bridge and approaches was developed in the course of the investigation.

It should be noted that the use of and reliance on Part 1 of the Report is governed by and limited to the terms and conditions set out in the Report and a reliance letter. The Preferred Proponent remains responsible to assess the need for additional investigations and to complete that work.



2 SITE DESCRIPTION

2.1 General

The site is located on Highway 17 approximately 1.0 km west of O'Brien Road (Highway 60). Highway 17 is generally oriented southeast to northwest and the Bonnechere River at the site is oriented roughly southwest to northeast. For project purposes, the highway and river are herein described as oriented east-west and north-south, respectively.

The land adjacent to the site typically consists of agricultural fields and forests. The historical riverbanks of the Bonnechere River Valley that abut the relatively flat terrain beyond (at Elevation 120 m and higher), are incised as much as 30 m (down to Elevation 83 m) to form the river valley. Along the proposed Bonnechere River Bridge alignment, the upper slope of the west bank is inclined at about 6H:1V, down to a bench at about mid-height (Elevation 102 m). The lower portion of the west bank is inclined as steep as about 1.8H:1V. The east bank is more uniform along its entire height and sloped at about 2.5H:1V. At the time of the current investigation, the east bank was heavily forested. It is noted that, similar to most river valleys, the existing slopes have a history of instability. Geocres Report 31F-018 indicates a major slump occurred about 400 m upstream of the existing bridge.

Existing Highway 17 in this area consists of a two-lane undivided highway with paved shoulders, 3-cable guiderails, and a posted speed limit of 90 km/hr. The AADT for the section of Highway 17 near the site was reported to be 13,900 in 2016. The existing embankment side slopes did not show any visible signs of distress at the time of the investigation and were sloped at approximately 2.0H:1V.

At the existing bridge approaches, the Highway 17 road surface elevation is approximately 110.4 m and 111.2 m at the east and west approaches, respectively. The river level is at approximate elevation 83.4 m

West of the river, the proposed Highway 17 approach to the bridge will require embankment fills up to about 11.5 m in height. East of the river, Highway 17 enters a cut section with the cuts up to about 6 m deep within the area of interest addressed herein.

Photographs showing the existing conditions in the area of the site at the time of the field investigation are included in Appendix E for reference.

2.2 Site Geology

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies within the physiographic region known as the Ottawa Valley Clay Plains. The Ottawa Valley Clay Plains are characterized primarily by clay plains deposited by the Champlain Sea (Leda Clay) interrupted by ridges of rock or sand.



Ontario Geological Survey Map P.3784 for Precambrian Geology for the Horton Area suggests the bedrock is comprised of dolomitic and calcitic carbonate metasedimentary bedrock including dolomite and calcite marble.

3 SITE INVESTIGATION AND FIELD TESTING

The foundation investigation for the existing bridge was carried out in 1971 and included 12 boreholes, as reported in Geocres 31F-018. The information from this report has been reviewed to establish stratigraphic context with some specific, relevant data included within the present report.

An initial foundation investigation for the proposed twin structure was carried out in October 2003 (Geocres 31F-136) as input to the preliminary design and environmental assessment study.

The current investigation was carried out in three phases between September 2020 and May 2024 to collect additional subsurface information for design of the proposed twin bridge structure and associated approaches.

3.1 Previous Investigation (2003)

A total of six boreholes were put down as part of the 2003 investigation. Please refer to Geocres Report 31F-136 for details on investigation methodology. The boreholes were advanced to depths ranging from 18.5 m to 34.4 m below the existing ground surface.

The northing, easting and ground surface elevation of each of the 2003 boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A, the individual Record of Borehole sheets in Appendix B, and in Table 3-1, below. The site is located within MTM Zone 9.

Table 3-1: Borehole Summary – Previous Investigation (2003)

Test Hole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface* Elevation (m)	Termination Depth (m)
BON-1	West Abutment	5038578.0 (45.487015)	292351.3 (-76.659255)	102.4	30.5
BON-2	Pier 1	5038548.1 (45.486747)	292414.8 (-76.658442)	87.2	34.4
BON-3	Pier 2	5038497.2 (45.486291)	292509.5 (-76.657229)	86.1	26.0
BON-4	Pier 3	5038463.3 (45.485987)	292564.5 (-76.656525)	89.7	18.5
BON-6	West Approach	5038595.5 (45.487172)	292317.1 (-76.659693)	103.0	27.5
BON-7	West Approach	5038628.5 (45.487468)	292261.1 (-76.660410)	113.0	31.1

* Ground surface elevation measured during investigation and may have changed in intervening time.



Piezometers, 19 mm in diameter, were installed in all six boreholes. The installation details are illustrated on the respective Record of Borehole sheets provided in Appendix B.

3.2 Current Investigation (2020, 2021, and 2024)

The current site investigation and field-testing program was carried out in three phases: August to September 2020, August to November 2021, and April to May 2024. The current investigation consisted of advancing a total of 17 test holes, comprising 15 boreholes (denoted as BON19-1 to BON19-9, BON-P1 to BON-P3, and BON24-1 to BON24-3) and two Cone Penetration Tests (CPT, denoted as BON-E and BON-W). Shear wave velocity measurements were taken at regular intervals of depth during advancement of the CPT soundings.

Multi-Channel Analysis of Surface Wave (MASW) testing was carried out near the proposed eastbound highway alignment on both sides of the river. The MASW testing was carried out by Geophysics GPR International Inc. and the results were provided to Thurber in:

- Geophysics GPR International Inc., “*Shear Wave Velocity Soundings for Determining Site Classifications, Three locations along Highway 17, in Renfrew County (ON),*” dated June 24, 2020 (Report No. GPR-19-01787).

A summary of the MASW test locations and results is included in Appendix B.

Prior to commencement of drilling, utility clearances were obtained in the vicinity of the test hole locations.

The locations and elevations of the testholes were surveyed by Thurber with a Trimble Catalyst DA1 antenna with centimeter accuracy. The northing, easting and ground surface elevation of the test holes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A, the individual Record of Borehole sheets and CPT plots in Appendix B, and in Table 3-2, below.

Table 3-2: Borehole Summary – Current Investigation (2019/2020/2021)

Test Hole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
BON19-1	West Approach	5038613.9 (45.487337)	292296.7 (-76.659955)	107.1	34.0* 39.6**
BON19-2	West Approach	5038599.4 (45.487207)	292321.5 (-76.659637)	103.0	32.6* 39.9**
BON19-3	West Abutment	5038587.0 (45.487096)	292358.5 (-76.659163)	103.0	47.7
BON19-4	East Abutment	5038442.4 (45.485799)	292616.2 (-76.655864)	98.9	20.1
BON19-5	East Abutment	5038435.7 (45.485741)	292610.5 (-76.655935)	98.9	22.5
BON19-6	East Approach	5038422.9 (45.485625)	292651.3 (-76.655414)	116.9	14.3

Test Hole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
BON19-7	East Approach	5038407.3 (45.485485)	292674.7 (-76.655113)	118.0	14.3
BON19-8	East Approach	5038384.8 (45.485283)	292718.9 (-76.654548)	117.7	14.3
BON19-9	East Approach	5038365.0 (45.485106)	292751.0 (-76.654137)	117.8	14.0
BON-P1	Pier 1	5038552.4 (45.486786)	292418.8 (-76.658392)	87.9	30.5
BON-P2	Pier 2	5038497.3 (45.486292)	292506.7 (-76.657266)	86.1	21.3
BON-P3	Pier 3	5038469.0 (45.486038)	292562.5 (-76.656551)	89.2	18.3
BON-E (CPT)	East Approach	5038418.8 (45.485588)	292650.9 (-76.655419)	116.9	14.5
BON-W (CPT)	West Approach	5038619.4 (45.487386)	292269.6 (-76.660301)	112.0	33.4
BON24-1	West Abutment	5038617.8 (45.487373)	292297.6 (-76.659943)	107.8	39.5
BON24-2	West Abutment	5038605.7 (45.487263)	292276.8 (-76.660209)	108.5	13.6
BON24-3	West Abutment	5038599.3 (45.487207)	292323.0 (-76.659618)	104.0	52.5

Notes: * - Termination of Sampled Borehole

** - DCPT refusal

The boreholes were drilled using a track-mounted drill rig (CME 850, CME 45, CME 75, or Diedrich D-50) equipped with hollow stem augers and either NW or HW casing. Bedrock was cored in Boreholes BON19-4 and BON19-5 with NQ-sized coring. Drill water for coring was obtained from temporary filtered pumps in the river.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A thin-walled (Shelby) tube sample of the cohesive materials at the west approach was obtained with open push advancement in Borehole BON19-3 for further laboratory testing. In-situ vane shear testing was conducted in cohesive deposits with an MTO 'N' sized vane.

Monitoring wells, 50 mm in diameter, were installed in Boreholes BON19-1, BON19-3, BON19-5, BON19-6, BON-P1, BON-P2 and BON-P3. The installation details are illustrated on the respective Record of Borehole sheets provided in Appendix B. The monitoring wells were installed as part of the current foundation investigation as well as a concurrent hydrogeological investigation. The piezometers and monitoring wells installed as part of the current investigation will be decommissioned by Thurber, as outlined in the Hydrogeological Investigation and Design Report.

The boreholes were backfilled in accordance with MOE requirements (O.Reg 903, as amended).



The drilling and sampling operations were supervised on a full-time basis by members of Thurber's geotechnical staff. The drilling supervisors logged the boreholes and processed the recovered soil samples for transport to Thurber's Ottawa geotechnical laboratory for further examination and testing, as well as submission to external laboratories.

4 LABORATORY TESTING

Laboratory testing was selected in accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. At least 25% of the recovered soil samples were subjected to testing for grain size distribution analysis and, where appropriate, Atterberg Limits in accordance with MTO and ASTM standards. One-dimensional consolidation testing was carried out on thin-walled tube samples from BON19-1 and BON24-1. Chemical analysis for determination of pH, conductivity, resistivity, sulphide, sulphate and chloride was carried out on selected soil samples.

Rock cores were logged and total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were determined in the field. Point load and unconfined compressive strength (UCS) testing was carried out on selected samples to give an indication of the bedrock strength.

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

5 GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. A general description of the stratigraphy based on the conditions encountered in the boreholes is given in the following sections. However, the factual data presented on the Borehole Records takes precedence over the Soil Strata Drawing and the general description. It must be recognized that the soil, bedrock and groundwater conditions may vary between and beyond borehole locations. Soil classification is in accordance with ASTM D2487. Description of cohesive soils and secondary components of all deposits from the current boreholes are described as outlined in the MTO Guideline for Foundation Engineering Services Manual (October 2020) and the 4th edition of the Canadian Foundation Engineering Manual (2006). Terminology from the historic borehole information may vary from current practice.

In general, the stratigraphy at the site consists of a deposit of silty clay to clayey silt overlying layer of sandy silt to clayey silt. These upper, generally fine-grained deposits are underlain by glaciofluvial deposits of silty sand to sand containing varying amounts of gravel, cobbles, and boulders which are, in turn, underlain by marble bedrock.



5.1 Topsoil

Topsoil was encountered at surface in boreholes BON-1 through BON-7, BON-P2, BON-P3, BON19-6 and BON19-7. The thickness ranged from 25 mm to 250 mm. The natural moisture content of the two samples tested was 31% and 44%.

5.2 Fill

Fill was encountered beneath the topsoil in Borehole BON-2 and at the ground surface at BON-P1 which are both located near the proposed Pier 1, just west of the river. The fill was described as a clayey silt with some sand to a sand with some gravel and silt. The thickness of the fill materials was 1.4 to 1.5 m (base elevation 85.8 m and 86.4 m). The moisture content ranged from 9% to 19%. The N-values obtained from SPTs conducted in the clayey silt fill ranged from 9 to 16, indicating a stiff to very stiff consistency. A single SPT N-value in the sand fill was 29, indicating a compact relative density.

5.3 Silty Clay to Clayey Silt

At ground surface or beneath the topsoil or fill, a deposit of silty clay to clayey silt was encountered at all test hole locations except BON-P2 and BON-P3. The deposit generally transitions from a silty clay to clayey silt with depth. The overall thickness of the deposit ranges from about 2 m within the river valley (Boreholes BON-2, BON-3, BON-4, BON-P1, BON19-4 and BON19-5) to over 31 m at the western approach (Borehole BON-7) with base elevations ranging from deeper than 81.9 m at the western approach, 81.1 m within the river valley, to 108.1 m at the eastern approach.

Further description of the material properties and field test results within the layers of the silty clay to clayey silt deposit are described in the following sections.

5.3.1 Silty Clay (Weathered Crust)

Away from the base of the river valley, the upper portion of the deposit is weathered to a grey-brown silty clay crust, which generally ranges from about 2 m to 10 m thick (approximate base elevations of 92.4 to 109.9 m). Sand seams were noted in this layer. The weathered portion of the deposit is generally not present within the lower river valley which has been incised into the overburden. SPTs conducted in the weathered crust gave N-values ranging from 3 to 26 blows per 0.3 m of penetration. In-situ shear vane tests in the weathered crust gave undrained shear strength values of 106 to 118 kPa (the maximum values recordable with the available shear vanes), indicating a very stiff consistency.

The corrected CPT tip resistance (q_t) recorded during advancement of the CPT through the weathered crust ranged between about 1,500 and 3,000 kPa. The shear wave velocity interpreted from the MASW and measured during advancement of the CPT through the weathered crust ranged from about 200 to 300 m/s.

The natural moisture content of samples of the weathered crust ranged from 19% to 51%. The results of grain size analysis test conducted on 18 samples of the weathered crust collected during the current investigation and four samples collected during the 2003 investigation are summarized below and are illustrated on Figures C1.1 to C1.3 in Appendix C and Figures D1.1 and D1.2 in Appendix D.

Soil Particle	Percentage (%)
Gravel	0 – 1
Sand	0 – 8
Silt	32 – 74
Clay	23 – 66

The results of Atterberg Limits testing carried out on 18 samples of the weathered silty clay crust collected during the current investigation and three samples obtained during the 2003 investigation are summarized below and are illustrated on Figures C2.1 to C2.3 in Appendix C and Figure D2 in Appendix D. The laboratory results indicate that the material is a generally a silty clay of intermediate plasticity (CI).

Parameter	Value
Liquid Limit	27 – 57
Plastic Limit	16 – 27
Plasticity Index	11 – 36

5.3.2 Clayey Silt (CL)

Below the weathered crust, the lower portion of the deposit consists of unweathered clayey silt which was encountered in all boreholes except BON19-04, BON19-05, BON19-6, BON-P2, BON-P3 and BON-6. Sand seams were observed in this layer. The thickness generally ranged from about 1.9 m to 8.4 m (base elevation 81.1 m to 106.4 m). The thickness of the deposit increases to the west, illustrated by Borehole BON-7, which was terminated in this layer at elevation 81.9 m with an observed layer thickness of greater than 25.3 m. The N-values obtained from SPTs conducted in the unweathered portion of the deposit ranged from weight of hammer (WH) to 17 blows per 0.3 m of penetration. In situ shear vane tests in the unweathered clayey silt gave undrained shear strengths as low as 47 kPa, but generally greater than 70 kPa, to the maximum recordable shear strength values of up to 118 kPa, indicating a stiff to very stiff consistency.

The peak shear strength values of the silty clay to clayey silt deposit measured at borehole locations along the west and east approaches are shown on Figures B5.1 and B5.2 in Appendix B, respectively.

The corrected CPT tip resistance (q_t) recorded during advancement of the CPT through the unweathered clayey silt ranged between about 1,500 and 2,200 kPa, with spikes up to about 5,000 kPa. The shear wave velocity interpreted from the MASW and measured during advancement of the CPT through the unweathered clayey silt ranged from about 200 to 250 m/s on the west side of the river, and about 300 to 400 m/s on the east side of the river.

The natural moisture content of samples of the clayey silt ranged from 22% to 51%. The results of grain size analysis test conducted on 11 samples of the unweathered clayey silt collected during the current investigation and five samples collected during the 2003 investigation are summarized below and are illustrated on Figures C3.1 to C3.2 in Appendix C and Figures D1.1 and D1.2 in Appendix D.

Soil Particle	Percentage (%)
Gravel	0 – 1
Sand	0 – 44
Silt	34 – 64
Clay	21 – 54

The results of Atterberg Limits testing carried out on 11 samples of the clayey silt collected during the current investigation and three samples obtained during the 2003 investigation are summarized below and are illustrated on Figures C4.1 to C4.2 in Appendix C and Figure D2 in Appendix D. The laboratory results indicate that the material is typically a clayey silt of low plasticity (CL). The lab results from Borehole BON-2 SS6 (Elevation 82.4 m) indicate that material is a highly elastic silt (MH).

Parameter	Typical Values	BON-2 SS6
Liquid Limit	25 – 42	52
Plastic Limit	15 – 22	30
Plasticity Index	8 – 20	22

The results of one-dimensional consolidation tests performed on four samples of the overall silty clay to clayey silt deposit are presented in Table 5-1, below.

Table 5-1: Summary of One-Dimensional Consolidation Testing – Silty Clay to Clayey Silt

Parameter	Results			
Borehole	BON 19-1	BON 24-1	BON-7	BH 2
Sample	ST1	ST9	TW1*	TW5
Material	Silty Clay (Crust)	Silty Clay	Clayey Silt	Clayey Silt (Crust)
Sample Depth, (m)	4.9	11.0	12.5	3.8
Sample Elevation, (m)	102.2	96.8	100.5	98.8
Approx. Existing Effective Stress, P_0' , (kPa)	85.8	192.5 kPa	155.0	66.5
Moisture Content, (%)	40.4	40.0	44.5	30.0
Liquid Limit, %	57	36	42	34
Plastic Limit, %	21	21	24	22
Plasticity Index	36	15	18	12

Parameter	Results			
Moist Unit Weight, γ (kN/m ³)	17.3	17.6	17.2	-
Degree of Saturation, S_{ro}	93.5	97.0	96.1	-
Specific Gravity, G_s	2.73	2.73	2.78	-
Initial Void Ratio e_o	1.179	1.129	1.287	0.929
Pre-consolidation Pressure, P_c' , (kPa)	620	350	130	315
Over Consolidation Ratio, OCR	7	1.8	1	4.7
Compression Index, C_c	0.80	0.58	0.34	0.17
Recompression Index, C_r	0.06	0.035	0.066	.02
Coefficient of consolidation, c_v (cm ² /s)	0.001	0.008	0.003	-
Coefficient of re-consolidation, c_{vr} (cm ² /s)	0.02	0.003	0.004	-

* test results indicate some sample disturbance prior to testing

The samples obtained from the current and 2003 investigations (Boreholes BON19-1 and BON-7, respectively) were obtained with open-push advancement of thin-walled Shelby tubes into the stiff to very stiff silty clay.

The consolidation results for BH 2 Sample 5 have been extracted from Geocres Report 31F-018. It is noted that Sample 12 of the clayey silt from the same borehole underwent an isotropically consolidated undrained triaxial test which indicated an apparent effective cohesion of zero and an apparent effective angle of friction of 28.5 degrees.

5.4 Silty Sand to Clayey Silt (SM, ML, CL-ML, CL)

A layer ranging from silty sand to clayey silt was encountered below the surficial topsoil in BON-P2 and BON-P3 and below the clayey silt in BON19-1 through BON19-7, BON-P1, BON-1, BON-2, BON-3, BON-4 and BON24-1. The layer composition was variable across the site but consisted predominantly of silt with varying amounts of sand and clay. Where the majority of the layer comprises fine-grained particles, laboratory test results indicated that it was low to non-plastic.

The thickness ranged from 0.3 m to 10.4 m (base elevation 78.1 m to 103.7 m). The N-values obtained from SPTs conducted in this material ranged from 1 to 45 blows per 0.3 m of penetration, indicating a very loose to dense relative density.

The natural moisture content of samples of the silty sand to clayey silt ranged from 4% to 39%. The results of grain size analysis test conducted on ten samples of the deposit collected during the current investigation and two samples collected during the 2003 investigation are summarized below and are illustrated on Figures C5.1 to C5.2 in Appendix C and Figure D3 in Appendix D.

Soil Particle	Percentage (%)
Gravel	0 – 7
Sand	13 – 83
Silt	26 – 64
Clay	11 – 27

Atterberg Limits testing was carried out on eight samples of the silt collected during the current investigation. The result from four cohesive samples are summarized below and are illustrated on Figure C6.1 in Appendix C. The laboratory results indicate that the material ranged from a non-plastic silt to a slightly or low plastic clayey silt (ML, CL-ML, CL). Four of the Atterberg Limit tests carried out gave non-plastic results.

Parameter	Values
Liquid Limit	18 – 24
Plastic Limit	15 – 16
Plasticity Index	2 – 9

5.5 Silty Sand to Sand Some Silt

A glaciofluvial sand deposit with varying quantities of silt and gravel was encountered beneath the silty sand to clayey silt in Boreholes BON19-1, BON-P1, BON-P2, BON-02 and BON-03. Clay layers were noted within this deposit. The thickness ranged from 2.9 m to 20.7 m (base elevation 60.5 m to 85.0 m). The N-values obtained from SPTs conducted in this material ranged from 2 to 40 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The natural moisture content of samples of the sand ranged from 1% to 37%. The results of grain size analysis test conducted on four samples of the sand collected during the current investigation and one sample collected during the 2003 investigation are summarized below and are illustrated on Figure C7.1 in Appendix C and Figure D4 in Appendix D.

Soil Particle	Percentage (%)
Gravel	0 – 2
Sand	59 – 89
Silt and Clay	11 – 41

An Atterberg Limit test was carried out on one sample; it was found to be non-plastic.

5.6 Sand and Gravel

A generally coarse deposit often with significant quantities of cobbles and boulders was encountered below the silty sand to sand some silt deposit in BON19-1, BON-P1, BON-P2, BON-2 and BON-3; below the silty sand to clayey silt in BON19-2, BON19-3, BON19-4, BON19-5, BON24-1, BON24-3, BON-P3, BON-1 and BON-4; and below the clayey silt in BON19-8, BON19-9 and BON 6. The sand and gravel layer was not observed in Boreholes BON19-6, BON19-7 and BON-7. The base of the sand and gravel layer was confirmed only in Boreholes BON19-4,



BON19-5, BON-2, BON-3 and BON-4. Where fully penetrated, the layer thickness ranges from 9.0 m to 18.8 m (base elevation 55.9 m to 82.3 m). At the borehole locations that did not fully penetrate the deposit, it ranged up to 24.8 m thick (BON19-3) and was encountered as deep as Elevation 51.5 m (BON24-3).

The material ranged in gradation from gravel some sand to silty sand some gravel with variable silt and gravel content. Cobbles and boulders were noted to be occasional to frequent components. The lower 5.6 m portion of this layer in Borehole BON-4 and the upper 2.0m thick portion of this layer in Borehole BON-6 consisted almost entirely of cobbles and boulders with some sand and gravel.

The N-values obtained from SPTs conducted in this material ranged from 1 to greater than 100 blows per 0.3 m of penetration, indicating a loose to very dense relative density, but was typically greater than 20 blows per 0.3 m of penetration indicating a compact to very dense relative density. The use of coring techniques was required in order to advance the boreholes through this deposit in numerous boreholes.

The CPT generally met effective refusal before penetrating the deposit. The shear wave velocity interpreted from the MASW in the deposit ranged from about 400 to 600 m/s.

The natural moisture content of samples of this layer ranged from 1% to 38%. The results of grain size analysis test conducted on 20 samples of the sand and gravel collected during the current investigation and six samples collected during the 2003 investigation are summarized below and are illustrated on Figures C8.1 to C8.4 in Appendix C and Figure D5 in Appendix D.

Soil Particle	Percentage (%)
Gravel	0 – 79
Sand	20 – 93
Silt and Clay	0 – 37

5.7 Bedrock

Bedrock was encountered in Boreholes BON19-4, BON19-5, BON-2, BON-3, and BON-4. The bedrock encountered consisted of moderately weathered to fresh, fine to coarse grained, marble that is predominantly white, grey, and black in colour. Bedrock logs are provided in Appendix B. Photographs of the bedrock cores are provided in Appendix C. The following table summarizes the rock core quality:

Table 5-2: Summary of Bedrock Core Quality

Summary of Rock Core Quality Parameter	Range	Average
Total Core Recovery (TCR), %	83 – 100	96
Solid Core Recovery (SCR), %	4 – 100	61
Rock Quality Designation (RQD), %	0 – 100	36
Fracture Index (fractures per 0.3m)	0 – >10	5

Based on the RQD values, the bedrock is classified as very poor to fair quality.

Table 5-3: Summary of Bedrock Depth/Elevation

Borehole No.	Depth to Bedrock Surface (mbgs)	Bedrock Surface Elevation (m)
BON19-4	16.8	82.1
BON19-5	16.6	82.3
BON-2	31.3	55.9
BON-3	22.3	63.8
BON-4	17.9	71.8

Unconfined compressive strength (UCS) testing was carried out on samples of the bedrock from Boreholes BON19-04 and BON19-05. The UCS values were 41 and 55 MPa, respectively. Based on the unconfined compressive strength testing the bedrock is classified as medium strong. The UCS values measured for samples obtained and tested as part of the 2003 investigation ranged from 110 to 139 MPa. However, it should be noted that the UCS values provided on the 2003 borehole logs were estimated from point load tests which can significantly overestimate the bedrock strength.

A summary of the bedrock surface information is provided in Table 5-3 above.

5.8 Groundwater

Groundwater levels recorded in the monitoring wells and piezometers are presented in Table 5-4.

Table 5-4: Summary of Groundwater Levels

Borehole No. [Diameter]	Bottom of Screen Elevation (m)	Screened Material	Groundwater Depth (m)	Groundwater Elevation (m)	Date of Measurement
BON19-1	76.6	Gravel some Sand	23.5	83.6	2021/09/21
			23.2	83.9	2021/11/21
			23.2	83.9	2021/11/29
			23.1	84.0	2022/01/11
BON19-3	75.7	Silty Sand some Gravel	19.2	83.8	2021/11/04
			19.2	83.8	2021/11/05
			19.0	84.0	2022/01/22



Borehole No. [Diameter]	Bottom of Screen Elevation (m)	Screened Material	Groundwater Depth (m)	Groundwater Elevation (m)	Date of Measurement
BON19-5	77.4	Bedrock	14.9	84.0	2020/09/29
			14.7	84.2	2021/08/04
			14.9	84.0	2021/12/01
			14.8	84.1	2022/01/11
BON19-6 (shallow)	110.2	Silty Clay	Dry	n/a	2020/09/17
			Dry	n/a	2020/09/29
			Dry	n/a	2020/11/11
			Dry	n/a	2021/08/06
			Dry	n/a	2021/09/29
			Dry	n/a	2022/01/11
BON19-6 (deep)	103.3	Sand some Silt	Dry	n/a	2020/09/17
			Dry	n/a	2020/09/29
			Dry	n/a	2020/11/11
			Dry	n/a	2021/08/04
			Dry	n/a	2021/08/06
			Dry	n/a	2021/12/21
			Dry	n/a	2022/01/11
BON-P1	57.4	Sand and Gravel	4.1	83.8	2021/11/04
			4.1	83.8	2021/11/30
			3.9	84.0	2022/01/25
BON-P2	65.4	Sand and Gravel	2.5	83.6	2021/11/17
			2.5	83.6	2021/11/30
			2.4	83.7	2022/01/11
BON-P3	71.7	Sand and Gravel	5.3	83.9	2021/11/09
			5.5	83.7	2021/11/17
			5.5	83.7	2021/12/01
			5.4	83.8	2022/01/05
			5.5	83.7	2022/01/11
BON-1	72.1	Sand and Gravel	18.59	83.8	2003/10/22
			18.15	84.3	2003/12/19
			17.95	84.5	2004/02/04
			18.71	83.7	2021/09/21

Borehole No. [Diameter]	Bottom of Screen Elevation (m)	Screened Material	Groundwater Depth (m)	Groundwater Elevation (m)	Date of Measurement
BON-2	54.7	Till/Bedrock	3.47	83.7	2003/11/22
			3.42	83.8	2003/12/19
			2.72	84.5	2004/02/04
			3.47	83.7	2021/09/21
BON-3	60.2	Bedrock	Destroyed		2003/12/19
BON-4	73.1	Sand and Gravel	5.35	84.4	2004/02/04
BON-6	83.2	Gravelly Sand	18.37	84.6	2003/12/19
			18.26	84.7	2004/02/04
BON-7	81.9	Silty Clay	Destroyed		2004/02/04

These observations are considered short term and it should be noted that the groundwater level at the time of construction may be different and seasonal fluctuations of the levels are to be expected. In particular, the levels may be at a higher elevation after periods of significant and/or prolonged precipitation. Though not encountered in the piezometers installed during the field investigations, artesian conditions may be encountered within the flood plain during construction.

The elevation of the Bonnechere River was surveyed during the course of the field work and was measured to be at approximate Elevations of 83.3 m and 83.6 m on September 17, 2020 and October 22, 2021, respectively. The river level is expected to fluctuate seasonally.

5.9 Analytical Testing

Six samples were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, resistivity, and conductivity. The analysis results are summarized below in Table 5-5. Copies of the test results are provided in Appendix C.

Table 5-5: Results of Chemical Analysis

Borehole	Sample (Soil Type)	Depth (m)	Chloride (µg/g)	Sulphate (µg/g)	Sulphide (%)	pH (-)	Resistivity (Ohm-cm)
BON19-3	SS 5 (Silty Clay)	3.1 – 3.7	9	< 5	< 0.04	7.66	7,360
BON19-5	SS2 (Clayey Silt)	0.8 – 1.4	8	9	<0.04	7.22	14,300
BON-P1	SS 6 (Sandy Silt)	3.8 – 4.4	34	260	0.05	7.72	3,050



BON-P2	SS 6 (Silty Sand)	3.8 – 4.4	5	< 5	< 0.04	7.63	14,100
BON-P3	SS 8 (Sand)	5.3 – 5.9	7	< 5	< 0.04	7.81	15,900
BON24-2	SS 4 (Clay)	3.1 – 3.7	12	24	< 0.01	6.79	3,500

6 MISCELLANEOUS

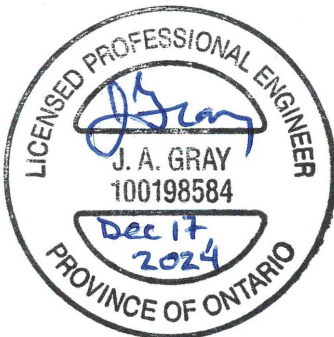
Please refer to Geocres Report 31F-136 for details on methodology and results from that investigation. It must be noted that conditions on site, particularly near ground surface may have been altered since that work was carried out.

Borehole locations for the current investigation were selected by Thurber relative to existing site features and were accessed from the adjacent properties or temporary access paths constructed from Highway 17. The as-drilled locations and ground surface elevation of the boreholes were surveyed by Thurber following completion of the field program. The elevation survey was carried out with reference to geodetic elevation benchmarks provided by the MTO.

Marathon Underground Ltd. of Greely, Ontario and Forage Downing Drilling Lt. of Grenville-sur-la-Rouge, Quebec supplied and operated the drilling equipment and carried out the drilling, soil sampling, in-situ testing, piezometer/monitoring well installation. ConeTec Investigations Ltd. of Richmond Hill, Ontario supplied and operated the CPT equipment and carried out the in-situ testing. The field investigation was supervised on a full-time basis by Richard Howarth, Nick Weil, Jamil Pirani, Anderson de Oliveira, Sarah Harrold, Justin Gray and Benoit Coote of Thurber. Overall supervision of the investigation program was provided by Justin Gray, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. UCS and consolidation testing was completed by Stantec's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa.

Overall project management and direction of the field program was provided by Fred Griffiths, P.Eng. Interpretation of the factual data and preparation of this report were carried out by Justin Gray, P.Eng., Matt Kennedy, P.Eng., and Fred Griffiths, P.Eng. The report was reviewed by P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



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**PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 17 TWINNING, RENFREW AREA
BONNECHERE RIVER BRIDGE
STA. 20+200, HORTON TOWNSHIP
EASTBOUND STRUCTURE - SITE NO. 29X-0192/B1
WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009**

Geocres No.: 31F-236

PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

Part 2 of the report provides an interpretation of the factual data from Part 1 and presents preliminary geotechnical recommendations to assist the project team in designing the foundations for the proposed Bonnechere River Bridge in the Township of Horton, Renfrew County, Ontario.

The site is located at the Highway 17 Bonnechere River crossing approximately 1.0 km west of O'Brien Road (Highway 60). Existing Highway 17 in the area will become the future westbound lanes, while the new eastbound alignment will be located approximately 40 m to the south. The existing bridge will carry the westbound traffic, and a new structure will be required to carry the eastbound Highway 17 traffic over the river. The new structure will comprise a five span bridge with piers outside the current river footprint.

This preliminary 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 design-build contractors. It should be noted that the use of and reliance on Part 1 of the Report is governed by and limited to the terms and conditions set out in the Report and a reliance letter. The Preferred Proponent remains responsible to assess the need for additional investigations and to complete that work. The Preferred Proponent must make their own interpretation based on the factual data in Part 1 of the report. The information included in Part 2 is not to be relied upon for design purposes and foundation design is the sole responsibility of the Preferred Proponent. No use shall be made of Part 2 or any part thereof. The Preferred Proponent must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The following sections provide preliminary geotechnical recommendations for the construction of the bridge approaches and the foundation elements for the proposed structure. The discussions and recommendations presented in this report are based on the information provided by the Ministry of Transportation of Ontario (MTO) and on the factual data obtained during the course of this investigation.



The original design drawings (Nos. 29-192-1 and 29-192-3) indicate that the existing Highway 17 bridge is supported on 153 HP 12x74 (HP 310x110) piles. The design drawings indicate that the piles at Pier 2 (west) and Pier 3 (main span west) were to be driven to bedrock, and that the piles at the abutments, Pier 1 (west), Pier 4 (main span east) and Pier 5 (east) were to be friction piles driven to a design load of 95 tons (950 kN) per pile.

During construction at all foundation elements, except for Pier 2, the piles had to be driven deeper than anticipated, with the majority of the additional pile length required at Pier 5 and the east abutment, resulting in approximately 970 m more pile length than the 3,200 linear metres tendered. Based on correspondence during construction and piling records included in Geocres Report No. 31F-018, the piles at the west abutment and Pier 1 encountered bedrock before meeting Hiley Formula refusal criteria. Further, comparing the historical borehole information with the reported pile lengths in the piling records, it is anticipated that the piles at Pier 4, Pier 5, and the east abutment may have also reached bedrock.

7.1 Proposed Structure

At the site, Highway 17 runs roughly northwest-southeast and the Bonnechere River, southeast-northwest. However, the travelled lanes of Highway 17 will be described herein as eastbound and westbound to maintain continuity with convention of the overall highway. The Bonnechere River will be described as flowing south to north. It is noted that the stations on the proposed East Bound Lanes (EBL) do not match those of the existing highway (future West Bound Lanes). For clarity, all stations references in this report will be with respect to the new EBL alignment unless otherwise noted.

Based on the available General Arrangement (GA) Drawing, dated July 17, 2023 (included in Appendix G), the new structure is to consist of a 333 m long, five-span structure with span lengths of 42 m, 70 m, 100 m (main span), 75 m, and 46 m. The GA drawing indicates that all foundation elements (abutments, wingwalls, piers) are to be supported by piles. Slope paving at 2H:1V is proposed for the forward slope beneath the east abutment.

A grade increase of up to about 9.2 m will be required for the new EBL embankment at the west approach. Due to the skew of the highway relative to the riverbank, the west embankment will increase in height from north to south, perpendicular to the highway, as well as from east to west along the approach. Near the east abutment of the new EBL, a grade raise of up to about 11.8 m will be required and will transition to an earth cut as deep as about 6.4 m below the existing ground surface at the centreline and 7.4 m at the final slope toe approximately 50 m east of the abutment.

As further described in Section 10.8.1, the location of the west abutment of the new EBL was optimized during the preliminary design stage based on geotechnical slope stability design considerations for the river valley slopes. The foundation design recommendations provided herein describe these considerations and provide recommendations based on the preferred General Arrangement (see Appendix G). The recommendations provided in the sections below are applicable for the pier and abutment locations described above. If the preferred pier or abutment locations differ from those considered herein, the recommendations provided below should be reviewed and revised as appropriate.



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 S6:19.

In accordance with CHBDC, the analysis and design of the structure 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 the new bridge is being designed to the “Major Route” importance category.

This project has been assigned Typical Consequence Classification, in accordance with Section 6.5.1 of the CHBDC. Accordingly, a consequence factor (Ψ) of 1.0, as per Table 6.1 of the CHBDC, has been used in assessing factored geotechnical resistances.

The degree of site and prediction model understanding for this site has been assessed to be typical understanding (Section 6.5.3 of CHBDC).

8 SEISMIC CONSIDERATIONS

8.1 Spectral and Peak Acceleration Hazard Values

The seismic hazard data considered herein for project design 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 ($S_a(T)$) 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, the peak ground acceleration (PGA), and $S_a(0.2)$. The PGA for this location for a *reference* Site Class C with a 2% probability of exceedance in 50 years is 0.23 g (1 in 2475 year). This value is to be scaled by the $F(PGA)$ based on the site-specific Site Class as per Section 4.4.3.3 (Table 4.8) of the CHBDC (see Section 8.2).

8.2 CHBDC Seismic Site Classification

In accordance with the CHBDC, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy that underlie the reference elevation of the underside of the foundation elements. The reference elevation at each abutment and pier foundation was taken as the elevation of the underside of the pile caps shown on the GA drawing (see Appendix G).

The shear wave velocity of the soil layers at the site were recorded during advancement of the CPTs BON-E and BON-W, and at the MASW locations (see CPT shear wave velocity summary and MASW locations and data summary in Appendix B). Although the non-intrusive MASW technique is generally considered to be less precise, the MASW method allows for shear wave velocity (V_s) profiles to be developed for the deeper strata that were below the SCPT refusal depth (approximately 33.4 m at CPT BON-W and 14.5 m at CPT BON-E). The Seismic Site Classes were developed based on the calculated/interpolated V_{s30} values of the site soils at the foundation element locations. Based on the results of the shear wave velocity measurements, the approximate average shear wave velocity of the soil deposits at the site were calculated. The harmonic mean, considering the thickness and representative shear wave velocity of each soil deposit at a given foundation location, was calculated. The harmonic mean of the interpreted shear wave velocity in the upper 30 m below the proposed pile cap at each of the foundation elements is provided in the table below.

Table 8-1 Estimated Average V_s in Upper 30 m

	West Abutment	Pier 1 (West Span)	Pier 2 (Main Span West)	Pier 3 (Main Span East)	Pier 4 (East Span)	East Abutment
Estimated V_s (m/s)	220	210	270	360	540	390
Site Class ¹	D	D	D	C	C	C

Note: 1) Site Class associated with shear wave velocity at given foundation element

Based on the values presented in Table 8-1, a Site Class D has been assumed for development of the foundation design recommendations provided below. For a Site Class D, the $F(PGA)$, as per Table 4.8 of Section 4.4.3.3 of the CHBDC, is equal to 1.14 for this site, resulting a site-adjusted PGA of 0.26 g.

Table 4.1 of the CHBDC specifies circumstances for which a Site Class F is applicable, including the presence of liquefiable soils. Further discussion on the potential for liquefaction at the site and considerations for design are presented in Section 8.4, below.

8.3 Seismic Performance Category

In consideration of the Site Class D spectral values for the site and the designated “Major Route” importance category, the bridge structure would fall into either Seismic Performance Category 2, if the bridge has a fundamental period greater than or equal to 0.5 seconds, or Seismic Performance Category 3, if the bridge has a fundamental period less than 0.5 seconds, as per Section 4.4.4 (Table 4.10) of the CHBDC.

8.4 Seismic Liquefaction Potential

The susceptibility of the cohesive soils at this site to experience liquefaction/cyclic softening was assessed following the Boulanger and Idriss (2007)ⁱ criteria using measured undrained shear strengths. This methodology is appropriate for cohesive soil that will exhibit “clay-like” behaviour



and the results of the analysis indicate that the cohesive material at the site is not susceptible to liquefaction or cyclic mobility.

The susceptibility of the cohesionless soils at the site to experience liquefaction was assessed using the SPT data following the simplified method for cohesionless soil as outlined in Boulanger and Idriss (2014)ⁱⁱ and Section C6.14.8 of the Commentary to the CHBDC. A design groundwater level at Elevation 84.0 m was used in the analyses. A PGA representative of the 2,475-year earthquake, appropriate for Site Class D conditions (for analyses at locations west of the main span) or Site Class C conditions (for analyses at locations east of the main span) was used. The current liquefaction assessment was carried out using the simplified method by comparing the Cyclic Resistance Ratio (CRR) calculated using the SPT data, collected at the boreholes put down at the piers, to the Cyclic Stress Ratio (CSR), calculated based on a site-modified PGA scaled by the Seismic Site Class.

The results of the analyses indicated that portions of the upper, loose to compact silt and sand deposits at the main span piers are potentially liquefiable under the design earthquake. At the western main span pier, the liquefiable sandy silt to sand is present below the surficial silty clay to about Elevation 75.4 m which is approximately 12.5 m below ground surface. At the eastern main span pier, the liquefiable sand and silt is present above about Elevation 79.7 m which is approximately 6.4 m below ground surface. Discontinuous liquefiable zones were also identified within the underlying sand and gravel deposit at the eastern main span pier. Based on the results of the liquefaction analyses of existing conditions, post-seismic reconsolidation settlements of up to about 200 mm at each of the main span piers may occur.

As per Table 4.1 in Section 4.4.3.2 of the CHBDC S6-19, sites with liquefiable soils should be considered a Site Class F and a site-specific evaluation is required. It is recommended that additional foundation investigation and design, including a more detailed liquefaction assessment considering the results of a site-specific ground response analysis, be carried out during a subsequent project stage. There are three outcomes upon completion of that more rigorous work:

1. liquefaction is determined to have a low risk of occurrence and does not need to be considered in design,
2. liquefaction is assessed to be an issue and the structure and embankments are designed to accommodate the forces and displacements induced by liquefaction; or
3. liquefaction is assessed to be an issue and ground improvement techniques are employed to densify the soils to reduce the risk of liquefaction to acceptable levels.

The following sections of this report have been prepared based on the assumption that the first or third scenarios will prevail, and that design of the structure and embankments will not be influenced by liquefaction. It is recommended that the structure be designed considering a Site Class D until the site-specific evaluation has been carried out.



9 STRUCTURE FOUNDATION ALTERNATIVES

9.1 Foundation Alternatives

It is understood that the new EBL Bonnechere River Bridge is to consist of a five-span, steel plate girder structure with piers and abutments supported on piles and a 100 m long main span over the Bonnechere River. Based on the most recent GA drawing (July 17, 2023, see Appendix G) the bridge will have a main span length of 100 m, and approach spans between 42 m and 75 m long. The deck is to be a total of about 12.6 m wide to accommodate two travelled lanes and shoulders. The GA drawing indicates wing walls integrated with the abutments, and slope paving at 2H:1V in front of the east abutment.

Along the west approach, embankment fill up to 9.2 m high will be required. Based on the GA, an underside of the west abutment and Pier 1 pile caps have been assumed to be at about Elevations 99.7 m and 97.5 m, respectively. Based on the boreholes put down near those proposed foundation elements locations (BON19-3/BON-1 and BON19-2/BON-6), the soil conditions below those elevation consist of very stiff weathered silty clay crust to Elevation 97 m over unweathered clayey silt to elevations ranging from about 87 m to 90 m which is, in turn, underlain by loose to compact sand and silt to Elevations ranging from about 80 m to 85 m. These upper deposits are underlain by compact to dense sand with silt, sand, and gravel that extends to about Elevation 61.0 m which is further underlain by greater than 9.5 m of very dense silty sand and gravel containing frequent cobbles and boulders. Effective refusal to the split-spoon sampler and/or HQ coring was required at various depths within the very dense silty sand and gravel deposit. The boreholes put down near the proposed west abutment and Pier 1 extended as deep as 52.5 m below existing ground surface (Elevation 51.5 m at BON24-3) and did not fully penetrate the very dense silty sand and gravel.

At the main span and eastern span pier locations, the undersides of pile cap caps are anticipated to range from 82.0 m to 83.4 m. Based on the boreholes put down at the proposed pier locations (BON-P1, BON-P2, BON-P3, BON-2, BON-3, and BON-4), the pile caps will be underlain by glaciofluvial deposits consisting of compact to dense silty sand over dense to very dense sand and gravel with an overall thickness ranging from about 22 m near the western main span pier to about 13 m at the eastern span pier.

The east approach will comprise an embankment fill section at the abutment, approximately 25 m long, and a cut section some 150 m beyond to the east. The existing riverbank slope on which the east approach is to be constructed is naturally sloped at about 2.5H:1V and will receive embankment fill up to about 11.8 m high at the abutment. It is anticipated that the underside of the east abutment pile cap will be at about Elevation 98.0 m. The boreholes put down at that location indicate that it will be underlain by up to about 1.5 m of very stiff weathered silty clay crust, overlying about 14.5 m of compact to very dense silty sand to sand and gravel which is, in turn, underlain by marble bedrock. Beyond the riverbank, the existing ground surface generally slopes up to the south, roughly parallel to and away from the existing Highway 17 to a relatively flat plateau south of the proposed alignment of the new eastbound lanes. Cuts of as much as about 6.5 m deep into weathered silty clay crust will be required in this area for the east approach.



Given the soil stratigraphy encountered, the following foundation options have been considered from a geotechnical perspective for the support of the bridge abutments and piers:

- Spread footings,
- Caissons (drilled shafts),
- Drilled-In Steel Pipe Piles, and
- Driven Steel H-piles.

The foundation alternatives are presented below and evaluated from a geotechnical perspective in terms of their respective advantages, disadvantages, risks, and consequences. The evaluation is summarized in the table provided in Appendix G.

- Spread Footings

Spread footings founded within the native soil would be within the stiff to very stiff silty clay or the underlying loose to compact silty sand, both of which would offer relatively low bearing resistance for the bridge foundations. Due to the compressible nature of the silty clay, total and differential settlements between founding units will occur. In addition, spread footings do not allow for construction of integral abutments.

It is not recommended to support the new bridge on spread footings.

- Caissons

Caisson foundations, particularly when they are socketed into bedrock, offer high geotechnical resistance. However, the groundwater level (within a few metres of the existing ground at the piers or river bottom surface) will pose additional construction challenges resulting from potential unbalanced hydraulic pressure heads and caisson base boiling when drilling through the granular silty sand, and sand and gravel deposits. This would require the use of temporary liners and synthetic slurry to counterbalance groundwater pressure. Artesian conditions were not encountered at the borehole locations during the investigation; however, artesian groundwater conditions may exist elsewhere in the flood plain.

The frequent presence of cobbles and boulders observed in the lower silty sand and gravel layer in all boreholes put down at the foundation locations could also present additional difficulties during caisson installation. Founding caissons on dissimilar stratigraphy (e.g., some on bedrock and some in boulders) could result in differential settlements.

It is considered feasible to support the new bridge piers on caissons.

- Drilled-In Steel Pipe Piles Socketed into Bedrock

Based on the foundation soils encountered as part of the current investigation, drilled-in steel pipe piles filled with concrete are considered to be feasible for the support of the new abutments and piers. Pipe piles would reduce the volumes of excavation required when compared to that for shallow foundations. Drilled-In pipe piles would reduce the risk for

“hanging up” or being deflected away from their intended vertical or battered orientation if cobbles or boulders are encountered during driving. However, where depth to bedrock is significant (i.e. below the depth of investigation at the west abutment and Pier 1), extending drilled-in pipe piles to socket into bedrock may be cost prohibitive.

It is considered feasible to support the new abutments and piers on drilled-in steel pipe piles.

- Driven Steel H-piles

Driven steel H-piles support the existing bridge, and are considered feasible for the support of the new bridge abutments and piers. Driven H-piles will typically reduce the volumes of excavation required when compared to shallow foundations. The use of H-Piles with reinforced tips is the option with the lower risk given the cobbles and boulders in the till layer above the bedrock observed at this site. The new bridge is to be offset at about 40 m center-to-center to the existing, with about 30 m in between. Based on guidance in Caltrans' Technical Advisory on Vibration publication (Figure 3, TAV-02-01-R9601), structures greater than about 20 m away from a typical impact pile driver are not expected to be impacted by vibration due to pile driving imparting Peak Particle Velocities greater than 5 mm/s.

It is recommended to support the new abutments and piers on driven steel H-piles.

9.2 Construction Methodology

It has been assumed that staging areas for the bridge construction will be set up within the new right-of-way for the proposed eastbound lanes and will be accessible from the existing eastbound Highway 17 to minimize conflict with the two-way Highway 17 traffic or the existing bridge present to the north. The foundation recommendations presented herein have been prepared based on the assumption that construction will be carried out at a distance sufficient to allow no impact on the existing Highway 17 and with no requirement for temporary roadway protection. Depending on the construction sequence, embankment construction in advance of construction of the foundation elements may be required. The existing bridge should be monitored to confirm that vibrations induced by pile driving are within acceptable levels.

10 FOUNDATION DESIGN RECOMMENDATIONS

The abutments and piers may be supported on steel H-piles or pipe piles driven to refusal in the till layer or bedrock. Approximate key elevations are as follows:

- | | |
|--|--------------------|
| • Original Grade at foundation element | 86.0 m to 103.0 m |
| • Proposed top of pavement | 109.6 m to 111.4 m |
| • Underside of abutment pile caps | 99.7 m to 98.0 m |
| • Underside of western span pier pile cap | 97.5 m |
| • Underside of main span and eastern span pier pile caps | 82.0 m to 83.4 m |
| • Groundwater elevation | 83.6 m to 84.7 m |
| • Bedrock surface | < 51.5 m to 82.3 m |

Pile cap elevations must satisfy the frost protection requirements of Section 10.6.

10.1 Driven Steel H-Piles

10.1.1 Axial Geotechnical Resistance and Founding Elevation

Bedrock was proven by coring at boreholes put down at the proposed east abutment and main span/eastern span pier locations (BON19-4, BON19-5, BON-2, BON-3, and BON-4). Additional boreholes were put down at these locations that penetrated the overburden and were terminated in the very dense sand and gravel with frequent cobbles that overlies the bedrock (BON-P1, BON-P2, and BON-P3). The proposed western span pier (Pier 1) and west abutment Boreholes BON19-3, BON19-2, BON24-3, BON-1, and BON-6 were terminated in the compact to very dense glaciofluvial deposits.

At all boreholes put down at proposed foundation element locations, cobbles and boulders were encountered or inferred in the lower glaciofluvial silty sand and gravel. Difficulty drilling or refusal of the sampler that suggested the presence of cobble or boulders and required penetration by coring, or a combination of coring and wash boring techniques was encountered throughout the deposit.

It is anticipated that piles may not be able to consistently penetrate the lower sand and gravel deposit that contains cobbles and boulders to reach bedrock. For preliminary design purposes, the pile recommendations provided below are based on driving the piles to refusal in the lower sand and gravel on cobbles and boulders. Piles that meet refusal in the portion of the sand and gravel deposit that contains cobbles and boulders may be designed with factored ULS and SLS resistance values provided below in Table 10-1.

**Table 10-1 Estimated Pile Tip Elevations and
Axial Geotechnical Resistances for Piles Driven to Dense Glacial Till**

Fndn	Location	Bedrock Elevation (m)	Estimated Pile Refusal Elevation (m)	Estimated Pile Length (m)	Factored ULS / Factored SLS	
					HP 310x110	HP 360x132
West Abutment	BON19-2	-	< 63.1 ¹	> 36.6 ¹	1,500 kN / 1,300 kN	1,800 kN / 1,600 kN
	BON24-3	-				
	BON-6	-				
Pier 1 (western span)	BON19-3	-	55.3	42.2	1,500 kN / 1,300 kN	1,800 kN / 1,600 kN
Pier 2 (main span west)	BON-P1	-	56.0	27.4	1,400 kN / 1,200 kN	1,500 kN / 1,300 kN
	BON-2	55.9				

Fndn	Location	Bedrock Elevation (m)	Estimated Pile Refusal Elevation (m)	Estimated Pile Length (m)	Factored ULS / Factored SLS	
					HP 310x110	HP 360x132
Pier 3 (main span east)	BON-P2	-	63.9	18.1	1,400 kN / 1,200 kN	1,500 kN / 1,300 kN
	BON-3	63.8				
Pier 4 (eastern span)	BON-P3	-	71.9	11.5	1,200 kN / 1,000 kN	1,300 kN / 1,100 kN
	BON-4	71.8				
East Abutment	BON19-4	82.1	82.4	15.6	1,200 kN / 1,000 kN	1,300 kN / 1,100 kN
	BON19-5	82.3				

Note: 1) To be confirmed at a subsequent detailed design stage

It should be noted that based on correspondence during construction and the piling records included in Geocres Report No. 31F-018 for the existing bridge, some of the piles reached bedrock. Higher resistances may be achieved if the piles penetrate the sand and gravel deposit to the underlying bedrock during driving or following pre-drilling of the pile socket. HP 310x110 or HP 360x132 piles driven to bedrock may be designed with factored ULS resistance values of 2,000 kN or 2,400 kN, respectively. The SLS condition will not govern for piles founded on bedrock. The potential increase in geotechnical resistance for piles driven to found in bedrock could reduce the number of piles required and the overall pile length. The Preferred Proponent should consider installing piles for completion of dynamic and/or load testing during the detailed design stage.

The structural resistance of the pile under static and seismic conditions must be checked by a structural engineer. The factored geotechnical resistances provided include the following factors:

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

The estimated pile tip elevations for piles end bearing at the site are summarized Table 10-1. With the pile caps at the elevations outlined in Section 10, the pile lengths required would range from greater than 40 m at the west abutment to up to about 12 m at the eastern span pier (Pier 3). At locations where the bearing stratum is expected at significant depth, piles with a heavier section (i.e. HP 360x132) may be considered to reduce the potential for buckling. At locations where the bearing stratum is relatively shallow and piles may get hung up at higher elevations (e.g. at the eastern span pier, and the east abutment), pre-drilling may be required to achieve the minimum pile length to satisfy lateral flexibility requirements for an integral abutment configuration.

Pile driving must be controlled by the Hiley Formula and an ultimate pile resistance should be specified by the designer in accordance with Clause 3.3.2 (b) Construction Stage of MTO's Structural Manual. Given the history of pile length overrun for the existing Bonnechere River Bridge and potential for hangup within the sand and gravel above the bedrock an assessment of the driveability of the piles with the selected hammer and driving system with a Wave Equation Analysis of Pile driving (WEAP) is recommended. Dynamic load testing (PDA) should be carried out to confirm pile capacity at the end of driving, as well as at re-strike, following construction. It is recommended the capacity of at least two piles per foundation unit are verified by PDA testing.

Steel piles (Grade 350W steel) at this site may be designed to resist uplift forces with the factored geotechnical resistances provided below in Table 10-2, applicable for HP 310x110 and HP 360x132 piles.

Table 10-2 Axial Geotechnical Tensile Resistances (HP 310x110 or larger)

Location	Factored Tensile Resistance (kN per pile)	
	Static	Seismic
West Abutment	1,000	3,000
Pier 1 (western span)	1,000	3,000
Pier 2 (main span west)	1,000	3,000
Pier 3 (main span east)	450	1,100
Pier 4 (eastern span)	230	750
East Abutment	200	650

The factored geotechnical tensile resistance values provided in Table 10-2 include the following factors:

- Consequence factor (Ψ) of 1.0
- Geotechnical resistance factors (CHBDC Table 6.2) of $\phi_{gu} = 0.3$ (static analysis; typical degree of understanding)
- Geotechnical resistance factors (CHBDC Table 6.3) of $\phi_{gu} = 1.0$ (seismic analysis; typical degree of understanding, performance-based design)

10.1.2 Downdrag

Downdrag forces (negative skin friction) are expected to develop as a result of settlement of the silty clay to clayey silt deposit under the imposed loading from the newly placed embankment fill. Downdrag loads need not be applied at the piers, where there is no considerable grade raise.

At the abutments, if the approach embankments are constructed with lightweight fill such that settlement in the underlying soil deposits is negligible, downdrag forces need not be applied. If initiation of the driving of the abutment piles is delayed until after completion of the settlement induced by construction of the embankments, downdrag forces need not be applied. However, if the embankments are constructed with conventional SSM or rock fill following completion of pile driving, downdrag forces must be considered in the structural design.



Downdrag loads were estimated as outlined in Section 6.11.4.10 of the CHBDC. The unfactored downdrag load acting on a single HP 310x110 or HP 360x132 pile is estimated to be about 640 kN and 750 kN, respectively, at the west abutment, and about 290 kN and 340 kN, respectively, at the east abutment. In addition to the downdrag loads on the piles, lateral deflection of the abutment piles resulting from the subsequent placement of embankment fill and associated settlement should be considered in the final design.

10.1.3 Lateral Geotechnical Resistance and Group Effects

Piles can be installed with a batter to resist lateral loads for a conventional or semi-integral abutment.

The lateral resistance for the soil adjacent to a vertical pile is developed on the face of the pile embedded in the foundation soils and estimated using P-y curves.

The P-y curves representing the response of the soil under static loading conditions are shown in Appendix H to allow for calculation of the *ultimate* lateral capacity of an individual pile.

Calculation of the P-y curves considered the abutment and pier pile cap underside elevations provided on the available GA drawings and as outlined above in Section 10. The values provided in Appendix H were calculated for a single, vertical HP 310x110 pile. The ground would provide greater resistance (i.e. increased stiffness) to a pile with a larger face width. The P-y curves for other pile sizes may be approximate by increasing the stiffness by the percentage increase of the face size.

A geotechnical resistance factor of 0.5 (ϕ_{gu}) and 0.8 (ϕ_{gs}) as per Table 6.2 of the CHBDC (static analysis – typical understanding) should be applied to the *ultimate* ULS and SLS values, respectively.

Where lateral spacing between an adjacent pile or another structural element is less than four equivalent pile diameters, the lateral resistance will also need to be further reduced based on the center-to-center spacing. The reduction factors to be used can be obtained from Figures C6.22, C6.23, and C6.24 of the Commentary to the CHBDC.

10.1.4 Pile Tips

It is expected the pile installation will encounter cobbles and boulders. Care must be exercised not to damage the piles while driving into layers with cobbles and boulders and to bedrock. The stratigraphy at the site also indicates sloping bedrock. The tips of all piles must be protected from damage when driving and should be fitted with a Titus Steel Rock Injector Point or approved equivalent.

10.1.5 Pile Driving

Pile driving must be carried out in accordance with OPSS.PROV 903 and Special Provision 109F57 for piles driven to refusal in the bedrock or cobble and boulder layer. Pile testing need not be used until piles are within 2 m of the design tip elevation. The appropriate pile driving note

is “Piles to be driven to an ultimate resistance of “R” kN per pile”. “R” must have a minimum value of twice the design load at ULS. The designer fill-in (*) in Section 903.07.02.07.03.01 shall be *High-Strain Dynamic Testing*.

10.1.6 Abutment Type

The subsurface conditions at this site are considered suitable for conventional, semi-integral, or integral abutments. At the abutments, a loose sand-filled, corrugated steel pipe (CSP) around the upper 3.0 m of the piles is recommended to allow for the required lateral movement for an integral abutment configuration.

10.2 Caisson Foundations at Piers

Augered caissons socketed into bedrock are considered a feasible foundation option for the main span and eastern span piers. Caisson construction would reduce the need for excavations when compared to that required for construction of shallow foundations or pile caps with sufficient frost protection. However, caisson installation would involve advancing the caisson holes through the loose silty sand to sand and the underlying glacial till, with the excavation extending well below the groundwater table. As such, the augered caisson installation would require the use of temporary steel liners and synthetic slurry to support the excavation.

10.2.1 Axial Geotechnical Resistance

Caissons extending through overburden soils and founded within the medium strong marble bedrock may be considered for support of the bridge piers. Table 10-3 presents the geotechnical resistances of typical caisson diameters for planning and design purposes.

Table 10-3: Axial Geotechnical Resistances for Caisson Design at Piers

Caisson Diameter (m)	Socket Length in Sound Rock (m)	Compressive Resistance (kN)		Tensile Resistance (kN)	
		Factored ULS	Factored SLS	Static	Seismic
1.2	3.0	11,300	N/A ⁽¹⁾	5,000	16,900
1.5	3.0	15,500	N/A ⁽¹⁾	6,300	21,200
2.1	3.0	25,700	N/A ⁽¹⁾	8,900	29,600

Notes: 1) The SLS condition will not govern for caissons bearing in the bedrock

The factored geotechnical resistances provided include the following factors:

- Consequence factor (Ψ) of 1.0
- Compressive geotechnical resistance factors (CHBDC Table 6.2) of $\phi_{gu} = 0.4$ and $\phi_{gs} = 0.8$ (static analysis; typical degree of understanding)



- Tensile geotechnical resistance factors (CHBDC Table 6.2) of $\phi_{gu} = 0.3$ (static analysis; typical degree of understanding), and $\phi_{gu} = 1.0$ (seismic analysis; typical degree of understanding, performance-based design)

The resistance values provided in Table 10-3 above are based on rock socket shaft friction and end bearing assuming that the walls and base of each caisson are free of loose, soft or otherwise disturbed material prior to placement of concrete. The structural resistance of the caissons must be checked by the structural designer.

Provided that the final grade at the piers is not altered significantly from the existing, downdrag forces on the pier caissons need not be applied.

10.2.2 Lateral Geotechnical Resistance

The lateral resistance for the soil adjacent to a caisson is developed on the face of the pile embedded in the foundation soils and estimated using P-y curves.

The P-y curves representing the response of the soil under static loading conditions are shown in Appendix H to allow for calculation of the *ultimate* lateral capacity of an individual caisson. Calculation of the P-y curves considered the abutment and pier pile cap underside elevations provided on the available GA drawings and as outlined above in Section 10.

Geotechnical resistance factors and consideration of group effects from adjacent structural elements should be applied, as described above in Section 10.1.3.

10.2.3 Caisson Installation

Caisson installation must be carried out in accordance with OPSS.PROV 903 where applicable.

The caisson installation equipment should be able to dislodge and remove any obstructions such as cobbles and boulders within the glacial till and to penetrate into the marble bedrock. Selection of the methods and equipment employed to install the caissons is the responsibility of the Contractor.

The caissons will extend below the groundwater table and will require temporary steel liners to stabilize the sidewall during drilling. High volumes of seepage from the water-bearing sands and silts should be anticipated into the caisson excavations. Placement of concrete using pumped tremie methods will be required and should be initiated within 6 hours of the completion of drilling and inspection of the base.

Caisson integrity testing such as cross hole sonic logging (CSL) testing or thermal integrity profiling (TIP) should also be considered during detailed design.

10.3 Drilled-In Pipe Piles

The main span and eastern span piers may be founded on steel pipe piles, drilled in and socketed into the marble bedrock.

10.3.1 Axial Geotechnical Resistance

The geotechnical axial resistances for various diameters of pipe piles socketed into sound bedrock with the bottom of the pipe pile seated on the base of the rock socket are provided in Table 10-4 below, assuming the pipes consist of 345 MPa steel with minimum 12.7 mm sidewalls.

Table 10-4: Axial Geotechnical Resistances for Drilled-In Pipe Piles at Piers

Pipe Pile Diameter (mm)	Compressive Resistance (kN per pile)	
	Factored ULS	Factored SLS
324	2,200	N/A ⁽¹⁾
356	2,600	N/A ⁽¹⁾
406	3,000	N/A ⁽¹⁾

The factored geotechnical resistances provided include the following factors:

- Consequence factor (Ψ) of 1.0
- Compressive geotechnical resistance factors (CHBDC Table 6.2) of $\phi_{gu} = 0.4$ and $\phi_{gs} = 0.8$ (static analysis; typical degree of understanding)
- Tensile geotechnical resistance factors (CHBDC Table 6.2) of $\phi_{gu} = 0.3$ (static analysis; typical degree of understanding), and $\phi_{gu} = 1.0$ (seismic analysis; typical degree of understanding, performance-based design)

The depth of the rock socket will need to satisfy lateral load demands and structural capacities which will vary based on the diameter of the tube pile but should be a minimum of 1.0 m into sound bedrock. After installation, the pipe piles should be filled with tremie concrete.

The structural resistance of the piles must be checked by the structural designer.

Provided that the final grade at the piers is not altered significantly from the existing, downdrag forces on the pier caissons need not be applied.

10.3.2 Lateral Geotechnical Resistance

The lateral geotechnical resistance of the drilled in-pipe piles may be calculated based on the recommendations provided in Section 10.1.3.

10.4 Wingwalls / Retaining Walls

Based on preliminary design documents, it is understood that the abutments will consist of foundations supported on piles. It has been assumed that slope paving inclined at 2H:1V will be provided in front of the east abutment as shown on the preliminary GA drawing. The GA drawing generally indicates that the east embankment sides will be retained by sloped embankment fill.



Following placement of the embankment fill, some post-construction settlement will occur due to the increase in effective stress in the underlying compressible clayey silt deposit.

The GA drawing indicates that retaining walls will be incorporated into the west approach. The clayey subsoils are not considered to be able to provide suitable geotechnical resistance for spread footings. Further, the settlement potential under the 9.5 m to 11 m high approach embankments would introduce excessive differential settlements between the walls and the abutments (see Section 10.8.2 for further discussion on embankment settlement). Consideration should be given to supporting retaining walls at the west abutment on driven piles to minimize the potential for differential settlement between the piled abutment and the retaining walls. Retaining wall foundations supported on driven piles should follow recommendations discussed in Section 10.1.

Alternatively, cantilevered wingwalls attached to the abutment may be considered.

10.5 Backfill and Lateral Earth Pressures

Structural backfill material should consist of Granular A or Granular B Type II meeting the OPSS.PROV 1010 and SP110S06 specifications. Large scale direct shear box testing on samples of Granular A and Granular B Type II from numerous nearby aggregate sources was completed for this project. The results indicate that for design of structural backfill for this project, an internal angle of friction of 42 and 40 degrees can be used respectively for Granular B Type II and quarry- sourced Granular A in this area provided the vertical pressure on the material is less than 150 kPa (Geocres Memorandum 31F-213). An Operational Constraint will be required in the contract restricting the source of Granular A to quarries. Throughout this report, the term “Granular A” is defined as “Quarry-Source Granular A” unless specifically described as “Pit-Source Granular A”.

The backfill must be in accordance with OPSS.PROV 902 and placed to the extents shown on OPSD 3101.150 for the abutment and wingwall/retaining walls. Structural backfill should consist of Granular A or Granular B Type II placed and compacted in accordance with OPSS.PROV 501. Heavy compaction equipment used adjacent to the walls must be restricted in accordance with OPSS.PROV 501.07.02. The design of the abutment and wingwall/retaining walls, where required, must incorporate a subdrain as shown in OPSD 3101.150. A geosynthetic drainage blanket is recommended to be placed vertically on the back wall of the abutment leading to the subdrain to enhance drainage.

Lateral earth pressure parameters provided in Table 10-5 and Table 10-6. in the sections below are based on the assumptions that the wall is vertical and the backfill is fully drained so that there are no unbalanced hydrostatic pressures above the permanent groundwater level. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in design.

Where back slopes are horizontal, the corresponding coefficients provided in Table 10-5 and Table 10-6 should be used. For other backfill and wall geometries, the appropriate earth pressure coefficients will need to be calculated once the final geometry is confirmed.

10.5.1 Static Lateral Earth Pressure

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC. Under drained conditions the lateral earth pressure is generally given by the following expression:

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

where:

σ_h	=	horizontal pressure on the wall at depth h (kPa)
K	=	earth pressure coefficient (see table below) (K_a for unrestrained walls, K_o for restrained walls)
γ	=	unit weight of retained soil (see table below), use submerged unit weight below groundwater level
h	=	depth below top of fill where pressure is computed (m)
q	=	value of 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 OPSS Granular A and OPSS Granular B Type II backfill are shown in Table 10-5.

Table 10-5 Static Earth Pressure Coefficients

Condition	OPSS Granular B Type II $\phi = 42^\circ$, $\gamma = 22.8 \text{ kN/m}^3$	Quarry Sourced OPSS Granular A $\phi = 40^\circ$, $\gamma = 22.8 \text{ kN/m}^3$	Pit Sourced OPSS Granular A $\phi = 35^\circ$, $\gamma = 22.8 \text{ kN/m}^3$
Coefficient of at Rest Earth Pressure, K_o (Restrained Wall)	0.33	0.36	0.43
Coefficient of Active Earth Pressure, K_A (Unrestrained Wall)	0.20	0.22	0.27
Coefficient of Passive Earth Pressure, K_P (Movement towards Soil Mass)	5.0	4.6	3.7

The parameters in the table correspond to full mobilization of active and passive earth pressures and require certain relative movements between the wall and adjacent soil to produce these conditions. The movement required can be assessed from Table C6.12 of the Commentary to the

CHBDC. Active earth pressures should be used for any wingwalls or unrestrained walls. For rigid structures, at-rest horizontal earth pressures would apply for design.

10.5.2 Combined Static and Seismic Lateral Earth Pressure

In accordance with Clause 6.14.7.2 of the CHBDC, retaining structures should be designed using dynamic earth pressure coefficients that incorporate the effects of earthquake loading. The following recommendations are per Section C6.14.7.2 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using the Mononobe-Okabe Method with:

- $k_h = \frac{1}{2} * F(PGA) * PGA$, for structures that allow 25 to 50 mm of movement, and
- $k_h = F(PGA) * PGA$, for non-yielding walls

The coefficients of horizontal earth pressure for combined static and seismic loading presented in Table 10-6 may be used. The provided earth pressure coefficients are based on a 1 in 2,475-year, site-adjusted (Site Class D) PGA of 0.26 g, as described previously in Section 8.

Table 10-6 Combined Static and Seismic Earth Pressure Coefficients

Condition	OPSS Granular B Type II	Quarry Sourced OPSS Granular A	Pit Sourced OPSS Granular A
	$\phi = 42^\circ$, $\gamma = 22.8 \text{ kN/m}^3$	$\phi = 40^\circ$, $\gamma = 22.8 \text{ kN/m}^3$	$\phi = 35^\circ$, $\gamma = 22.8 \text{ kN/m}^3$
Coefficient of Active Earth Pressure, K_{AE} (Restrained Wall)	0.34	0.37	0.44
Coefficient of Active Earth Pressure, K_{AE} (Unrestrained Wall)	0.26	0.28	0.35

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, use submerged unit weight below groundwater level
K_{AE}	=	combined static and seismic earth pressure coefficient
H	=	total height of the wall (m)



10.6 Frost Depth

The depth of frost penetration at this site is estimated to be 1.9 m (as per OPSD 3090.101). Footings and pile caps for the abutments and retaining walls should be founded at or below this depth or provided with equivalent insulation.

10.7 Existing Riverbank Stability

As described in the original foundation investigation and design report for the existing bridge (Geocres 31F-018), natural slope failures have been observed along the river valley, with significant portions of the existing riverbank slopes in a state of limiting equilibrium. The localized failures have been described as ranging in size from minor slumps to major slide failures.

Slope stability assessment of the existing riverbank slopes were carried out using GeoStudio 2020 Slope/W software for limit equilibrium analysis. Input parameters for the embankment fill and foundation soils for the analysis are based on the SPT N-values, shear vane test results, observations in the field, and the results of laboratory testing. A summary table of soil parameters are shown on the stability analyses output figures provided in Appendix I.

The existing riverbank slope at Sta. 20+085 (Section B-B' on Drawing I1), near the proposed western span pier (Pier 1), naturally sloped at about 1.8H:1V, was analyzed. The results of the stability analyses indicate a Factor of Safety of about 1.3 (Figure I1.1).

The riverbank slope at the proposed east abutment (Sta. 20+371) is naturally sloped as steep as about 1.9H:1V and was also analyzed. The results of the stability analyses indicate a Factor of Safety of about 1.4 (Figure I1.2), indicating similar natural slope condition. The stability of the east embankment and foreslope, considering the earth cut extending from the top of the natural riverbank slope to the east, is further discussed in Section 10.8.1.3, below.

Our analyses of the existing riverbank slopes on the proposed bridge alignment at approximate Sta. 20+085 similarly indicate that existing slopes have Factors of Safety of 1.3 to 1.4 and have shown visual signs of instability. Our analyses further indicated that, due to the geometry of the existing terrain and skew to the proposed bridge alignment, the west abutment would have to be set back to approx. Sta. 20+038 to construct a conventional SSM embankment. Additional comments on the setback distance for the west abutment are provided in Section 10.8.1.1 below.

10.8 Embankment Fill

10.8.1 Embankment Stability

Slope stability assessment of the proposed bridge approach embankments were carried out using the methodology described above (Section 10.7).

Table 6.2 of Section 6.9.1 of the CHBDC requires minimum Factors of Safety of 1.5 and 1.3 for embankments in permanent and temporary static conditions, respectively, for a typical degree of understanding and a Ψ of 1.0. MTO policy MERO #2020-01 allows for some adjustment to the



geotechnical resistance factors upon approval by MTO. Based on MERO #2020-01, the target Factors of Safety for this site would be 1.43 and 1.25 for permanent and temporary conditions, respectively.

For seismic analysis, Table 6.3 in Section 6.14.4.1 of the CHBDC indicates a minimum resistance factor of 0.95 ($\phi_{gu, static(temporary)} = 0.75 + 0.2$) for force-based design and 1.0 for performance-based design. Based on these values and Ψ of 1.0, a target Factor of Safety of 1.1 for this temporary condition with a typical degree of understanding is appropriate for the pseudo-static seismic analysis. However, as is stated in Section 6.14.9.1 of the CHBDC, some embankment displacement can occur where the pseudo-static Factor of Safety is less than 1.3; in this case, the bridge foundations must be designed to withstand the permanent deformations and/or slope stabilizing measures shall be incorporated into the design. Where the pseudo-static Factor of Safety is greater than 1.3, the slope is considered to be seismically stable with deformations of less than 50 mm.

In addition, Sections 6.14.2.1 and 6.14.2.3 of the CHBDC present performance criteria requirements for Major Route geotechnical systems (embankments) inside and outside the bridge interface zone, respectively. Based on Clause 6.14.2.2, the bridge interface zone at this site extends to 20 m behind the west abutment (based on a fill height of up to about 9.2 m) and 24 m behind the east abutment (based on a fill height of up to about 11.8 m). The performance criteria for the Major Route embankments are as follows:

- Within the bridge interface zone (bridge approaches): 100% of the travelled lanes shall be available for use following a ground motion event with a return period of at least 475 years.
- Outside the bridge interface zone (beyond bridge approaches): sites that fall within Seismic Performance Category 2 or 3 (See Section 8.3) shall have at least 50% of travelled lanes, but not less than one, available for use following ground motions with a return period of at least 475 years.

The stability analyses considered site-adjusted (Site Class D) design PGA values of 0.26 g and 0.10 g for ground motions with return periods of 2,475 and 475 years, respectively, as per Section 4.4.3.2 of the CHBDC.

Based on the preliminary design profiles and general arrangement drawings available at the time of preparation of this report, the proposed road grade at the east abutment is to be at about Elevation 110.3 m. The proposed road grade at the west abutment (Sta. 20+038) is about Elevation 112.4 m. Embankment fill of up to about 11.8 m high above the existing ground surface at the east abutment and 9.2 m above the existing ground surface at the west abutment (Sta. 20+038) will be required.

Slope stability assessments of the proposed critical abutment embankment slopes have been carried out, initially considering two different embankment materials: Select Subgrade Material (SSM) and compacted rock fill. It is noted that fill geometry typically includes a 2 m wide bench for earth or granular fills equal to or greater than 8 m in height. The locations of the critical embankment slope sections discussed herein are shown on Drawing I1, included in Appendix I.



Since a multitude of slopes sections were assessed, those not directly relevant to the recommendations presented below have been omitted from the report for brevity.

The following additional parameters were used in the analysis:

- Soil stratigraphy was based on the nearest boreholes.
- Maximum embankment fill heights of 11.8 m at the east abutment (Sta. 20+371) and 9.2 m (Sta. 20+038) at the west abutment were considered.
- Side slopes of 2H:1V for OPSS Select Subgrade Material (SSM) fill and 1.25H:1V for rock fill were modelled.
- Mid-height 2 m wide benches were used for conventional SSM slopes greater than 8 m in height (OPSD 202-010).
- A design groundwater level at Elevation 84.0 m.
- Site-adjusted horizontal PGA values of 0.13 g and 0.05 g, equal to $\frac{1}{2}$ of the site-adjusted horizontal PGA values were used for the 2,475-year and 475-year seismic analyses, respectively, as per Section 4.4.3.3 of the CHBDC and outlined in Sections 8.1 and 8.2 above.
- A traffic surcharge of 17 kPa has been applied as a temporary load, where appropriate.

Copies of the output from the stability analyses are provided on the figures presented in Appendix I. Each output figure shows the slope geometry, groundwater conditions, soil stratigraphy and soil strength parameters utilized in the analysis.

10.8.1.1 West Embankment

Stability analyses were carried out for the embankment side slopes at the proposed west abutment (Sta. 20+038, Section I-I' on Drawing I1). The stability analyses considered the west abutment constructed atop the critical slope (roughly perpendicular to the highway alignment). The factor of safety values generated are presented in the table below:

Table 10-7 Slope Stability Analysis Results – West Embankment Side Slopes (Sta. 20+038)

Condition	Case	Factor of Safety	
		2H:1V [SSM]	1.25H:1V [Rock Fill]
Permanent	Long Term (Drained)	1.5 (Fig I2.1)	1.6 (Fig I3.1)
Temporary (traffic loading)	Short Term (Undrained)	1.6 (Fig I2.2)	1.7 (Fig I3.2)
Temporary (seismic loading)	Pseudo-Static (Undrained) 2,475-year	1.2 (Fig I2.3)	1.3 (Fig I3.3)
	Pseudo-Static (Undrained) 475-year	1.4 (Fig I2.4)	n/a

The results of the static design analyses (temporary/traffic and permanent conditions) presented above for the west embankment, constructed with conventional SSM or rock fill at Sta. 20+038, meet or exceed the target Factors of Safety. However, it should be noted that the southern embankment toes constructed at Sta. 20+038 with SSM extended beyond the existing southern right-of-way limit (Figures I2.1 to I2.4). If the right-of-way cannot be widened to accommodate, a retaining structure at the embankment toe would be required.

The results of the associated seismic analyses meet or exceed the target Factor of Safety for seismic design for the 2475-year seismic event. All pseudo-static analyses yielded factors of safety values equal to or greater than 1.3, with the exception of the west abutment constructed at Sta. 20+038 with SSM fill (Figure I2.3), which yielded a factor of safety of 1.2. Additional analyses were carried out for that case to determine if performance criteria would be met for the Major Route geotechnical systems inside and outside the bridge interface zone. Pseudo-static analyses considering the 475-year earthquake event were completed and yielded a factor of safety of 1.4 for the west abutment at that location (Figure I2.4) indicating that the performance requirements would be met for that scenario.

The setback distance for the west abutment could be reduced by lowering of the highway grade and associated approach embankment heights or reducing embankment load by constructing with lightweight fill such as EPS or Lightweight Cellular Concrete.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankments. Normally slope vegetation should be established as soon as possible after completion of embankment construction to control surficial erosion in general accordance with OPSS.PROV 804.

10.8.1.2 Western Span Pier (Pier 1)

The GA drawing indicates that the western span pier is to be constructed at about Sta. 20+080 with underside of pile cap elevation of about 97.5 m. As outlined above in Section 10.7, stability analyses of the natural riverbank slope in this area were carried out and gave a long-term, static Factor of Safety of about 1.3 (Figure I1.1).

Further analysis of the slope indicated that the existing slope at this location would achieve acceptable Factors of Safety greater than 1.5 with a surface inclination of about 2.2H:1V or shallower. The factor of safety values generated from slope stability analyses carried out at the approximate location of the western span pier, considering a section perpendicular to the adjacent riverbank slope (Section B-B' on Drawing I1) are presented below in Table 10-8.

Flattening of the slope will reduce the final grade at the crest of the slope and may influence the acceptable design depth of the pier pile cap to accommodate frost protection requirements (see Section 10.6).

Table 10-8 Slope Stability Analysis Results – West Bank, near Pier 1 (Sta. 20+085)

Condition	Case	Factor of Safety
		2H:1V [SSM]
Permanent	Long Term (Drained)	1.5 (Fig I4.1)
Temporary (with no traffic loading)	Short Term (Undrained)	2.4 (Fig I4.2)
Temporary (seismic loading)	Pseudo-Static (Undrained) 2,475-year	1.6 (Fig I4.3)
	Pseudo-Static (Undrained) 475-year	n/a

10.8.1.3 East Embankment

The factor of safety values generated from slope stability analyses carried out at the proposed east embankment, considering a section parallel to the abutment face (Section C-C' on Drawing I1) and a section perpendicular to the abutment face (Section D-D') are presented below in Table 10-9 and Table 10-10, respectively. If the east approach embankment is constructed with SSM fill and 2H:1V side slopes, the southern toe would require a retaining wall to limit encroachment beyond the southern limit of the right-of-way (Figures I5.1 to I5.3).

The results of the static design analyses (temporary/traffic and permanent conditions) presented for the east embankment meet or exceed the target Factors of Safety.

The results of the associated seismic analyses meet or exceed the target Factor of Safety for seismic design for the 2475-year seismic event. All pseudo-static analyses yielded factors of safety values equal to or greater than 1.3, with the exception of the east abutment foreslope (Figures I7.3 and I8.3).

Additional analyses were carried out for these cases to determine if performance criteria would be met for the major route geotechnical systems inside and outside the bridge interface zone. Pseudo-static analysis considering the 475-year earthquake event were completed and yielded a factor of safety of 1.3 for the east abutment with rock fill embankment (Figure I8.4) indicating that the performance requirements would be met for that scenario.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankments. Normally slope vegetation should be established as soon as possible after completion of embankment construction to control surficial erosion in general accordance with OPSS.PROV 804.

Table 10-9 Slope Stability Analysis Results – East Embankment Side Slopes (Sta. 20+371)

Condition	Case	Factor of Safety	
		2H:1V [SSM]	1.25H:1V [Rock Fill]
Permanent	Long Term (Drained)	1.6 (Fig I5.1)	1.6 (Fig I6.1)
Temporary (traffic loading)	Short Term (Undrained)	1.7 (Fig I5.2)	1.8 (Fig I6.2)
Temporary (seismic loading)	Pseudo-Static (Undrained) 2,475-year	1.3 (Fig I5.3)	1.4 (Fig I6.3)
	Pseudo-Static (Undrained) 475-year	n/a	n/a

Table 10-10 Slope Stability Analysis Results – East Abutment Foreslope (Sta. 20+371)

Condition	Case	Factor of Safety	
		2H:1V [SSM]	1.25H:1V [Rock Fill]
Permanent	Long Term (Drained)	2.3 (Fig I7.1)	2.3 (Fig I8.1)
Temporary (traffic loading)	Short Term (Undrained)	1.3 (Fig I7.2)	1.4 (Fig I8.2)
Temporary (seismic loading)	Pseudo-Static (Undrained) 2,475-year	1.1 (Fig I7.3)	1.2 (Fig I8.3)
	Pseudo-Static (Undrained) 475-year	1.2 (Fig I7.4)	1.3 (Fig I8.4)

10.8.2 Embankment Settlement

Construction of the new East Bound Lanes (EBL) will require placement of significant thicknesses of embankment fill. Based on the preliminary design profiles and general arrangement drawing available at the time of preparation of this report, the proposed approach embankments will be as high as 9.2 m near the west abutment (at Sta. 20+038) and 11.8 m near the east abutment (at Sta. 20+371).

The loading imposed from the new fill will increase the effective stress in underlying soil deposits and induce settlement in the compressible silty clay to clayey silt layers. Settlement analyses were carried out using the software Settle3 (Version 5) by Rocscience and/or by manual calculation considering a Boussinesq stress distribution with depth.

In accordance with MTO's document "Embankment Settlement Criteria for Design" (March 2, 2010), the criteria adopted for embankment design at this site is as follows:

Table 10-11. Summary of MTO Settlement Criteria

Distance from Abutment	0-20 m	20-50 m	50-75 m	>75 m	Post Construction Settlement Period
Settlement Limits Non-Freeway	25 mm	50 mm	100 mm	200 mm	15 years

Representative site stratigraphy near the abutments were developed based on the Record of Borehole logs with material properties based on the results of in-situ field testing and laboratory testing. The design stratigraphy considered material parameters of the weathered crust and underlying unweathered portions on the silty clay to clayey silt deposit based on laboratory and in-situ test results. The material parameters of the lower, cohesionless layers were estimated based on in-situ test results and engineering judgement and experience.

Based on the measured groundwater levels at the borehole and CPT locations, the design groundwater level was taken to be at the approximate river level at Elevation 84.0 m.

Preconsolidation pressure and its variation with depth for each compressible stratum was estimated based on the consolidation test results (see Section 5.3 and Appendix C and Appendix D) and interpretation of the data collected during advancement of the CPTs. Primary consolidation settlement parameters were estimated based on the results of the consolidation tests. The coefficients of consolidation to determine settlement rate were estimated based on the results of the consolidation tests and the results of the pore water pressure dissipation (PPD) tests carried out during advancement of the CPTs considering a c_h/c_v ratio of 1.3 for the marine deposit (Lerouil and Jamilkowski, 1991)ⁱⁱⁱ.

The soil parameters used in the west and east embankment models for the new EBL are summarized below in Table 10-12 and Table 10-13, respectively.

Table 10-12 Summary of Material Parameters – West Embankment new EBL

Soil Type	Thickness (m)	Unit Weight (kN/m ³)	Settlement Parameters				
			P _c ' (kPa)	Primary			
				C _c	C _r	C _v (cm ² /s)	C _{vr} (cm ² /s)
Silty Clay (Crust)	5.7 – 6.1	17.5	450	0.80	0.05	0.001	0.020
Clayey Silt	6.4 – 14.7	17.5	450 to 400	0.45	0.06	0.01	0.012
Silty Sand to Clayey Silt	2.6 – 10.5	18.0	E _s = 12 MPa				
Silty Sand (Till)	18.7 – 24.8	21.0	E _s = 65 MPa				

Table 10-13 Summary of Material Parameters – East Embankment new EBL

Soil Type	Thickness (m)	Unit Weight (kN/m ³)	Settlement Parameters
Silty Clay (Crust)	2.3	17.5	$E_s = 50 \text{ MPa}$
Silty Sand	5.3	18.0	$E_s = 15 \text{ MPa}$
Sand and Gravel (Till)	9.0	21.0	$E_s = 80 \text{ MPa}$

Analyses were carried out to calculate the predicted settlement with time, considering SSM embankments inclined at 2H:1V with a unit weight of 21 kN/m³, and rock fill embankments inclined at 1.25H:1V with a unit weight of 20 kN/m³, constructed with thicknesses of up to 9.2 m and 11.8 m at the west and east abutments of the new EBL. Though the design static groundwater table is generally below the compressible silty clay to clayey silt deposits within the footprint of the west embankment, the settlement models considered the excess porewater pressures generated within these fine-grained layers from the embankment fill loading.

The results of the settlement analyses are summarised below in **Error! Reference source not found..**

At the west embankment of the new EBL, the values include up to about 45 mm of elastic settlement in the lower silty sand and sand and gravel layers. The elastic settlement would occur almost immediately, and the consolidation settlement in the silty clay would occur over time, with 90% of the primary settlement occurring within about 6 months. The compressible silty clay to clayey silt deposits will continue to settle following completion of the primary settlement. The results of the settlement analyses indicated that an *additional* 40 mm of secondary consolidation settlement is expected to occur at the abutments over a post-construction settlement period of 15 years, which exceeds the limits set out above in Table 10-11.

At the east embankment of the new EBL, the settlement is expected to be elastic in nature and occur within the construction period of the embankment, prior to construction of the superstructure.

Table 10-14 Embankment Settlement Analysis Summary

Location on new EBL	Maximum Estimated Embankment Settlement (mm)							
	2H:1V [SSM]				1.25H:1V [Rock Fill]			
	Elastic	Primary	Secondary	Total	Elastic	Primary	Secondary	Total
West Emb. (Sta. 20+038)	45	165	40	250	40	155	35	230
East Emb. (Sta. 20+371)	70	-	-	70	60	-	-	60



Should the abutment piles be driven prior to construction of the embankments, downdrag loads will be subsequently imposed on the abutment piles, as discussed in Sections 10.1 and 10.4. Depending on the project schedule and sequencing of embankment and foundation construction, preloading (pre-constructing) the embankments prior to constructing the structure or retaining walls is recommended.

In addition to the settlement described above, there will be self-compression of the embankment material itself. For embankments constructed with compacted rockfill the short term settlement will be approximately 100 mm (up to 1 year after completion of construction with 90% of this value occurring in the first six months). In addition, rockfill embankments continue to settle after the first year with an estimate of an additional 15 mm. Similarly, an embankment constructed of SSM material will undergo approximately 50 to 100 mm of self settlement with the majority of that complete within the one year of completion of construction. Embankments must be overbuilt to compensate for the estimated settlement.

Construction of the embankments with lightweight fill (such as Expanded Polystyrene, EPS, or Lightweight Cellular Concrete) would reduce the imposed load on the underlying soil at the site and, therefore, reduce the anticipated settlement of the embankments. This could also be achieved by lowering the highway grade and associated approach embankment height. Alternatively, construction staging can be designed to include a delay to allow settlement to occur (preloading, preloading combined with surcharging, installation of vertical drains, ground improvement). Selection of the construction methodology should be within the purview of the preferred proponent. Regardless of the technique, monitoring of the embankments during construction would be required to determine the actual rate and magnitude of settlement of the embankment. A suitable settlement monitoring program will be required.

Settlements along the existing WBL induced by the construction of the proposed west approach of the new EBL are expected to be less than 40 mm at the existing embankment crest and less than 10 mm at the existing WBL west abutment. These settlements are not anticipated to be an issue for the existing WBL west approach embankment and abutment, but should be verified at a subsequent design stage following selection of the technically preferred alternative.

10.9 Earth Cuts

Beyond an approximately 30 m long fill section near the east abutment, the east approach of the new EBL will require earth cuts to achieve the proposed design grades. Cuts deeper than 4.5 m will be required between about Station 20+400 and 20+450. The natural ground in the vicinity of the cut, slopes nominally up to the south, resulting in overall total slope heights of up to about 7.4 m considering cut slopes of 2H:1V, with the cut slope daylighting approximately 25 m south of the proposed centreline.

Slope stability assessments of the earth cut slopes at their deepest (about Sta. 20+441) have been carried out using GeoStudio 2020 Slope/W software for limit equilibrium analysis. Input parameters for the analysis are based on the SPT N values, shear vane test results, and the results of laboratory testing. A summary table of soil parameters are shown on the stability

analyses output figures provided in Appendix I. The following additional parameters were used in the analysis:

- Soil stratigraphy was based on the nearest boreholes.
- Existing ground contours were based on latest available topographic information.
- Cut slopes of 2H:1V were modelled.
- Maximum cut depth of 6.4 m at the proposed centreline and 7.4 m at the final slope toe.
- A design groundwater level at Elevation 84.0 m (below the elevation of influence of the model) based on the results from monitoring of the two piezometers installed in the area.
- A site-adjusted horizontal PGA value of 0.13 g, equal to $\frac{1}{2}$ of the site-adjusted horizontal PGA value was used for the 2,475-year seismic analyses, as per Section 4.4.3.3 of the CHBDC and outlined in Sections 8.1 and 8.2 above.
- A traffic surcharge was not included in the analyses as there will be no traffic at the top of the cut slopes.

Copies of the output from the stability analyses are provided on the figures presented in Appendix I. Each output figure shows the slope geometry, groundwater conditions, soil stratigraphy and soil strength parameters utilized in the analysis. The stability analyses generated the following factor of safety values:

Table 10-15 Slope Stability Analysis Results – EBL East Approach Embankment Cut (Sta. 20+441)

Condition	Case	Factor of Safety
		2H:1V
Permanent	Long Term (Drained)	1.6 (Fig I9.1)
Temporary	Short Term (Undrained)	4.5 (Fig I9.2)
Temporary (seismic loading)	Pseudo-Static (Undrained) 2,475-year	3.1 (Fig I9.3)

The results of all static design analyses (temporary and permanent conditions) presented above meet or exceed the target Factors of Safety. The result of the seismic analysis exceeds the target Factor of Safety for seismic design for the 2475-year seismic event.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankments. Normally slope vegetation should be established as soon as possible after completion of embankment construction to control surficial erosion in general accordance with OPSS.PROV 804. Inclusion of an interceptor ditch at the top of the slope would also minimize the impact of overland flow on the slopes.



10.10 Cement Type and Corrosion Potential

Chemical analysis for determination of pH, water soluble sulphate, sulphides, chloride concentrations, resistivity and electrical conductivity was carried out on samples of the native silty clay soil. The analysis results are summarized in Section 5.9 and a copy of the test results is provided in Appendix C.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The test results provided in Section 5.9 were compared with Table 3.2 of the MTO Gravity Pipe Design Guideline and generally indicated a very low corrosive environment with the exception of one test carried out on a soil sample from Borehole BON-P1 which indicated a moderately corrosive environment. The test results provided in Section 5.9 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with the soil and groundwater at the site. The sulphate results were compared with Table 3 of Canadian Standards Association Standards A23.1-19 (CSA A23.1) and indicate a low degree of sulphate attack potential on concrete structures at this site.

The corrosive effects of road de-icing salts should also be considered.

11 CONSTRUCTION CONSIDERATIONS

11.1 Temporary Excavations

All temporary excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of OHSA, silty clay, clayey silt, or silty sand present above the groundwater table and the native stiff silty clay to clayey silt may be classified as Type 3 soil. Silty clay, clayey silt, or silty sand present below the water table should be classified as Type 4 soil. **Side slopes for excavations through more than one soil type must be entirely based on the highest soil type number.** Unsupported excavations in Type 4 soil must have side slopes no steeper than 3H:1V from the base of the excavation if no dewatering is employed. Unsupported excavations made in Type 3 soils must have side slopes no steeper than 1H:1V from the base of the excavation. However, the stability of temporary excavations may decrease with depth and must be assessed.

Excavations for the pile caps must be carried out in accordance with OPSS.PROV 902 and will extend into the silty clay/clayey silt at the abutments and western span pier, and into or through the underlying silty sand to clayey silt at the main span piers, and into the underlying sand at the eastern span pier. Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor. Stockpiling or surface surcharge should not be allowed on the embankment or side slopes.

Based on the proposed pile cap elevations, excavation at all pier locations may extend below the groundwater/river level and will require water-tight temporary shoring to limit the ingress of water



into the excavations. If there are space restrictions at the abutment locations or where a slope must be retained, those excavations will also need to be carried out within a protection system. Further discussion on temporary protection systems (TPS) and groundwater control are presented below in Sections 11.2 and 11.3, respectively.

11.2 Temporary Protection Systems

Temporary Protection Systems (TPS) could be used for excavation support or groundwater control, they must be implemented in accordance with OPSS.PROV 539 and designed for Performance Level 2. The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system. The protection system should be installed at a suitable distance away from the new structures to limit the disturbance to subgrade associated with removal of the protection system following completing of construction. Alternatively, the protection system near the structures could be left in place and cut off in accordance with OPSS.PROV 903 to limit the disturbance of subgrade during removal of the TPS.

Lateral earth pressure coefficients, under fully mobilized conditions, that can be used in design for the structural backfill are provided in Table 10-5. The lateral earth pressure coefficients for the underlying native soils are given below for a vertical wall and a horizontal backslope:

Native Cohesive Silty Clay (CI) to Clayey Silt (CL):

$$\begin{aligned}\gamma &= 17.5 \text{ (kN/m}^3 \text{ bulk unit weight of soil, to be adjusted below water)} \\ S_u &= 75 \text{ kPa}\end{aligned}$$

Non-cohesive Silty Sand to Clayey Silt (CL-ML, ML):

$$\begin{aligned}\gamma &= 18.0 \text{ (kN/m}^3 \text{ bulk unit weight of soil, to be adjusted below water)} \\ K_A &= 0.33 \\ K_P &= 3.0 \\ K_o &= 0.50\end{aligned}$$

Silty Sand and Gravel:

$$\begin{aligned}\gamma &= 20.0 \text{ (kN/m}^3 \text{ bulk unit weight of soil, to be adjusted below water)} \\ K_A &= 0.31 \\ K_P &= 3.3 \\ K_o &= 0.47\end{aligned}$$

If the backslope behind, or if the ground surface in front of the temporary protection systems is not horizontal, the lateral earth pressure parameters provided above do not apply and recalculation of the earth pressure parameters will be required.

Based on the anticipated depth of excavation and subsurface conditions at the site, it is anticipated that a TPS consisting of steel sheet piles or soldier piles and lagging driven to depth



within the native silty clay and silty sand to clayey silt deposit are feasible. The presence of cobbles and boulders in the sand and gravel deposit may impede the penetration of sheet piles, particularly at Pier 3, and should be considered in the design of the temporary protection system.

A more robust, water-tight protection system such as interlocking sheet piles or secant walls will be required at the piers where excavation for the pile caps extend below the groundwater/river level.

The design of temporary protection systems is the responsibility of the Contractor. All protection systems should be designed by a licensed Professional Engineer experienced in such designs and retained by the Contractor. The design of the protection systems must incorporate traffic loading and surcharge loading due to construction equipment and operations.

11.3 Surface and Groundwater Control

Foundation construction, subgrade preparation and placement and compaction of granular bedding must be carried out in the dry. The groundwater elevation at the site is anticipated to be controlled by the natural river level, which is at about Elevation 84.0 m. At the abutments, the pile caps are to be constructed at significantly higher elevation (proposed undersides at Elevations 99.7 m and 98.0 m). Significant groundwater inflow is not expected, but surface runoff will tend to seep into and accumulate into the excavations. The Contractor must control groundwater, perched groundwater, and surface water flow at the abutment locations to permit the construction of the pile caps in a dry and stable excavation.

At the main span and eastern span piers, the pile caps are to be constructed at elevations ranging from 83.4 m to 82.0 m. Depending on the groundwater and river level at the time of construction, excavations required to construct the pier pile caps may extend to as much as 3 m below the groundwater level. Due to the proximity to the river, the excavations for the main span piers in particular are expected to have a significant groundwater inflow, requiring a water-tight shoring system to limit the inflow from the sides and bottom of the enclosure. A sheet pile cofferdam is considered to be a feasible option and should be designed with a depth to eliminate the potential for basal heave.

It is noted that a Hydrogeological Investigation and Design Report is under preparation for the Highway 17 Trinning Project. Please refer to that document for additional discussion on groundwater impacts and dewatering with respect to this assignment.

The design of dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP 517F01 which amends OPSS.PROV 517. The contractor's design should include an assessment of any adverse effects the dewatering method, construction layout and staging may have on adjacent structures, utilities and facilities. Given the site conditions (potential for bottom heave from underlying silty sand) and anticipated works (excavating to more than 3 m below groundwater level), the Designer Fill-In (Note 2) in SP 517F01 Table 1 should be "Yes" for dewatering systems; the design Engineer and design-checking Engineer need a minimum of 5 years of experience in designing similar dewatering systems. A preconstruction survey is not



recommended; thus, Designer Fill-In Note 4 in this SP should be “N/A”. Based on the groundwater elevation at the time of the investigation, it is anticipated that the site will require dewatering to lower the groundwater to below the final excavation or footing level; Note 5 of SP 517F01 Table 1 should be 0.5 m but will need to be confirmed by the designer of the dewatering system.

The dewatering plan should be coordinated with TPS design. The dewatering system will be required to remain operational and effective until the temporary excavations are backfilled and then should be decommissioned and removed.

Further assessment of dewatering requirements and the need for registration on the Environmental Activity and Sector Registry (EASR) or a Permit to take Water (PTTW) should be carried out by specialists experienced in this field.

Please refer to Hydrogeological Investigation and Design Report for additional discussion on dewatering with respect to this assignment.

11.4 Scour and Erosion Control

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the earth and granular embankment slopes. A vegetation cover should be established on exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804. Slope vegetation should be established as soon as possible after completion of the embankment fills in order to limit surficial erosion. Particle size analysis on samples of the existing silty clay to clayey silt at the east approach cut indicate that they may be considered to have a low to moderate potential for erosion (based on Wischmeier Nomograph factor, K, ranging from 0.18 to 0.30).

Effective erosion protection should be provided on all exposed slopes including approach embankments and the slopes cut into native soil along east approach.

Due to their proximity to the active river channel in the base of the overall river valley, suitable scour protection should be provided at the pier locations. Further assessment of the potential impacts of river scour on the piers and surrounding soil and design of suitable protection measures should be carried out by specialists experienced in this field. The Preferred Proponent should engage a Hydraulics Engineer to complete the scour design. The design should be reviewed by the Preferred Proponent’s Bridge Engineer and Foundation Engineer.

12 DESIGN AND CONSTRUCTION CONCERNS

The preliminary recommendations presented herein must be reassessed once the type, location, elevation and orientation of the works are established.

The seismic hazard data considered for the preliminary design recommendations provided in this report were obtained from the fifth-generation seismic model developed by the Geological Survey of Canada (GSC). Additional seismic analyses will be required to reflect the reference seismic hazard available at the time of detailed design.



The DB Contractor must review the existing factual information and determine the extent of additional field investigations and laboratory testing required to support the foundation design of the proposed works. Of particular note, further review of the potential for liquefaction of the native soils near Piers 1 and 2 should be completed with a site-specific evaluation. If liquefaction potential is confirmed, the feasibility of treating the soils should be considered.

Depending on the selected embankment fill material and geometries, the approach embankment footprints will extend beyond the existing southern right-of-way limit. Further review and assessment of the stability of the embankments and requirement for retaining walls at the embankment toes should be carried out following any relevant property acquisitions and confirmation of the final right-of-way limits.

The planned construction methodology includes open cut excavations for the construction of foundation elements at the abutments and piers, excavations near and below the active river channel at the piers, high fills for the approach embankments, and significant cuts for the east approach. Potential construction concerns include, but are not necessarily limited to:

- The Contractor's selection of construction equipment and methodology must include assessment of the capability of the existing soils to support the proposed construction equipment and supplies.
- Stability of the west bank at the selected west abutment location. Construction methods must not destabilize the valley slopes.
- Control of groundwater during excavation for construction of the pier pile caps.
- Settlement of the approach embankments under the increased load from the high fills.
- Lightweight fill should be considered within the higher portions of the embankments to reduce the magnitude of settlement resulting from embankment construction, depending on the selected west abutment location.
- Pile driving at the abutments should be carried out following embankment construction.
- Refusal of the piles at various depths within the glacial till, resulting in variable pile lengths.

The successful performance of the structure installations will depend largely upon good workmanship and quality control during construction. Observation of the excavation and backfilling operations will be required during construction as per OPSS.PROV 902 to confirm that the foundation recommendations are correctly implemented, and material specifications are met.

13 RECOMMENDATIONS FOR ADDITIONAL WORK

The recommendations provided above are in support of the preliminary design of the proposed eastbound Highway 17 bridge over the Bonnechere River, as part of the overall Highway 17



twinning design project. Depending on the final technically preferred alternative design carried forward, additional foundation investigation and design input will be required at subsequent design stages, including:

- Additional investigation (such as seismic CPT, VSP, etc.) and site-specific ground response analysis as input to the liquefaction assessment to provide a more detailed evaluation of the seismic site class and the liquefaction potential at the pier locations.
- Additional boreholes at the final foundation element locations to verify the variable and sloping bedrock at the site and to establish impact on design lengths for pile and/or caisson foundations.
- Additional boreholes with sufficient sampling to allow additional consolidation testing of the compressible silty clay to clayey silt at the site.
- Evaluation of the impact of the new construction on the stability of the foreslope of the west abutment of the existing bridge.
- Driving test pile(s) and load testing should be considered to provide more information on anticipated pile refusal depths and design loads.
- Development and implementation of monitoring programs will be required for preload/surcharge programs.

The required supplementary foundation field investigation and design input should be reviewed at a subsequent design stage following selection of the technically preferred alternative design.



14 CLOSURE

Engineering analysis and preparation of this report was carried out by Matt Kennedy, P.Eng., and Dr. Fred Griffiths, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.
Report Prepared By:



Matt Kennedy, M.Sc.(Eng.), P.Eng.
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Senior Geotechnical Engineer,
Principal



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



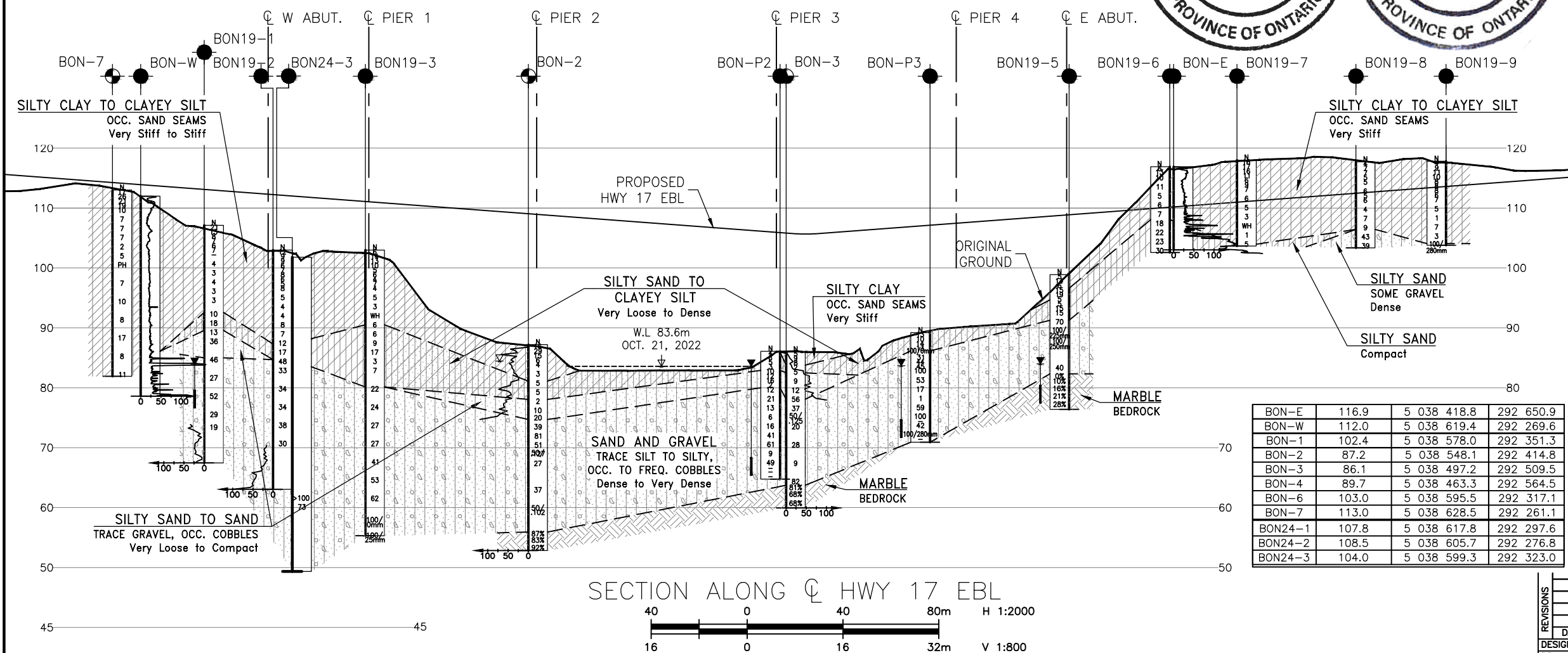
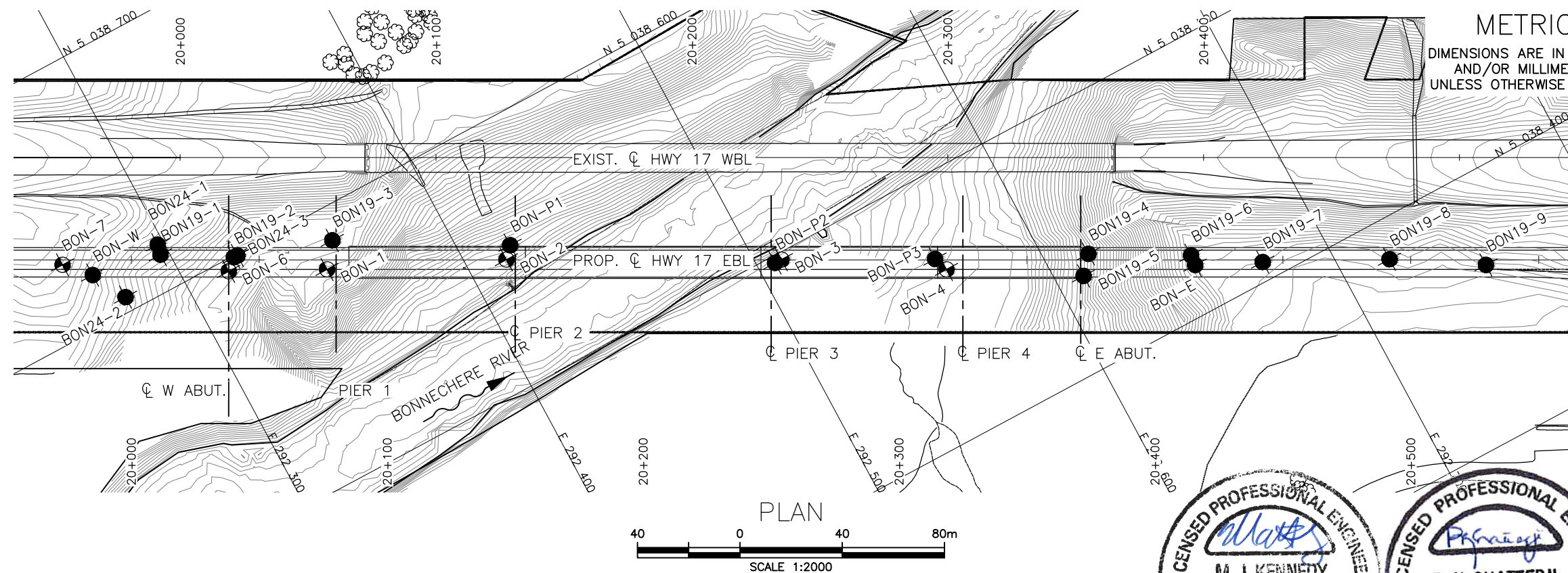
REFERENCES

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- ⁱ Boulanger, R. W. and Idriss, I. M. (2007). Evaluation of cyclic softening in silts and clays, ASCE, Journal of Geotechnical and Geoenvironmental Engineering, 133(6), 641-652.
- ⁱⁱ Boulanger, R. W., and Idriss, I. M. (2014). CPT and SPT based liquefaction triggering procedures, Report No. UCD/CGM-14/01, Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, CA, 134 pp.
- ⁱⁱⁱ Leroueil, S., Jamiolkowski, M. (1991). Exploration of soft soil and determination of design parameters, Proceedings, GeoCoast, Vol. 2, Port & Harbor Res. Institute, 969-998.



Appendix A.






Borehole Location Plan and Stratigraphic Drawing



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BON-W	112.0	5 038 619.4	292 269.6
BON-1	102.4	5 038 578.0	292 351.3
BON-2	87.2	5 038 548.1	292 414.8
BON-3	86.1	5 038 497.2	292 509.5
BON-4	89.7	5 038 463.3	292 564.5
BON-6	103.0	5 038 595.5	292 317.1
BON-7	113.0	5 038 628.5	292 261.1
BON24-1	107.8	5 038 617.8	292 297.6
BON24-2	108.5	5 038 605.7	292 276.8
BON24-3	104.0	5 038 599.3	292 323.0

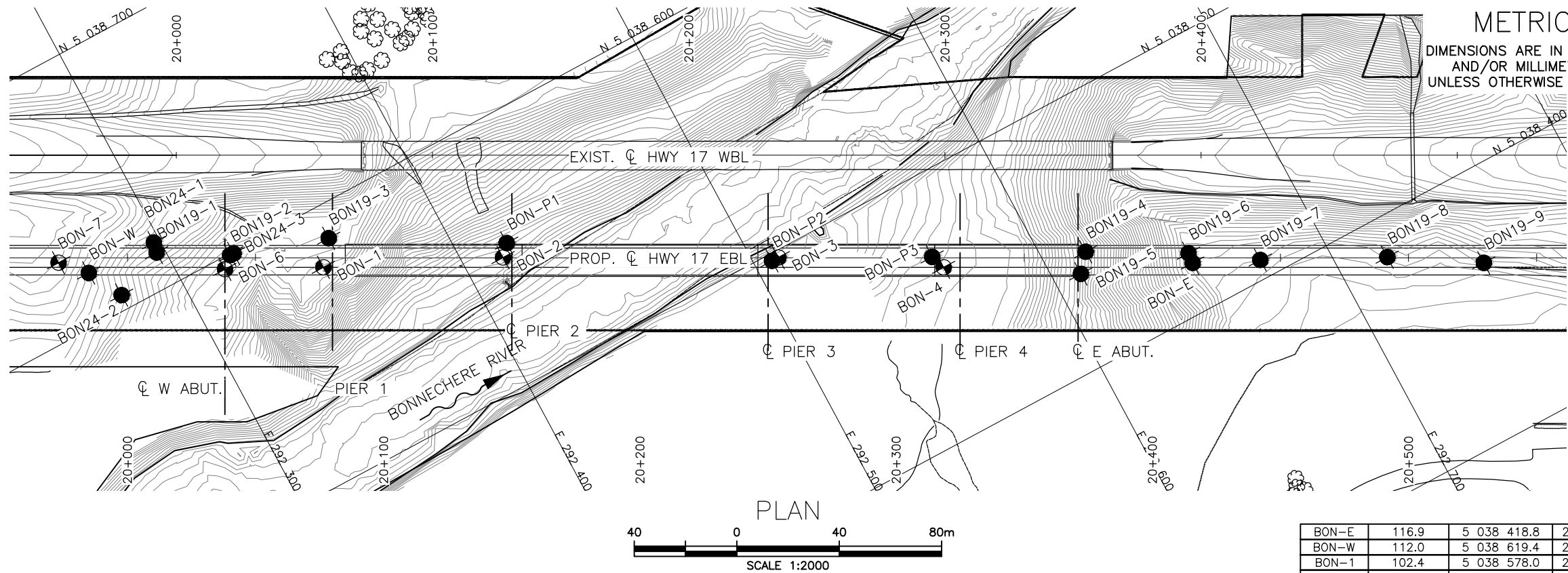
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	Borehole (Previous Investigation)		
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CONE	Blows /0.3m (60° Cone, 475J/blow)		
PH	Pressure, Hydraulic		
	Water Level Upon Completion of Drilling		
	Water Level in Monitoring Well/Piezometer		
	Monitoring Well/Piezometer Screen		
90%	Rock Quality Designation (RQD)		
A/R	Auger Refusal		
NO	ELEVATION	NORTHING	EASTING
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BON19-2	103.0	5 038 599.4	292 321.5
BON19-3	103.0	5 038 587.0	292 358.5
BON19-4	98.9	5 038 442.4	292 616.2
BON19-5	98.9	5 038 435.7	292 610.5
BON19-6	116.9	5 038 422.9	292 651.3
BON19-7	118.0	5 038 407.3	292 674.7
BON19-8	117.7	5 038 384.8	292 718.9
BON19-9	117.8	5 038 365.0	292 751.0
BON-P1	87.9	5 038 552.4	292 418.8
BON-P2	86.1	5 038 497.3	292 506.7
BON-P3	89.2	5 038 469.0	292 562.5

-NOTES-

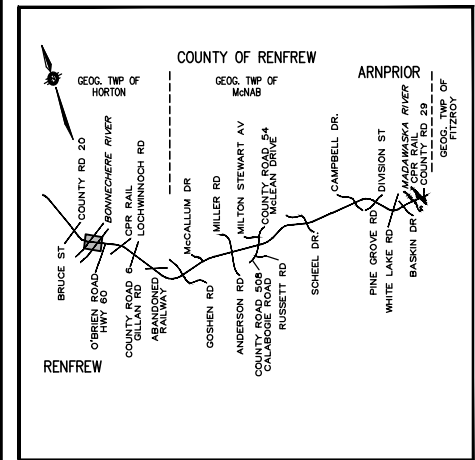
- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is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



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

CONT No
WP No 4068-09-00

HIGHWAY 17 TWINNING
BONNECHERE RIVER
BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA



KEYPLAN

LEGEND

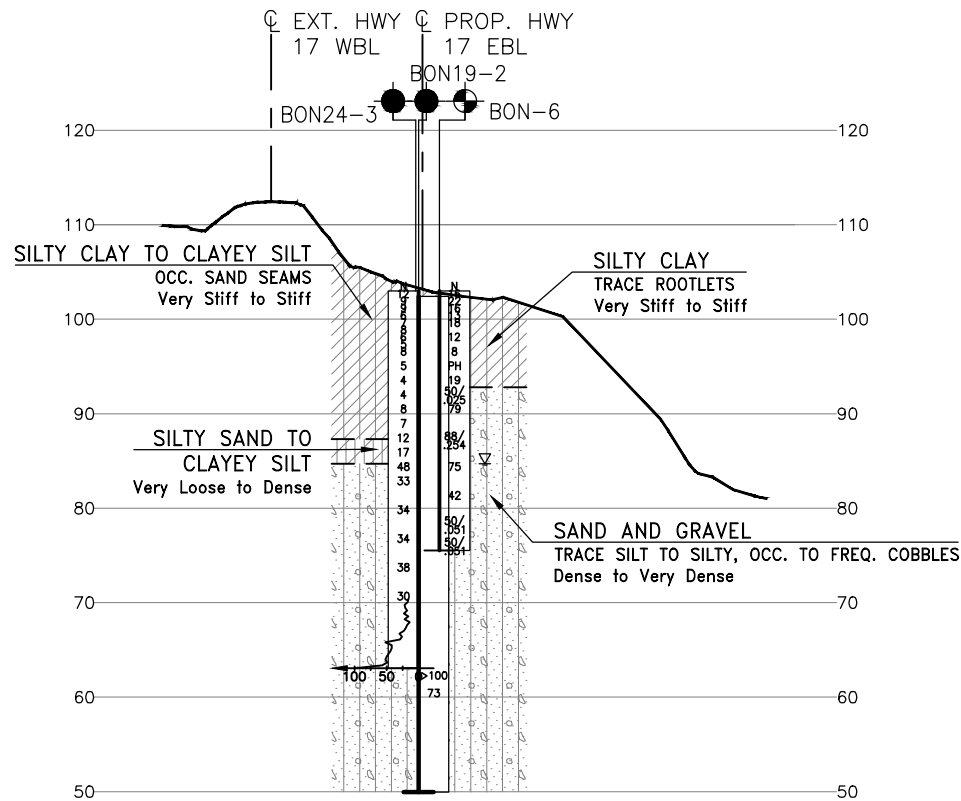
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- PH Pressure, Hydraulic
- Water Level Upon Completion of Drilling
- Water Level in Monitoring Well/Piezometer
- Monitoring Well/Piezometer Screen
- Rock Quality Designation (RQD)
- Auger Refusal

NO	ELEVATION	NORTHING	EASTING
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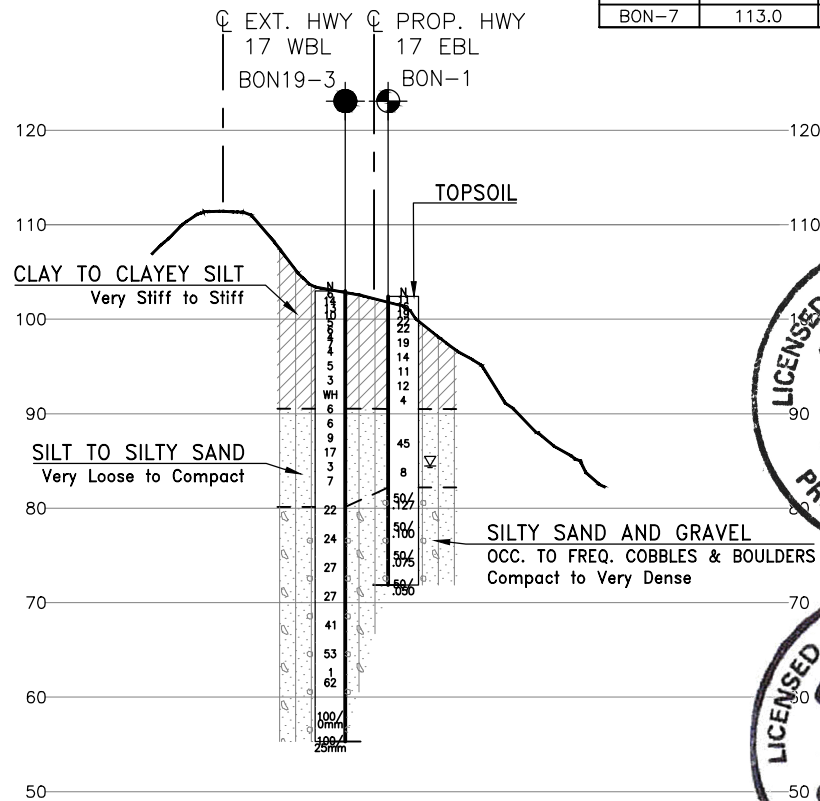
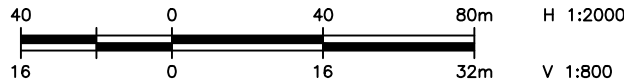
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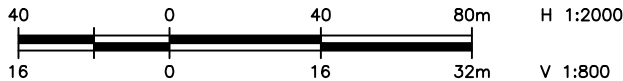
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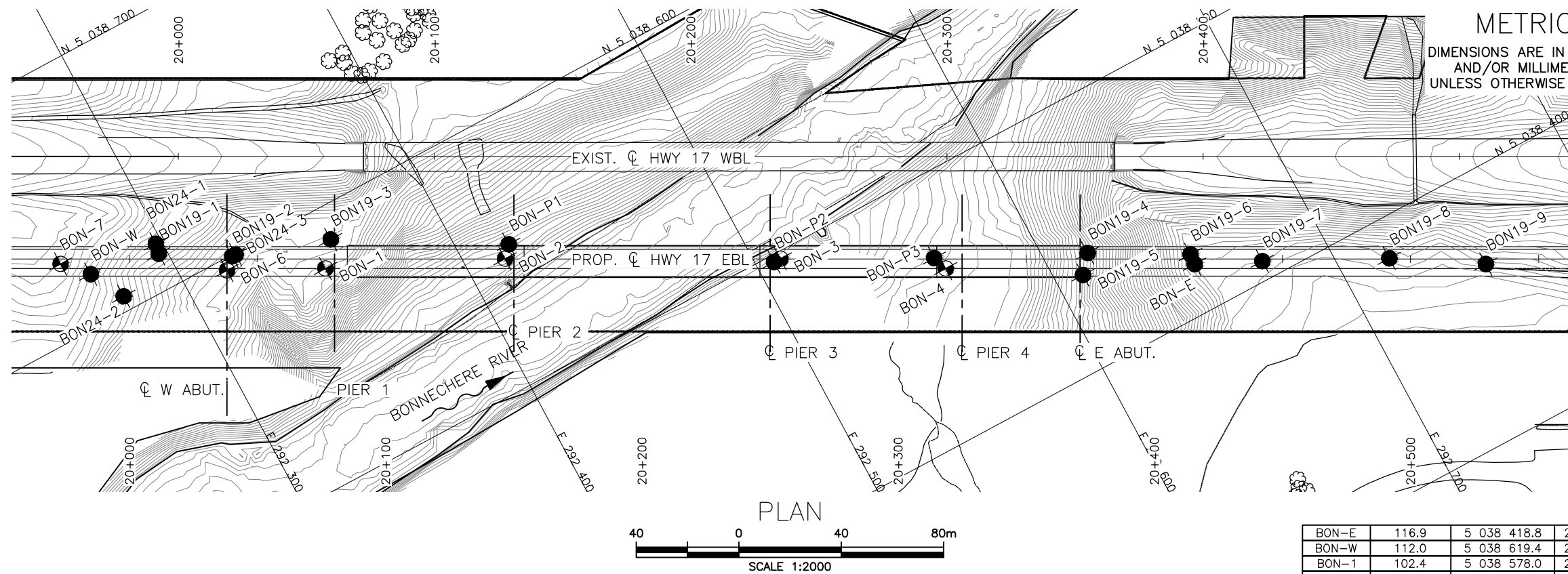
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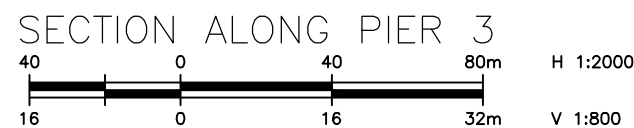
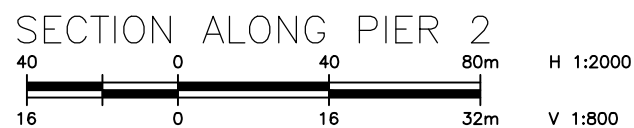
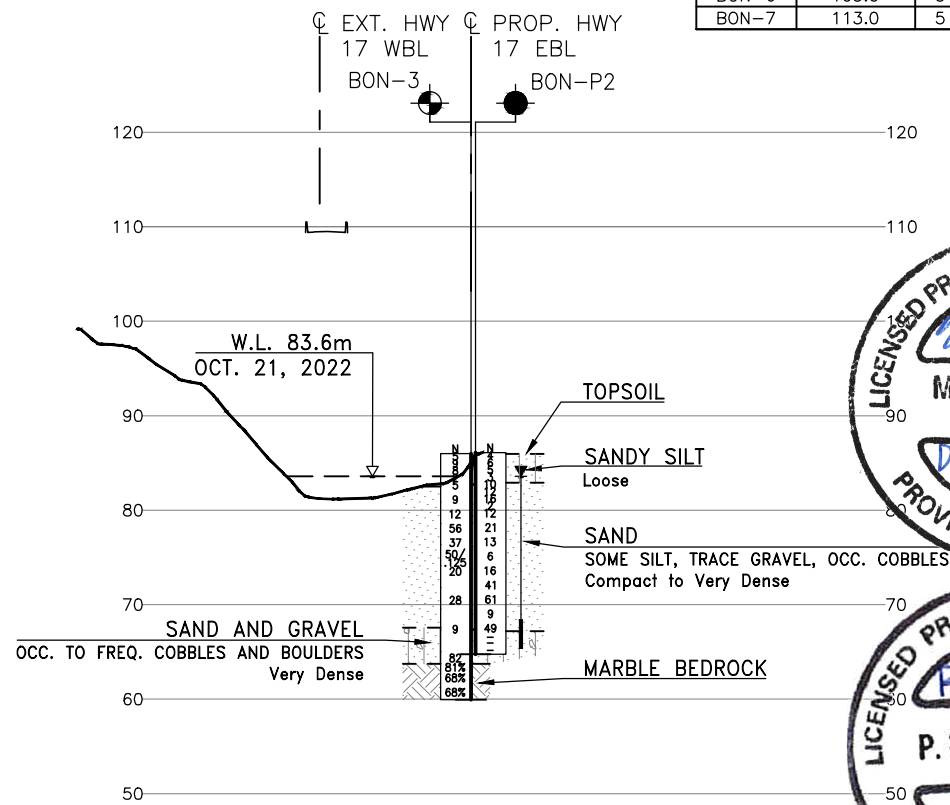
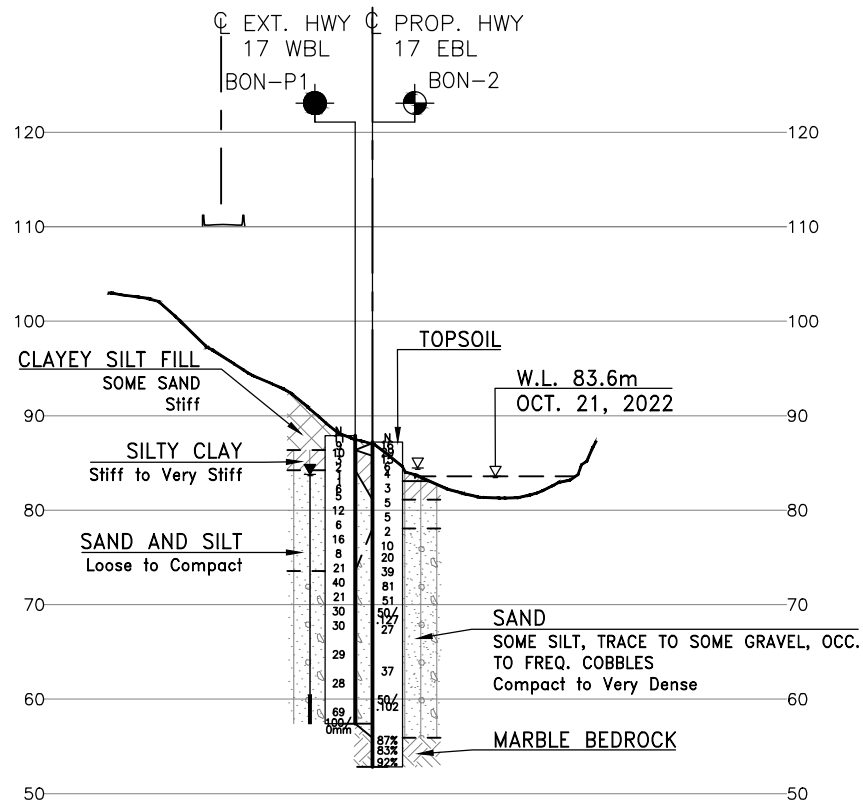
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SITE			
STRUCT			
DWG			2



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BON-6	103.0	5 038 595.5	292 317.1
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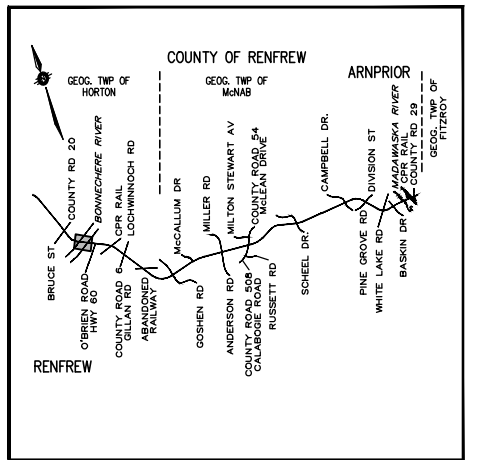
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HIGHWAY 17 TWINNING
BONNECHERE RIVER
BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario 







THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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|  | 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 Upon Completion of Drilling |
|  | Water Level in Monitoring Well/Piezometer |
| | Monitoring Well/Piezometer Screen |
| 90% | Rock Quality Designation (RQD) |
| A/R | Auger Refusal |

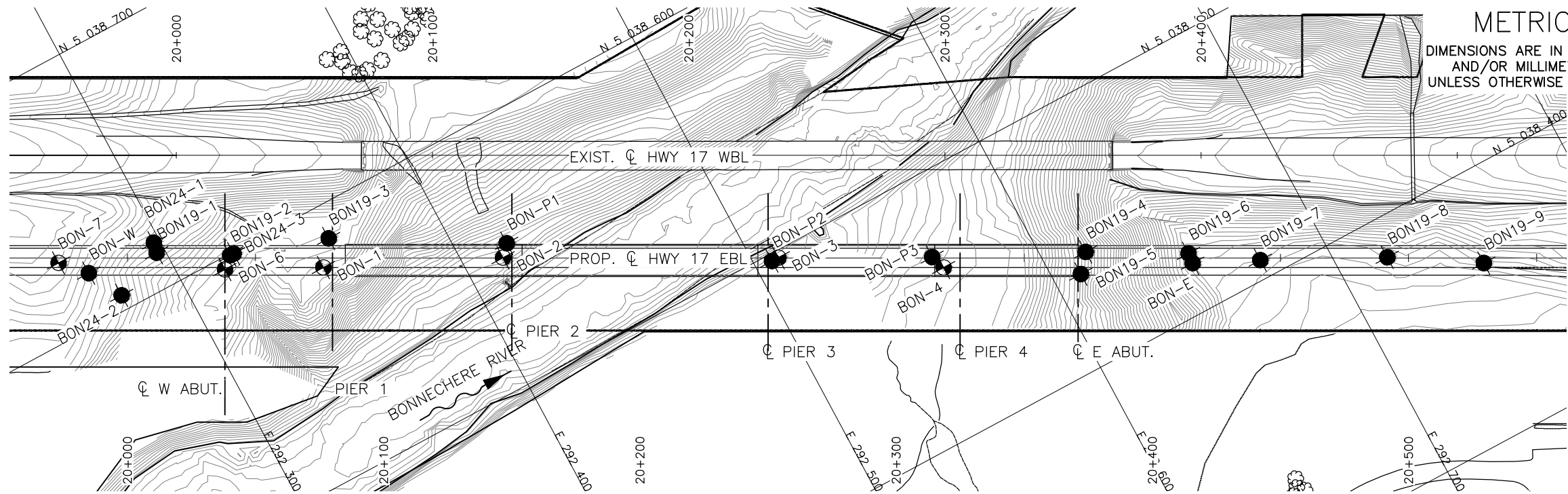
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GEOCRES No. 31F-236

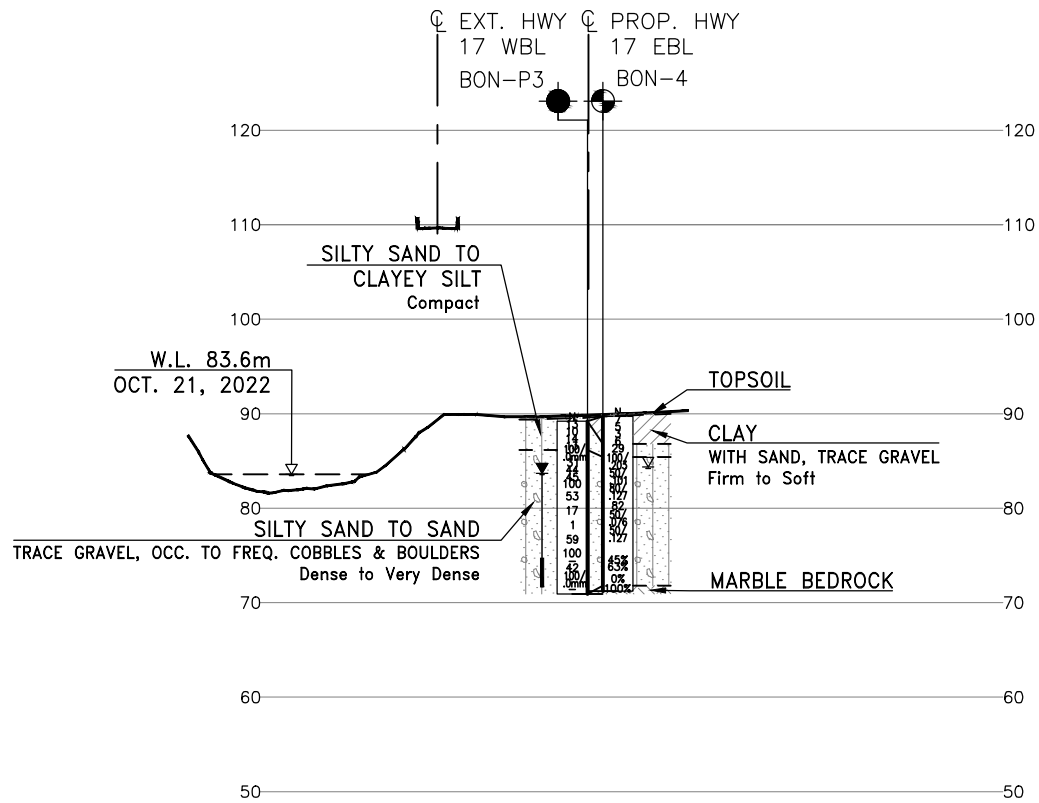
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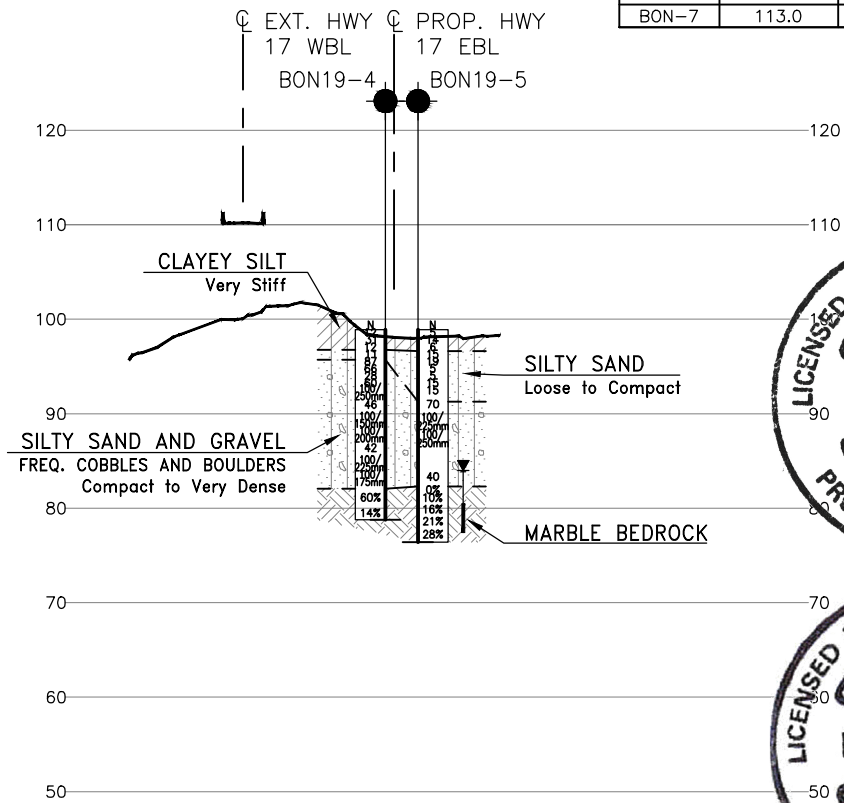
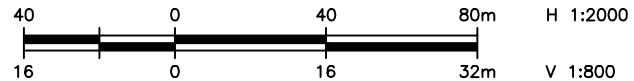
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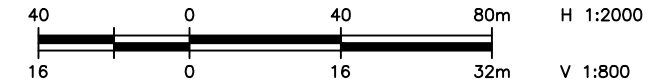
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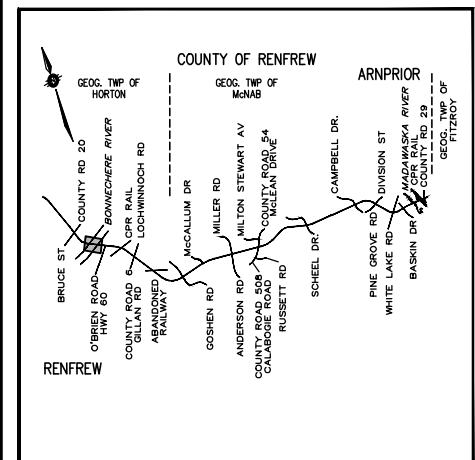


CONT No
WP No 4068-09-00

HIGHWAY 17 TWINNING
BONNECHERE RIVER
BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario

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 Upon Completion of Drilling
- Water Level in Monitoring Well/Piezometer
- Monitoring Well/Piezometer Screen
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
BON19-1	107.1	5 038 613.9	292 296.7
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GEOCRES No. 31F-236

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CODE	LOAD	DATE	OCT 2023
SITE	STRUCT	DWG	4



Appendix B.

Record of Testhole Sheets and Field Testing



Appendix B.1

Current (2020/2021/2024) Investigation



SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

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

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

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

RECOVERY:

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

N-VALUE:

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

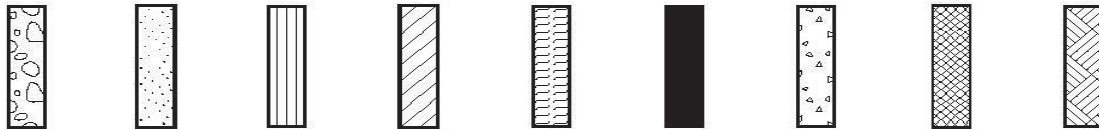
DYNAMIC CONE PENETRATION TEST (DCPT):

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



STRATA PLOT:

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



Boulders
Cobbles
Gravel Sand Silt Clay Organics Asphalt Concrete Fill Bedrock

TEXTURING CLASSIFICATION OF SOILS

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

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

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

SAMPLE TYPES

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

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

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

MODIFIED UNIFIED SOIL CLASSIFICATION

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

Note - W_L = Liquid Limit



EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

TERMS

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

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

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

RECORD OF BOREHOLE No BON19-1

1 OF 5

METRIC

WP# 4068-09-00 LOCATION Lat: 45.487337°, Long: -76.659955°
Bonnechere River Bridge N 5 038 613.9 E 292 296.7 ORIGINATED BY BC
HWY 17 BOREHOLE TYPE CME 850 Trackmount / HSA / HW Casing COMPILED BY MIK
DATUM Geodetic DATE 2021.09.07 - 2021.09.14 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE		W _P W W _L WATER CONTENT (%)							
107.1	Ground Surface							20	40	60	80	100					
0.0	CLAY (CH) to SILTY CLAY (CI) trace sand Occasional sand seams Very stiff Grey-brown [WEATHERED CRUST]		1	SS	21		107										
			2	SS	13		106										
			3	SS	8		105										
			4	SS	7		104										
			5	SS	6		103										
			6	SS	7		102										
			1	ST	-		101										
							100										
							99										
							98										
101.0																	
6.1	CLAYEY SILT (CL) Occasional sand seams Stiff to very stiff Grey-brown to grey		7	SS	4		101										
			8	SS	3		100										
							99										
			9	SS	4		98										

Continued Next Page

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

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

RECORD OF BOREHOLE No B0N19-1

2 OF 5

METRIC

WP# 4068-09-00 LOCATION Lat: 45.487337°, Long: -76.659955°
Bonnehore River Bridge N 5 038 613.9 E 292 296.7 ORIGINATED BY BC
HWY 17 BOREHOLE TYPE CME 850 Trackmount / HSA / HW Casing COMPILED BY MIK
DATUM Geodetic DATE 2021.09.07 - 2021.09.14 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W P W W L			
	Continued From Previous Page							20 40 60 80 100					
	CLAYEY SILT (CL) Occasional sand seams Stiff to very stiff Grey-brown to grey		10	SS	3								
			11	SS	3								
92.6													
14.5	SILT to CLAYEY SILT (CL-ML) some sand Occasional sand seams Compact Grey-brown to grey		12	SS	10								
			13	SS	18								
89.6													
17.5	SAND some silt Compact to dense Brown		14	SS	13								
			15	SS	36								

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

RECORD OF BOREHOLE No B0N19-1

3 OF 5

METRIC

WP# 4068-09-00 LOCATION Lat: 45.487337°, Long: -76.659955°
Bonnehcchere River Bridge N 5 038 613.9 E 292 296.7 ORIGINATED BY BC
HWY 17 BOREHOLE TYPE CME 850 Trackmount / HSA / HW Casing COMPILED BY MIK
DATUM Geodetic DATE 2021.09.07 - 2021.09.14 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page							SHEAR STRENGTH kPa						
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL × LAB VANE						
								WATER CONTENT (%)						
								20	40	60	80	100		
85.0							87							
22.1	Gravelly SAND Dense Brown		16	SS	46		86							
							85							
							84							
							83							
82.0							82							
25.1	GRAVEL some sand Compact to dense Red-brown to dark grey		17	SS	27		81							
							80							
							79							
			18	SS	52		78							

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

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

METRIC

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+³, ×³: Numbers refer to Sensitivity

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

RECORD OF BOREHOLE No BON19-1

5 OF 5

METRIC

WP# 4068-09-00 LOCATION Lat: 45.487337°, Long: -76.659955°
Bonnechere River Bridge N 5 038 613.9 E 292 296.7 ORIGINATED BY BC
HWY 17 BOREHOLE TYPE CME 850 Trackmount / HSA / HW Casing COMPILED BY MIK
DATUM Geodetic DATE 2021.09.07 - 2021.09.14 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
	Monitoring well installation consists of 50 mm diameter Schedule 40 PVC pipe with a 3.0 m slotted screen																
	WATER LEVEL READINGS:																
	Date Depth (m) Elev. (m)																
	2021.09.21 23.5 83.6																
	2021.11.21 23.2 83.9																
	2021.11.29 23.2 83.9																
	2022.01.11 23.1 84.0																

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

RECORD OF BOREHOLE No B0N19-2

1 OF 5

METRIC

WP# 4068-09-00 LOCATION Lat: 45.487207°, Long: -76.659637°
Bonnechere River Bridge N 5 038 599.4 E 292 321.5 ORIGINATED BY RH
HWY 17 BOREHOLE TYPE Diedrich D-50 / HW Casing COMPILED BY MIK
DATUM Geodetic DATE 2021.10.07 - 2021.10.08 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
103.0	Ground Surface													
0.0	SILTY CLAY (CI) Very stiff Grey-brown [WEATHERED CRUST]		1	SS	12									
			2	SS	9		102							
			3	SS	9		101							0 4 53 43
			4	SS	6		100							
			5	SS	7		99							
			6	SS	8		98							
			7	SS	6		97							
			8	SS	5		96							
			9	SS	8		95							0 1 59 40
95.4							94							
7.6	CLAYEY SILT (CL) Very stiff Grey		10	SS	5		93							
			11	SS	4		92							

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

DOUBLE LINE 24726 B0N.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

RECORD OF BOREHOLE No B0N19-2

3 OF 5

METRIC

WP# 4068-09-00 LOCATION Lat: 45.487207°, Long: -76.659637°
Bonnechere River Bridge N 5 038 599.4 E 292 321.5 ORIGINATED BY RH
HWY 17 BOREHOLE TYPE Diedrich D-50 / HW Casing COMPILED BY MIK
DATUM Geodetic DATE 2021.10.07 - 2021.10.08 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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+³, ×³: Numbers refer to
Sensitivity 20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No B0N19-2

4 OF 5

METRIC

WP# 4068-09-00 LOCATION Lat: 45.487207°, Long: -76.659637°
Bonnechere River Bridge N 5 038 599.4 E 292 321.5 ORIGINATED BY RH
HWY 17 BOREHOLE TYPE Diedrich D-50 / HW Casing COMPILED BY MIK
DATUM Geodetic DATE 2021.10.07 - 2021.10.08 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
70.4	Gravelly SAND trace silt Occasional cobbles Dense Grey-brown		22	SS	30									
32.6	Inferred gravelly sand													
63.1														

Continued Next Page

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

RECORD OF BOREHOLE No B0N19-2

5 OF 5

METRIC

WP# 4068-09-00 LOCATION Lat: 45.487207°, Long: -76.659637°
Bonnechere River Bridge N 5 038 599.4 E 292 321.5 ORIGINATED BY RH
 HWY 17 BOREHOLE TYPE Diedrich D-50 / HW Casing COMPILED BY MIK
 DATUM Geodetic DATE 2021.10.07 - 2021.10.08 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W P W W L 20 40 60					
39.9	Continued From Previous Page End of Borehole (DCPT Refusal)																

RECORD OF BOREHOLE No B0N19-3

1 OF 5

METRIC

WP# 4068-09-00 LOCATION Lat: 45.487096°, Long: -76.659163°
Bonnechere River Bridge N 5 038 587.0 E 292 358.5 ORIGINATED BY NW/RH
HWY 17 BOREHOLE TYPE Diedrich D-50 / HW Casing COMPILED BY MIK
DATUM Geodetic DATE 2021.10.01 - 2021.10.07 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE		WATER CONTENT (%) w _p w w _L			
103.0	Ground Surface												
0.0	CLAY (CH) to SILTY CLAY (CI) Very stiff Brown [WEATHERED CRUST]		1	SS	6								
			2	SS	14		102						0 4 42 54
			3	SS	13		101						
			4	SS	10		100						
			5	SS	5		99						0 2 61 37
			6	SS	6		98						
			7	SS	4		97						
			8	SS	7		96						
96.9	-300mm thick sand with gravel layer at 5.6 m depth						95						
6.1	CLAYEY SILT (CL) Very stiff to stiff Brown		9	SS	4		94						
			10	SS	5		93						
			11	SS	3		92						

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

DOUBLE LINE 24726 B0N.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

METRIC

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+³, ×³: Numbers refer to Sensitivity

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

METRIC

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+³, ×³: Numbers refer to Sensitivity

METRIC

SOIL PROFILE						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER TYPE "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	
<div>DYNAMIC CONE PENETRATION RESISTANCE PLOT<div>20 40 60 80 100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div> <div><div>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT</div><div>w_P w w_L</div><div>WATER CONTENT (%)</div><div>20 40 60</div></div> <div>UNIT WEIGHT γ kN/m³</div> <div>REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL</div>						
	Continued From Previous Page					
63.1	SILTY SAND, trace to some gravel Compact to very dense Grey		22	SS	27	
			23	SS	41	
			24	SS	53	

+³, ×³: Numbers refer to Sensitivity

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

RECORD OF BOREHOLE No BON19-3

5 OF 5

METRIC

WP# 4068-09-00 LOCATION Lat: 45.487096°, Long: -76.659163°
Bonnechere River Bridge N 5 038 587.0 E 292 358.5 ORIGINATED BY NW/RH
HWY 17 BOREHOLE TYPE Diedrich D-50 / HW Casing COMPILED BY MIK
DATUM Geodetic DATE 2021.10.01 - 2021.10.07 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								○ UNCONFINED + FIELD VANE											
								● QUICK TRIAXIAL × LAB VANE											
							WATER CONTENT (%)												
							20	40	60	80	100	20	40	60					
39.9	Continued From Previous Page		1	GS	-														
							62												
			25	SS	62														
61.1							61												
41.9	Inferred SAND and GRAVEL Frequent cobbles and boulders [TILL] - casing refusal on 400mm boulder at 41.9m - gravel/cobbles 20mm to 100mm recovered in core barrel		1	NQ			60												
							59												
			2	NQ			58												
			26	SS	100/ 0mm		57												
			3	NQ			56												
55.3			27	SS	100/ 25mm														
47.7	End of Borehole Monitoring well installation consists of 50 mm diameter Schedule 40 PVC pipe with a 3.0 m slotted screen WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2021.11.04 19.2 83.8 2021.11.05 19.2 83.8 2022.01.22 19.0 84.0																		

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

RECORD OF BOREHOLE No B0N19-4

1 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.485799°, Long: -76.655864°
Bonnechere River Bridge N 5 038 442.4 E 292 616.2 ORIGINATED BY JP
HWY 17 BOREHOLE TYPE CME 850 Trackmount / HSA/ HW Casing / HQ Coring COMPILED BY JP
DATUM Geodetic DATE 2020.08.26 - 2020.09.03 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						WATER CONTENT (%) W _P W W _L			
98.9	Ground Surface							20	40	60	80	100	20	40	60		
0.0	CLAYEY SILT (CL) Very Stiff Brown to Grey-Brown [WEATHERED CRUST]		1	SS	12									○			
			2	SS	31									○			0 1 66 33
			3	SS	12									○			
96.8																	
2.1	SILTY SAND Compact Brown		4	SS	11									○			
95.7																	
3.2	SILTY SAND some gravel to GRAVEL, some sand Frequent Cobbles/Boulders Compact to Very Dense Brown		5	SS	87									○			26 37 37 (SI+CL)
			6	SS	66									○			
			7	SS	28									○			
			8	SS	60									○			51 39 10 (SI+CL)
			9	SS	100/ 250mm												
			10	SS	46									○			32 62 6 (SI+CL)
			11	SS	100/ 150mm												
</																	

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

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

RECORD OF BOREHOLE No B0N19-4

2 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.485799°, Long: -76.655864°
Bonnechere River Bridge N 5 038 442.4 E 292 616.2 ORIGINATED BY JP
HWY 17 BOREHOLE TYPE CME 850 Trackmount / HSA/ HW Casing / HQ Coring COMPILED BY JP
DATUM Geodetic DATE 2020.08.26 - 2020.09.03 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				w _P w w _L				
								20 40 60 80 100				20 40 60				
	Continued From Previous Page															
	SILTY SAND some gravel to GRAVEL , some sand Frequent Cobbles/Boulders Compact to Very Dense Brown		12	SS	100/ 200mm		88						○			
							87									
				13	SS	42							○			
								86								
				14	SS	100/ 225mm		85					○			
								84						○		
			15	SS	100/ 175mm		83									
82.1							82							FI		
16.8	MARBLE BEDROCK White-Grey Coarse Grained Smooth Fresh Jointed to Slightly Weathered		1	RUN			81							2	RUN #1 TCR=96% SCR=93% RQD=60% UCS=41.2MPa	
													2	2		
													2	3		
													3	4		
			2	RUN			80							3		
														>10	RUN #2 TCR=100% SCR=58% RQD=14%	
													6	5		
													>10			
							79									

Continued Next Page

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


DOUBLE LINE 24726 B0N.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

RECORD OF BOREHOLE No BON19-4

3 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.485799°, Long: -76.655864°
Bonnechere River Bridge N 5 038 442.4 E 292 616.2 ORIGINATED BY JP
 HWY 17 BOREHOLE TYPE CME 850 Trackmount / HSA/ HW Casing / HQ Coring COMPILED BY JP
 DATUM Geodetic DATE 2020.08.26 - 2020.09.03 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
78.8	Continued From Previous Page																
20.1	End of Borehole																

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

RECORD OF BOREHOLE No BON19-5

1 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.485741°, Long: -76.655935°
Bonnechere River Bridge N 5 038 435.7 E 292 610.5 ORIGINATED BY JP
HWY 17 BOREHOLE TYPE CME 850 Trackmount / HSA/ HW Casing / HQ Coring COMPILED BY JP
DATUM Geodetic DATE 2020.09.08 - 2020.09.11 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _P w w _L				GR	SA	SI	CL	
98.9	Ground Surface																			
0.0	CLAYEY SILT (CL) Very Stiff Grey-Brown [WEATHERED CRUST]		1	SS	5															
			2	SS	14		98													
			3	SS	6		97										0	8	61	31
96.6	SILTY SAND Loose to Compact Brown to Grey-Brown		4	SS	15															
2.3			5	SS	19		96													
			6	SS	5		95													
			7	SS	5		94													
			8	SS	15		93										0	62	38	(SI+CL)
			9	SS	15		92													
							91													
							90													
91.3	SAND and GRAVEL, some silt to silty Occasional To Frequent Cobbles/Boulders Brown to Grey-Brown Dense to Very Dense		10	SS	70		91													
7.6																				
			11	SS	100/ 225mm															
							89													

Continued Next Page

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

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

METRIC

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No B0N19-5

3 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.485741°, Long: -76.655935°
Bonnechere River Bridge N 5 038 435.7 E 292 610.5 ORIGINATED BY JP
HWY 17 BOREHOLE TYPE CME 850 Trackmount / HSA/ HW Casing / HQ Coring COMPILED BY JP
DATUM Geodetic DATE 2020.09.08 - 2020.09.11 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)											
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)			GR	SA	SI	CL				
								20	40	60	80	100																
								○ UNCONFINED	+	FIELD VANE																		
						● QUICK TRIAXIAL	×	LAB VANE																				
	Continued From Previous Page		4	RUN			78									3	RUN #4											
																4	TCR=97%											
																>10	SCR=54%											
			5	RUN												6	RQD=21%											
																0												
																3	RUN #5											
76.4							77									4	TCR=89%											
22.5	End of Borehole															4	SCR=57%											
	Monitoring well installation consists of 50 mm diameter Schedule 40 PVC pipe with a 3.0 m slotted screen																UCS=55.1MPa											
	DATE DEPTH (m) ELEV. (m)																											
	2020.09.29 14.9 84.0																											
	2021.08.04 14.7 84.2																											
	2021.12.01 14.9 84.0																											
	2022.01.11 14.8 84.1																											

RECORD OF BOREHOLE No B0N19-6

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.485625°, Long: -76.655414°
Bonnechere River Bridge N 5 038 422.9 E 292 651.3 ORIGINATED BY JG
HWY 17 BOREHOLE TYPE CME 45 Trackmount / HSA COMPILED BY JP
DATUM Geodetic DATE 2020.09.17 - 2020.09.17 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL LIMIT MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)										
								○ UNCONFINED + FIELD VANE		w P w w L										
								● QUICK TRIAXIAL × LAB VANE												
116.9	Ground Surface						20	40	60	80	100	20	40	60	kN/m ³	GR SA SI CL				
0.0	TOPSOIL 100mm																			
0.1	SILTY CLAY (CI) Occasional silty sand seam Very Stiff Brown [WEATHERED CRUST]		1	SS	6															
			2	SS	13															
			3	SS	10															
			4	SS	11															
			5	SS	5															
			6	SS	6															
			7	SS	7															
108.1	SAND some silt to silty Compact Brown																			
8.8			8	SS	18															

Continued Next Page

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

METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES		GROUND WATER CONDITIONS
			NUMBER	TYPE	"N" VALUES
	Continued From Previous Page				
	SAND some silt to silty Compact Brown		9	SS	22
			10	SS	23
			11	SS	30
102.6					
14.3	End of Borehole				
	Borehole dry on completion				
	Monitoring well installation consists of two nested 50 mm diamater Schedule 40 PVC pipe with a 3.0 m slotted screen				
	WATER LEVEL READINGS:				
	Shallow Well				
	Date Depth (m) Elev. (m)				
	2020.09.29 dry				
	2020.11.11 dry				
	2021.08.06 dry				
	2022.01.11 dry				
	Deep Well				
	Date Depth (m) Elev. (m)				
	2020.09.29 dry				
	2020.11.11 dry				
	2021.08.06 dry				
	2022.01.11 dry				

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No B0N19-7

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.485485°, Long: -76.655113°
Bonnechere River Bridge N 5 038 407.3 E 292 674.7 ORIGINATED BY SH
HWY 17 BOREHOLE TYPE CME 45 Trackmount / HSA COMPILED BY JP
DATUM Geodetic DATE 2020.09.16 - 2020.09.17 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _P W W _L								
								○ UNCONFINED + FIELD VANE										
							● QUICK TRIAXIAL × LAB VANE			WATER CONTENT (%)								
118.0	Ground Surface						20	40	60	80	100							
0.0	TOPSOIL 150mm						20	40	60	80	100							
0.2	SILTY CLAY (CI) Occasional sand seam Very Stiff Grey-Brown [WEATHERED CRUST]		1	SS	16													
			2	SS	17		117											0 2 36 62
			3	SS	16		116											
			4	SS	11		115											
			5	SS	6		114											
			6	SS	9		113											0 0 54 46
			7	SS	7		112											
			8	SS	6		111											
			9	SS	5		110											
			109.9															
8.1	CLAYEY SILT (CL) Very Stiff Grey																	
			10	SS	3		109										0 0 58 42	

Continued Next Page

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



DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

RECORD OF BOREHOLE No BON19-7

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.485485°, Long: -76.655113°
Bonnechere River Bridge N 5 038 407.3 E 292 674.7 ORIGINATED BY SH
HWY 17 BOREHOLE TYPE CME 45 Trackmount / HSA COMPILED BY JP
DATUM Geodetic DATE 2020.09.16 - 2020.09.17 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
	Continued From Previous Page						20	40	60	80	100	20	40	60						
104.0	CLAYEY SILT (CL) Very Stiff Grey		11	SS	WH		107										0 1 62 37			
			12	SS	1															
14.0	SILTY SAND		13	SS	5		104													
103.7	Compact																			
14.3	Brown																			
	End of Borehole Borehole dry upon completion																			

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

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

RECORD OF BOREHOLE No B0N19-8

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.485283°, Long: -76.654548°
Bonnechere River Bridge N 5 038 384.8 E 292 718.9 ORIGINATED BY JP
HWY 17 BOREHOLE TYPE CME 45 Trackmount / HSA COMPILED BY JP
DATUM Geodetic DATE 2020.09.15 - 2020.09.15 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
117.7	Ground Surface							20	40	60	80	100	20	40	60	GR SA SI CL
0.0	SILTY CLAY (CI) Occasional sand seams Very Stiff Grey-Brown [WEATHERED CRUST]		1	SS	4											
			2	SS	7											0 7 40 53
			3	SS	7											
			4	SS	5											
			5	SS	5											
			6	SS	6											0 0 52 48
			7	SS	5											
			8	SS	6											
			9	SS	4											0 1 56 43
109.5																
8.2	CLAYEY SILT (CL) Stiff to very stiff Grey-Brown to Brown															
			10	SS	7											

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

Continued Next Page






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

RECORD OF BOREHOLE No BON19-8

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.485283°, Long: -76.654548°
Bonnechere River Bridge N 5 038 384.8 E 292 718.9 ORIGINATED BY JP
HWY 17 BOREHOLE TYPE CME 45 Trackmount / HSA COMPILED BY JP
DATUM Geodetic DATE 2020.09.15 - 2020.09.15 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE					w _P w w _L				
								● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page							20	40	60	80	100					
106.4	CLAYEY SILT (CL) Stiff to very stiff Grey-Brown to Brown		11	SS	9		107										0 8 59 33
11.3	SILTY SAND some gravel Dense Brown		12	SS	43		106										
							105										
							104										
103.4			13	SS	39												
14.3	End of Borehole Borehole dry upon completion																

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

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

RECORD OF BOREHOLE No BON19-9

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.485106°, Long: -76.654137°
Bonnechere River Bridge N 5 038 365.0 E 292 751.0 ORIGINATED BY JP
HWY 17 BOREHOLE TYPE CME 45 Trackmount / HSA COMPILED BY JP
DATUM Geodetic DATE 2020.09.14 - 2020.09.14 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE												
117.8	Ground Surface																				
0.0	SILTY CLAY (CI) Occasional sand seams Very stiff Grey-brown [WEATHERED CRUST]		1	SS	4																
			2	SS	9																
			3	SS	11																
			4	SS	10																
			5	SS	8																
			6	SS	8																
			7	SS	8																
			8	SS	6																
			9	SS	7																
			10	SS	5																
109.9			11	SS	1																
7.9	CLAYEY SILT (CL) Occasional sand seams Stiff Grey																				
											</										

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

Continued Next Page

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

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No BON-P1

1 OF 4

METRIC

WP# 4068-09-00 LOCATION Lat: 45.486786°, Long: -76.658392°
Bonnechere River Bridge N 5 038 552.4 E 292 418.8 ORIGINATED BY NW
HWY 17 BOREHOLE TYPE Diedrich D-50 / HSA / HW Casing COMPILED BY MIK
DATUM Geodetic DATE 2021.09.29 - 2021.10.01 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE		WATER CONTENT (%) w _p w w _L				GR	SA	SI	CL	
87.9	Ground Surface							20	40	60	80	100						
0.0	CLAYEY SILT some sand Stiff Brown [FILL]		1	SS	11													
			2	SS	9													
86.4																		
1.5	SILTY CLAY (CI) Stiff to very stiff Brown-grey		3	SS	10													
			4	SS	3													
			5	SS	2													
84.2																		
3.7	SILT (ML) some sand Very loose to loose Grey		6	SS	1													
			7	SS	1													
			8	SS	6													
			9	SS	5													
81.2																		
6.7	SILTY SAND (SM) Loose to compact Grey		10	SS	12													
			11	SS	6													

Continued Next Page

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

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

METRIC

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No BON-P1

4 OF 4

METRIC

WP# 4068-09-00 LOCATION Lat: 45.486786°, Long: -76.658392°
Bonnechere River Bridge N 5 038 552.4 E 292 418.8 ORIGINATED BY NW
HWY 17 BOREHOLE TYPE Diedrich D-50 / HSA / HW Casing COMPILED BY MIK
DATUM Geodetic DATE 2021.09.29 - 2021.10.01 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
	Continued From Previous Page							20	40	60	80	100					
57.4			22	SS	100/												
30.5	End of Borehole Monitoring well installation consists of 50 mm diameter Schedule 40 PVC pipe with a 3.0 m slotted screen WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2021.11.04 4.1 83.8 2021.11.30 4.1 83.8 2022.01.25 3.9 84.0				0mm												

RECORD OF BOREHOLE No BON-P2

1 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.486292°, Long: -76.657266°
Bonnechere River Bridge N 5 038 497.3 E 292 506.7 ORIGINATED BY AO
HWY 17 BOREHOLE TYPE CME 850 Trackmount / NW Casing COMPILED BY AO
DATUM Geodetic DATE 2021.11.09 - 2021.11.10 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
86.1	Ground Surface													
0.0	TOPSOIL (150 mm)						86							
0.2	SANDY SILT (ML) Loose to very loose Brown with orange mottling		1	SS	4									
			2	SS	6		85							
	- clayey silt interbedding													
			3	SS	5		84							
			4	SS	3									
82.9							83							
3.2	SAND, some silt trace gravel Compact to very loose Brown		5	SS	10									
			6	SS	12		82							
			7	SS	16		81							
			8	SS	2									
80.0							80							
6.1	SAND some silt, some gravel Loose to very dense Grey Stratified structure		9	SS	12									
							79							
			10	SS	21		78							
							77							
			11	SS	13									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

RECORD OF BOREHOLE No BON-P2

2 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.486292°, Long: -76.657266°
Bonnehcchere River Bridge N 5 038 497.3 E 292 506.7 ORIGINATED BY AO
HWY 17 BOREHOLE TYPE CME 850 Trackmount / NW Casing COMPILED BY AO
DATUM Geodetic DATE 2021.11.09 - 2021.11.10 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page													
	SAND some silt, some gravel Loose to very dense Grey Stratified structure		12	SS	6		76							
							75							
			13	SS	16		74							
							73							
			14	SS	41		72							
							71							
			15	SS	61		70							
							69							
			16	SS	9		68							
							67							
67.2			17	SS	49									
18.9	Inferred SAND and GRAVEL Frequent cobbles, occasional boulders [TILL] - 220mm boulder cored at 19.2m		18	NQ	-									

Continued Next Page

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

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 10-19-23

RECORD OF BOREHOLE No BON-P2

3 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.486292°, Long: -76.657266°
Bonnechere River Bridge N 5 038 497.3 E 292 506.7 ORIGINATED BY AO
HWY 17 BOREHOLE TYPE CME 850 Trackmount / NW Casing COMPILED BY AO
DATUM Geodetic DATE 2021.11.09 - 2021.11.10 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W _P	W		
	Continued From Previous Page							20 40 60 80 100					20 40 60				
	Inferred SAND and GRAVEL Frequent cobbles, occasional boulders [TILL]		19	NQ	-		66										
			20	NQ	-		65										
64.8																	
21.3	End of Borehole Monitoring well installation consists of 50 mm diameter Schedule 40 PVC pipe with a 3 m slotted screen Unstabilized water level at 2.3m below the ground surface upon completion of drilling. WATER LEVEL READINGS: Date Depth (m) Elev. (m) 2021.11.17 2.5 83.6 2021.11.30 2.5 83.6 2022.01.11 2.4 83.7																

RECORD OF BOREHOLE No BON-P3

1 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.486038°, Long: -76.656551°
Bonnechere River Bridge N 5 038 469.0 E 292 562.5 ORIGINATED BY AO
HWY 17 BOREHOLE TYPE CME 850 Trackmount / NW Casing COMPILED BY AO
DATUM Geodetic DATE 2021.11.08 - 2021.11.09 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _p w w _L				GR	SA	SI	CL
89.2	Ground Surface							20	40	60	80	100							
0.0	TOPSOIL (150 mm)							20	40	60	80	100							
0.2	SILTY SAND to SANDY SILT Compact Dark brown to brown		1	SS	13		89							○					
			2	SS	10		88							○					
			3	SS	14									○					
87.1							87							○					
2.1	SANDY CLAYEY SILT, trace Gravel Occasional sand partings Very stiff Light brown with orange mottling		4	SS	13									○					
86.2			5	SS	100/		86							○					
3.0	SAND, trace to some gravel and silt Occasional cobbles Very dense to very loose Light brown				0mm		85							○					
			6	SS	31									○					
			7	SS	44		84							○					
			8	SS	45									○					
			9	SS	100		83							○					
							82							○					
			10	SS	53		81							○					
							80							○					

Continued Next Page

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

RECORD OF BOREHOLE No BON-P3

2 OF 3

METRIC

WP# 4068-09-00 LOCATION Lat: 45.486038°, Long: -76.656551°
Bonnehore River Bridge N 5 038 469.0 E 292 562.5 ORIGINATED BY AO
HWY 17 BOREHOLE TYPE CME 850 Trackmount / NW Casing COMPILED BY AO
DATUM Geodetic DATE 2021.11.08 - 2021.11.09 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	20	40					

	Continued From Previous Page																
	SAND , trace to some gravel and silt Occasional cobbles Very dense to very loose Light brown		12	SS	1		79										7 87 6 (SI+CL)
							78										
77.0							77										
12.2	SAND , some gravel Occasional to frequent cobbles Very dense Light brown [TILL]		13	SS	59		76										
			14	SS	100		75										
			15	NQ	-		74										15 81 4 (SI+CL)
			16	SS	42		73										
			17	SS	100/ 280mm		72										
	- Frequent cobbles below 16.8 m depth		18	NQ	-		71										
70.9																	
18.3	End of Borehole Monitoring well installation consists of 50 mm diameter Schedule 40 PVC pipe with a 3.0 m slotted screen Unstabilized water level at 5.3 m below the ground surface upon completion of drilling.																

Continued Next Page

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

METRIC

[illegible]


+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No B0N24-1

1 OF 4

METRIC

WP# 4068-09-00 LOCATION Lat: 45.487373°, Long: -76.659943°
Bonnechere River Bridge N 5 038 617.8 E 292 297.6 ORIGINATED BY BC
HWY 17 BOREHOLE TYPE CME 750 Trackmount / NW Casing COMPILED BY RH
DATUM Geodetic DATE 2024.04.10 - 2024.04.23 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE					w _p w w _L							
								● QUICK TRIAXIAL × LAB VANE												
107.8	Ground Surface						20	40	60	80	100	20	40	60						
0.0	CLAY (CH) to SILTY CLAY (CI) contains sand partings very stiff grey-brown [WEATHERED CRUST]		1	SS	9								○							
			2	SS	9									○						
			3	SS	9									○						
			4	SS	5										○					

Continued Next Page

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

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 12-9-24

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 12-9-24




METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 12-9-24

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)									
								20 40 60 80 100	w _p w w _L												
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE													
Continued From Previous Page																					
GRAVEL and SAND to SANDY GRAVEL (GW) compact to dense grey-brown										18	SS	28									
										19	SS	31									
70.3 37.5 SANDY GRAVEL compact grey-brown										1	RUN	-									
										20	SS	24									
68.9 38.9 GRAVELLY SAND occasional cobbles compact grey-brown										2	RUN	-									
68.3 39.5 End of Borehole										21	SS	20									

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 12-9-24

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No B0N24-2

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.487263°, Long: -76.660209°
Bonnechere River Bridge N 5 038 605.7 E 292 276.8 ORIGINATED BY BC
HWY 17 BOREHOLE TYPE CME 750 Trackmount / NW Casing COMPILED BY RH
DATUM Geodetic DATE 2024.04.09 - 2024.04.09 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE												
108.5	Ground Surface																						
0.0	CLAY (CH) very stiff brown to grey-brown [WEATHERED CRUST]		1	SS	9																		
			2	SS	9																		
			3	SS	12															0 2 39 59			
			4	SS	8																		

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 12-9-24

METRIC

SOIL PROFILE						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE	
<div>DYNAMIC CONE PENETRATION RESISTANCE PLOT</div> <div>SHEAR STRENGTH kPa</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>WATER CONTENT (%)</div> <div>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT</div> <div>UNIT WEIGHT γ</div> <div>REMARKS & GRAIN SIZE DISTRIBUTION (%)</div>						
	Continued From Previous Page					
	SILTY CLAY (CI) stiff to very stiff brown					
			9	SS	WH	
			10	SS	WH	
94.9	End of Borehole					

+³, ×³: Numbers refer to Sensitivity

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

2 OF 6

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity


DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 12-9-24

METRIC

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

METRIC


ELEV DEPTH	SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								W P W W L ————— WATER CONTENT (%)
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
	Continued From Previous Page							20 40 60 80 100					

[illegible]

+³, ×³: Numbers refer to Sensitivity

DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 12-9-24

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			WATER CONTENT (%) w _p w w _L				
Continued From Previous Page															
	Inferred SAND and GRAVEL Frequent cobbles and boulders [TILL]		1	SS	>100		63								
			2	SS	73		62							4 89 7 (SI+CL)	
			1	GS	-		61								
							60							18 79 3 (SI+CL)	
							59								
							58								
							57								
							56								
			3	RUN	-		55								

+³, ×³: Numbers refer to Sensitivity


DOUBLE LINE 24726 BON.GPJ 2012TEMPLATE(MTO).GDT 12-9-24

RECORD OF BOREHOLE No B0N24-3

6 OF 6

METRIC

WP# 4068-09-00 LOCATION Lat: 45.487207°, Long: -76.659618°
Bonnetchere River Bridge N 5 038 599.3 E 292 323.0 ORIGINATED BY BC
HWY 17 BOREHOLE TYPE CME 750 Trackmount / NW Casing COMPILED BY RH
DATUM Geodetic DATE 2024.05.03 - 2024.05.07 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE																	
	Continued From Previous Page						20	40	60	80	100						
	Inferred SAND and GRAVEL Frequent cobbles and boulders [TILL]		4	RUN	-												
			5	RUN	-												
			6	RUN	-												
51.5																	
52.5	End of Borehole																



Appendix B.2

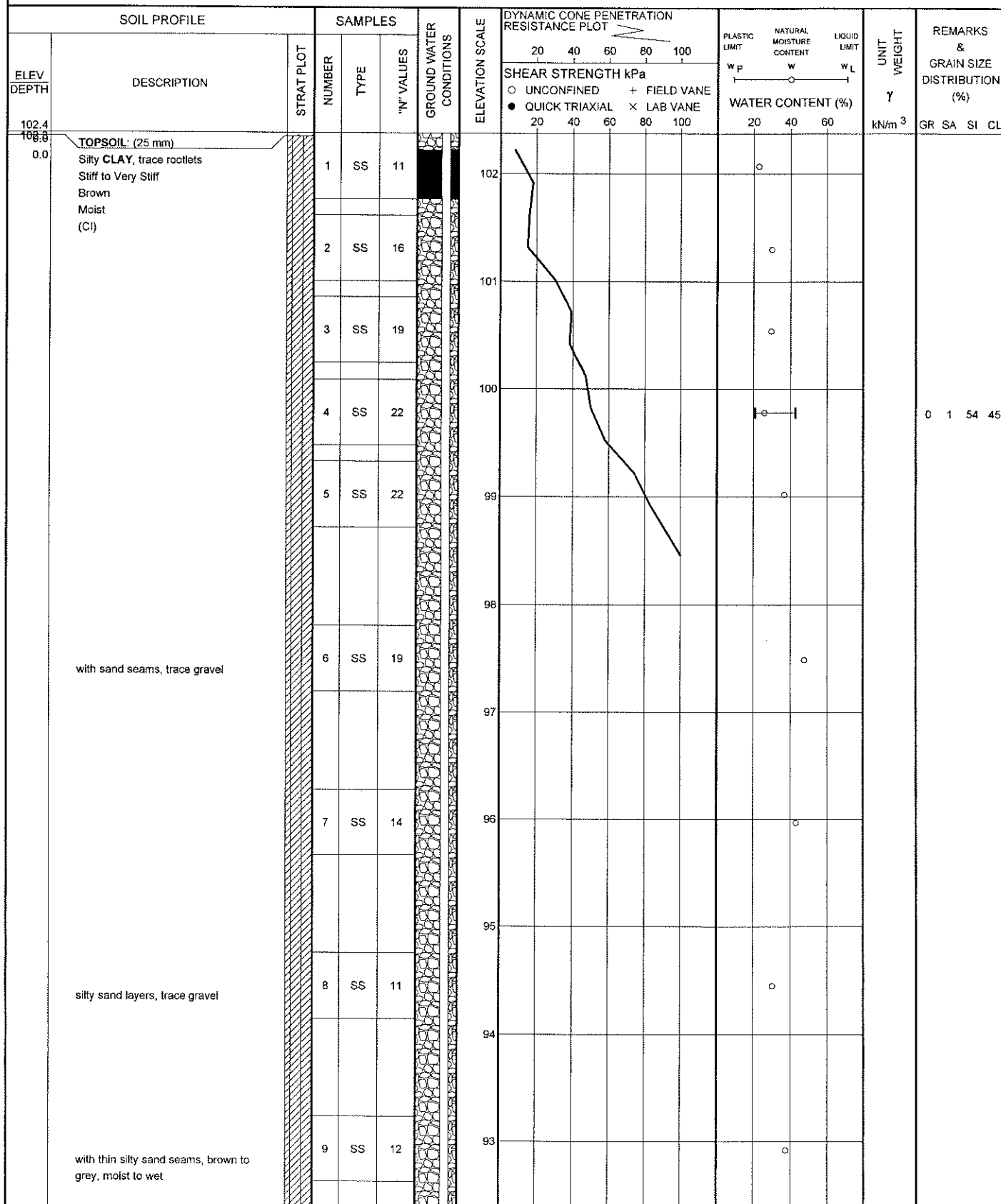
Previous (2003) Investigation

RECORD OF BOREHOLE No BON-1

1 OF 4

METRIC

G.W.P. 647-92-00 LOCATION N 5 038 578.0, E 292 351.3 (Bonnechere River) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 16.10.03 - 20.10.03 CHECKED BY SMS



Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

+ 3, × 3: Numbers refer to Sensitivity

ONTMT4 7450BON.GPJ 11/05/04

METRIC

ELEV DEPTH	SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100 SHEAR STRENGTH kPa					w _p ——— w ——— w _L WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE				
								20 40 60 80 100					

[illegible]

+ 3, x 3: Numbers refer to Sensitivity

ONTMT4 7450BQN.GPJ 11/05/04

RECORD OF BOREHOLE No BON-1

4 OF 4

METRIC

G.W.P. 647-92-00 LOCATION N 5 038 578.0, E 292 351.3 (Bonnechere River) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 16.10.03 - 20.10.03 CHECKED BY SMS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
71.8			16	SS	507		72										
30.5	END OF BOREHOLE AT 30.53m. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) 22/10/03 18.59 19/12/03 18.15 04/02/04 17.95				050												

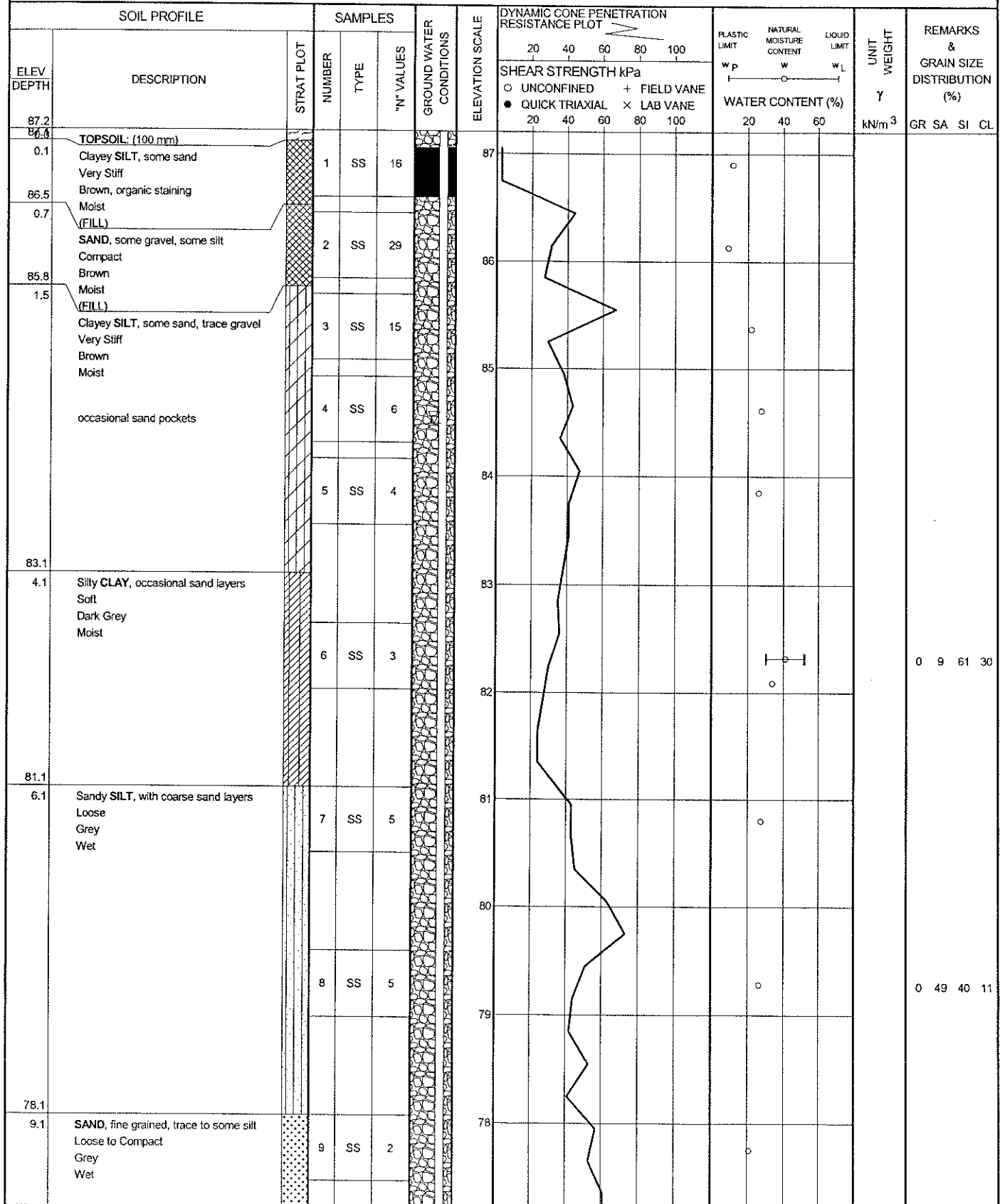
ONTMT4 7450BON.GPJ 11/05/04

RECORD OF BOREHOLE No BON-2

1 OF 4

METRIC

G.W.P. 647-92-00 LOCATION N 5 038 548.1, E 292 414.8 (Bonnechere River) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, HQ Casing, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 14.10.03 - 16.10.03 CHECKED BY SMS



Continued Next Page

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

RECORD OF BOREHOLE No BON-2

2 OF 4

METRIC

G.W.P. 647-92-00 LOCATION N 5 038 548.1, E 292 414.8 (Bonnechere River) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, HQ Casing, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 14.10.03 - 16.10.03 CHECKED BY SMS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
74.7	with clay layers to 50 mm thick		10	SS	10		77					
12.5	SAND, medium to coarse grained, trace gravel, occasional cobbles Compact to Very Dense Grey Wet clay layers to 25 mm thick		11	SS	20		76					
			12	SS	39		75					
			13	SS	81		74					
			14	SS	51		73					
			15	SS	50/ .127		72					
			16	SS	27		71					
							70					
							69					
							68					

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BON-2

3 OF 4

METRIC

G.W.P. 647-92-00 LOCATION N 5 038 548.1, E 292 414.8 (Bonnechere River) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, HQ Casing, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 14.10.03 - 16.10.03 CHECKED BY SMS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	boulders from 20.6m to 21.34m						67							start coring from 20.6m to 21.3m
							66							
							65							
							64							
			17	SS	37		63						2 93 5 (SI+CL)	
							62							
							61							
59.8			18	SS	50		60							
27.4	SAND, coarse grained, trace gravel, occasional cobbles and boulders				102		59						continuous coring	
	boulders and cobbles from 28.22m to 28.55m						58							
	400 mm boulder from 29.9m to 30.33m.													

Continued Next Page

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

ONTMT4 7450BON.GPJ 13/08/04

RECORD OF BOREHOLE No BON-2

4 OF 4

METRIC

G.W.P. 647-92-00 LOCATION N 5 038 548.1, E 292 414.8 (Bonnechere River) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, HQ Casing, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 14.10.03 - 16.10.03 CHECKED BY SMS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
55.9					FI		57					
31.3	MARBLE, BEDROCK Slightly to moderately weathered, very thinly to thinly bedded, grey with dark grey and white subhorizontal banding, very strong Subvertical joints from 31.85m to 31.9m, from 31.93m to 32.13m Multiple rock fragments in gravel and cobble sizes with clay coating from 30.63m to 31.24m Multiple joints from 32.79m to 32.89m, 34.26m to 34.37m		1	RUN	1		56					RUN 1# TCR=100%, SCR=100%, RQD=87%, UCS=139.0MPa RUN 2# TCR=100%, SCR=100%, RQD=83%, UCS=110.4MPa
			2		2		55					
			2	RUN	1		54					
			4		4							
			1		1							
			3	RUN	0							RUN 3# TCR=100%, SCR=100%, RQD=92%, UCS=135.9MPa
			2		2							
			0		0		53					
52.8												
34.4	END OF BOREHOLE AT 34.37m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.83m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) 22/11/03 3.47 19/12/03 3.42 04/02/04 2.72											

METRIC

ORIGINATED BY SL

COMPILED BY SS

CHECKED BY SMS

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

METRIC

[illegible]

+ 3, x 3: Numbers refer to Sensitivity

METRIC

[illegible]



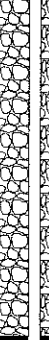

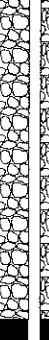









+ 3, x 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No BON-4

2 OF 3

METRIC

G.W.P. 647-92-00 LOCATION N 5 038 463.3, E 292 564.5 (Bonnechere River) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 30.10.03 - 31.10.03 CHECKED BY SMS

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa			WATER CONTENT (%)						
							○ UNCONFINED + FIELD VANE	20 40 60 80 100	20 40 60						
							● QUICK TRIAXIAL × LAB VANE	20 40 60 80 100	20 40 60						
10.0	Gravelly SAND with cobbles, occasional boulders Dense to Very Dense Grey Wet Grey		10	SS	50/ .076										
77.4			11	SS	50/ .127										
12.3	COBBLES and BOULDERS, some sand and gravel Very Dense Grey Wet														continuous coring
	large boulder from 15.0m to 16.4m		1	RUN											RUN 2# TCR=83%, SCR=83%, RQD=45%, UCS=127.5MPa
			2	RUN											RUN 3# TCR=93%, SCR=68%, RQD=63%, UCS=119.6MPa
			3	RUN											RUN 4# TCR=45%, SCR=23%, RQD=0%
			4	RUN											
71.8															
17.9	MARBLE, BEDROCK Moderately weathered, thinly bedded, grey with white subhorizontal banding, very strong		5	RUN											RUN 5# TCR=100%, SCR=100%, RQD=100%, UCS=125.4MPa
71.2															
18.5	Subvertical joints from 15.72m to 15.9m, 18.06m to 18.16m, 18.21m to 18.29m Vertical joint from 17.91m to 18.16m Multiple joints, broken core and gravel pieces from 14.94m to 15.14m, 16.03m to 16.38m, 16.38m to 17.91m END OF BOREHOLE AT 18.47m. Piezometer installation consists of														

ONTMT4 7450BON GPJ 11/05/04

Continued Next Page

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

RECORD OF BOREHOLE No BON-4

3 OF 3

METRIC

G.W.P. 647-92-00 LOCATION N 5 038 463.3, E 292 564.5 (Bonnechere River) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 30.10.03 - 31.10.03 CHECKED BY SMS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	UNCONFINED					
	19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) 04/02/04 5.35													

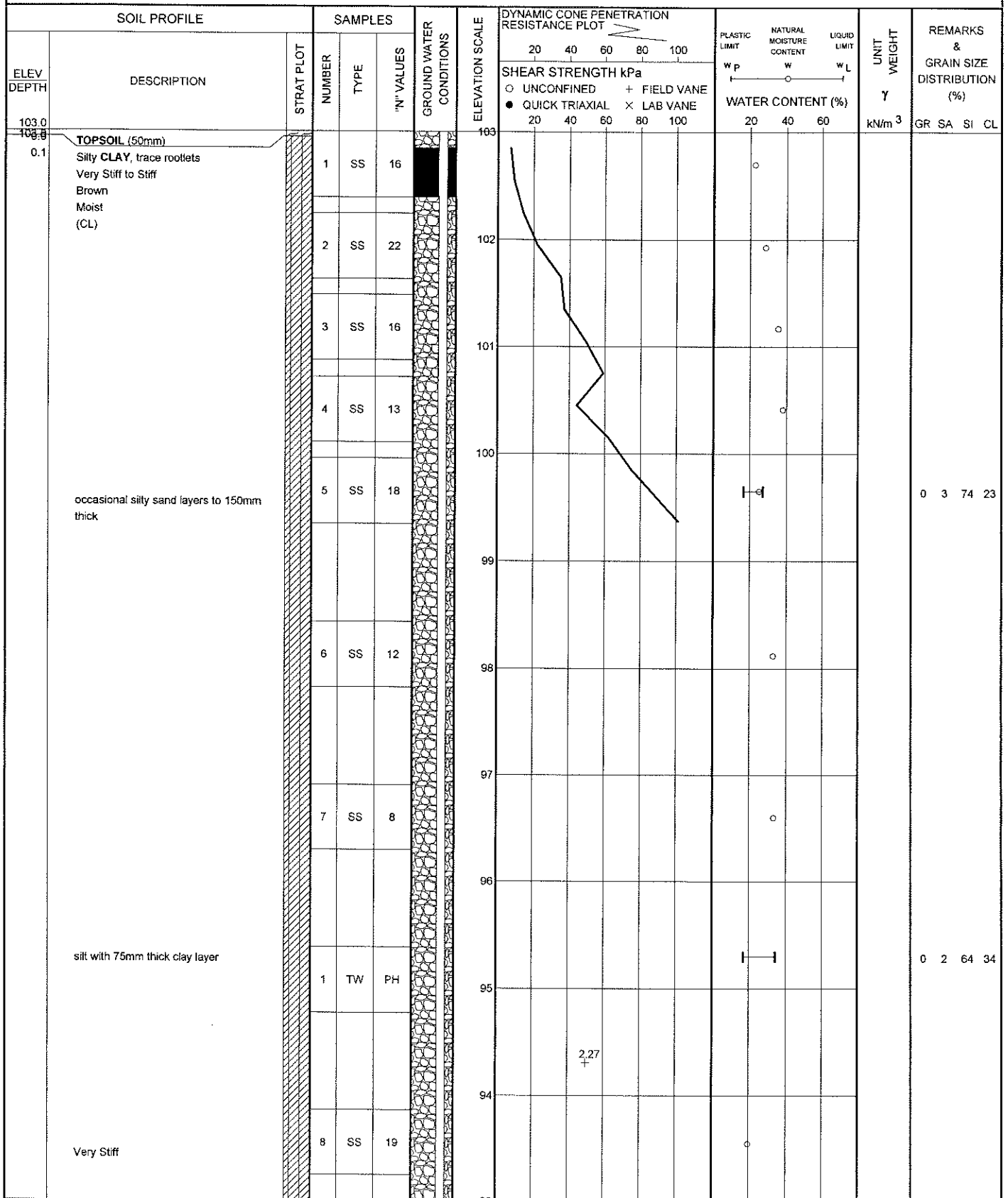
ONTMT4 7450BON GPJ 11/05/04

RECORD OF BOREHOLE No BON-6

1 OF 3

METRIC

G.W.P. 647-92-00 LOCATION N 5 038 595.5, E 292 317.1 (Bonnechere River) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 20.10.03 - 21.10.03 CHECKED BY SMS



Continued Next Page

+ 3 × 3 : Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

METRIC

ORIGINATED BY SL

COMPILED BY SS

CHECKED BY SMS

Continued Next Page

(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W P W W L					WATER CONTENT (%)
								20 40 60 80 100	20 40 60 80 100	20 40 60					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
								20 40 60 80 100				20 40 60			

		Soil Description				Grain Size Analysis (%)				Liquid Limit (LL) & Plasticity Index (PI)				Shrinkage Ratio (SR) & Shrinkage Value (SV)				Other Data			
Depth (m)	Interval (m)	Soil Type	Color	Texture	No.	% Gravel	% Sand	% Fines	LL (%)	PI	SR	SV	Moisture Content (%)	Compaction	Notes						
82.0																					
21.0		SAND and GRAVEL, trace silt, occasional cobbles and boulders																			
					13	SS	42														
		Dense to Very Dense Grey Wet			14	SS	50/	.051													
75.5																					
27.5		END OF BOREHOLE AT 27.48m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.83m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) 19/12/03 18.37 04/02/04 18.28			15	SS	50/	.051													

ONTMT4 7450BON.GPJ 11/05/04

+ 3, × 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No BON-7

1 OF 4

METRIC

G.W.P. 647-92-00 LOCATION N 5 038 628.5, E 292 261.1 (Bonnechere River) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 25.11.03 - 26.11.03 CHECKED BY SMS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						× LAB VANE		
113.0																		
110.9	TOPSOIL (125mm)																	
0.1	Silty CLAY Very Stiff to Stiff Brown Moist (Cl) occasional sand pockets		1	SS	17													
			2	SS	26													
			3	SS	21													
			4	SS	19										0 2 32 66			
			5	SS	10													
			6	SS	7													
107.2																		
5.8	Silty CLAY, trace shell fragments Firm to Stiff Grey Moist to Wet Grey (Cl)		7	SS	7													
			8	SS	7													
			9	SS	2													
	Soft																	

Continued Next Page

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

RECORD OF BOREHOLE No BON-7

2 OF 4

METRIC

G.W.P. 647-92-00 LOCATION N 5 038 628.5, E 292 261.1 (Bonnechere River) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 25.11.03 - 26.11.03 CHECKED BY SMS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								○ UNCONFINED + FIELD VANE					
								● QUICK TRIAXIAL × LAB VANE					
						WATER CONTENT (%)							
									PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L		
									20 40 60 80 100	20 40 60			
	Stiff to Very Stiff (CH)						103						
			10	SS	5		102						0 0 56 44
							101						
			1	TW	PH								
							100						
							99						
							98						
			11	SS	7								
							97						
							96						
							95						
			12	SS	10								
							94						

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity

20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BON-7

3 OF 4

METRIC

G.W.P. 647-92-00 LOCATION N 5 038 628.5, E 292 261.1 (Bonnechere River) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 25.11.03 - 26.11.03 CHECKED BY SMS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES												
92.5	Silty CLAY , with occasional sand layers to 100mm thick Very Stiff Grey (CL)		13	SS	8		93										
92																	
91																	
90																	
89			14	SS	17		89										
88							88										
87							87										
86							86										
85			15	SS	8		85										
84							84										
83							83										

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BON-7

4 OF 4

METRIC

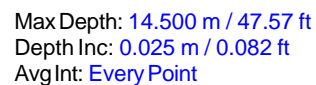
G.W.P. 647-92-00 LOCATION N 5 038 628.5, E 292 261.1 (Bonnechere River) ORIGINATED BY SL
 HWY HWY 17 BOREHOLE TYPE Hollow Stem Augers, NQ Coring COMPILED BY SS
 DATUM Geodetic DATE 25.11.03 - 26.11.03 CHECKED BY SMS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								
81.9			16	SS	11								
31.1	END OF BOREHOLE AT 31.09m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) 04/02/04 destroyed												




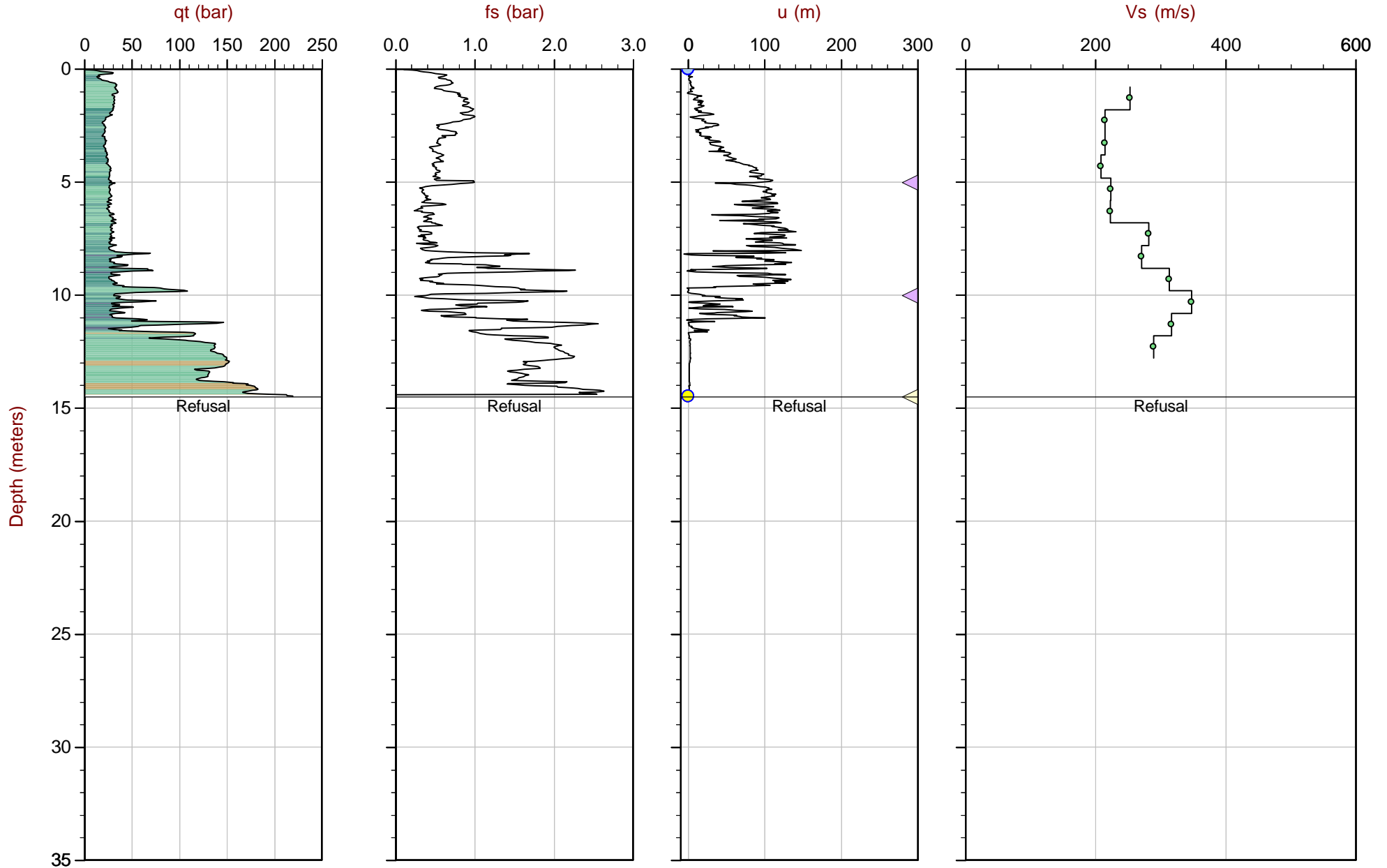
Appendix B.3

Cone Penetration Test Summary Sheets (ConeTec Investigations Ltd.)



SBT: [Robertson, 2009 and 2010](#)
 Coords: [MTM 9N N:5038418.8m E:292650.9m Elev.116.9m](#)
 Page No: 1 of 1

 Hydrostatic Line Equilibrium Profile
 Dissipation, equilibrium not achieved



Max Depth: 14.500 m / 47.57 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 21-05-22576_SP-BON-E.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: MTM 9N N:5038418.8m E:292650.9m Elev.116.9m
Page No: 1 of 1

Overplot Item:

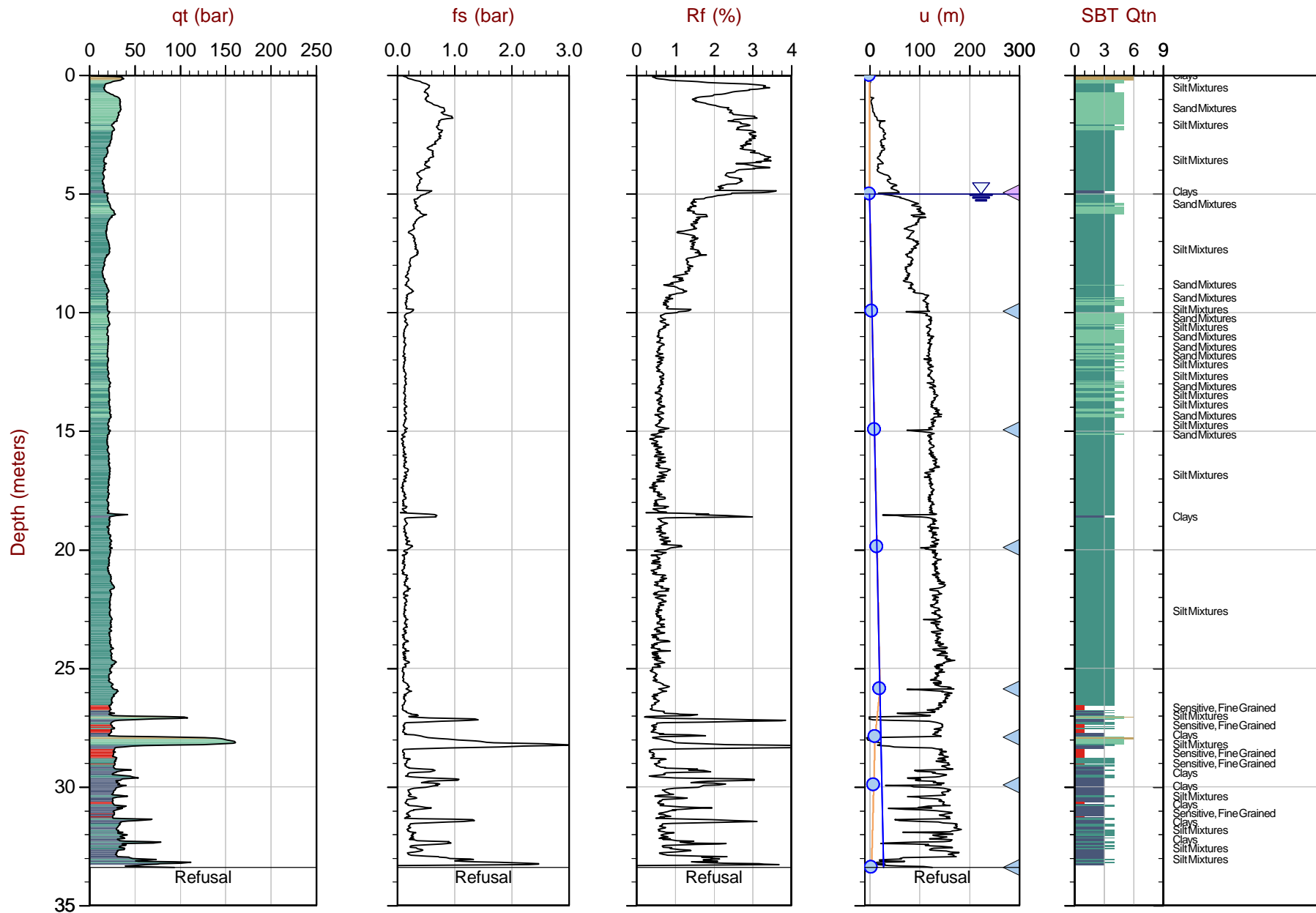
- Assumed Ueq
- Ueq
- ▲ Dissipation, equilibrium achieved
- ▲ Dissipation, equilibrium assumed
- Hydrostatic Line
- Dissipation, equilibrium not achieved
- Equilibrium Profile



Thurber Engineering

Job No: 21-05-22576
Date: 2021-08-05 05:21
Site: Renfrew Ontario

Sounding: BON-W
Cone: 609:T1500F15U35

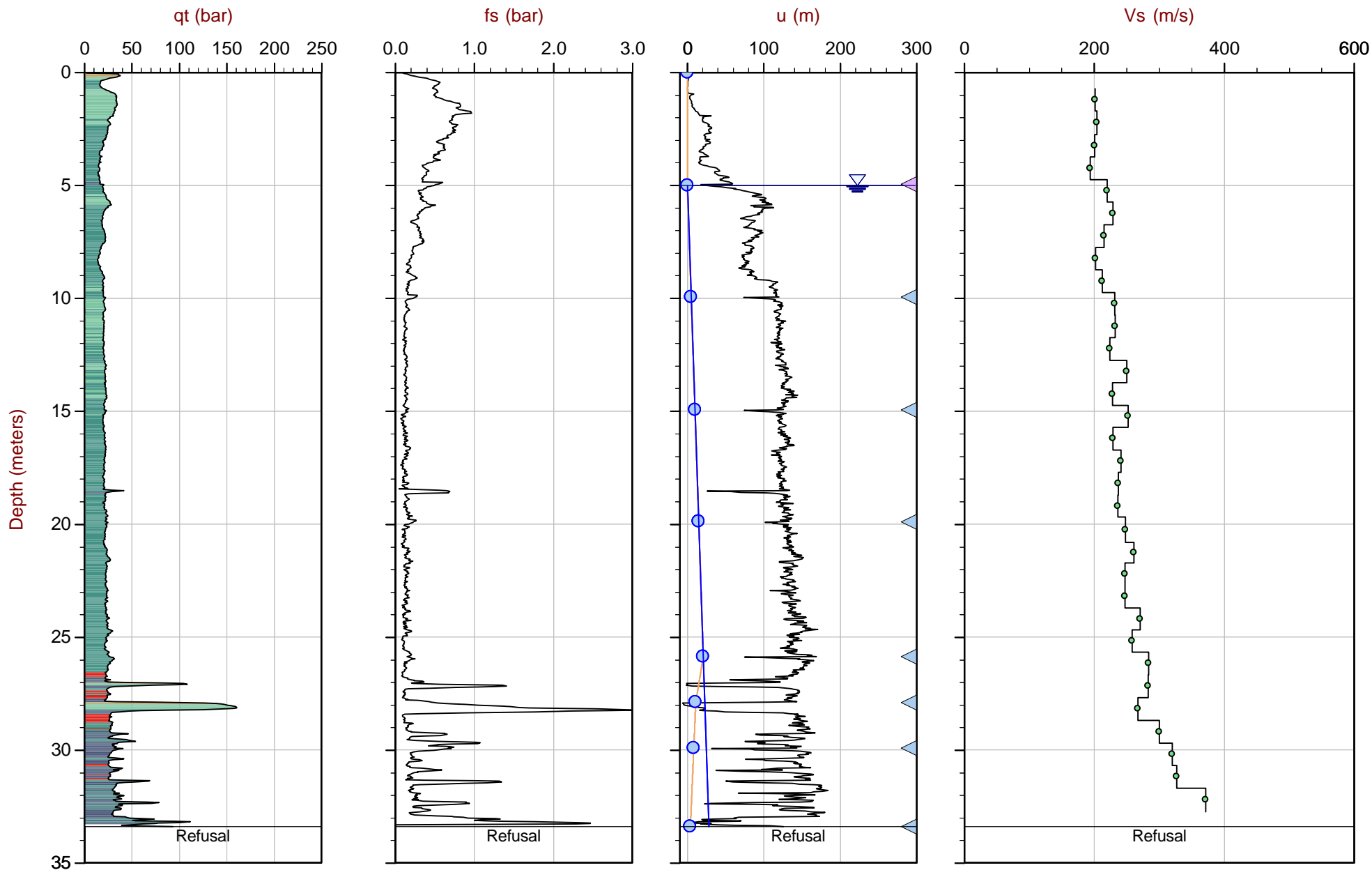




Thurber Engineering

Job No: 21-05-22576
Date: 2021-08-05 05:21
Site: Renfrew Ontario

Sounding: BON-W
Cone: 609:T1500F15U35



Max Depth: 33.400 m / 109.58 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 21-05-22576_SP-BON-W.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: MTM 9N N:5038619.4m E:292269.6m Elev.112.0m
Page No: 1 of 1

Overplot Item:
● Assumed Ueq
● Ueq
◀ Dissipation, equilibrium achieved
◀ Dissipation, equilibrium assumed
— Hydrostatic Line
— Equilibrium Profile
◀ Dissipation, equilibrium not achieved



Appendix B.4

MASW Testing Summary (Geophysics GPR International Inc.)



Figure 2b: Location of the seismic spread SL-3
(source: Google Earth™)



Figure 2c: Location of the seismic spreads SL-4 and SL-5
(source: Google Earth™)

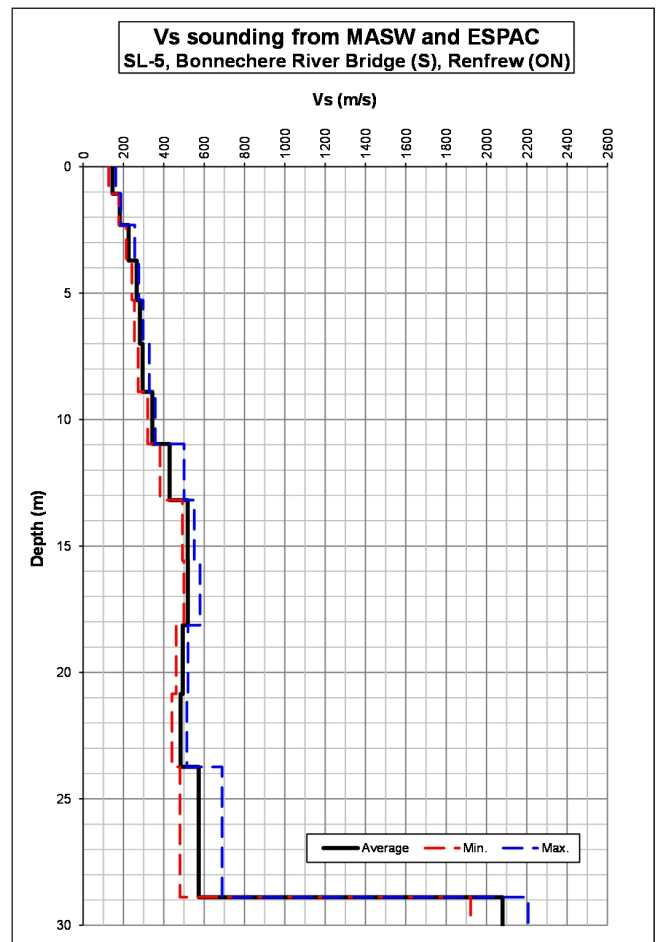
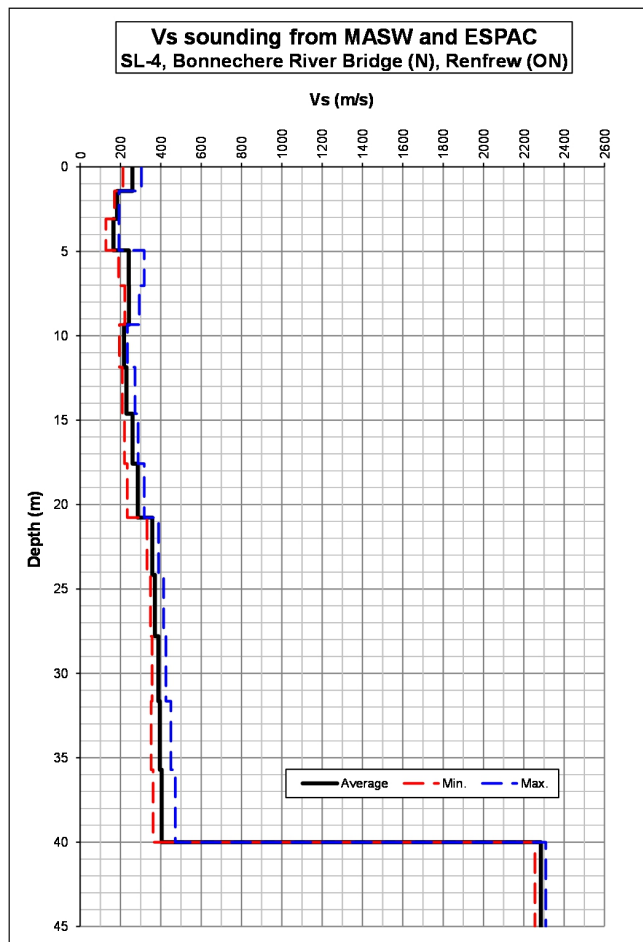


Figure 6c: MASW Shear-Wave Velocity Soundings





Appendix B.5

Soil Summary Plots

FIGURE B5.1

SOIL SUMMARY - BONNECHERE RIVER BRIDGE

WEST APPROACH (BON19-1, BON19-2, BON19-3, BON24-1, BON24-2, BON-1, BON-2, BON-7, BON-W)
SILTY CLAY TO CLAYEY SILT

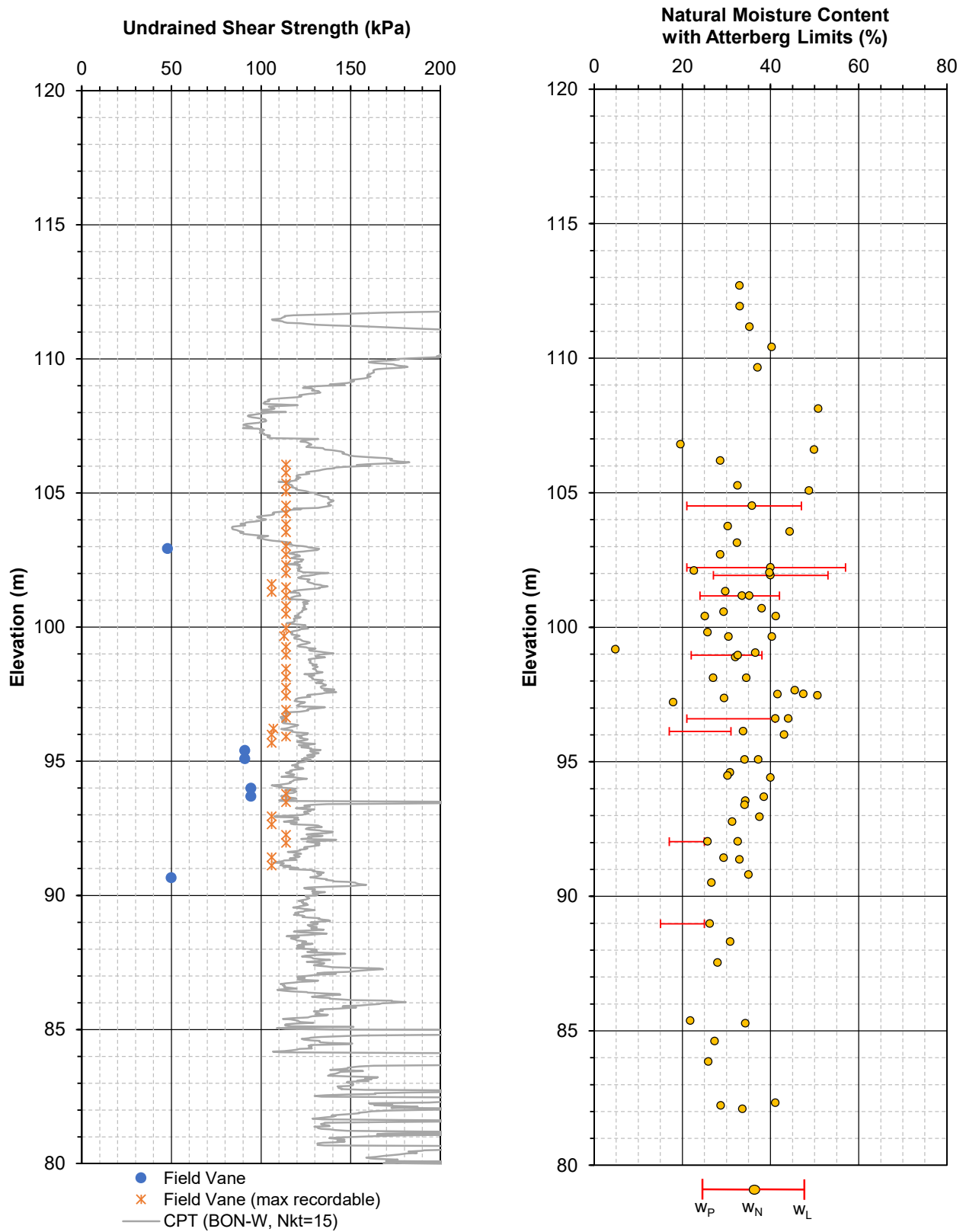
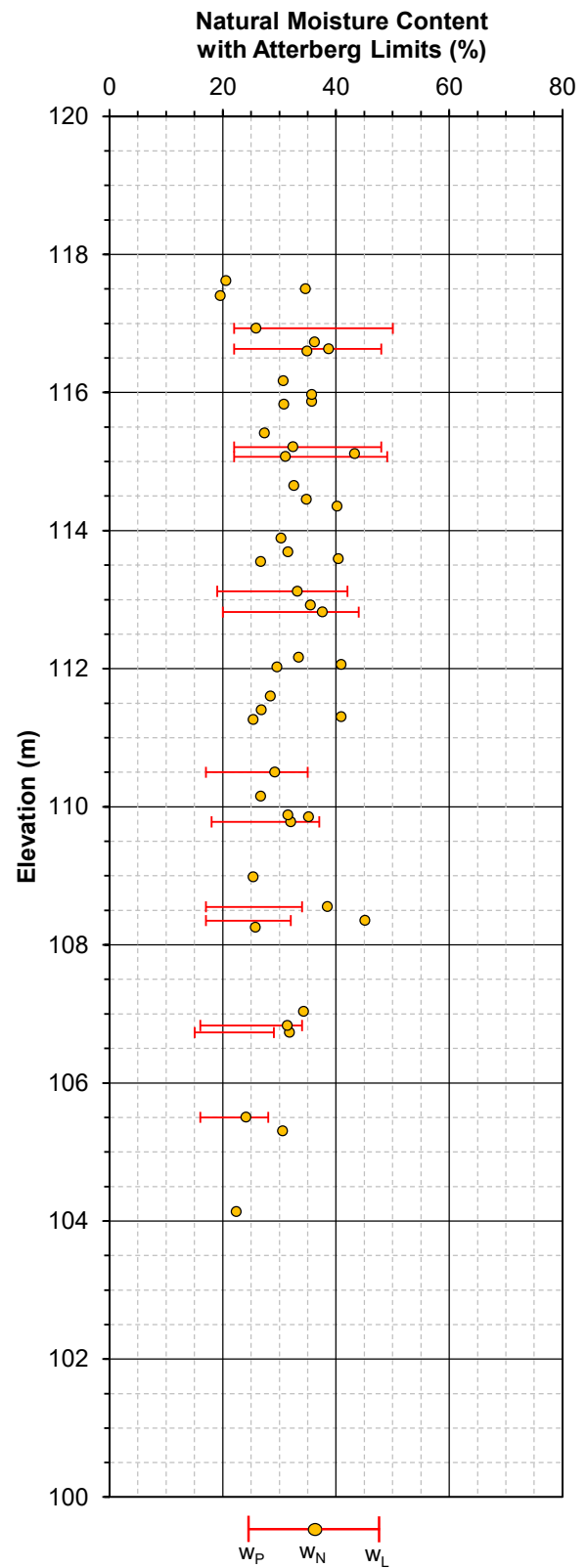
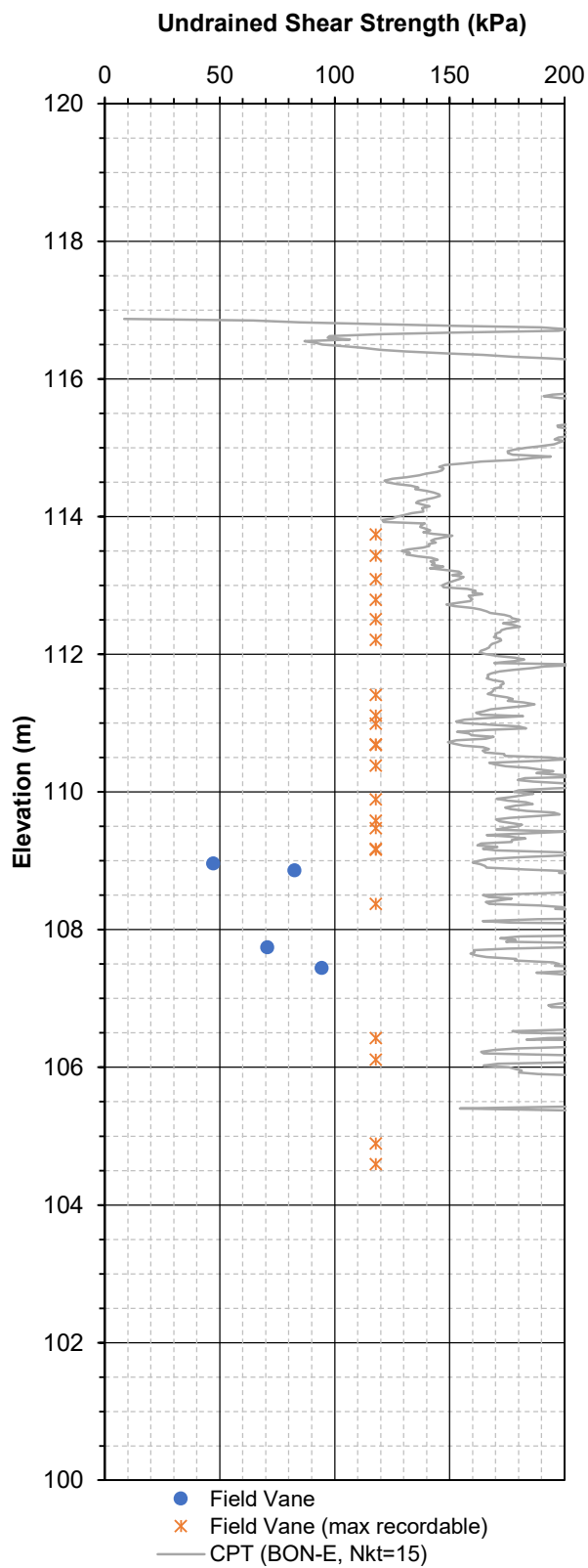


FIGURE B5.2

SOIL SUMMARY - BONNECHERE RIVER BRIDGE
 EAST APPROACH (BON19-6, BON19-7, BON19-8, BON19-9, BON-E)
 SILTY CLAY TO CLAYEY SILT





Appendix C.

Laboratory Testing

Current (2020/2021/2024) Investigation



Appendix C.1

Particle Size Analysis Figures

Atterberg Limit Test Results

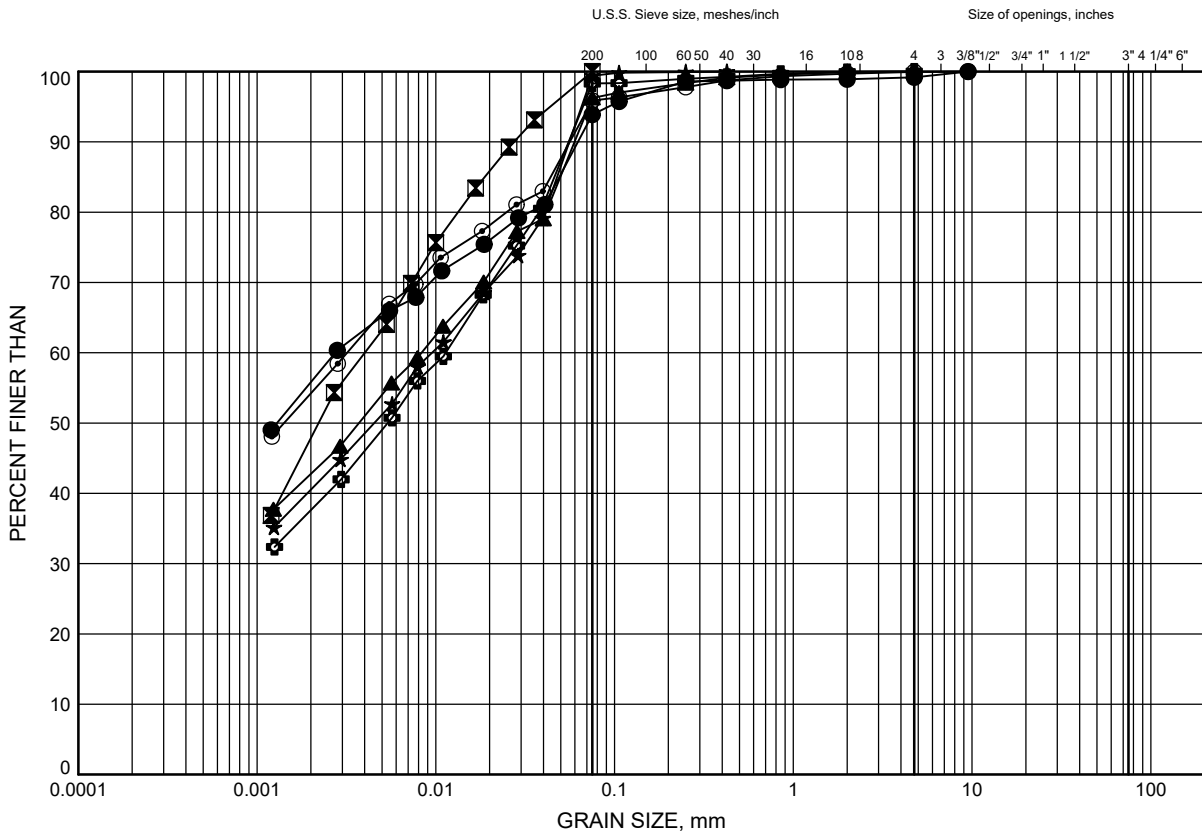
One Dimensional Consolidation Test Results

Highway 17 Twinning, Bonnechere River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C1.1

Silty Clay (Weathered Crust)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-1	2.6	104.5
⊠	BON19-1	4.9	102.2
▲	BON19-2	1.8	101.2
★	BON19-2	6.4	96.6
⊙	BON19-3	1.1	101.9
⊕	BON19-3	4.1	98.9

Date April 2022
WP# 4068-09-00



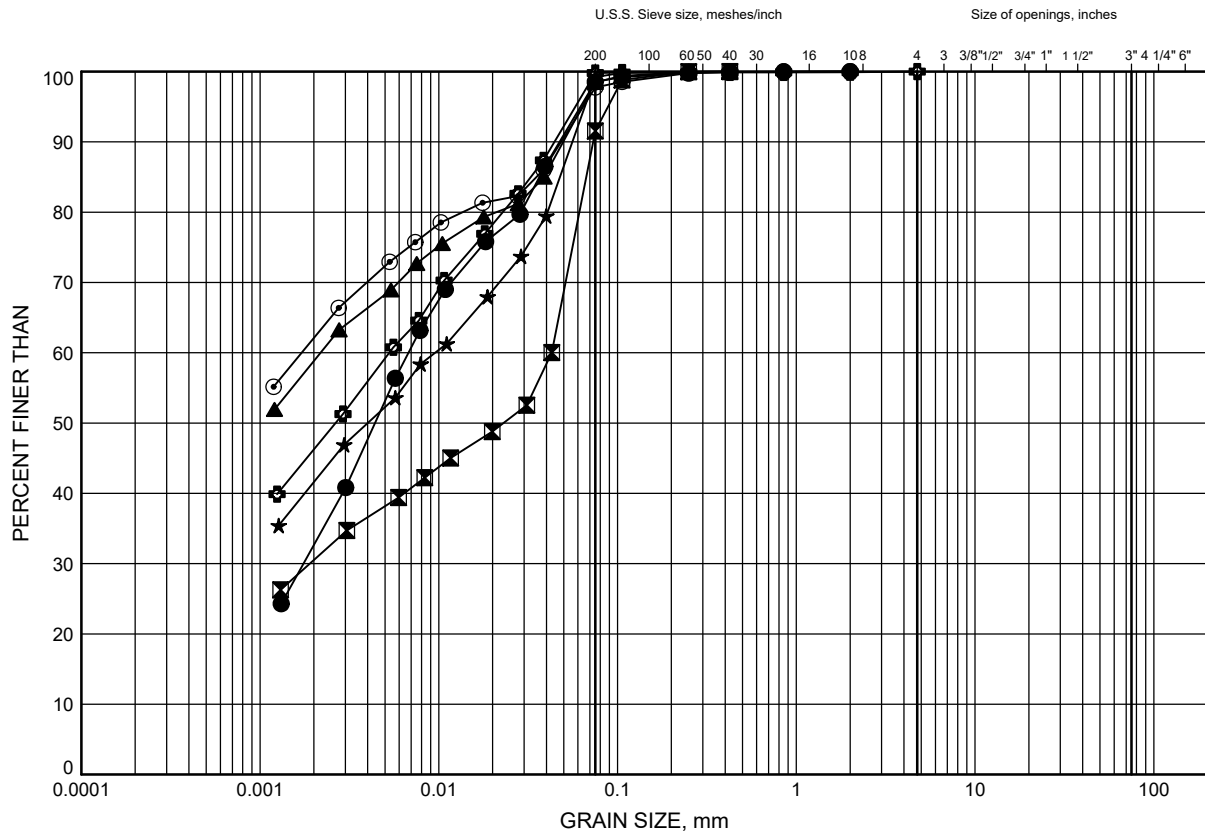
Prep'd MIK
Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C1.2

Silty Clay (Weathered Crust)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-4	1.1	97.8
⊠	BON19-5	1.8	97.1
▲	BON19-6	1.8	115.1
★	BON19-6	6.4	110.5
⊙	BON19-7	1.1	116.9
⊕	BON19-7	4.9	113.1

Date April 2022
WP# 4068-09-00



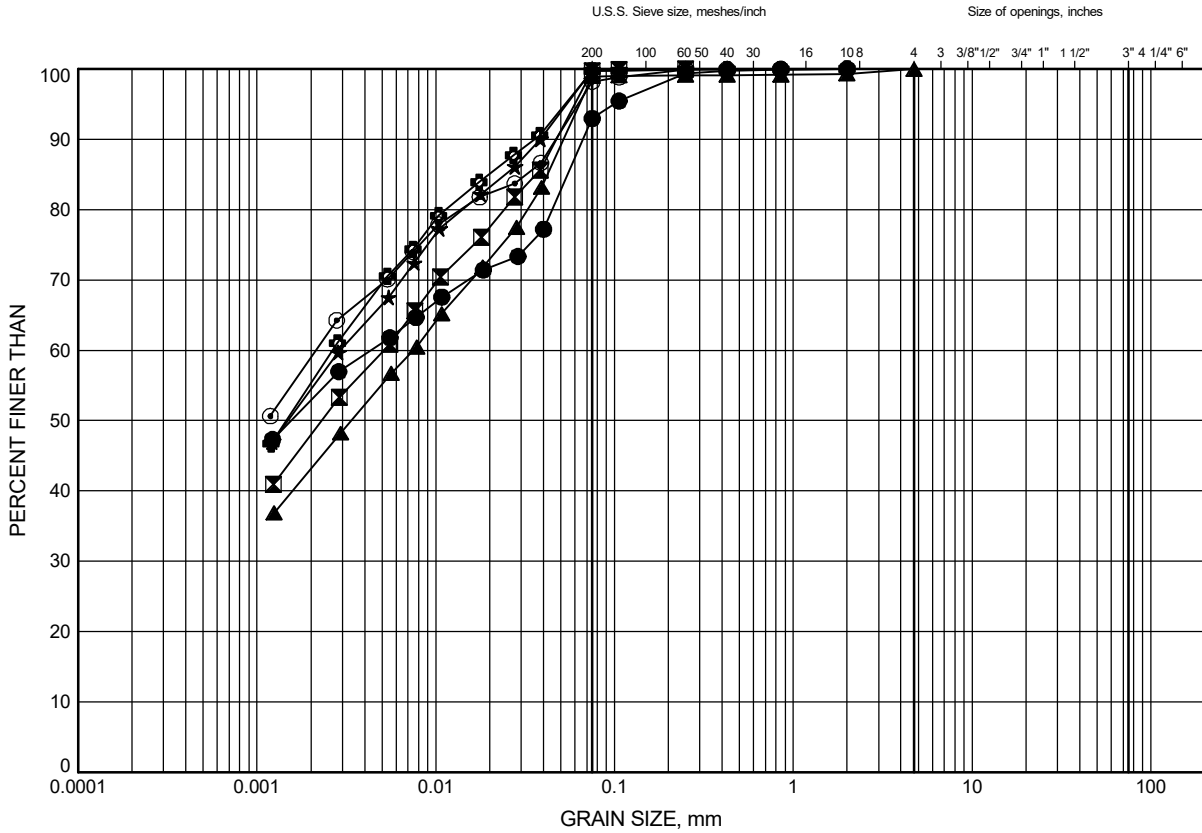
Prep'd MIK
Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C1.3

Silty Clay (Weathered Crust)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-8	1.1	116.6
⊠	BON19-8	4.9	112.8
▲	BON19-8	7.9	109.8
★	BON19-9	2.6	115.2
⊙	BON24-2	1.8	106.7
⊕	BON24-2	6.4	102.1

Date August 2024
 WP# 4068-09-00

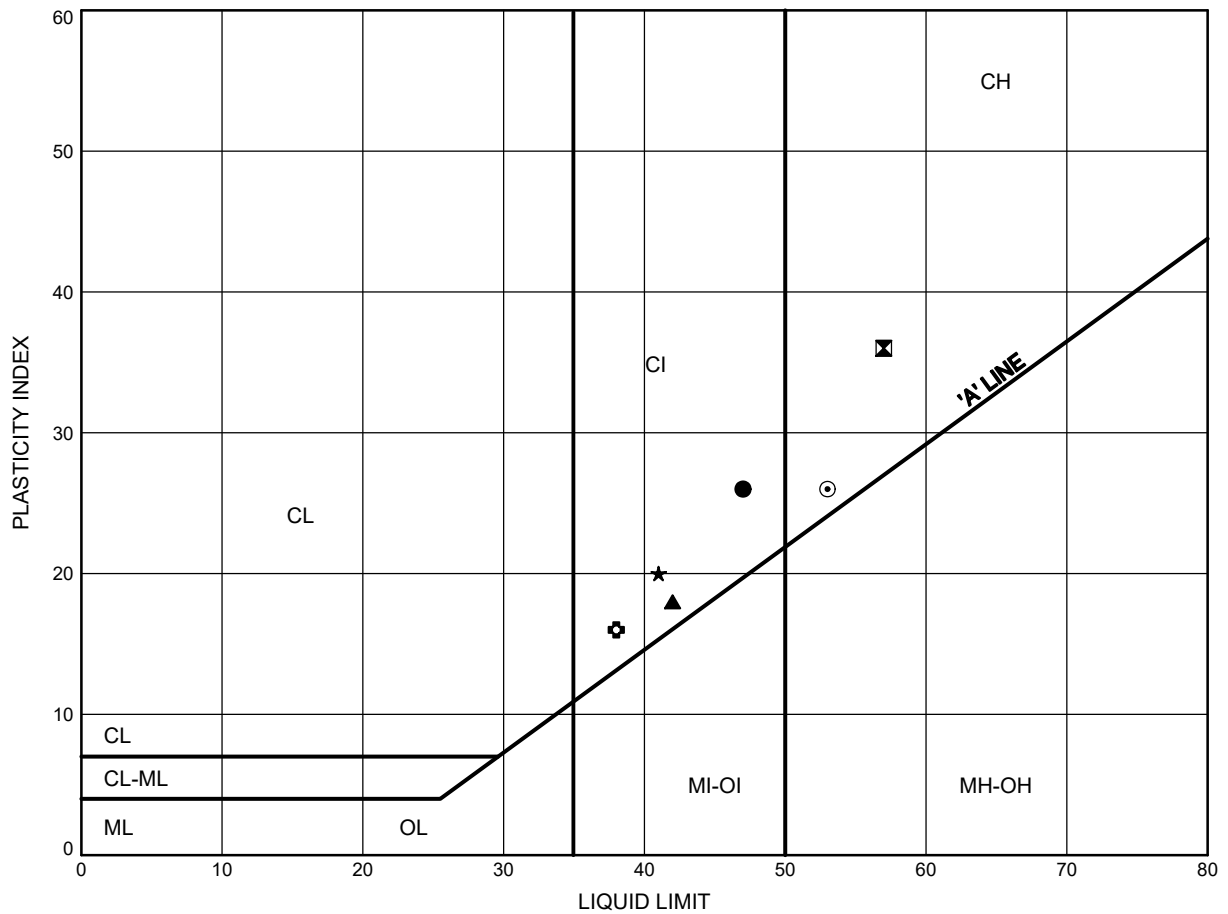


Prep'd RH
 Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge
ATTERBERG LIMITS TEST RESULTS

FIGURE C2.1

Silty Clay (Weathered Crust)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-1	2.6	104.5
⊠	BON19-1	4.9	102.2
▲	BON19-2	1.8	101.2
★	BON19-2	6.4	96.6
⊙	BON19-3	1.1	101.9
⊕	BON19-3	4.1	98.9

Date April 2022
 WP# 4068-09-00

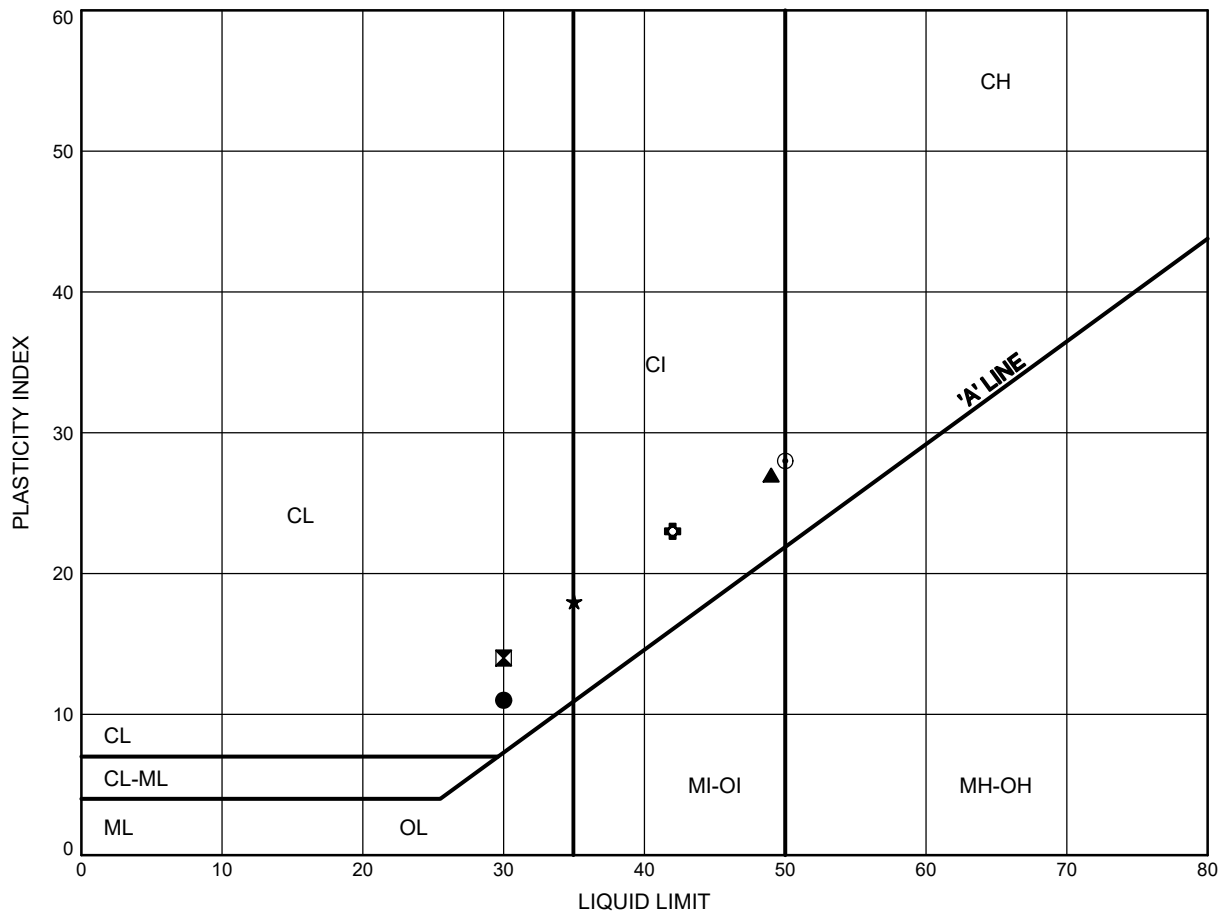


Prep'd MIK
 Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge ATTERBERG LIMITS TEST RESULTS

FIGURE C2.2

Silty Clay (Weathered Crust)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-4	1.1	97.8
⊠	BON19-5	1.8	97.1
▲	BON19-6	1.8	115.1
★	BON19-6	6.4	110.5
⊙	BON19-7	1.1	116.9
⊕	BON19-7	4.9	113.1

Date April 2022
 WP# 4068-09-00

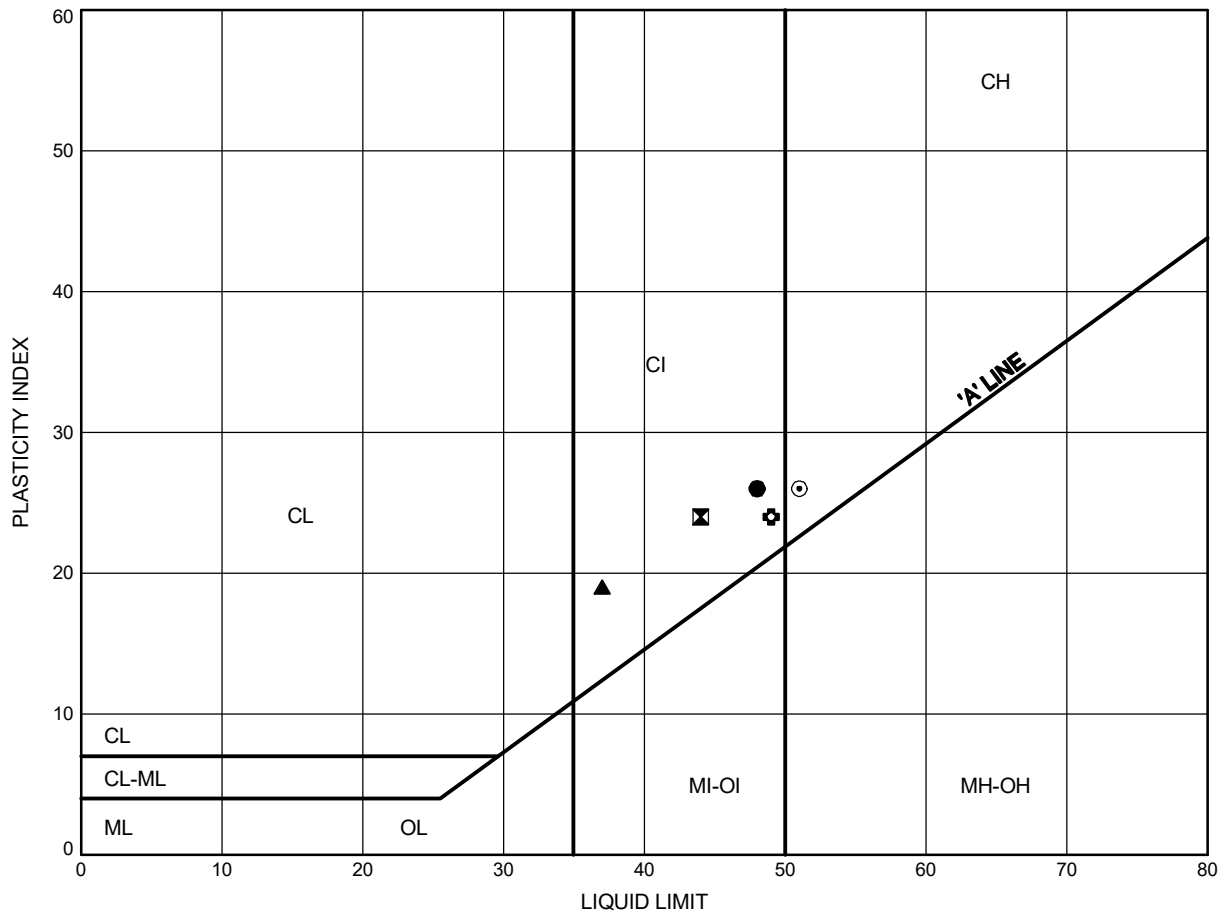


Prep'd MIK
 Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge ATTERBERG LIMITS TEST RESULTS

FIGURE C2.3

Silty Clay (Weathered Crust)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-8	1.1	116.6
⊠	BON19-8	4.9	112.8
▲	BON19-8	7.9	109.8
★	BON19-9	2.6	115.2
⊙	BON24-2	1.8	106.7
⊕	BON24-2	6.4	102.1

Date August 2024
 WP# 4068-09-00

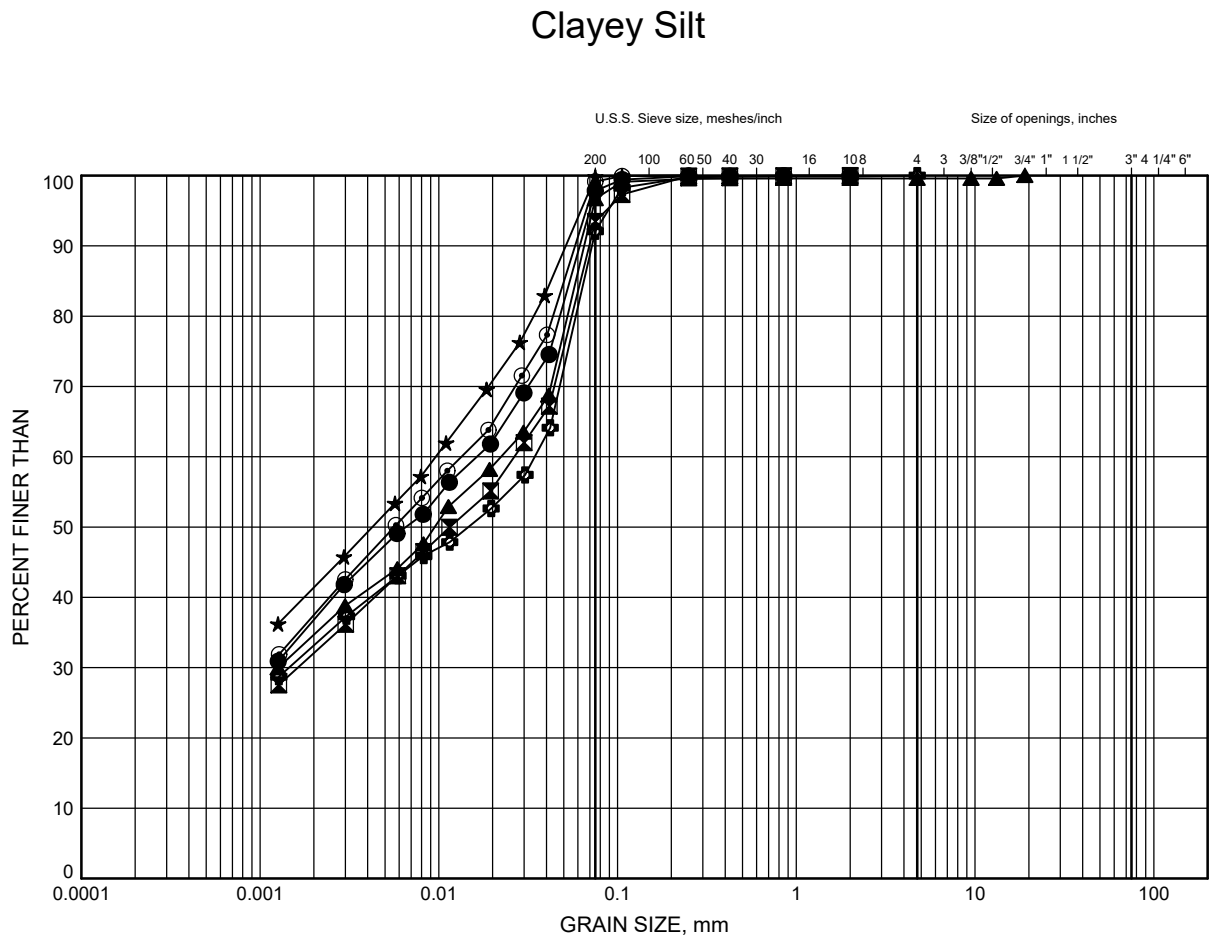


Prep'd RH
 Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C3.1



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-1	11.0	96.1
⊠	BON19-2	14.0	89.0
▲	BON19-3	11.0	92.0
★	BON19-7	9.4	108.6
⊙	BON19-7	12.5	105.5
⊕	BON19-8	11.0	106.7

Date April 2022
WP# 4068-09-00

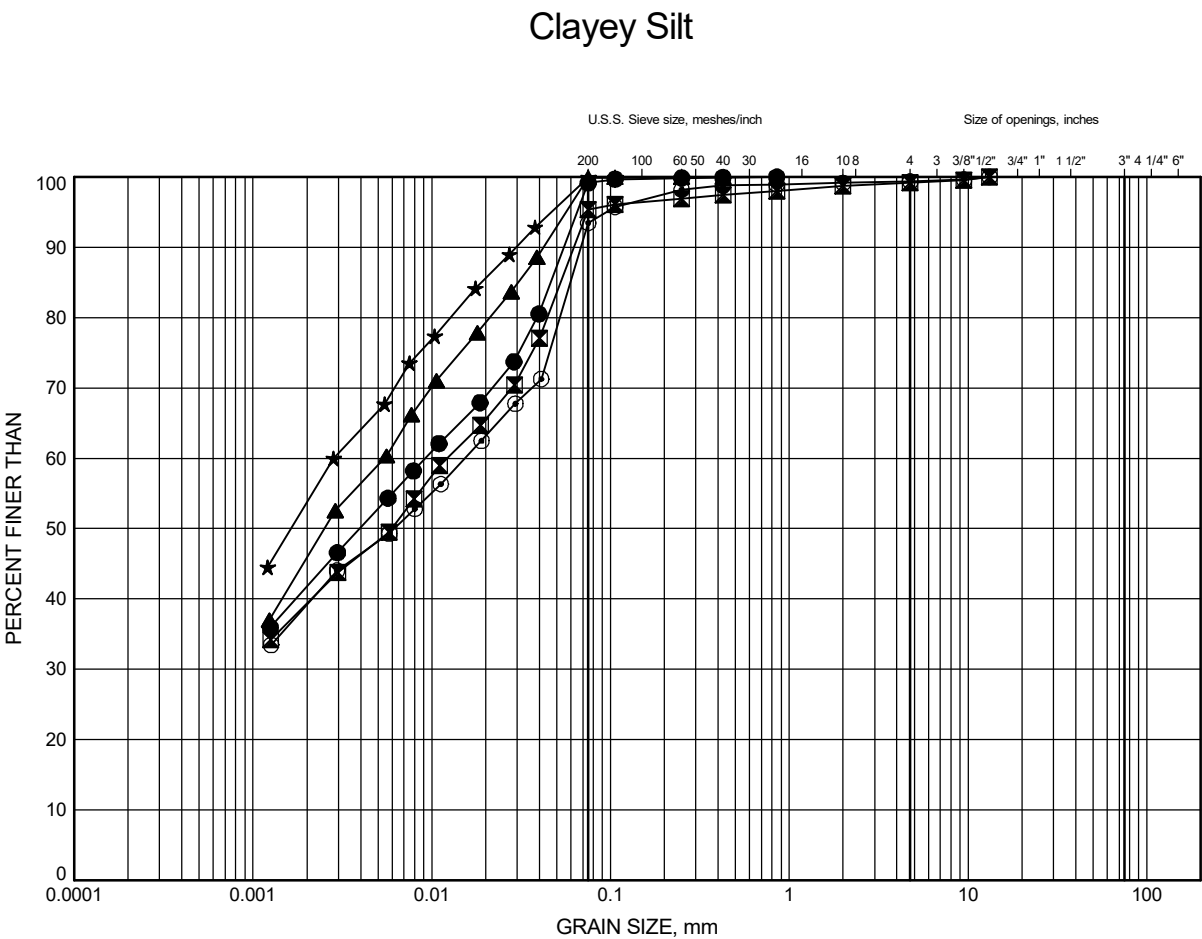


Prep'd MIK
Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C3.2



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-9	9.4	108.4
⊠	BON19-9	11.0	106.8
▲	BON24-1	11.0	96.8
★	BON24-2	11.0	97.5
⊙	BON-P1	2.6	85.3

GRAIN SIZE DISTRIBUTION - THURBER 24726 BON.GPJ 8-22-24

Date August 2024
WP# 4068-09-00

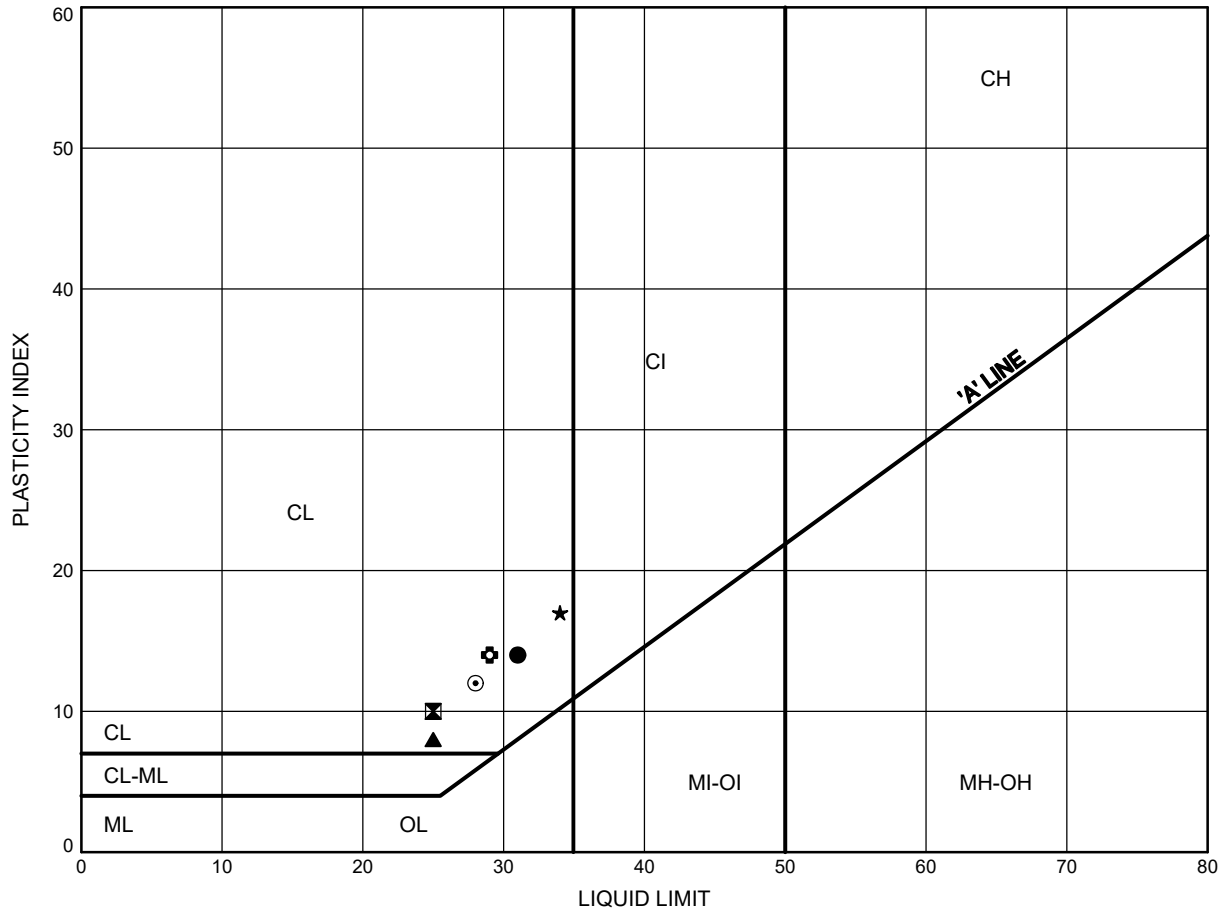


Prep'd RH
Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge ATTERBERG LIMITS TEST RESULTS

FIGURE C4.1

Clayey Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-1	11.0	96.1
⊠	BON19-2	14.0	89.0
▲	BON19-3	11.0	92.0
★	BON19-7	9.4	108.6
⊙	BON19-7	12.5	105.5
⊕	BON19-8	11.0	106.7

Date April 2022
 WP# 4068-09-00

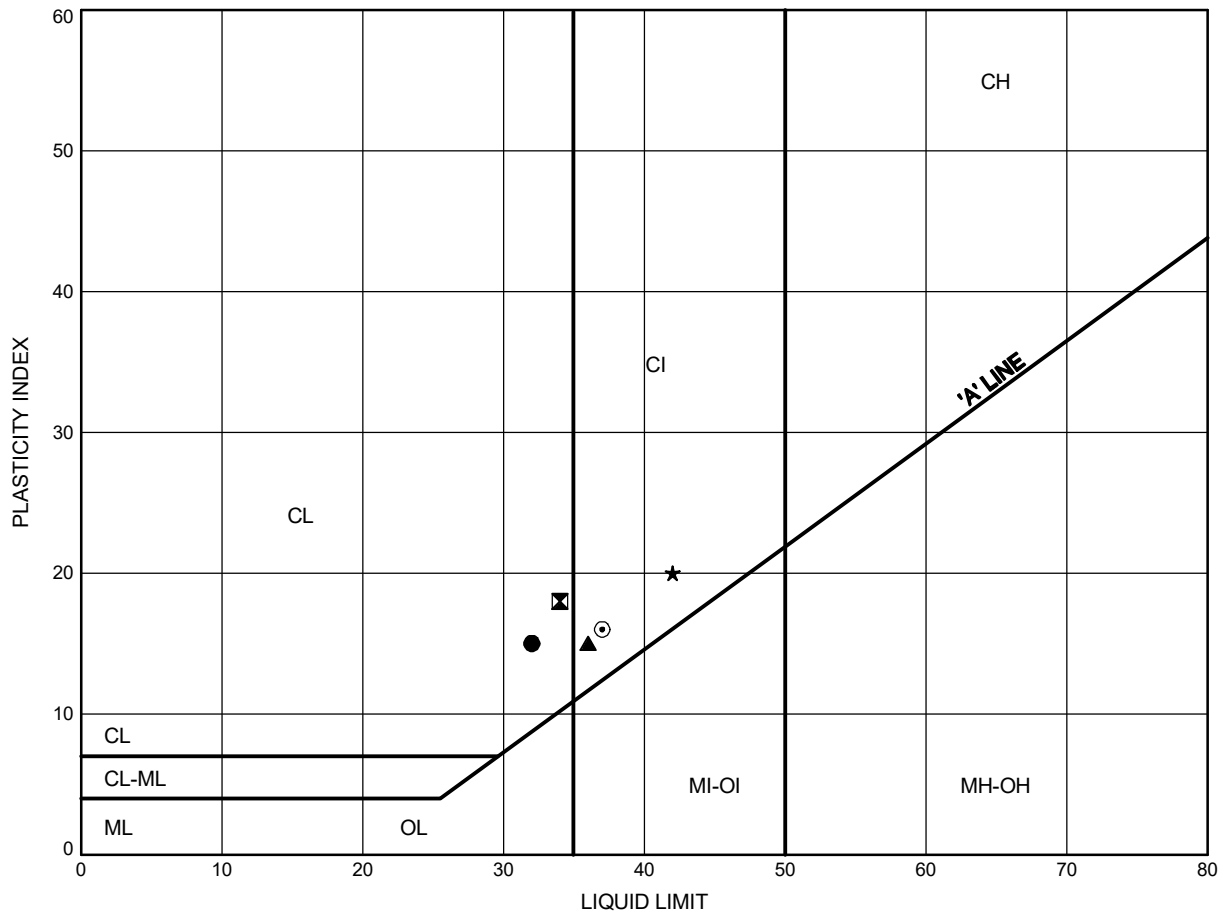


Prep'd MIK
 Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge ATTERBERG LIMITS TEST RESULTS

FIGURE C4.2

Clayey Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-9	9.4	108.4
⊠	BON19-9	11.0	106.8
▲	BON24-1	11.0	96.8
★	BON24-2	11.0	97.5
⊙	BON-P1	2.6	85.3

Date August 2024
 WP# 4068-09-00



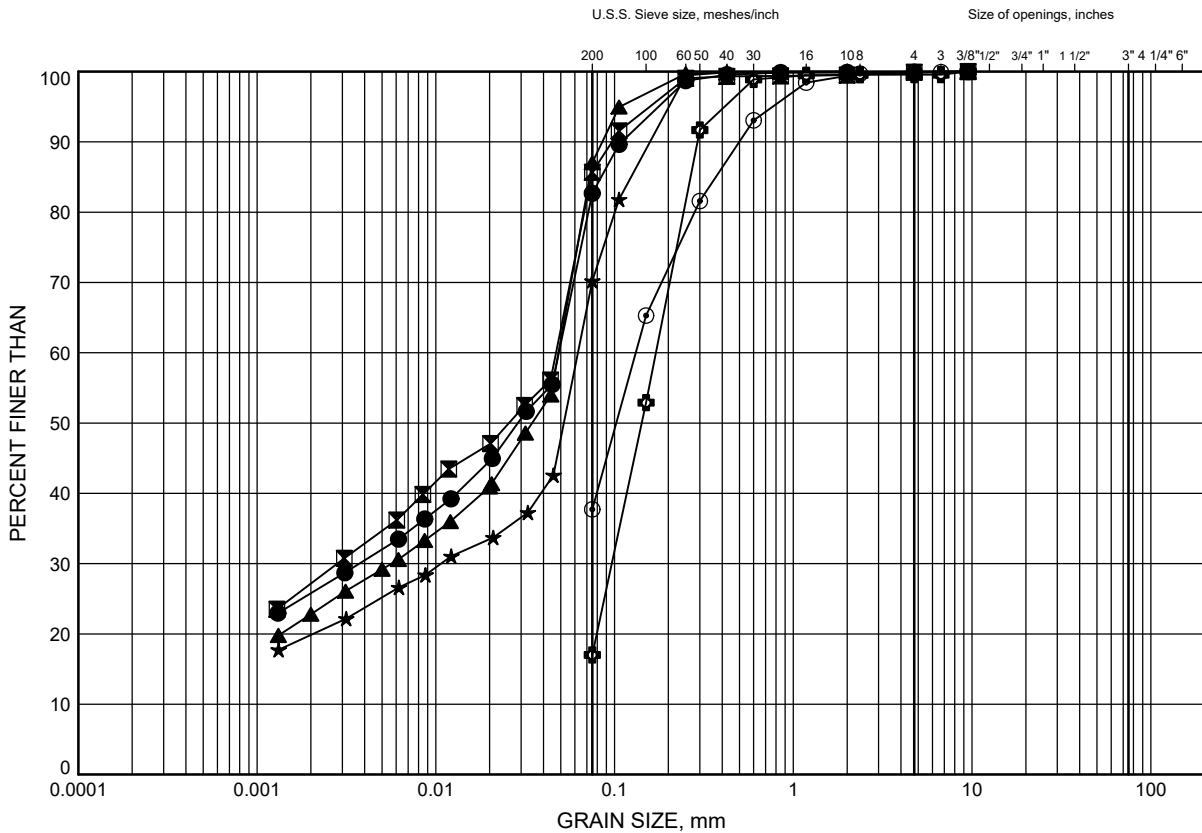
Prep'd RH
 Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C5.1

Silty Sand to Clayey Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-1	16.3	90.8
⊠	BON19-2	17.1	85.9
▲	BON19-3	14.0	89.0
★	BON19-3	20.1	82.9
⊙	BON19-5	5.6	93.3
⊕	BON19-6	11.0	105.9

Date April 2022
WP# 4068-09-00



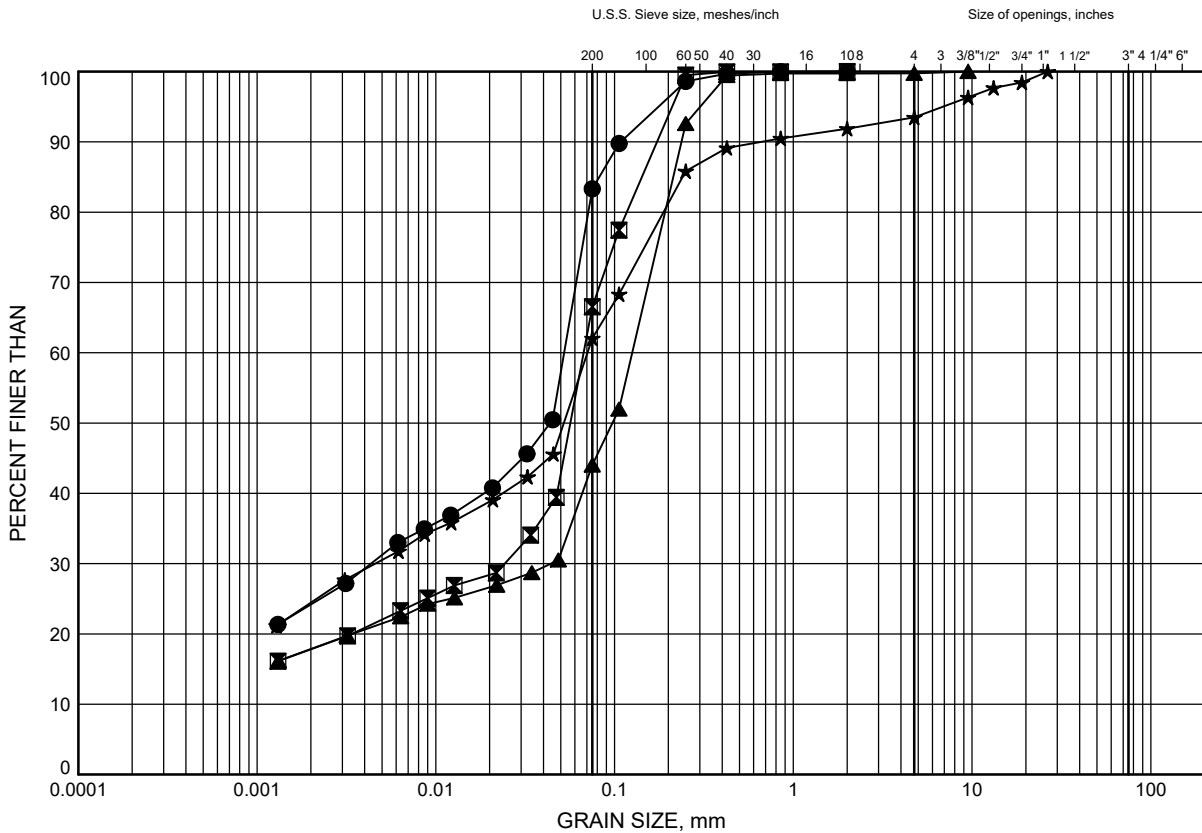
Prep'd MIK
Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C5.2

Silty Sand to Clayey Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON-P1	4.9	83.0
⊠	BON-P2	2.6	83.5
▲	BON-P3	1.1	88.1
★	BON-P3	2.6	86.6

Date April 2022
WP# 4068-09-00

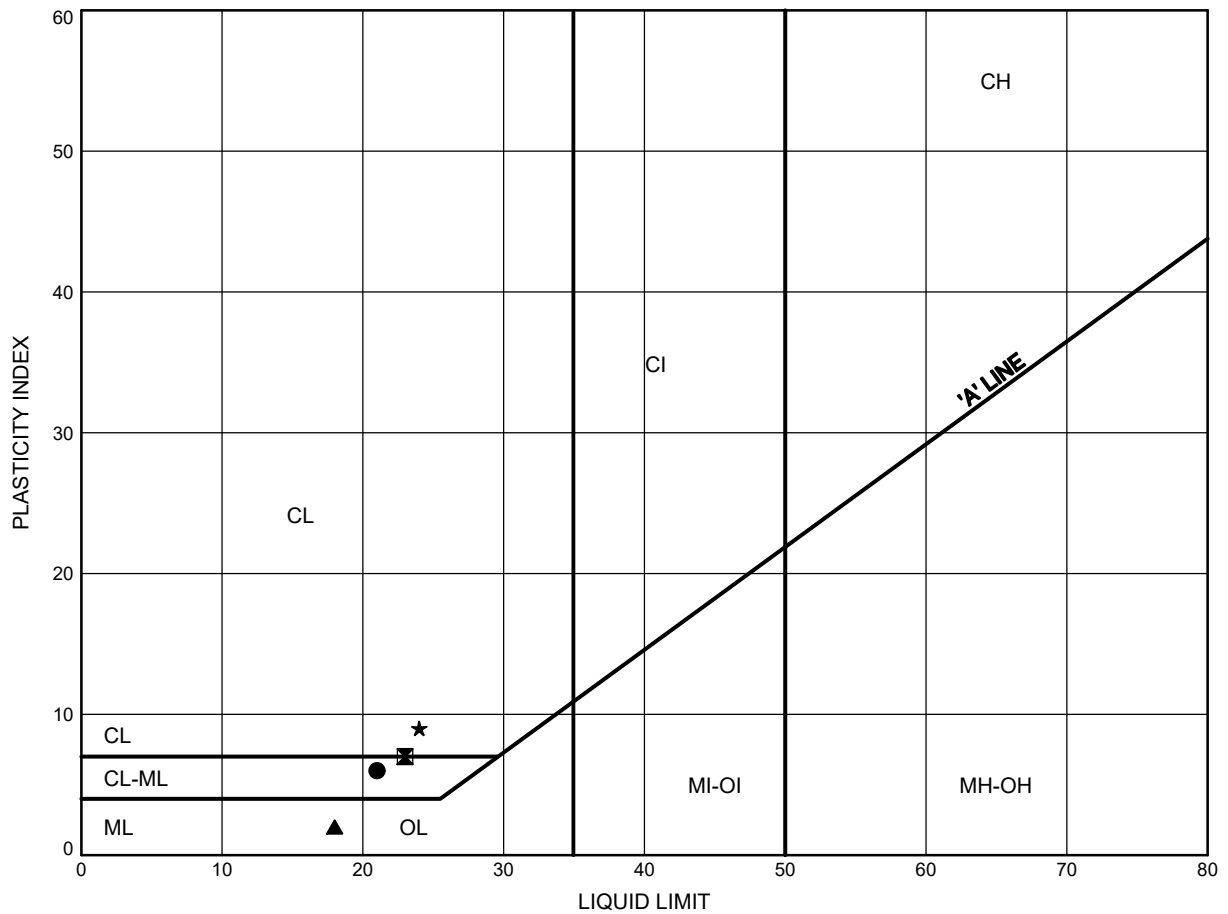


Prep'd MIK
Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge ATTERBERG LIMITS TEST RESULTS

FIGURE C6.1

Silty Sand to Clayey Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-1	16.3	90.8
⊠	BON19-2	17.1	85.9
▲	BON-P1	4.9	83.0
★	BON-P3	2.6	86.6

Date April 2022
 WP# 4068-09-00



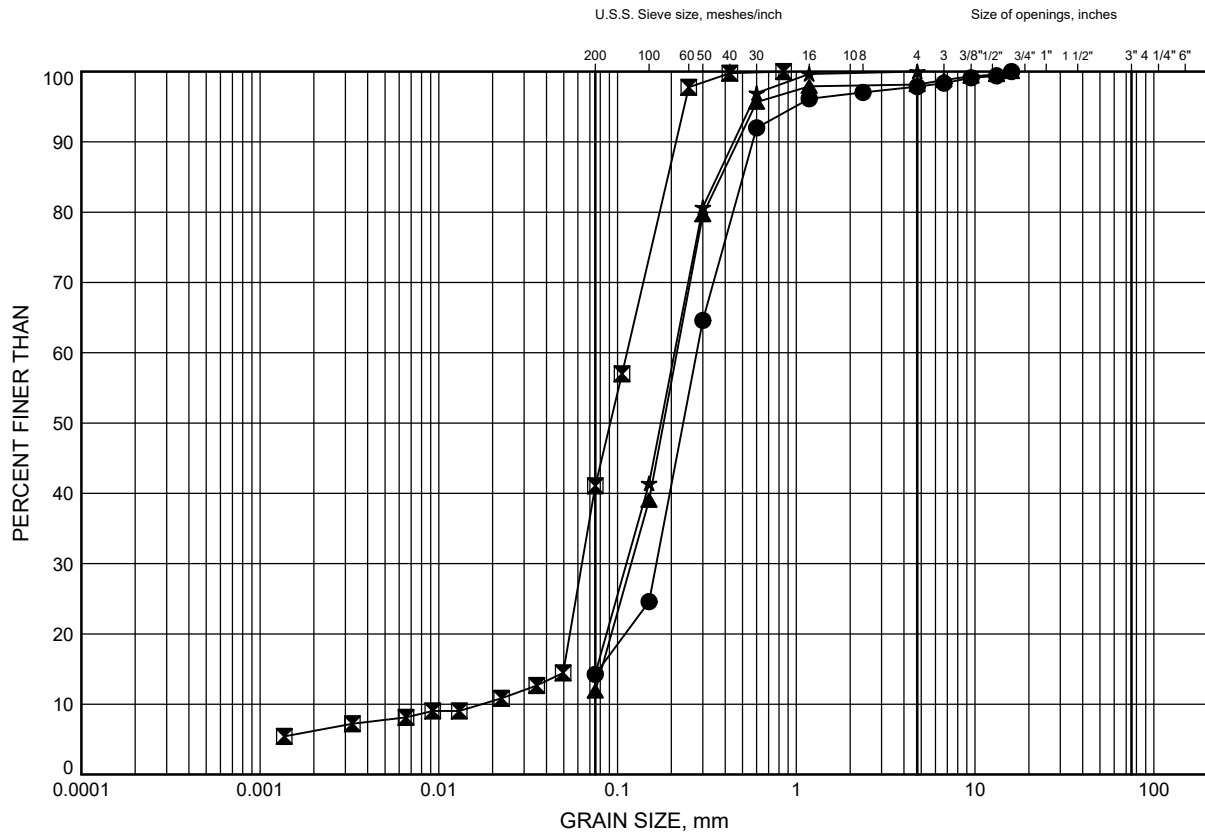
Prep'd MIK
 Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C7.1

Silty Sand to Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-1	17.8	89.3
⊠	BON-P1	7.9	80.0
▲	BON-P1	15.5	72.4
★	BON-P2	3.4	82.7

Date April 2022
WP# 4068-09-00



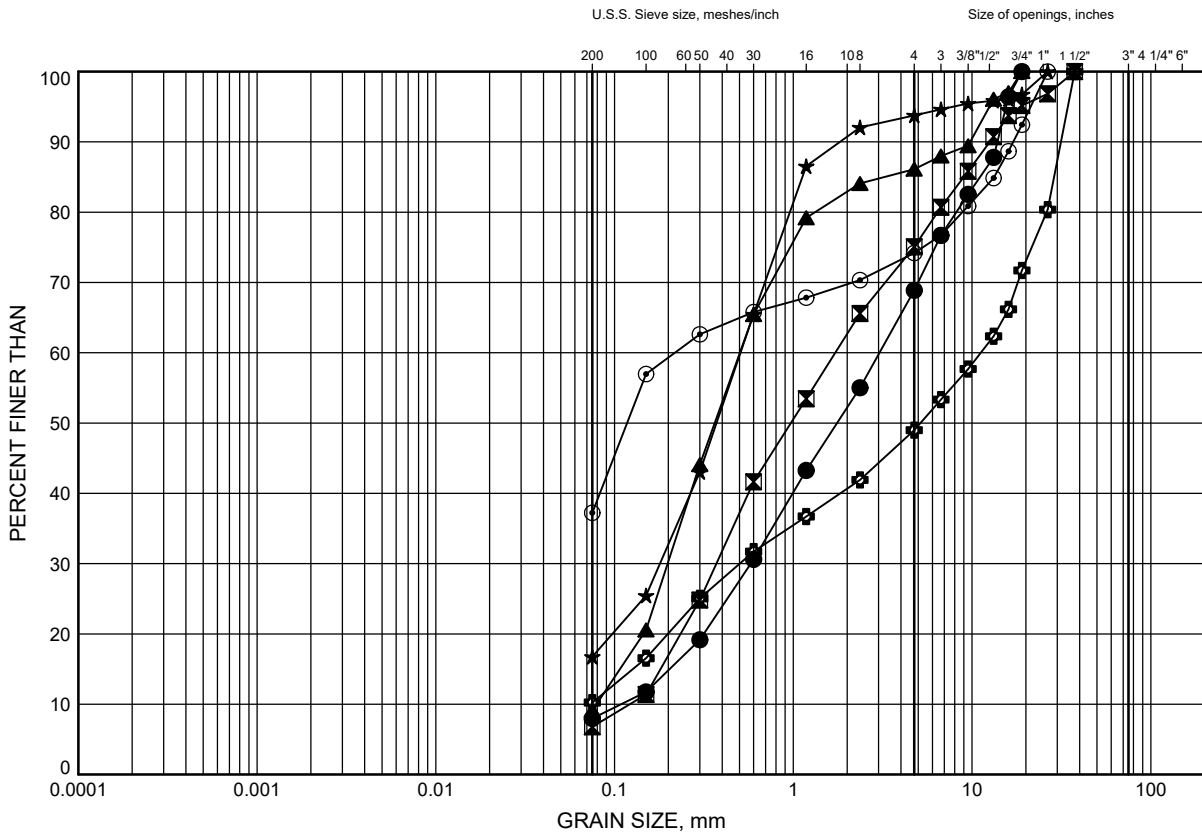
Prep'd MIK
Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C8.1

Sand and Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-1	22.4	84.7
⊠	BON19-2	23.2	79.8
▲	BON19-2	32.3	70.7
★	BON19-3	38.4	64.6
⊙	BON19-4	3.4	95.5
⊕	BON19-4	5.6	93.3

Date May 2022
WP# 4068-09-00



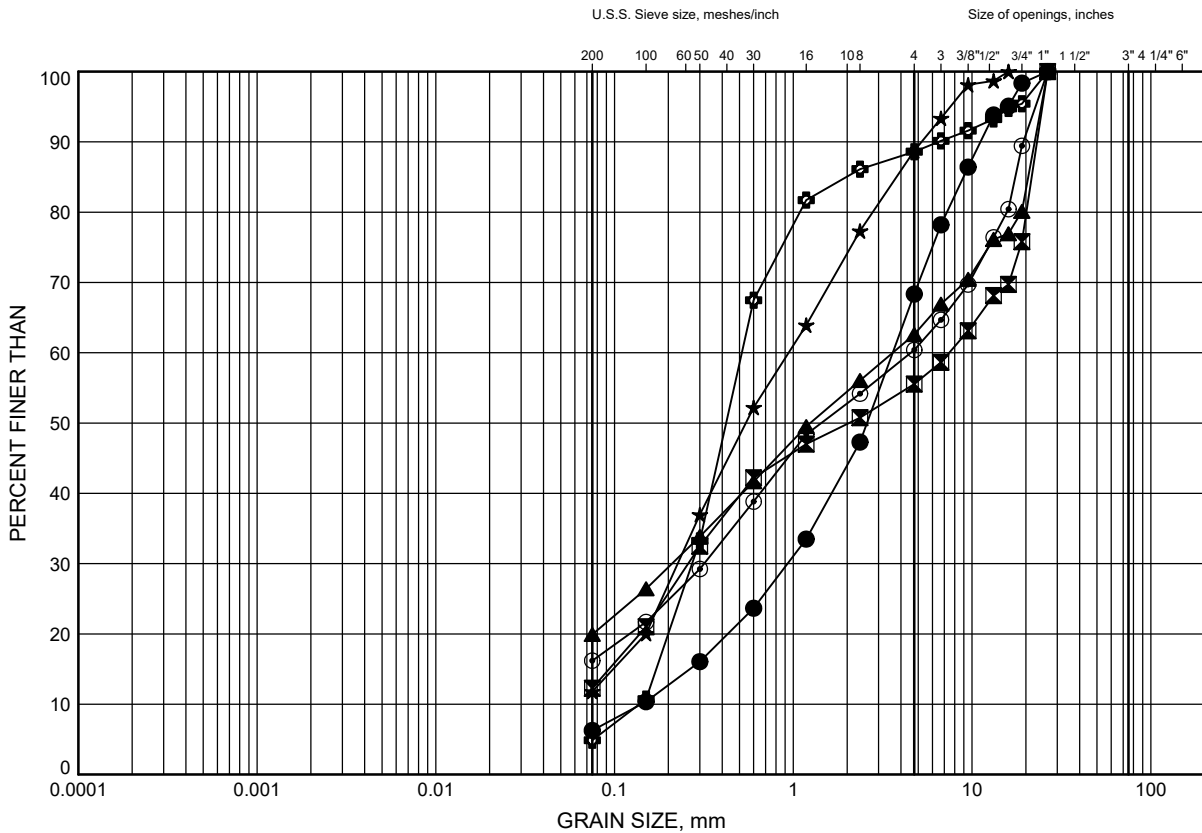
Prep'd MIK
Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C8.2

Sand and Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON19-4	7.9	91.0
⊠	BON19-5	7.9	91.0
▲	BON19-5	15.5	83.4
★	BON19-9	13.9	103.9
⊙	BON-P1	29.3	58.6
⊕	BON-P2	15.5	70.6

Date May 2022
WP# 4068-09-00



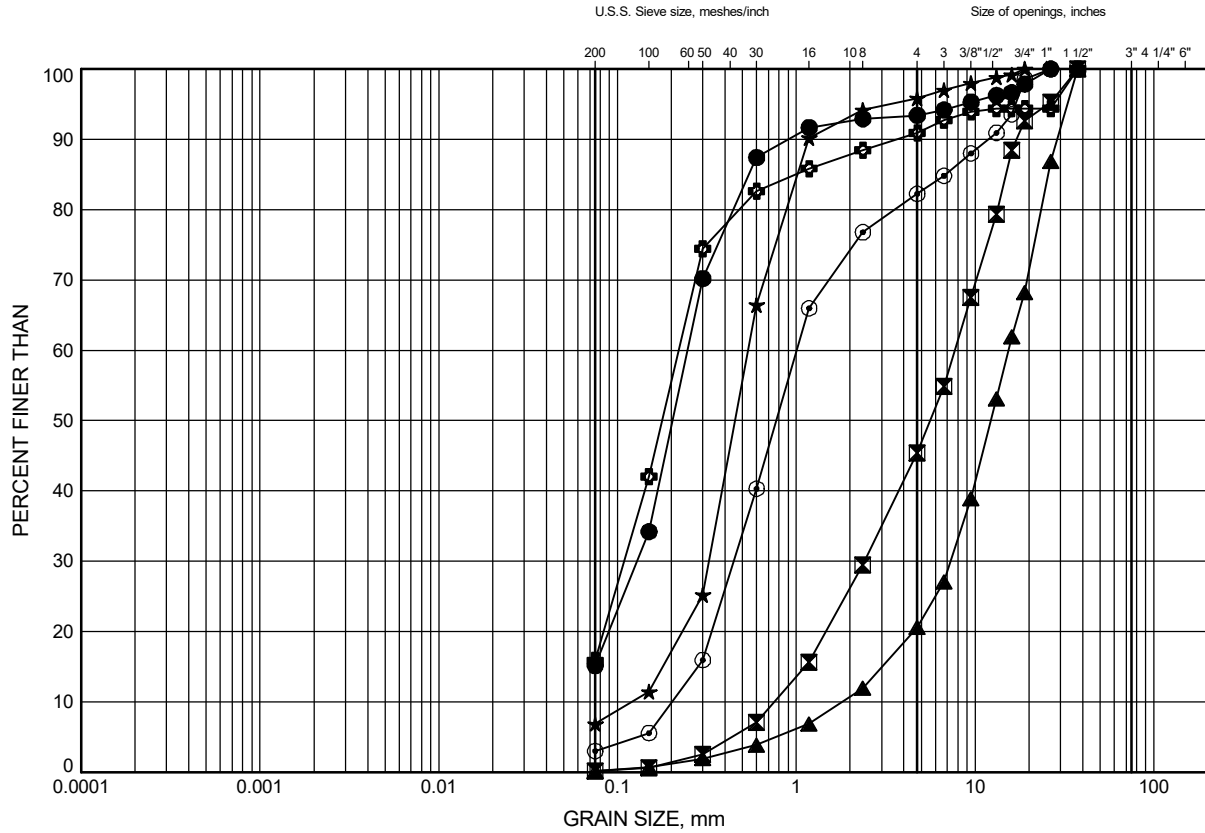
Prep'd MIK
Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C8.3

Sand and Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON24-1	22.6	85.2
⊠	BON24-1	28.7	79.1
▲	BON24-1	34.7	73.1
★	BON24-3	41.8	62.2
⊙	BON24-3	44.2	59.8
⊕	BON-P3	4.9	84.3

Date August 2024
WP# 4068-09-00



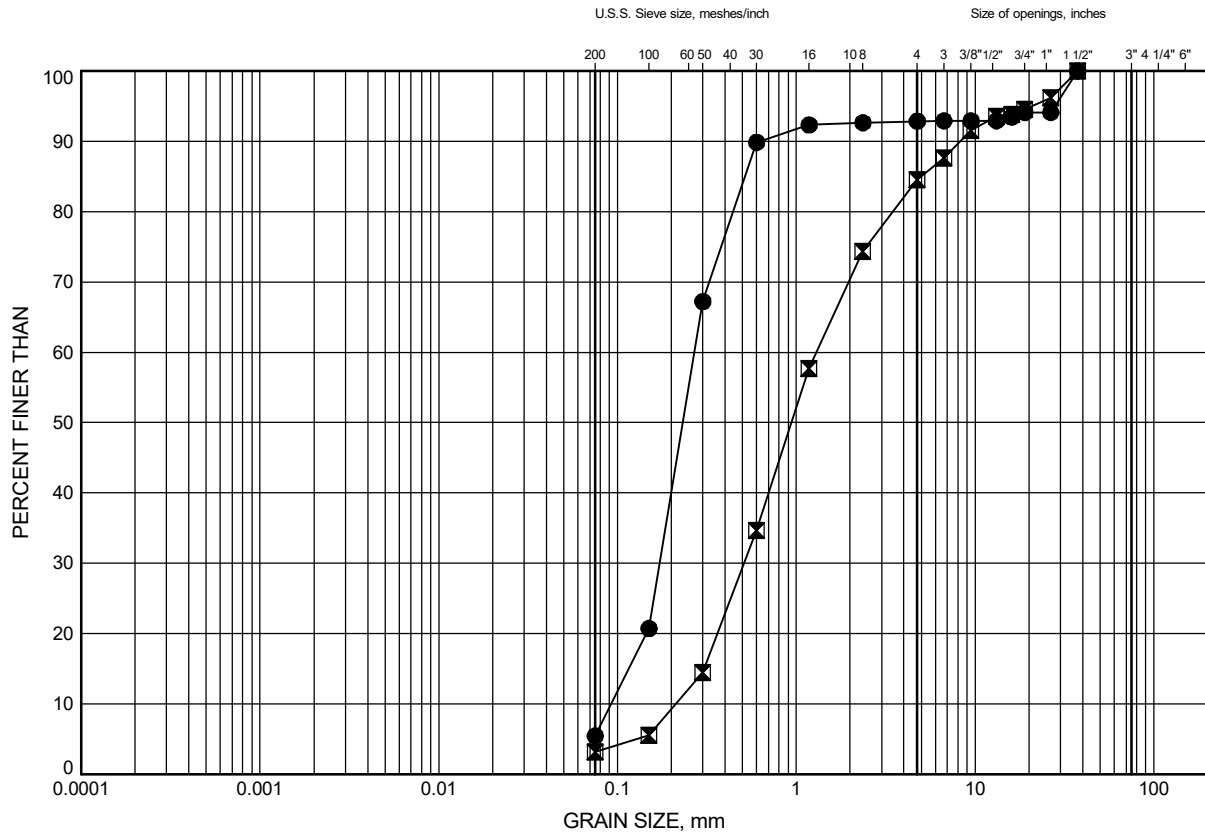
Prep'd RH
Chkd. MJK

Highway 17 Twinning, Bonnechere River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE C8.4

Sand and Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BON-P3	11.0	78.2
⊠	BON-P3	15.4	73.8

Date August 2024
 WP# 4068-09-00



Prep'd RH
 Chkd. MJK



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

October 18, 2021
File: 122410864

Attention: Deanna Pizycki, M.Eng., P.Eng.

Thurber Engineering Ltd.
104-2460 Lancaster Road
Ottawa, Ontario, Canada, K1B 4S5
Tel: 1-613-274-2121 ext. 7106
E-mail: dpizycki@thurber.ca

Dear Ms. Pizycki,

**Reference: Consolidation Test Results: Hwy 17 Twinning, Hwy 17, ON, Thurber Engineering Ltd.,
File # 24726.200a.202**

This letter presents the results of one-dimensional consolidation test carried out on one Shelby tube sample in accordance with ASTM D2435/D2435M – 11(2020). The test results are provided in the attached tables and figures.

Summary of sample tested

Sample ID	Depth (ft)	Date sampled
BON 19-1, ST1	15-17	September 7, 2021

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,

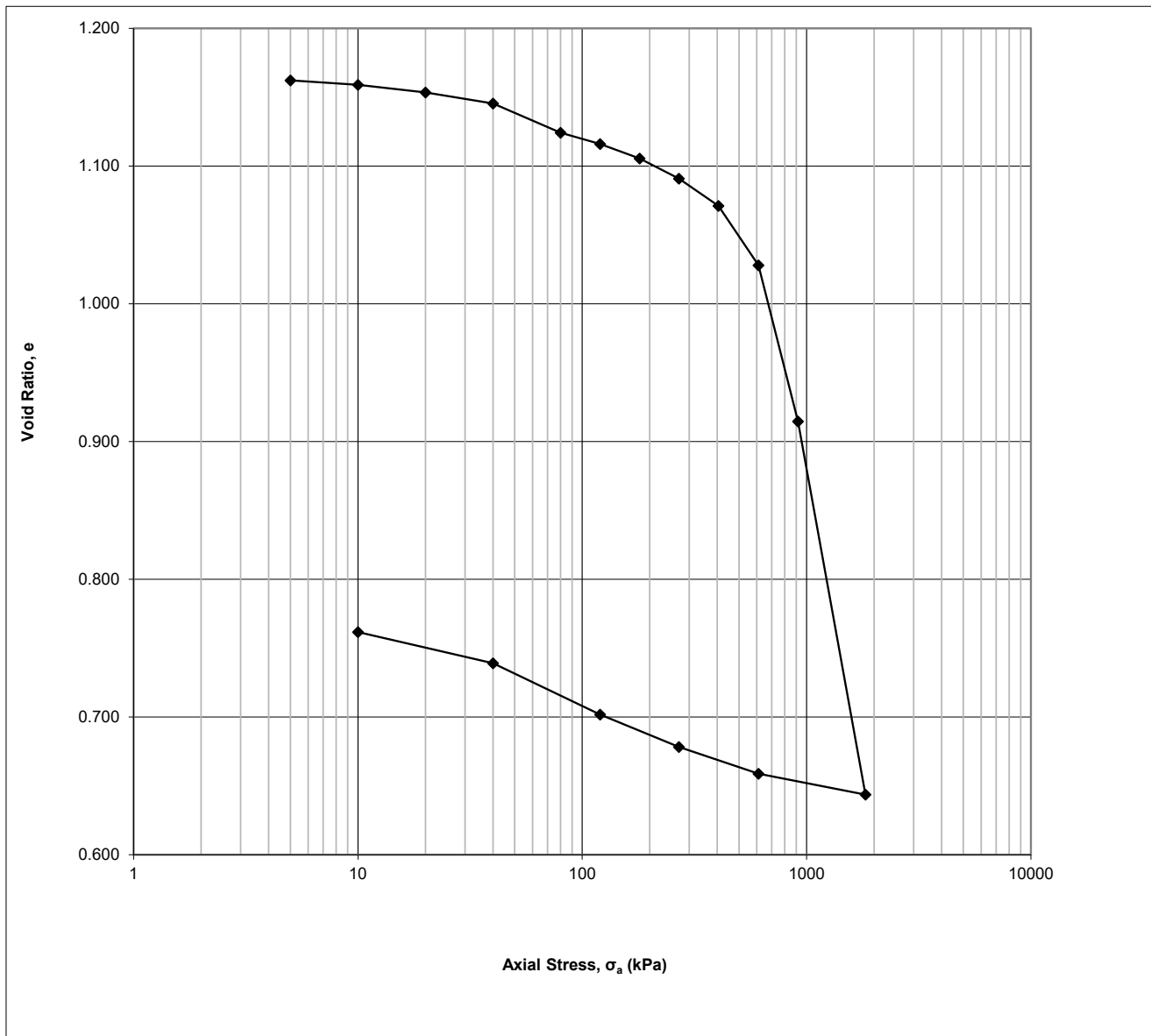
Stantec Consulting Ltd.

Gwangha Roh Ph.D., P.Eng.
Technical Lead
Mobile: 435 770-2425
Gwangha.Roh@stantec.com

v:\01216\active\laboratory_standing_offers\2021 laboratory standing offers\122410864 thurber engineering\september 16, 1 consol, 1 limits, 1 hydro, 1 sg, file# 24726\122410864_let_24726.200a.202_consolidation_hwy 17 twinning.docx

Project
Project No.
Borehole No.
Sample No.
Sample Depth

Thurber Engineering, File#24726.200a.202
122410864
BON 19-1
ST1
15-17 ft



One-Dimensional Consolidation Test using Incremental Loading
ASTM D2435/D2435M - 11(2020)

October 18, 2021
October 18, 2021

Date: Date:
D. Boateng R. Gwangha

Checked by: Approved by:

Specimen Details

Project Name	Thurber Engineering, File#24726.200a.202
Project Location	Ontario, Canada
Borehole	BON 19-1
Sample No.	ST1
Depth	15-17 ft
Sample Date	September 7, 2021
Test Number	One
Technician Name	Daniel Boateng

Soil Description & Classification

<i>Silts & clays, brown, desiccated, moist- (Fat clay)-CH</i>	
Specific Gravity of Solids	2.731
Liquid Limit %	56.6
Plastic Limit %	20.5
Plasticity Index %	36.1
Average water content of trimmings %	40.37
Additional Notes (information source, occurrence and size of large isolated particles etc.)	
<i>Loading schedule provided by the client</i>	

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm ²	1963
Volume	mm ³	39270
Mass	g	69.07
Dry Mass	g	49.21
Density	Mg/m ³	1.759
Dry Density	Mg/m ³	1.253
Water Content	%	40.36
Degree of Saturation	%	93.5
Height of Solids	mm	9.18
Initial Void Ratio		1.179

Final Specimen Conditions

Water Content	%	29.04
Final Void Ratio		0.762
Final Height	mm	16.17

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11(2020)

Specimen Details

Project Name	Thurber Engineering, File#24726.200a.202
Project Location	Ontario, Canada
Borehole	BON 19-1
Sample No.	ST1
Depth	15-17 ft
Sample Date	September 7, 2021
Test Number	One
Technician Name	Daniel Boateng

Test Procedure

Date Started	September 17, 2021
Date Finished	October 5, 2021
Machine Number	Frame D
Cell Number	D
Ring Number	D
Trimming Procedure	Turntable/Cutting ring
Moisture Condition	Inundated
Axial Stress at Inundation	5 kPa
Water Used	Deaired tap water
Test Method	A
Interpretation Procedure for c_v	2

All Departures from Outlined ASTM D2435/D2435M-11 (2020) Procedure

--

Calculations

Load	Increment	Axial	Corrected	Specimen	Axial	Void
Increment	Duration	Stress	Deformation	Height	Strain	Ratio
	min	σ_a kPa	ΔH mm	H mm	ϵ_a %	e
Seating	0.0	0	0.0000	20.0000	0.00	1.179
1	1440.0	5	0.1570	19.8430	0.79	1.162
2	1440.0	10	0.1864	19.8136	0.93	1.159
3	1440.0	20	0.2377	19.7623	1.19	1.153
4	1440.0	40	0.3108	19.6892	1.55	1.145
5	1440.0	80	0.5060	19.4940	2.53	1.124
6	1440.0	120	0.5802	19.4198	2.90	1.116
7	1440.0	180	0.6768	19.3232	3.38	1.106
8	1440.0	270	0.8113	19.1887	4.06	1.091
9	1440.0	405	0.9929	19.0071	4.96	1.071
10	1440.0	610	1.3894	18.6106	6.95	1.028
11	1440.0	915	2.4290	17.5710	12.15	0.915
12	1440.0	1830	4.9163	15.0837	24.58	0.644
13	1440.0	610	4.7776	15.2224	23.89	0.659
14	1440.0	270	4.5987	15.4013	22.99	0.678
15	1440.0	120	4.3833	15.6167	21.92	0.702
16	1440.0	40	4.0408	15.9592	20.20	0.739
17	1440.0	10	3.8336	16.1664	19.17	0.762

One-Dimensional Consolidation Test using Incremental Loading

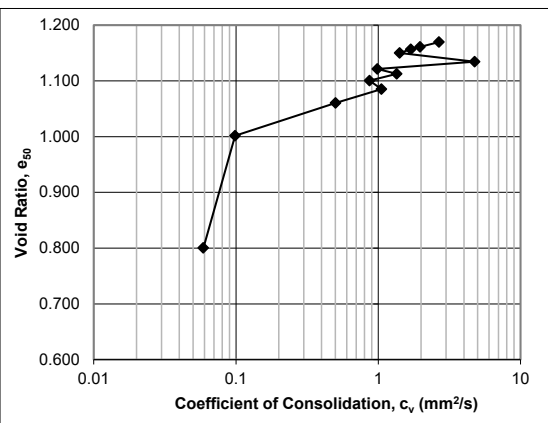
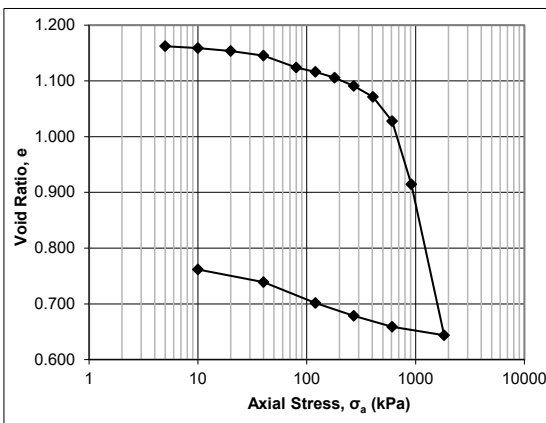
ASTM D2435/D2435M - 11(2020)


Specimen Details

Job Ref.	Thurber Engineering, File#24726.200a.202
Job Location	Ontario, Canada
Borehole	BON 19-1
Sample No.	ST1
Depth	15-17 ft
Sample Date	September 7, 2021
Test Number	One
Technician Name	Daniel Boateng

Calculations

Load Increment	Axial Stress σ_a , average kPa	Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
		Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\epsilon_{a,50}$ %	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	0								
1	3	0.0888	19.9112	0.44	1.170			31	2.67E+00
2	8	0.1663	19.8337	0.83	1.161			42	1.96E+00
3	15	0.2073	19.7927	1.04	1.157			49	1.70E+00
4	30	0.2687	19.7313	1.34	1.150			58	1.41E+00
5	60	0.4116	19.5884	2.06	1.135			17	4.76E+00
6	100	0.5310	19.4690	2.65	1.121			81	9.87E-01
7	150	0.6114	19.3886	3.06	1.113			59	1.35E+00
8	225	0.7219	19.2781	3.61	1.101			91	8.69E-01
9	338	0.8629	19.1371	4.31	1.085			74	1.05E+00
10	508	1.0914	18.9086	5.46	1.060			151	5.02E-01
11	763	1.6321	18.3679	8.16	1.002			727	9.84E-02
12	1373	3.4796	16.5204	17.40	0.800			980	5.90E-02
13	1220	4.8464	15.1536	24.23	0.651				
14	440	4.6935	15.3065	23.47	0.668				
15	195	4.4977	15.5023	22.49	0.689				
16	80	4.2309	15.7691	21.15	0.718				
17	25	4.0271	15.9729	20.14	0.741				



	Project No.: 122410864	Photo Log
	Project Name: Thurber, File# 24726.200a.202	

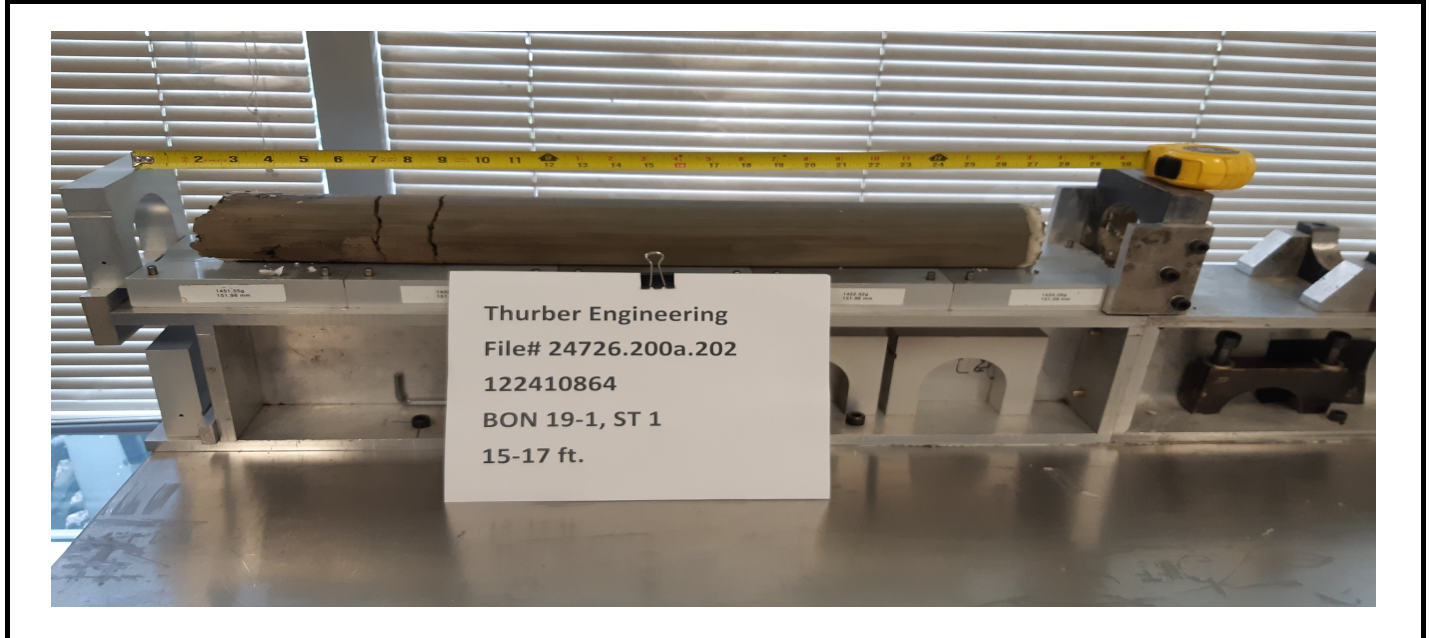


Photo No.:	1	Borehole: BON 19-1, ST1	Depth: 15 – 17 ft
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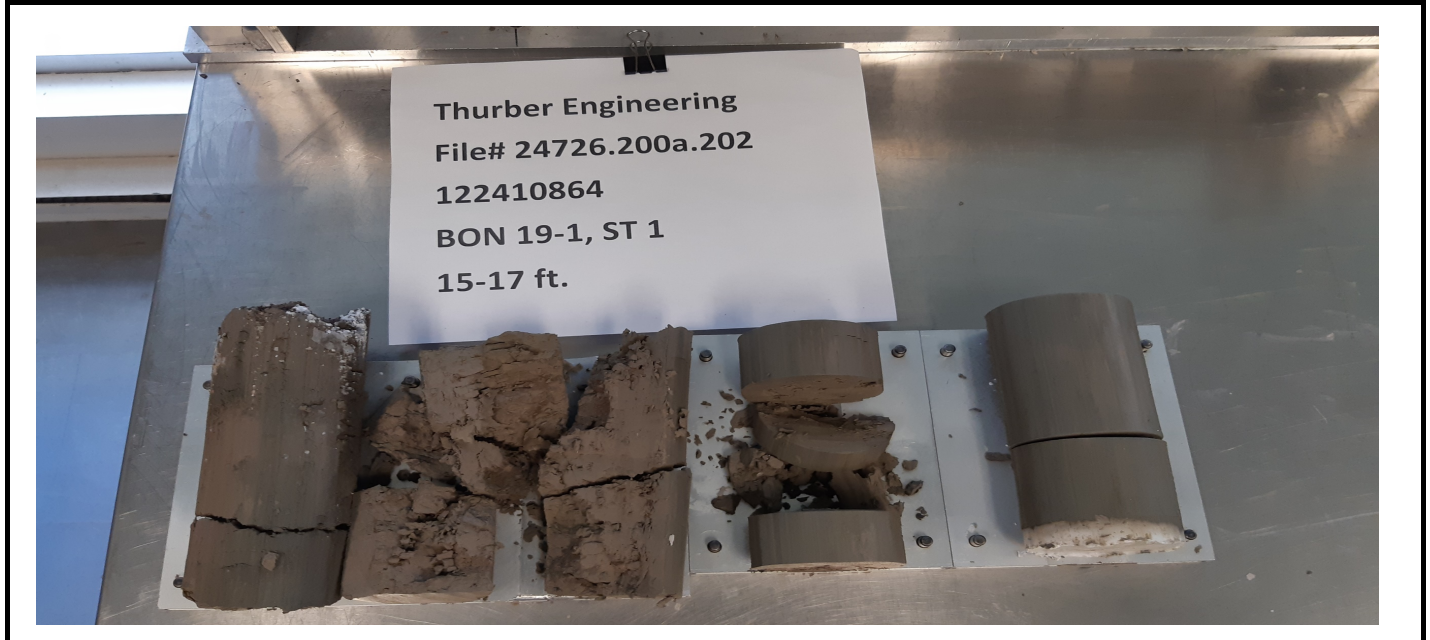
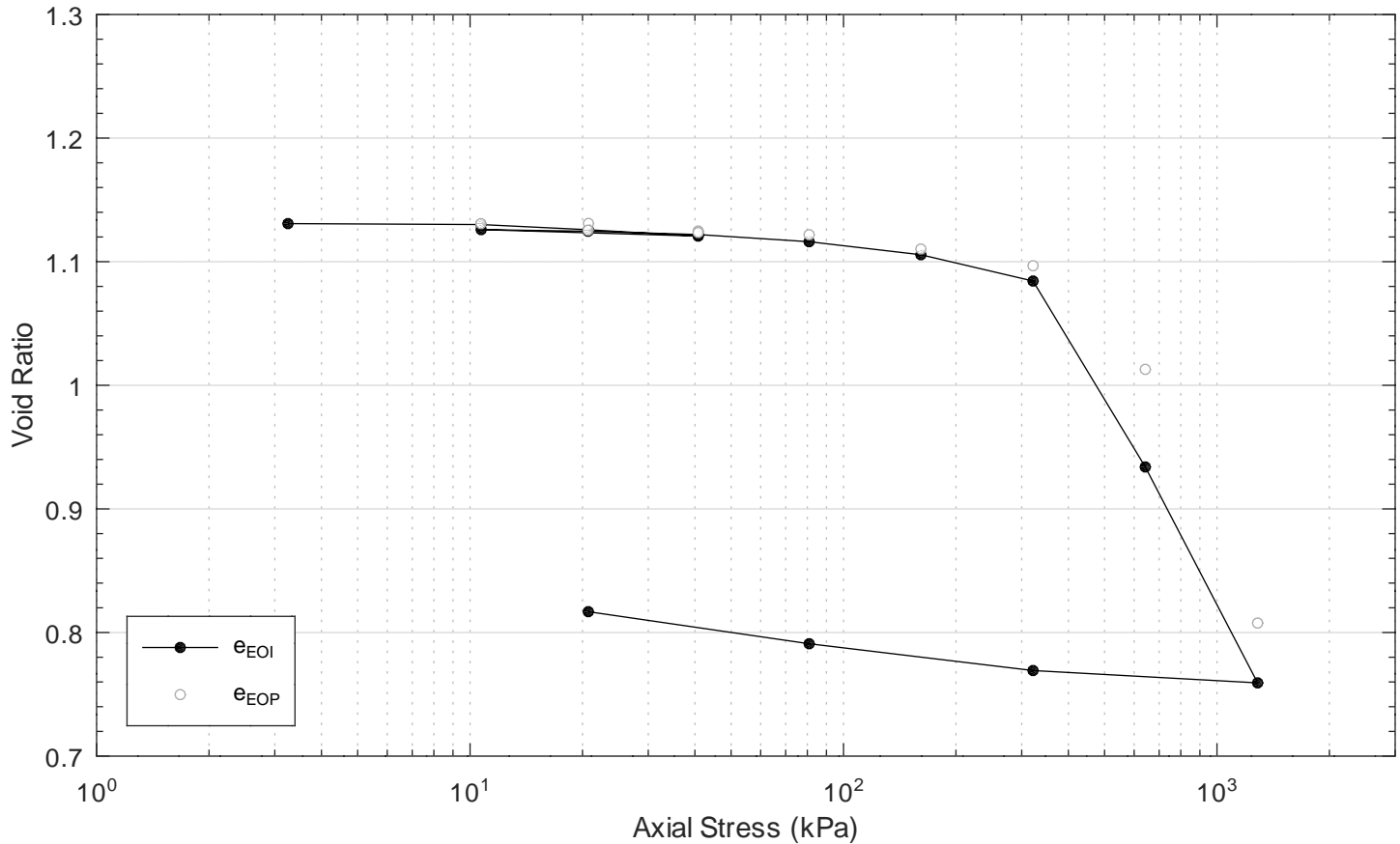


Photo No.:	2	Borehole: BON 19-1, ST1	Depth: 15 – 17 ft
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Project: 24726
 Hwy 17 Twinning
 Borehole: BON24-1
 Sample: ST9
 Depth: 11.0m
 Client: Ministry of Transportation



Start of Test		2024-06-28	
Diameter of Sample	cm	D	6.340
Height of Sample	cm	H_o	2.547
Height of Solids	cm	H_s	1.196
Water Content	%	w_o	39.96
Dry Density	g/cm ³	ρ_d	1.28
Moist Unit Weight	kN/m ³	γ	17.6
Void Ratio	-	e_o	1.129
Degree of Saturation	-	S_{ro}	0.97
Specific Gravity	-	G_s	2.730
End of Test		2024-07-13	
Height of Sample	cm	H_f	2.173
Water Content	%	w_f	30.30
Void Ratio	-	e_f	0.817

TRIMMING: the specimen was manually trimmed to the size of the consolidation ring, then mounted in a fixed ring consolidometer

LOADING: the consolidometer was flooded with water with the seating load adjusted to limit swelling

CALCULATIONS: coefficients of consolidation were calculated by the square root time method, secondary consolidation was calculated based on the available duration of the time step

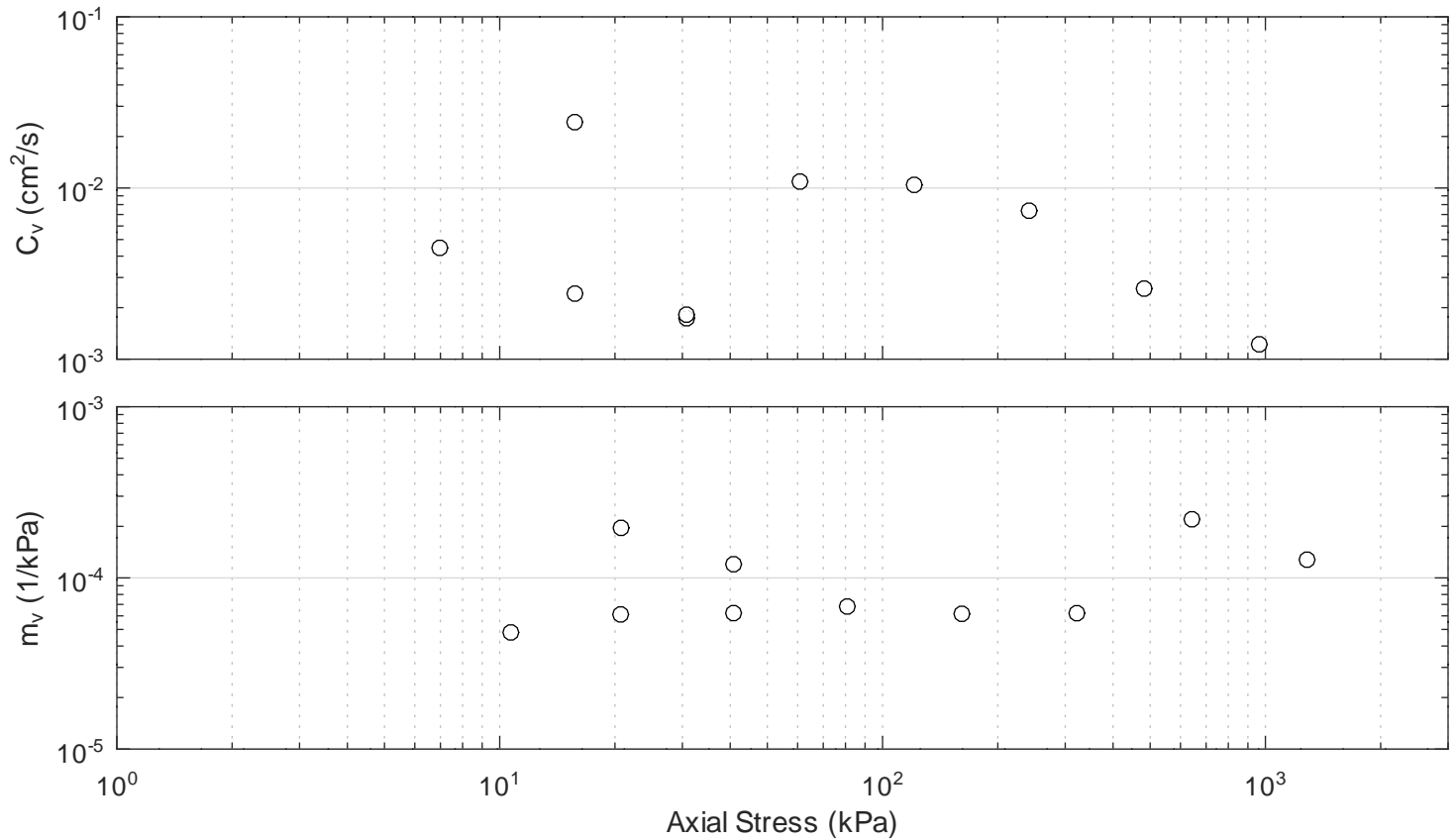
Interpreted Results

Recompression Index (reloading)	-	C_r	0.035
Compression Index	-	C_c	0.581
Recompression Index (unloading)	-	C_r	0.036
Probable Preconsolidation Pressure	kPa	p'_c	361

Check: AO/SP Review: KS



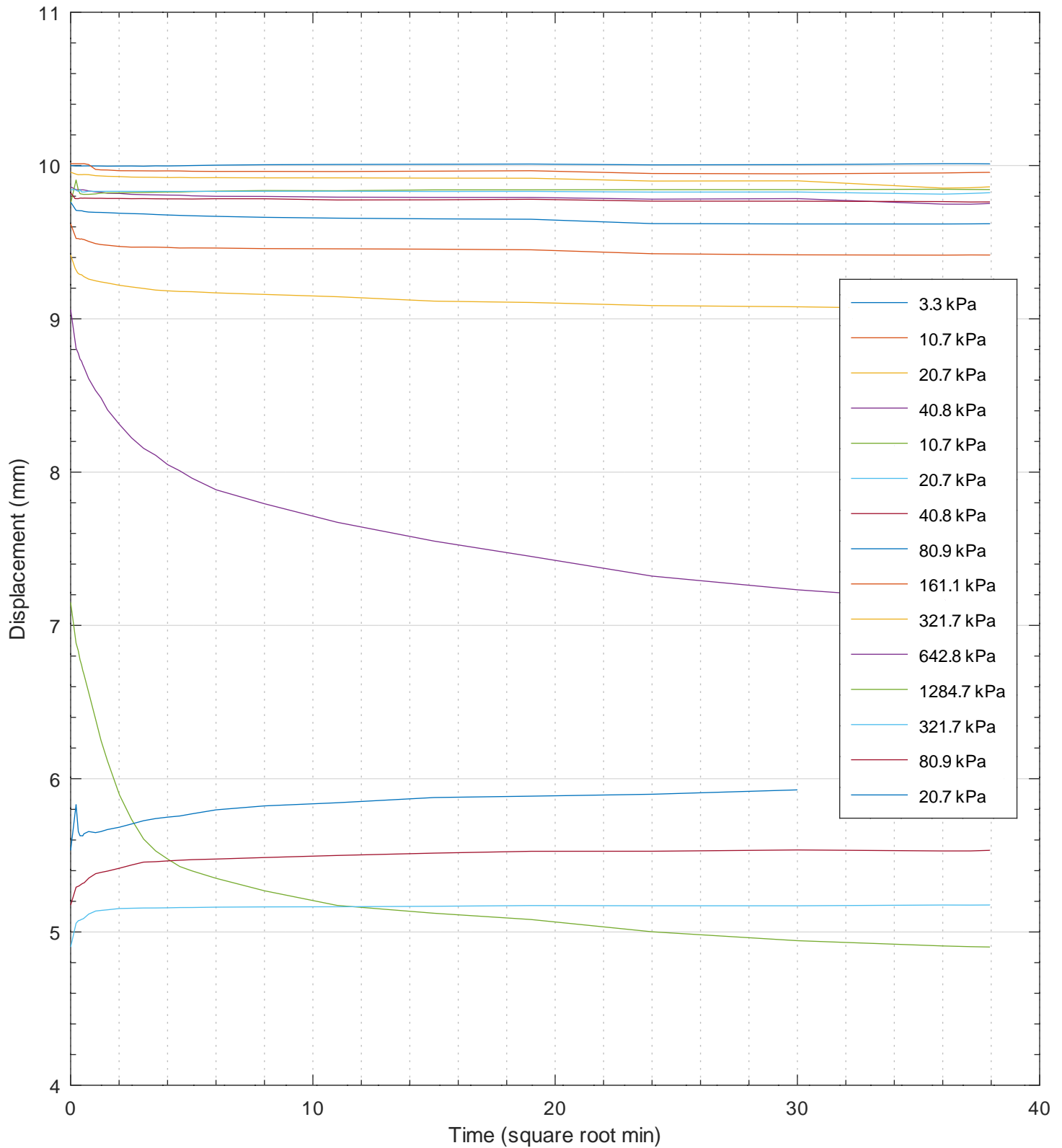
Project: 24726
 Hwy 17 Twinning
 Borehole: BON24-1
 Sample: ST9
 Depth: 11.0m
 Client: Ministry of Transportation



Load No.	Axial Stress	Load Duration	System Deflec.	Dial	Sample Height	Axial Strain	Void Ratio	Void Ratio	Time U(0.99)	C_v	k_v	C_{ae}
	kPa	min	mm	mm	cm	%	(EOI)	(EOP)	min	cm ² /s	cm/s	-
0				10.000	2.547	0.00	1.129					
1	3.3	1440.2	0.006	10.012	2.549	-0.07	1.131					
2	10.7	1440.1	0.053	9.956	2.548	-0.03	1.130	1.131	10.7	4.47e-03	2.11e-08	0.0003
3	20.7	1440.0	0.098	9.861	2.543	0.16	1.126	1.131	19.8	2.42e-03	4.65e-08	0.0012
4	40.8	1440.1	0.145	9.752	2.537	0.40	1.121	1.125	27.3	1.73e-03	2.04e-08	0.0012
5	10.7	1440.0	0.117	9.844	2.543	0.16	1.126					
6	20.7	1440.5	0.123	9.822	2.541	0.22	1.125	1.125	2.0	2.42e-02	1.46e-07	0.0001
7	40.8	1440.0	0.150	9.763	2.538	0.34	1.122	1.124	26.3	1.82e-03	1.11e-08	0.0004
8	80.9	1440.5	0.222	9.620	2.531	0.62	1.116	1.122	4.3	1.09e-02	7.28e-08	0.0012
9	161.1	1440.5	0.301	9.415	2.519	1.11	1.106	1.110	4.4	1.04e-02	6.31e-08	0.0009
10	321.7	1440.1	0.403	9.060	2.493	2.11	1.084	1.097	6.1	7.37e-03	4.49e-08	0.0025
11	642.8	1440.0	0.514	7.149	2.313	9.18	0.934	1.013	12.8	2.58e-03	5.58e-08	0.0192
12	1284.7	1440.0	0.673	4.902	2.104	17.38	0.759	0.808	14.6	1.22e-03	1.53e-08	0.0133
13	321.7	1440.3	0.519	5.176	2.116	16.91	0.769					
14	80.9	1440.1	0.421	5.532	2.142	15.89	0.791					
15	20.7	900.1	0.336	5.927	2.173	14.67	0.817					



Project: 24726
 Hwy 17 Twinning
 Borehole: BON24-1
 Sample: ST9
 Depth: 11.0m
 Client: Ministry of Transportation





Appendix C.2

Analytical Testing Results

Certificate of Analysis

Thurber Engineering Ltd.

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

Client PO:
Project: 24726 Task 200a.202
Custody: 53443

Report Date: 28-Sep-2020
Order Date: 22-Sep-2020

Order #: 2039214

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

Paracel ID

2039214-01

Client ID

BON 19-05, SS2 (2'6-4'6)

Approved By:



Dale Robertson, BSc
Laboratory Director

Certificate of Analysis

Report Date: 28-Sep-2020

Client: Thurber Engineering Ltd.

Order Date: 22-Sep-2020

Client PO:

Project Description: 24726 Task 200a.202

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	24-Sep-20	24-Sep-20
Conductivity	MOE E3138 - probe @25 °C, water ext	24-Sep-20	24-Sep-20
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	22-Sep-20	23-Sep-20
Resistivity	EPA 120.1 - probe, water extraction	24-Sep-20	24-Sep-20
Solids, %	Gravimetric, calculation	23-Sep-20	23-Sep-20

Certificate of Analysis

Report Date: 28-Sep-2020

Client: Thurber Engineering Ltd.

Order Date: 22-Sep-2020

Client PO:

Project Description: 24726 Task 200a.202

Client ID:	BON 19-05, SS2 (2'6-4'6)	-	-	-
Sample Date:	08-Sep-20 09:00	-	-	-
Sample ID:	2039214-01	-	-	-
MDL/Units	Soil	-	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	83.9	-	-	-
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General Inorganics

Conductivity	5 uS/cm	70	-	-	-
pH	0.05 pH Units	7.22	-	-	-
Resistivity	0.10 Ohm.m	143	-	-	-

Anions

Chloride	5 ug/g dry	8	-	-	-
Sulphate	5 ug/g dry	9	-	-	-

Certificate of Analysis

Report Date: 28-Sep-2020

Client: Thurber Engineering Ltd.

Order Date: 22-Sep-2020

Client PO:

Project Description: 24726 Task 200a.202

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						

Certificate of Analysis

Report Date: 28-Sep-2020

Client: Thurber Engineering Ltd.

Order Date: 22-Sep-2020

Client PO:

Project Description: 24726 Task 200a.202

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	31.5	5	ug/g dry	29.5			6.5	20	
Sulphate	7.38	5	ug/g dry	7.44			0.8	20	
General Inorganics									
Conductivity	222	5	uS/cm	217			2.3	5	
pH	7.64	0.05	pH Units	7.67			0.4	2.3	
Resistivity	45.0	0.10	Ohm.m	46.0			2.3	20	
Physical Characteristics									
% Solids	95.4	0.1	% by Wt.	95.7			0.3	25	

Certificate of Analysis

Report Date: 28-Sep-2020

Client: Thurber Engineering Ltd.

Order Date: 22-Sep-2020

Client PO:

Project Description: 24726 Task 200a.202

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	124	5	ug/g	29.5	94.6	82-118			
Sulphate	103	5	ug/g	7.44	95.7	80-120			

Certificate of Analysis

Report Date: 28-Sep-2020

Client: Thurber Engineering Ltd.

Order Date: 22-Sep-2020

Client PO:

Project Description: 24726 Task 200a.202

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.

NC: Not Calculated

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.

Subcontracted Analysis

Thurber Engineering Ltd.

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

Tel: (613) 408-6795
Fax: (613) 247-2185

Paracel Report No. **2039214**
Client Project(s): **24726 Task 200a.202**
Client PO:
Reference: **Standing Offer**
CoC Number: **53443**

Order Date: 22-Sep-20
Report Date: 30-Sep-20

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
2039214-01	BON 19-05, SS2 (2'6-4'6)	Sulphide, solid

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Paracel Laboratories

Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax:613-731-9064

30-September-2020

Date Rec. : 24 September 2020
LR Report: CA14785-SEP20
Reference: Project#:2039214

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide (Na ₂ CO ₃) %
1: Analysis Start Date		28-Sep-20
2: Analysis Start Time		15:19
3: Analysis Completed Date		29-Sep-20
4: Analysis Completed Time		14:46
5: QC - Blank		< 0.04
6: QC - STD % Recovery		96%
7: QC - DUP % RPD		ND
8: RL		0.02
9: BON 19-05, SS2 (2'6-4'6)	08-Sep-20	<0.04 UAL

RL - SGS Reporting Limit

ND - Not Detected

UAL - Unreliable: Sample Age Exceeds Normal Limit

Processed past holding time as per client's instructions.

Kimberley Didsbury
Project Specialist,
Environment, Health & Safety

Certificate of Analysis

Thurber Engineering Ltd.

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

Client PO:
Project: 24726 Task 200a.202
Custody: 133258

Report Date: 5-May-2022
Order Date: 29-Apr-2022

Order #: 2218690

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

Paracel ID	Client ID
2218690-01	BON 19-3, SS5 (10'-0"-12'-0")
2218690-02	BON-P1-MW, SS6 (12'-6"-14'-6")
2218690-03	BON-P2-MW, SS6 (12'-6"-14'-6")
2218690-04	BON-P3-MW, SS8 (17'-6"-19'-6")

Approved By:



Mark Foto, M.Sc.
Lab Supervisor

Certificate of Analysis

Report Date: 05-May-2022

Client: Thurber Engineering Ltd.

Order Date: 29-Apr-2022

Client PO:

Project Description: 24726 Task 200a.202

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	3-May-22	3-May-22
Conductivity	MOE E3138 - probe @25 °C, water ext	3-May-22	4-May-22
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	3-May-22	3-May-22
Resistivity	EPA 120.1 - probe, water extraction	3-May-22	4-May-22
Solids, %	Gravimetric, calculation	3-May-22	3-May-22

Certificate of Analysis

Report Date: 05-May-2022

Client: Thurber Engineering Ltd.

Order Date: 29-Apr-2022

Client PO:

Project Description: 24726 Task 200a.202

	Client ID:	BON 19-3, SS5 (10'-0"-12'-0")	BON-P1-MW, SS6 (12'-6"-14'-6")	BON-P2-MW, SS6 (12'-6"-14'-6")	BON-P3-MW, SS8 (17'-6"-19'-6")
	Sample Date:	01-Oct-21 09:00	29-Sep-21 09:00	09-Nov-21 09:00	08-Nov-21 09:00
	Sample ID:	2218690-01	2218690-02	2218690-03	2218690-04
	MDL/Units	Soil	Soil	Soil	Soil

Physical Characteristics

% Solids	0.1 % by Wt.	72.8	81.7	82.7	88.1
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General Inorganics

Conductivity	5 uS/cm	131 [1]	327 [1]	71 [1]	63 [1]
pH	0.05 pH Units	7.66 [1]	7.72 [1]	7.63 [1]	7.81 [1]
Resistivity	0.10 Ohm.m	76.3 [1]	30.5 [1]	141	159

Anions

Chloride	5 ug/g dry	9 [1]	34 [1]	5 [1]	7 [1]
Sulphate	5 ug/g dry	<5 [1]	260 [1]	<5 [1]	<5 [1]

Certificate of Analysis

Report Date: 05-May-2022

Client: Thurber Engineering Ltd.

Order Date: 29-Apr-2022

Client PO:

Project Description: 24726 Task 200a.202

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						

Certificate of Analysis

Report Date: 05-May-2022

Client: Thurber Engineering Ltd.

Order Date: 29-Apr-2022

Client PO:

Project Description: 24726 Task 200a.202

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	14.8	5	ug/g	13.1			12.1	20	
Sulphate	54.6	5	ug/g	50.9			7.1	20	
General Inorganics									
Conductivity	116	5	uS/cm	112			3.6	5	
pH	7.30	0.05	pH Units	7.32			0.3	2.3	
Resistivity	86.3	0.10	Ohm.m	89.4			3.6	20	
Physical Characteristics									
% Solids	85.0	0.1	% by Wt.	85.3			0.4	25	

Certificate of Analysis

Report Date: 05-May-2022

Client: Thurber Engineering Ltd.

Order Date: 29-Apr-2022

Client PO:

Project Description: 24726 Task 200a.202

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	116	5	ug/g	13.1	103	82-118			
Sulphate	159	5	ug/g	50.9	108	80-120			

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 05-May-2022

Order Date: 29-Apr-2022

Project Description: 24726 Task 200a.202

Qualifier Notes:

Login Qualifiers :

Sample - One or more parameter received past hold time - Chloride, pH, resistivity, sulphide, sulphate

Applies to samples: BON 19-3, SS5 (10'-0"-12'-0"), BON-P1-MW, SS6 (12'-6"-14'-6")

Sample - One or more parameter received past hold time - Chloride, pH, sulphide, sulphate

Applies to samples: BON-P2-MW, SS6 (12'-6"-14'-6"), BON-P3-MW, SS8 (17'-6"-19'-6")

Sample Qualifiers :

- 1 : Holding time had been exceeded upon receipt of the sample at the laboratory or prior to the analysis being requested.

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.

NC: Not Calculated

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.

Subcontracted Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104

Ottawa, ON K1B 4S5

Attn: Justin Gray

Paracel Report No. **2218690**

Client Project(s): **24726 Task 200a.202**

Client PO:

Reference: **Standing Offer**

CoC Number: **133258**

Order Date: 29-Apr-22

Report Date: 11-May-22

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
2218690-01	BON 19-3, SS5 (10'-0"-12'-0")	Sulphide, solid
2218690-02	BON-P1-MW, SS6 (12'-6"-14'-6")	Sulphide, solid
2218690-03	BON-P2-MW, SS6 (12'-6"-14'-6")	Sulphide, solid
2218690-04	BON-P3-MW, SS8 (17'-6"-19'-6")	Sulphide, solid

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Paracel Laboratories

Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax:613-731-9064

11-May-2022

Date Rec. : 03 May 2022
LR Report: CA12045-MAY22
Reference: Project#: 2218690

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide (Na ₂ CO ₃) %
1: Analysis Start Date		11-May-22
2: Analysis Start Time		07:08
3: Analysis Completed Date		11-May-22
4: Analysis Completed Time		09:07
5: QC - Blank		< 0.04
6: QC - STD % Recovery		100%
7: QC - DUP % RPD		ND
8: RL		0.02
9: BON 19-3, SS5 (10'-0"-12'-0")	01-Oct-21 09:00	< 0.04
10: BON-P1-MW, SS6 (12'-6"-14'-6")	29-Sep-21 09:00	0.05
11: BON-P2-MW, SS6 (12'-6"-14'-6")	09-Nov-21 09:00	< 0.04
12: BON-P3-MW, SS8 (17'-6"-19'-6")	08-Nov-21 09:00	< 0.04

RL - SGS Reporting Limit
ND - Not Detected

Note: Results for sulphide analysis performed past the 28 day holding time may be unreliable; processed past holding times as per client's instructions.

Kimberley Didsbury
Project Specialist,
Environment, Health & Safety

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104

Ottawa, ON K1B 4S5

Attn: Justin Gray

Client PO: Highway 17 Renfrew, Various Sites

Project: 24726 task 700.706a

Custody:

Report Date: 18-Apr-2024

Order Date: 12-Apr-2024

Order #: 2415421

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

Paracel ID	Client ID
2415421-01	SC18-3 SS3A 5'-6'3"
2415421-02	SC23-2 SS5 10'-12'
2415421-03	DOC23-1 SS7, 15'-17'
2415421-04	OBR23-1 SS16 48'-50'
2415421-05	BON24-2 SS4 10'-12'
2415421-06	NSC20-2 SS2A 2'6"-3'3"
2415421-07	SC10-1 SS2B 3'-4'
2415421-08	SC10-4 SS2 2'6"-4'6"

Approved By:

Mark Foto

Mark Foto, M.Sc.

Lab Supervisor

Certificate of Analysis

Report Date: 18-Apr-2024

Client: Thurber Engineering Ltd.

Order Date: 12-Apr-2024

Client PO: Highway 17 Renfrew, Various Sites

Project Description: 24726 task 700.706a

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	15-Apr-24	15-Apr-24
Conductivity	MOE E3138 - probe @25 °C, water ext	15-Apr-24	15-Apr-24
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	15-Apr-24	15-Apr-24
Resistivity	EPA 120.1 - probe, water extraction	15-Apr-24	15-Apr-24
Solids, %	CWS Tier 1 - Gravimetric	15-Apr-24	16-Apr-24

Certificate of Analysis

Report Date: 18-Apr-2024

Client: Thurber Engineering Ltd.

Order Date: 12-Apr-2024

Client PO: Highway 17 Renfrew, Various Sites

Project Description: 24726 task 700.706a

Client ID:	SC18-3 SS3A 5'-6'3"	SC23-2 SS5 10'-12'	DOC23-1 SS7, 15'-17'	OBR23-1 SS16 48'-50'	
Sample Date:	11-Mar-24 09:00	13-Mar-24 09:00	11-Mar-24 09:00	27-Mar-24 09:00	-
Sample ID:	2415421-01	2415421-02	2415421-03	2415421-04	-
Matrix:	Soil	Soil	Soil	Soil	
MDL/Units					

Physical Characteristics

% Solids	0.1 % by Wt.	84.8	62.4	68.0	87.9	-	-
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General Inorganics

Conductivity	5 uS/cm	108 [1]	1950 [2]	1660 [1]	100	-	-
pH	0.05 pH Units	7.32 [1]	6.91 [2]	7.12 [1]	7.37	-	-
Resistivity	0.1 Ohm.m	92.9 [1]	5.1 [2]	6.0 [1]	100	-	-

Anions

Chloride	10 ug/g	10 [1]	175 [1]	682 [1]	<10	-	-
Sulphate	10 ug/g	<10 [1]	2080 [1]	29 [1]	<10	-	-

Certificate of Analysis

Report Date: 18-Apr-2024

Client: Thurber Engineering Ltd.

Order Date: 12-Apr-2024

Client PO: Highway 17 Renfrew, Various Sites

Project Description: 24726 task 700.706a

		Client ID:	BON24-2 SS4 10'-12'	NSC20-2 SS2A 2'6"-3'3"	SC10-1 SS2B 3'-4'	SC10-4 SS2 2'6"-4'6"		
		Sample Date:	09-Apr-24 09:00	02-Apr-24 09:00	21-Mar-24 09:00	04-Apr-24 09:00	-	-
		Sample ID:	2415421-05	2415421-06	2415421-07	2415421-08		
		Matrix:	Soil	Soil	Soil	Soil		
		MDL/Units						
Physical Characteristics								
% Solids	0.1 % by Wt.		72.6	69.1	73.2	77.5	-	-
General Inorganics								
Conductivity	5 uS/cm		286	203	316	247	-	-
pH	0.05 pH Units		6.79	6.65	6.95	6.84	-	-
Resistivity	0.1 Ohm.m		35.0	49.2	31.6	40.5	-	-
Anions								
Chloride	10 ug/g		12	37	97	27	-	-
Sulphate	10 ug/g		24	21	44	<10	-	-

Certificate of Analysis

Report Date: 18-Apr-2024

Client: Thurber Engineering Ltd.

Order Date: 12-Apr-2024

Client PO: Highway 17 Renfrew, Various Sites

Project Description: 24726 task 700.706a

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions								
Chloride	ND	10	ug/g					
Sulphate	ND	10	ug/g					
General Inorganics								
Conductivity	ND	5	uS/cm					
Resistivity	ND	0.1	Ohm.m					

Certificate of Analysis

Report Date: 18-Apr-2024

Client: Thurber Engineering Ltd.

Order Date: 12-Apr-2024

Client PO: Highway 17 Renfrew, Various Sites

Project Description: 24726 task 700.706a

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	10.1	10	ug/g	10.1			0.3	35	
Sulphate	ND	10	ug/g	ND			NC	35	
General Inorganics									
Conductivity	1040	5	uS/cm	1050			1.1	5	
pH	7.44	0.05	pH Units	7.46			0.3	2.3	
Resistivity	8.98	0.1	Ohm.m	9.51			5.7	20	
Physical Characteristics									
% Solids	84.9	0.1	% by Wt.	84.7			0.2	25	

Certificate of Analysis

Report Date: 18-Apr-2024

Client: Thurber Engineering Ltd.

Order Date: 12-Apr-2024

Client PO: Highway 17 Renfrew, Various Sites

Project Description: 24726 task 700.706a

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	110	10	ug/g	10.1	99.4	82-118			
Sulphate	106	10	ug/g	ND	106	80-120			

Certificate of Analysis

Report Date: 18-Apr-2024

Client: Thurber Engineering Ltd.

Order Date: 12-Apr-2024

Client PO: Highway 17 Renfrew, Various Sites

Project Description: 24726 task 700.706a

Qualifier Notes:**Login Qualifiers :**

Sample - One or more parameter received past hold time - Conductivity, chloride, pH, resistivity, and sulphate.

Applies to Samples: SC18-3 SS3A 5'-6'3", DOC23-1 SS7, 15'-17'

Sample Qualifiers :

- 1: Holding time had been exceeded upon receipt of the sample at the laboratory or prior to the analysis being requested.
- 2: This analysis was conducted after the accepted holding time had been exceeded.

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.

NC: Not Calculated

Soil results are reported on a dry weight basis unless otherwise noted.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Any use of these results implies your agreement that our total liability in connection with this work, however arising, shall be limited to the amount paid by you for this work, and that our employees or agents shall not under any circumstances be liable to you in connection with this work.



Client Name: Thurber Engineering Ltd.	Project Ref: Highway 17 Renfrew, Various Sites	Page 1 of 1
Contact Name: Justin Gray	Quote #:	Turnaround Time <input type="checkbox"/> 1 day <input type="checkbox"/> 3 day <input type="checkbox"/> 2 day <input checked="" type="checkbox"/> Regular
Address: 104 - 2460 Lancaster Rd Ottawa	PO #: 24726 task 700.706a	
Telephone: 343-542-7957	E-mail: jgray@thurber.ca	
Date Required:		

<input type="checkbox"/> REG 153/04 <input type="checkbox"/> REG 406/19 <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> Table _____ For RSC: <input type="checkbox"/> Yes <input type="checkbox"/> No		Other Regulation <input type="checkbox"/> REG 558 <input type="checkbox"/> PWQO <input type="checkbox"/> CCME <input type="checkbox"/> MISA <input type="checkbox"/> SU - Sani <input type="checkbox"/> SU - Storm Mun: _____ <input type="checkbox"/> Other: _____	Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)	Required Analysis															
Sample ID/Location Name		Matrix	Air Volume	# of Containers	Sample Taken		pH	Resist. & Conductivity	Chloride	Sulphate	Sulphide								
					Date	Time													
✓ 1	SC18-3 SS3A 5'-6'3"	S		1	2024/03/11		✓	✓	✓	✓	✓								
✓ 2	SC23-2 SS5 10'-12'	S		1	2024/03/13		✓	✓	✓	✓	✓								
✓ 3	DOC23-1 SS7,15'-17'	S		1	2024/03/11		✓	✓	✓	✓	✓								
✓ 4	OBR23-1 SS16 48'-50'	S		1	2024/03/27		✓	✓	✓	✓	✓								
✓ 5	BON24-2 SS4 10'-12'	S		1	2024/04/09		✓	✓	✓	✓	✓								
✓ 6	NSC20-2 SS2A 2'6"-3'3"	S		1	2024/04/02		✓	✓	✓	✓	✓								
✓ 7	SC10-1 SS2B 3'-4'	S		1	2024/03/21		✓	✓	✓	✓	✓								
✓ 8	SC10-4 SS2 2'6"-4'6"	S		1	2024/04/04		✓	✓	✓	✓	✓								
9																			
10																			

Comments: Please proceed with testing even with hold times expired -JG				Method of Delivery: <u>Walk In</u>	
Relinquished By (Sign): <u>[Signature]</u>	Received at Depot:	Received at Lab: <u>[Signature]</u>	Verified By: <u>SP</u>		
Relinquished By (Print): <u>Justin Gray</u>	Date/Time:	Date/Time: <u>April 12, 2024</u>	Date/Time: <u>April 12, 2024 9:57am</u>		
Date/Time: <u>Apr 12, 2024 9pm</u>	Temperature: _____ °C	Temperature: <u>19.1</u>	pH Verified: <input type="checkbox"/> By: _____		

Subcontracted Analysis

Thurber Engineering Ltd.2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5

Attn: Justin Gray

Paracel Report No. **2415421**
Client Project(s): **24726 task 700.706a**
Client PO: **Highway 17 Renfrew, Various Sites**
Reference: **#24-079 Standing Offer**

Order Date: 12-Apr-24
Report Date: 19-Apr-24

CoC Number:

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	Client ID	Analysis
2415421-01	SC18-3 SS3A 5'-6'3"	Sulphide, solid
2415421-02	SC23-2 SS5 10'-12'	Sulphide, solid
2415421-03	DOC23-1 SS7, 15'-17'	Sulphide, solid
2415421-04	OBR23-1 SS16 48'-50'	Sulphide, solid
2415421-05	BON24-2 SS4 10'-12'	Sulphide, solid
2415421-06	NSC20-2 SS2A 2'6"-3'3"	Sulphide, solid
2415421-07	SC10-1 SS2B 3'-4'	Sulphide, solid
2415421-08	SC10-4 SS2 2'6"-4'6"	Sulphide, solid

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Paracel Laboratories

Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax: 613-731-9064

19-April-2024

Date Rec. : 16 April 2024
LR Report: CA12714-APR24
Reference: Project#: 2415421

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide (Na ₂ CO ₃) %
1: Analysis Start Date		19-Apr-24
2: Analysis Start Time		13:06
3: Analysis Completed Date		19-Apr-24
4: Analysis Completed Time		13:12
5: RL		0.01
6: SC18-3 SS3A 5'-6'3"	11-Mar-24	< 0.01
7: SC23-2 SS5 10'-12'	13-Mar-24	0.83
8: DOC23-1 SS7, 15'-17'	11-Mar-24	0.01
9: OBR23-1 SS16 48'-50'	27-Mar-24	< 0.01
10: BON24-2 SS4 10'-12'	09-Apr-24	< 0.01
11: NSC20-2 SS2A 2'6"-3'3"	02-Apr-24	< 0.01
12: SC10-1 SS2B 3'-4"	21-Mar-24	< 0.01
13: SC10-4 SS2 2'6"- 4'6"	04-Apr-24	< 0.01

RL - SGS Reporting Limit

Note: Samples taken March 11 and 13th were past the 28 day holding time for Sulphide analysis when received; result may be unreliable. Processed past holding time as per client's instructions.

Kimberley Didsbury
Project Specialist,
Environment, Health & Safety



SGS Canada Inc.

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2HO

Phone: 705-652-2000 FAX: 705-652-6365

LR Report :

CA12714-APR24

Quality Control Report

Inorganic Analysis													
Parameter	Reporting Limit	Unit	Method Blank	Duplicate				LCS / Spike Blank			Matrix Spike / Reference Material		
				Result 1	Result 2	RPD	Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
							%		Low	High		Low	High
Carbon/Sulphur - QCBatchID: ECS0068-APR24													
Sulphide (Na2CO3)	0.01	%	< 0.01										



Client Name: Thurber Engineering Ltd.	Project Ref: Highway 17 Renfrew, Various Sites	Page 1 of 1
Contact Name: Justin Gray	Quote #:	Turnaround Time <input type="checkbox"/> 1 day <input type="checkbox"/> 3 day <input type="checkbox"/> 2 day <input checked="" type="checkbox"/> Regular Date Required: _____
Address: 104 - 2460 Lancaster Rd Ottawa	PO #: 24726 task 700.706a	
Telephone: 343-542-7957	E-mail: jgray@thurber.ca	

<input type="checkbox"/> REG 153/04 <input type="checkbox"/> REG 406/19 <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> Table _____ For RSC: <input type="checkbox"/> Yes <input type="checkbox"/> No	Other Regulation <input type="checkbox"/> REG 558 <input type="checkbox"/> PWQO <input type="checkbox"/> CCME <input type="checkbox"/> MISA <input type="checkbox"/> SU - Sani <input type="checkbox"/> SU - Storm Mun: _____ <input type="checkbox"/> Other: _____	Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)	Required Analysis																	
Sample ID/Location Name		Matrix	Air Volume	# of Containers	Sample Taken		pH	Resist. & Conductivity	Chloride	Sulphate	Sulphide									
					Date	Time														
✓ 1	SC18-3 SS3A 5'-6'3"	S		1	2024/03/11		✓	✓	✓	✓	✓									
✓ 2	SC23-2 SS5 10'-12'	S		1	2024/03/13		✓	✓	✓	✓	✓									
✓ 3	DOC23-1 SS7 15'-17'	S		1	2024/03/11		✓	✓	✓	✓	✓									
✓ 4	OBR23-1 SS16 48'-50'	S		1	2024/03/27		✓	✓	✓	✓	✓									
✓ 5	BON24-2 SS4 10'-12'	S		1	2024/04/09		✓	✓	✓	✓	✓									
✓ 6	NSC20-2 SS2A 2'6"-3'3"	S		1	2024/04/02		✓	✓	✓	✓	✓									
✓ 7	SC10-1 SS2B 3'-4'	S		1	2024/03/21		✓	✓	✓	✓	✓									
✓ 8	SC10-4 SS2 2'6"-4'6"	S		1	2024/04/04		✓	✓	✓	✓	✓									
9																				
10																				

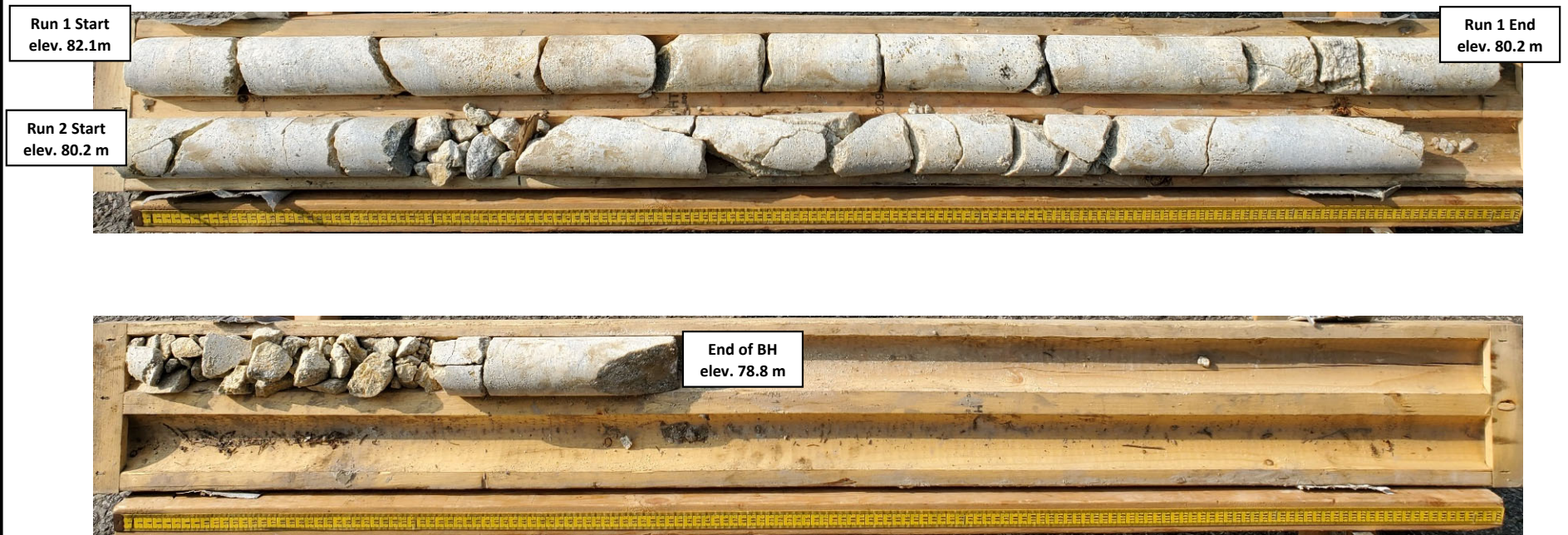
Comments: Please proceed with testing even with hold times expired -JG			Method of Delivery: <u>Walk In</u>	
Relinquished By (Sign): <u>[Signature]</u>	Received at Depot:	Received at Lab: <u>9:10</u>	Verified By: <u>SP</u>	
Relinquished By (Print): <u>Justin Gray</u>	Date/Time:	Date/Time: <u>April 12/24</u>	Date/Time: <u>April 12, 2024 9:57am</u>	
Date/Time: <u>Apr 12, 2024 9pm</u>	Temperature: _____ °C	Temperature: <u>19.1</u>	pH Verified: <input type="checkbox"/> By: _____	



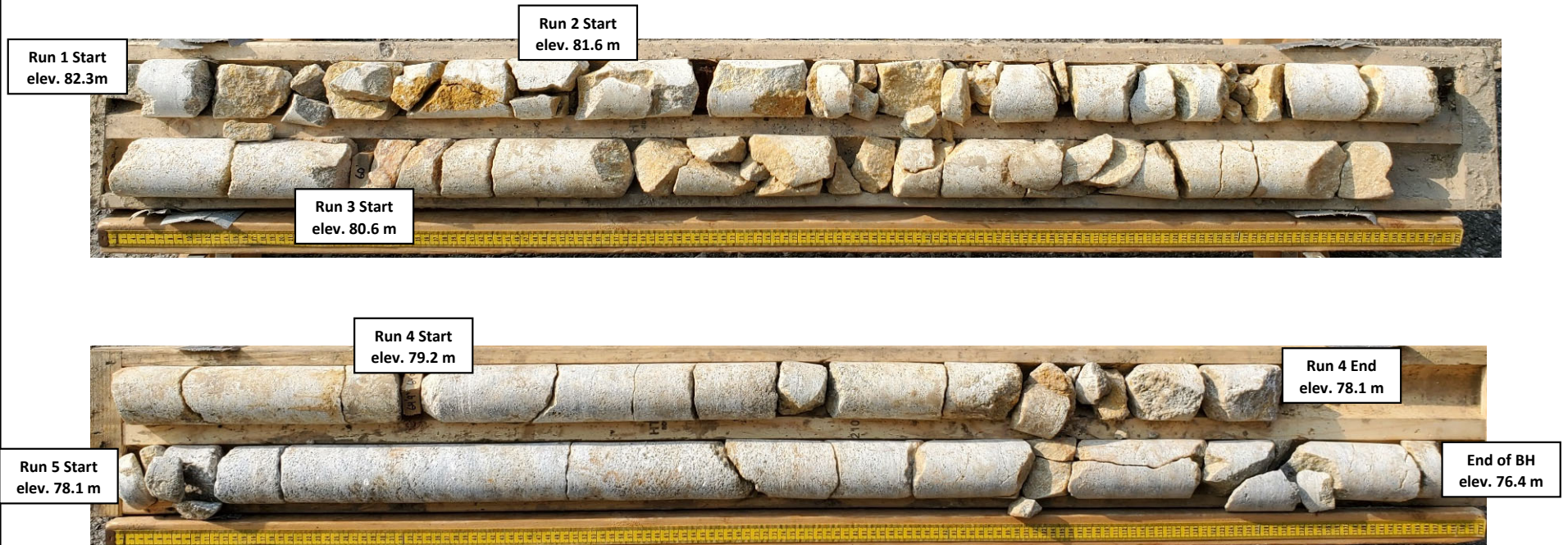
Appendix C.3

Rock Core Photos and UCS Results

Borehole BON19-4
Run 1 to 2 (of 2)
Elevation 82.1 m to 78.8 m



Borehole BON19-5
Run 1 to 2 (of 2)
Elevation 82.3 m to 76.4 m



THURBER ENGINEERING LTD.

Foundation Investigation
Bonnechere River Bridge
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726



Stantec Consulting Ltd.
2781 Lancaster Rd, Suite 100 A&B, Ottawa ON K1B 1A7

February 14, 2022
File: 122410864

Client: Thurber Engineering, File #24726.200a202

**Reference: ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core
Highway 17 Twinning**

The following table summarizes unconfined compressive strength results for two intact rock cores.

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
BON19-4 Run-1	60'	41.2	Well-formed cones at both ends.
BON19-5 Run-5	69'6"	55.1	Well-formed cones at both ends.

Sincerely,

Stantec Consulting Ltd.

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
Fax: 613-722-2799
brian.prevost@stantec.com



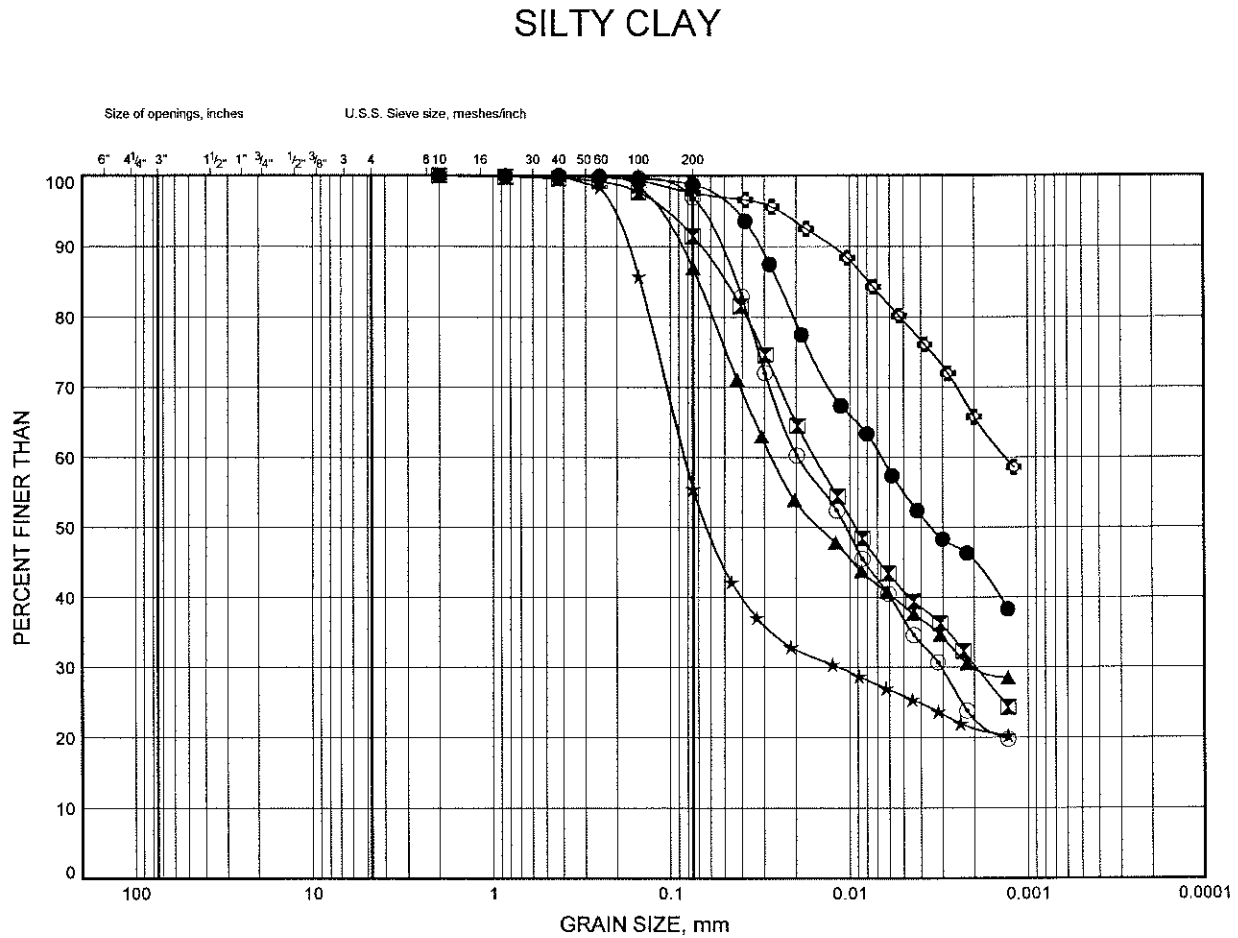
Appendix D.

Laboratory Testing

Previous (2003) Investigation

HWY 17 Twinning, Arnprior to Renfrew GRAIN SIZE DISTRIBUTION

FIGURE D1.1

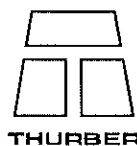


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	BON-1	2.59	99.78
⊠	BON-2	4.88	82.36
▲	BON-3	1.83	84.29
★	BON-4	1.83	87.86
⊙	BON-6	3.35	99.65
⊛	BON-7	2.59	110.41

Date April 2004

Project 647-92-00



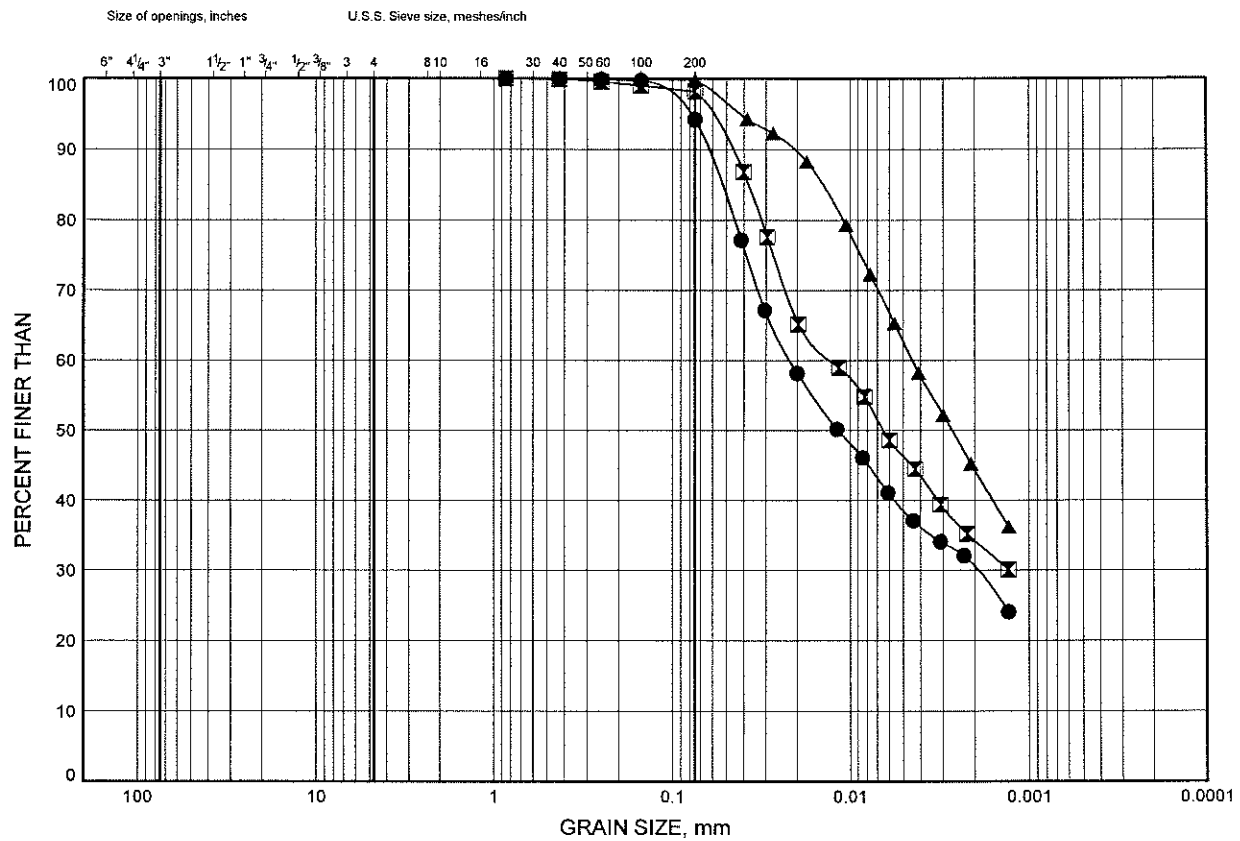
Prep'd SS

Chkd. SMS

HWY 17 Twinning, Arnprior to Renfrew GRAIN SIZE DISTRIBUTION

FIGURE D1.2

SILTY CLAY

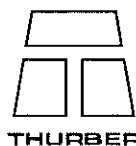


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	BON-1	10.97	91.40
⊠	BON-6	7.70	95.30
▲	BON-7	10.97	102.03

Date April 2004

Project 647-92-00



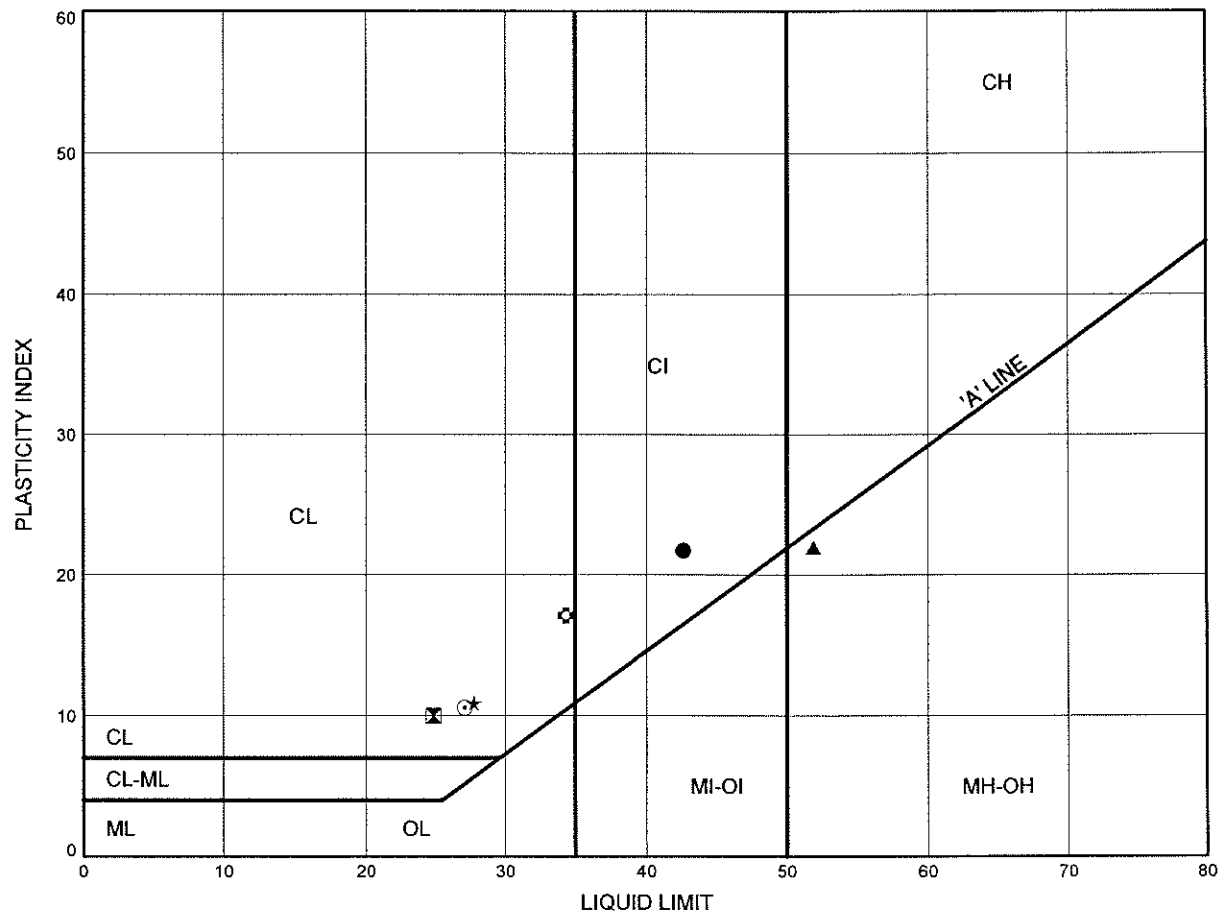
Prep'd SS

Chkd. SMS

HWY 17 Twinning, Arnprior to Renfrew ATTERBERG LIMITS TEST RESULTS

FIGURE D2

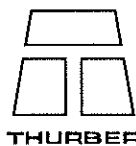
SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	BON-1	2.59	99.78
⊠	BON-1	10.97	91.40
▲	BON-2	4.88	82.36
★	BON-3	1.83	84.29
⊙	BON-6	3.35	99.65
⊛	BON-6	7.70	95.30

Date April 2004

Project 647-92-00



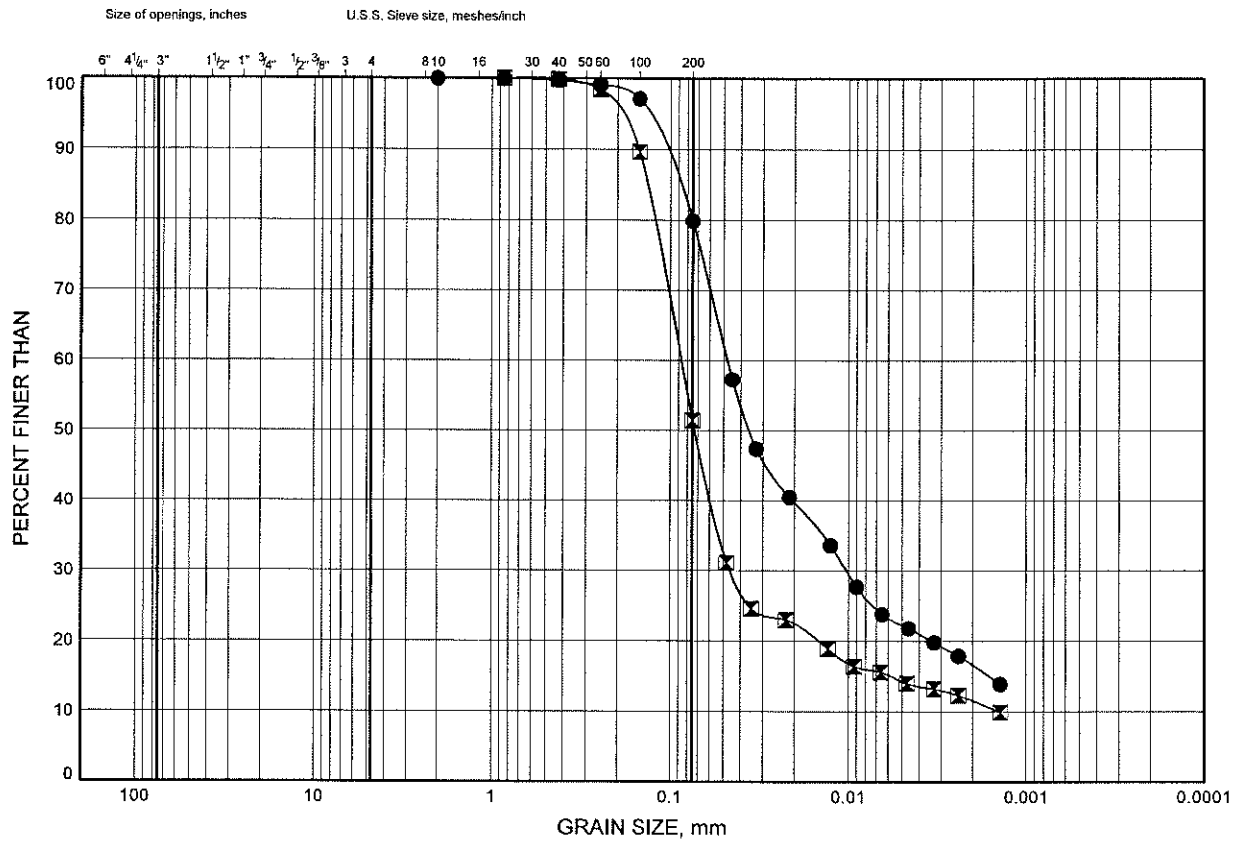
Prep'd SS

Chkd. SMS

HWY 17 Twinning, Arnprior to Renfrew GRAIN SIZE DISTRIBUTION

FIGURE D3

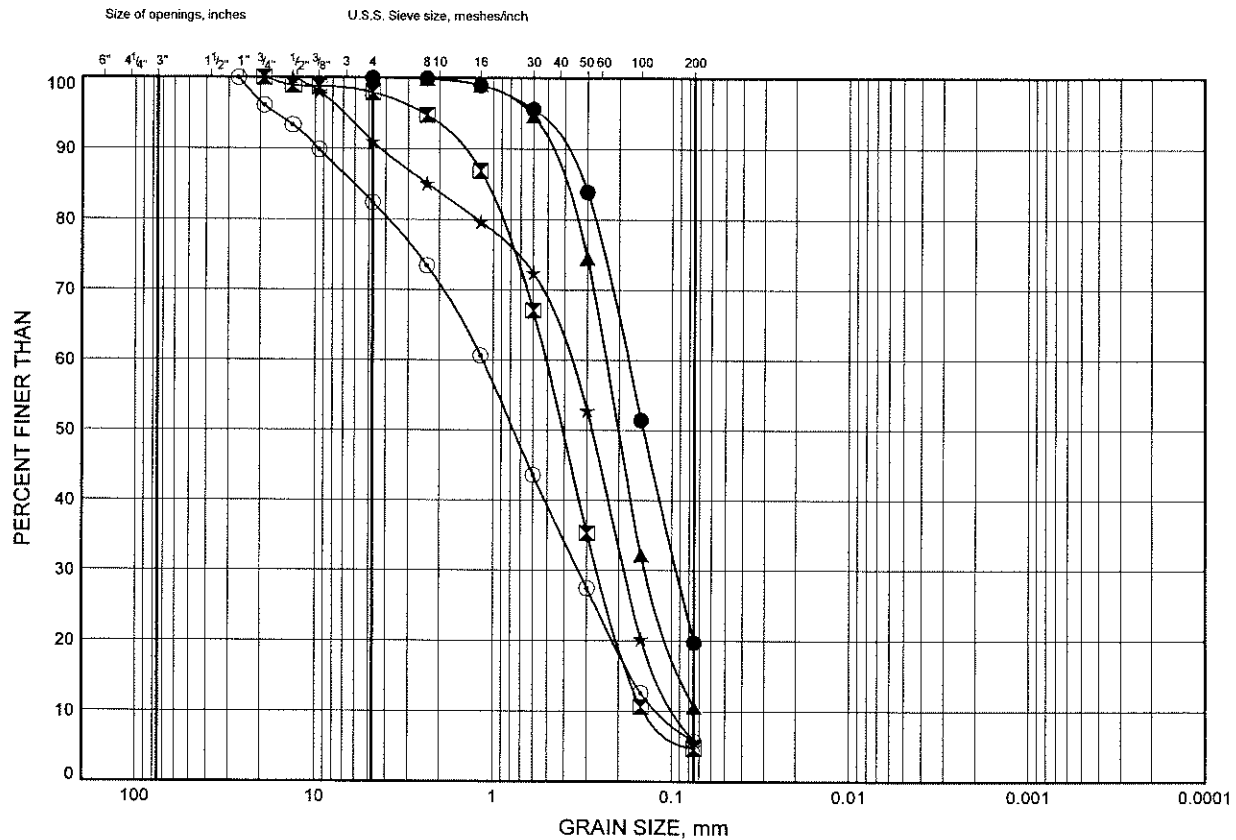
SANDY SILT



HWY 17 Twinning, Arnprior to Renfrew GRAIN SIZE DISTRIBUTION

FIGURE D4

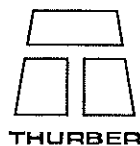
SAND, trace to some silt



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	BON-2	13.72	73.52
⊠	BON-2	24.23	63.01
▲	BON-3	4.88	81.24
★	BON-4	6.25	83.44
⊙	BON-6	15.44	87.56

Date April 2004

Project 647-92-00



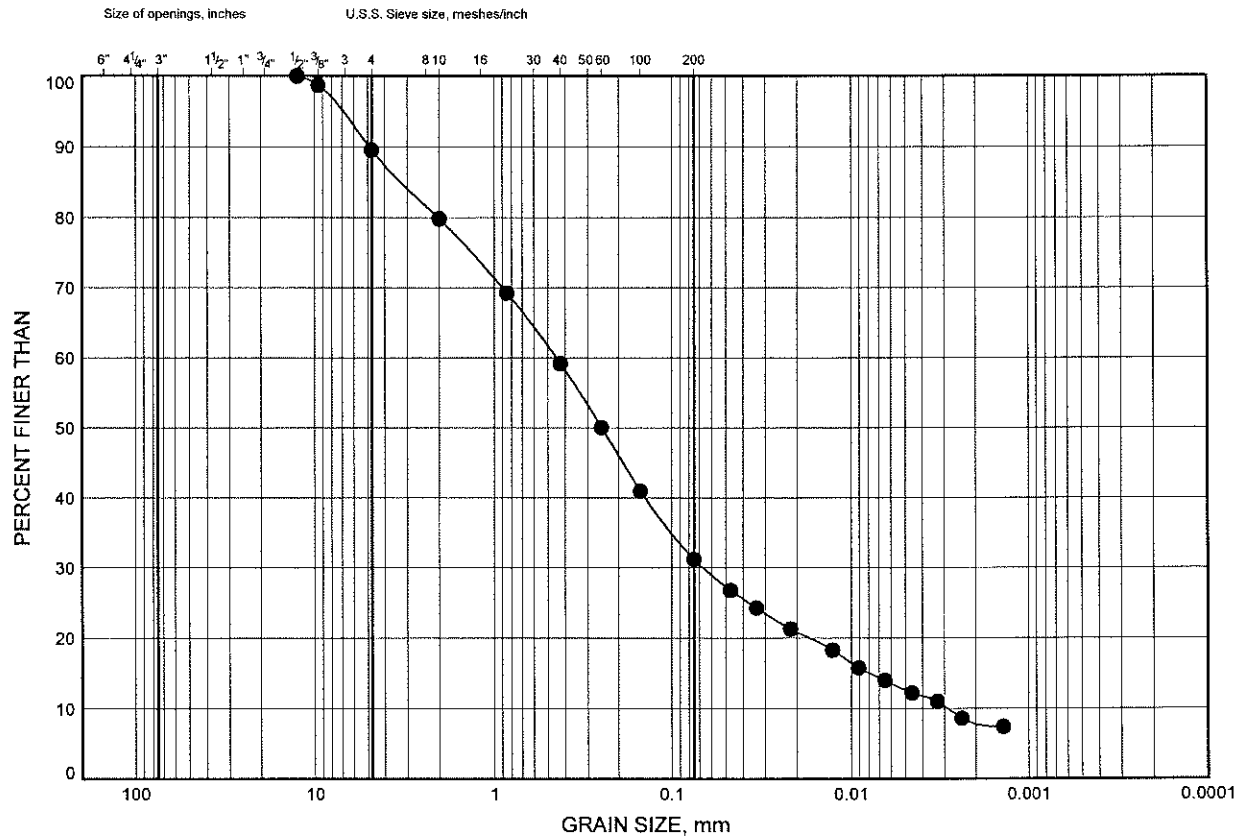
Prep'd SS

Chkd. SMS

HWY 17 Twinning, Amprior to Renfrew GRAIN SIZE DISTRIBUTION

FIGURE D5

SANDY SILT TILL

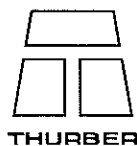


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	BON-3	18.67	67.45

Date April 2004

Project 647-92-00



Prep'd SS

Chkd. SMS

OEDOMETER CONSOLIDATION SUMMARY

SAMPLE IDENTIFICATION

Project Number	04-1116-011	Sample Number	ST #1
Borehole Number	BON 7	Sample Depth, m	12.2-12.8

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	5		
Date Started	2/3/2004		
Date Completed	2/12/2004		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.92	Unit Weight, kN/m ³	17.22
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	11.92
Area, cm ²	31.67	Specific Gravity, measured	2.78
Volume, cm ³	60.80	Solids Height, cm	0.840
Water Content, %	44.50	Volume of Solids, cm ³	26.59
Wet Mass, g	106.80	Volume of Voids, cm ³	34.22
Dry Mass, g	73.91	Degree of Saturation, %	96.1

TEST COMPUTATIONS

Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv, cm ² /s	mv m ² /kN	k cm/s
0.00	1.920	1.287	1.920				
4.69	1.910	1.275	1.915	124	6.27E-03	1.11E-03	6.82E-07
9.53	1.904	1.268	1.907	158	4.88E-03	6.46E-04	3.09E-07
19.28	1.887	1.248	1.896	321	2.37E-03	9.08E-04	2.11E-07
38.69	1.856	1.211	1.872	540	1.38E-03	8.32E-04	1.12E-07
77.39	1.814	1.161	1.835	356	2.01E-03	5.65E-04	1.11E-07
154.57	1.759	1.095	1.787	304	2.23E-03	3.71E-04	8.10E-08
309.16	1.686	1.008	1.723	171	3.68E-03	2.46E-04	8.87E-08
618.34	1.594	0.899	1.640	211	2.70E-03	1.55E-04	4.10E-08
1237.37	1.501	0.788	1.548	211	2.41E-03	7.82E-05	1.85E-08
2472.12	1.416	0.687	1.459	171	2.64E-03	3.59E-05	9.27E-09
1237.37	1.422	0.694	1.419				
309.16	1.447	0.724	1.435				
77.39	1.479	0.762	1.463				
19.28	1.506	0.794	1.493				
4.69	1.548	0.844	1.527				

Notes:

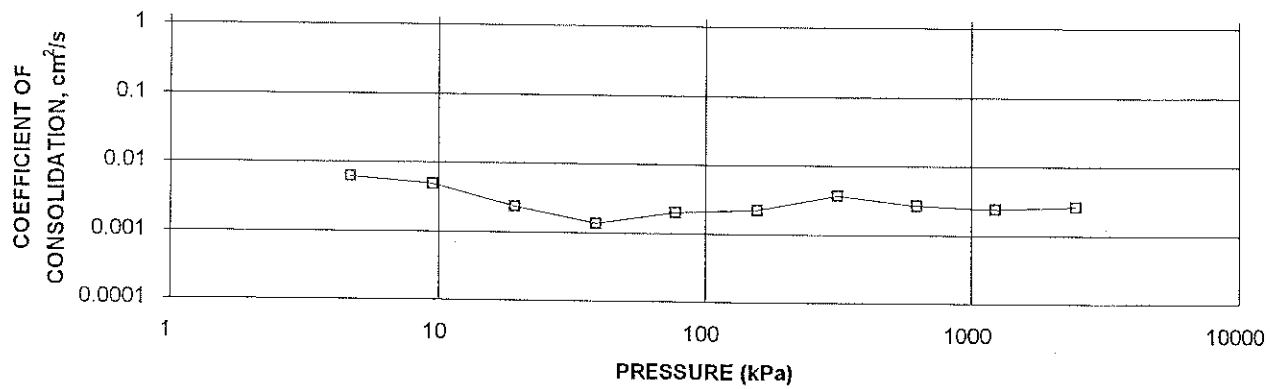
k calculated using cv based on e_0 values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

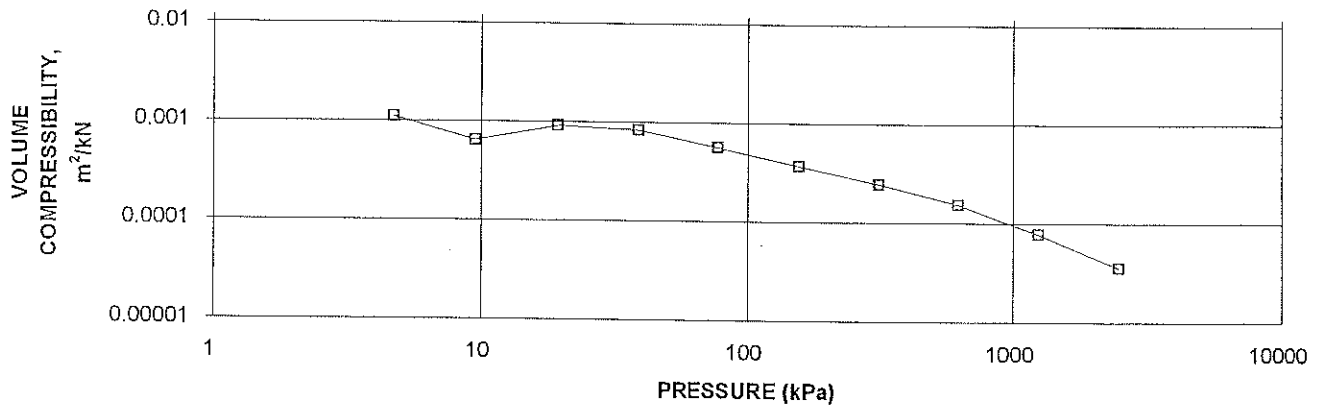
Sample Height, cm	1.55	Unit Weight, kN/m ³	19.35
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	14.78
Area, cm ²	31.67	Specific Gravity, measured	2.78
Volume, cm ³	49.02	Solids Height, cm	0.840
Water Content, %	30.86	Volume of Solids, cm ³	26.59
Wet Mass, g	96.72	Volume of Voids, cm ³	22.44
Dry Mass, g	73.91		

OEDOMETER CONSOLIDATION SUMMARY

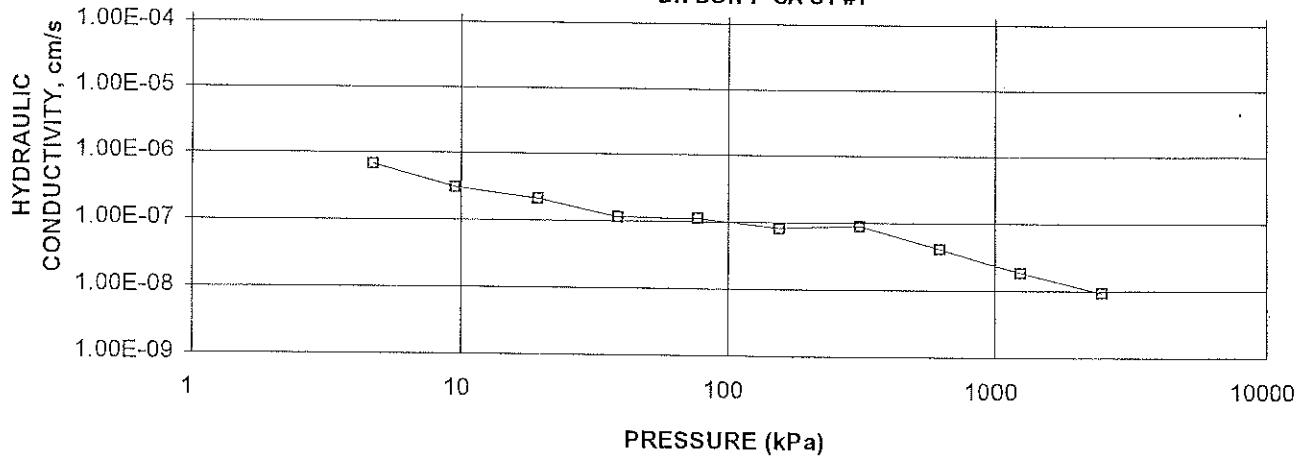
CONSOLIDATION TEST
CV cm²/s VS PRESSURE (kPa)
BH BON 7 SA ST #1



CONSOLIDATION TEST
MV m²/kN vs PRESSURE (kPa)
BH BON 7 SA ST #1



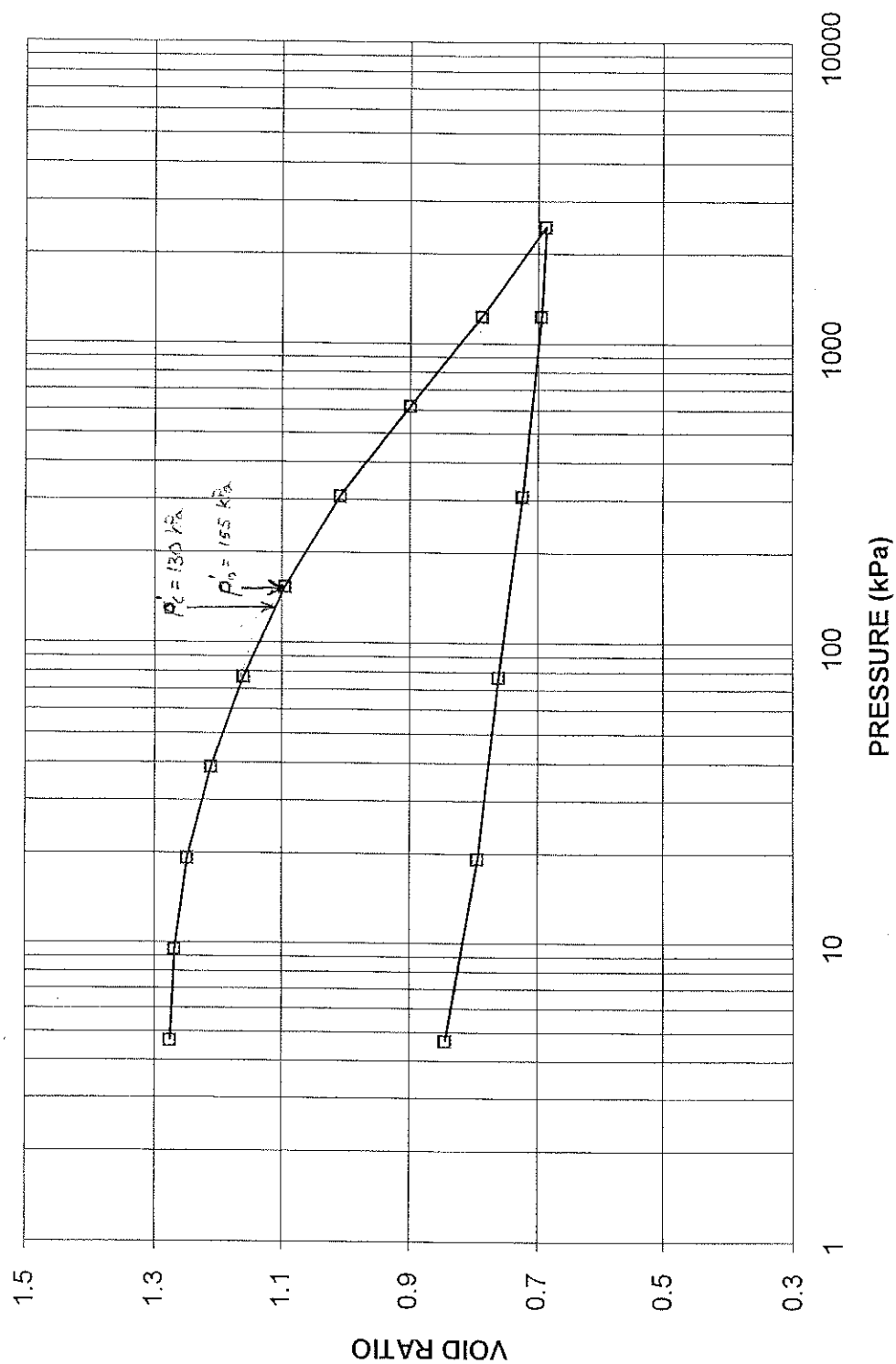
CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH BON 7 SA ST #1



CONSOLIDATION TEST VOID RATIO VS. LOG PRESSURE

FIGURE D6

CONSOLIDATION TEST
VOID RATIO vs. PRESSURE
BH BON 7 SA ST #1





Appendix E.
Site Photographs



Photo 1. Looking west towards Bonnechere River from below proposed east abutment. (2020/08/28)



Photo 2. Looking west from lowland flood plain on east bank of Bonnechere River, near Borehole BON-P2. (2021/11/15)



Photo 3. Looking west from near existing west abutment, showing approximate locations of Boreholes BON-P2 and BON-P3. (2021/11/08)



Photo 4. Looking east from below existing west abutment. (2019/09/24)



Photo 5. Looking east toward east abutment, showing approximate location of Borehole BON-19-4. (2020/09/04)



Photo 6. Looking east toward east approach cut section. (2019/09/24)



Appendix F.

GSC Seismic Hazard Calculation

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

Site: 45.487N 76.657W

User File Reference: Bonnechere River Bridge

2022-04-05 16:01 UT

Requested by: Thurber Engineering Ltd.

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.353	0.181	0.104	0.031
Sa (0.1)	0.419	0.226	0.136	0.045
Sa (0.2)	0.350	0.196	0.122	0.043
Sa (0.3)	0.267	0.153	0.097	0.035
Sa (0.5)	0.190	0.112	0.072	0.026
Sa (1.0)	0.097	0.058	0.038	0.013
Sa (2.0)	0.047	0.028	0.018	0.005
Sa (5.0)	0.013	0.007	0.004	0.001
Sa (10.0)	0.005	0.003	0.002	0.001
PGA (g)	0.225	0.124	0.075	0.024
PGV (m/s)	0.159	0.090	0.055	0.017

Notes: Spectral ($S_a(T)$, 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" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. 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.**

References

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

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
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



Natural Resources
Canada

Ressources naturelles
Canada

Canada



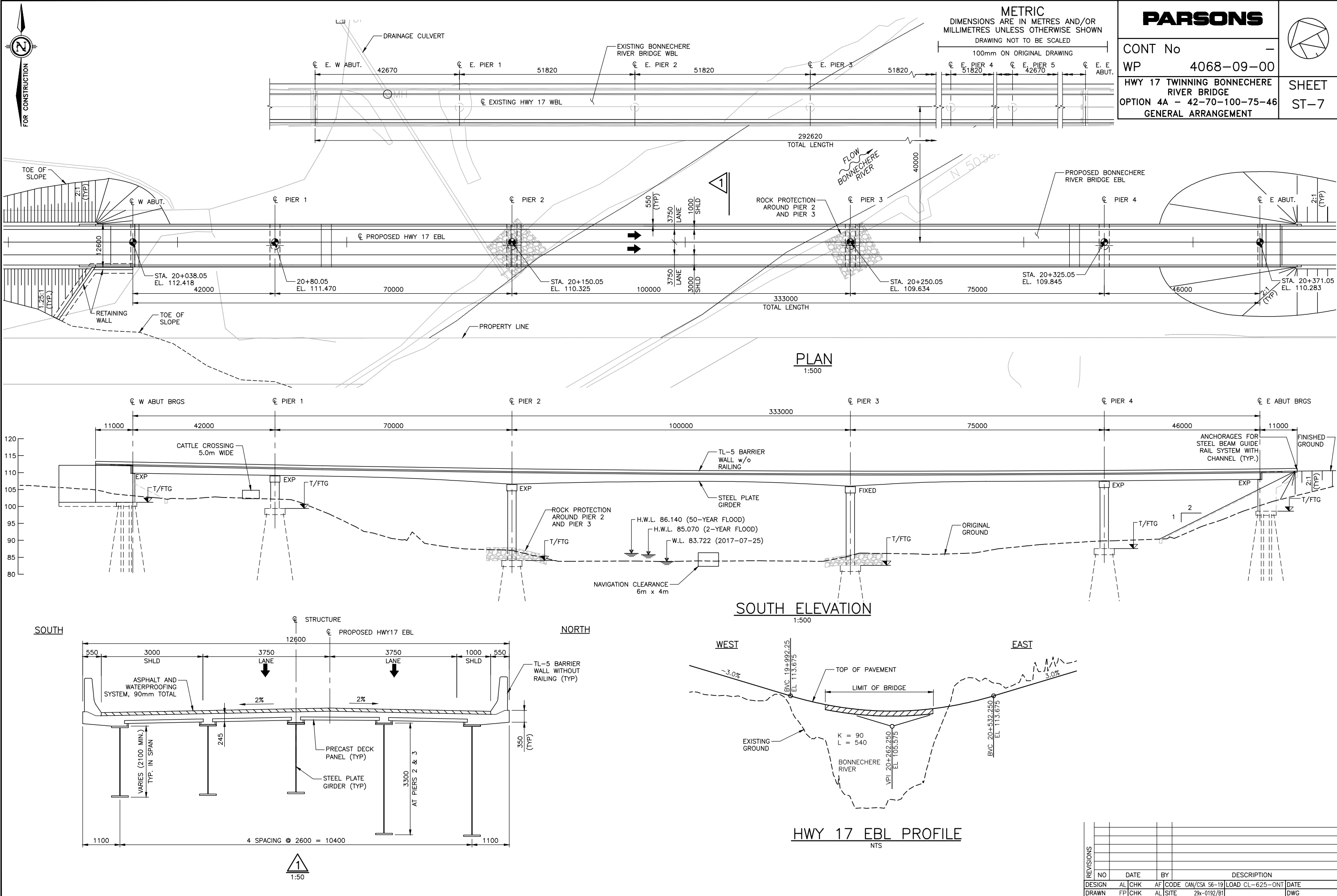
Appendix G.

Foundation Comparison Preliminary General Arrangement Drawing

COMPARISON OF BRIDGE FOUNDATION ALTERNATIVES

Shallow Foundation	Caisson (Drilled Shafts)	Drilled-In Pipe Piles	Driven Steel Piles
Advantages			
<ul style="list-style-type: none"> Requires less specialized construction equipment 	<ul style="list-style-type: none"> Higher geotechnical resistance than spread footings and steel piles Construction can continue in winter weather conditions Requires minimal excavation (installed from ground surface) 	<ul style="list-style-type: none"> Down-the-hole hammer and cuttings return increases penetration efficiency through most obstructions High drilling production rates Moderate geotechnical resistance due to end-bearing only capacity in bedrock 	<ul style="list-style-type: none"> Higher geotechnical capacity than spread footings Construction can continue in winter weather conditions Requires less concrete than spread footings or caissons Likely requires less dewatering effort Allows for integral abutments Requires minimal excavation (installed from ground surface)
Disadvantages			
<ul style="list-style-type: none"> Requires large excavations, extending below groundwater table Lower geotechnical resistance than deep foundations Less efficient for resistance to uplift or overturning Does not allow for integral abutments 	<ul style="list-style-type: none"> Specialized installation measures such as equipment, liners and drilling mud will be required Difficulty in cleaning and inspecting base Does not allow for integral abutments 	<ul style="list-style-type: none"> Smaller number of contractors with suitable equipment Not commonly used for integral abutments 	<ul style="list-style-type: none"> Lower geotechnical resistance than caissons Has potential to encounter obstructions in the till
Risks/Consequences			
<ul style="list-style-type: none"> Large Excavation Differential settlement Temporary Protection required to excavate into silty clay layer 	<ul style="list-style-type: none"> Unbalanced pressure heads and base boiling in the submerged site soils requires liners and/or mud Difficulties advancing through obstructions 	<ul style="list-style-type: none"> Increased concrete volume may be required if additional soil is pulled in from sidewall while advancing through obstructions. Position and alignment could be affected by obstructions 	<ul style="list-style-type: none"> Difficulties advancing through obstructions, design based on refusal in till
Moderate	High	Moderate to High	Moderate to High
Recommendation			
Not Recommended	Feasible for support of Piers	Feasible for support of Piers	Recommended for support of Abutments and Wingwalls

2017-08
ANS-D
MINISTRY OF TRANSPORTATION, ONTARIO
FILE NAME: C:\pw_working\ontario\parsons\002695a\drns41758\Bonnechere River Bridge _ST7_ CA-Option 4A.dwg
MODIFIED: 2023-07-13 09:21



REVISIONS					
	NO	DATE	BY	DESCRIPTION	
DESIGN	AL	CHK	AF	CODE	CAN/CSA S6-19 LOAD CL-625-ONT DATE
DRAWN	FP	CHK	AL	SITE	29x-0192/81 DWG

DOCUMENT CODE:



Appendix H.

P-y Curves



L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
West Abutment (BON19-2)
Static Conditions

GENERAL NOTES

- The values P(kN/m) represent soil reaction per metre of pile length
- The values y(m) represent soil/pile deflection
- The underside of pile cap is at Elev. 99.7 m
- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)
- If lateral spacing between adjacent piles is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.22, C6.33, and C6.24 of the CHBDC (S6-19)

Soil Type	Silty Clay [WC]		Silty Clay [WC]		Silty Clay [WC]		Silty Clay [WC]		Clayey Silt		Clayey Silt		Clayey Silt		Clayey Silt		Clayey Silt	
Depth (m)	1		2		3		4		5		6		7		8		9	
Elev. (m)	98.7		97.7		96.7		95.7		94.7		93.7		92.7		91.7		90.7	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0000	18.6	0.0000	18.6	0.0000	18.6	0.0000	18.6	0.0000	18.6	0.0000	18.6	0.0000	18.6	0.0000	18.6	0.0000	18.6
	0.0000	37.2	0.0000	37.2	0.0000	37.2	0.0000	37.2	0.0000	37.2	0.0000	37.2	0.0000	37.2	0.0000	37.2	0.0000	37.2
	0.0001	55.8	0.0001	55.8	0.0001	55.8	0.0001	55.8	0.0001	55.8	0.0001	55.8	0.0001	55.8	0.0001	55.8	0.0001	55.8
	0.0003	74.4	0.0003	74.4	0.0003	74.4	0.0003	74.4	0.0003	74.4	0.0003	74.4	0.0003	74.4	0.0003	74.4	0.0003	74.4
	0.0008	93.0	0.0008	93.0	0.0008	93.0	0.0008	93.0	0.0008	93.0	0.0008	93.0	0.0008	93.0	0.0008	93.0	0.0008	93.0
	0.0016	111.6	0.0016	111.6	0.0016	111.6	0.0016	111.6	0.0016	111.6	0.0016	111.6	0.0016	111.6	0.0016	111.6	0.0016	111.6
	0.0029	130.2	0.0029	130.2	0.0029	130.2	0.0029	130.2	0.0029	130.2	0.0029	130.2	0.0029	130.2	0.0029	130.2	0.0029	130.2
	0.0050	148.8	0.0050	148.8	0.0050	148.8	0.0050	148.8	0.0050	148.8	0.0050	148.8	0.0050	148.8	0.0050	148.8	0.0050	148.8
	0.0080	167.4	0.0080	167.4	0.0080	167.4	0.0080	167.4	0.0080	167.4	0.0080	167.4	0.0080	167.4	0.0080	167.4	0.0080	167.4
	0.0122	186.0	0.0122	186.0	0.0122	186.0	0.0122	186.0	0.0122	186.0	0.0122	186.0	0.0122	186.0	0.0122	186.0	0.0122	186.0
	0.0179	204.6	0.0179	204.6	0.0179	204.6	0.0179	204.6	0.0179	204.6	0.0179	204.6	0.0179	204.6	0.0179	204.6	0.0179	204.6
	0.0254	223.2	0.0254	223.2	0.0254	223.2	0.0254	223.2	0.0254	223.2	0.0254	223.2	0.0254	223.2	0.0254	223.2	0.0254	223.2
	0.0350	241.8	0.0350	241.8	0.0350	241.8	0.0350	241.8	0.0350	241.8	0.0350	241.8	0.0350	241.8	0.0350	241.8	0.0350	241.8
	0.0470	260.4	0.0470	260.4	0.0470	260.4	0.0470	260.4	0.0470	260.4	0.0470	260.4	0.0470	260.4	0.0470	260.4	0.0470	260.4
	0.0620	279.0	0.0620	279.0	0.0620	279.0	0.0620	279.0	0.0620	279.0	0.0620	279.0	0.0620	279.0	0.0620	279.0	0.0620	279.0
	0.0775	279.0	0.0775	279.0	0.0775	279.0	0.0775	279.0	0.0775	279.0	0.0775	279.0	0.0775	279.0	0.0775	279.0	0.0775	279.0

Soil Type	Clayey Silt		Clayey Silt		Clayey Silt		Silt - Clayey Silt		Silt - Clayey Silt		Silt - Clayey Silt		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)	
Depth (m)	10		11		12		13		14		15		16		17		18	
Elev. (m)	89.7		88.7		87.7		86.7		85.7		84.7		83.7		82.7		81.7	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0000	18.6	0.0000	18.6	0.0000	18.6	0.0039	855.5	0.0045	1028.5	0.0037	1226.1	0.0033	1453.7	0.0032	1492.9	0.0032	1532.0
	0.0000	37.2	0.0000	37.2	0.0000	37.2	0.0079	1501.3	0.0090	1805.0	0.0075	2151.8	0.0066	2551.2	0.0064	2619.9	0.0063	2688.6
	0.0001	55.8	0.0001	55.8	0.0001	55.8	0.0118	1892.9	0.0135	2275.8	0.0112	2713.1	0.0099	3216.7	0.0097	3303.3	0.0095	3389.9
	0.0003	74.4	0.0003	74.4	0.0003	74.4	0.0158	2099.6	0.0180	2524.4	0.0149	3009.4	0.0131	3568.0	0.0129	3664.1	0.0126	3760.2
	0.0008	93.0	0.0008	93.0	0.0008	93.0	0.0197	2200.8	0.0224	2646.1	0.0186	3154.4	0.0164	3739.9	0.0161	3840.7	0.0158	3941.4
	0.0016	111.6	0.0016	111.6	0.0016	111.6	0.0237	2248.5	0.0269	2703.4	0.0224	3222.8	0.0197	3821.0	0.0193	3923.9	0.0189	4026.8
	0.0029	130.2	0.0029	130.2	0.0029	130.2	0.0276	2270.6	0.0314	2730.0	0.0261	3254.4	0.0230	3858.5	0.0225	3962.5	0.0221	4066.4
	0.0050	148.8	0.0050	148.8	0.0050	148.8	0.0316	2280.7	0.0359	2742.2	0.0298	3269.0	0.0263	3875.8	0.0258	3980.2	0.0253	4084.5
	0.0080	167.4	0.0080	167.4	0.0080	167.4	0.0355	2285.4	0.0404	2747.7	0.0335	3275.6	0.0296	3883.7	0.0290	3988.3	0.0284	4092.8
	0.0122	186.0	0.0122	186.0	0.0122	186.0	0.0395	2287.5	0.0449	2750.3	0.0373	3278.7	0.0329	3887.3	0.0322	3991.9	0.0316	4096.6
	0.0179	204.6	0.0179	204.6	0.0179	204.6	0.0434	2288.4	0.0494	2751.5	0.0410	3280.1	0.0362	3888.9	0.0354	3993.6	0.0347	4098.4
	0.0254	223.2	0.0254	223.2	0.0254	223.2	0.0473	2288.9	0.0539	2752.0	0.0447	3280.7	0.0394	3889.7	0.0386	3994.4	0.0379	4099.2
	0.0350	241.8	0.0350	241.8	0.0350	241.8	0.0513	2289.1	0.0584	2752.2	0.0484	3281.0	0.0427	3890.0	0.0418	3994.8	0.0410	4099.5
	0.0470	260.4	0.0470	260.4	0.0470	260.4	0.0552	2289.2	0.0628	2752.3	0.0522	3281.1	0.0460	3890.2	0.0451	3994.9	0.0442	4099.7
	0.0620	279.0	0.0620	279.0	0.0620	279.0	0.0592	2289.2	0.0673	2752.4	0.0559	3281.2	0.0493	3890.2	0.0483	3995.0	0.0474	4099.8
	0.0775	279.0	0.0775	279.0	0.0775	279.0	0.0631	2289.2	0.0718	2752.4	0.0596	3281.2	0.0526	3890.3	0.0515	3995.0	0.0505	4099.8

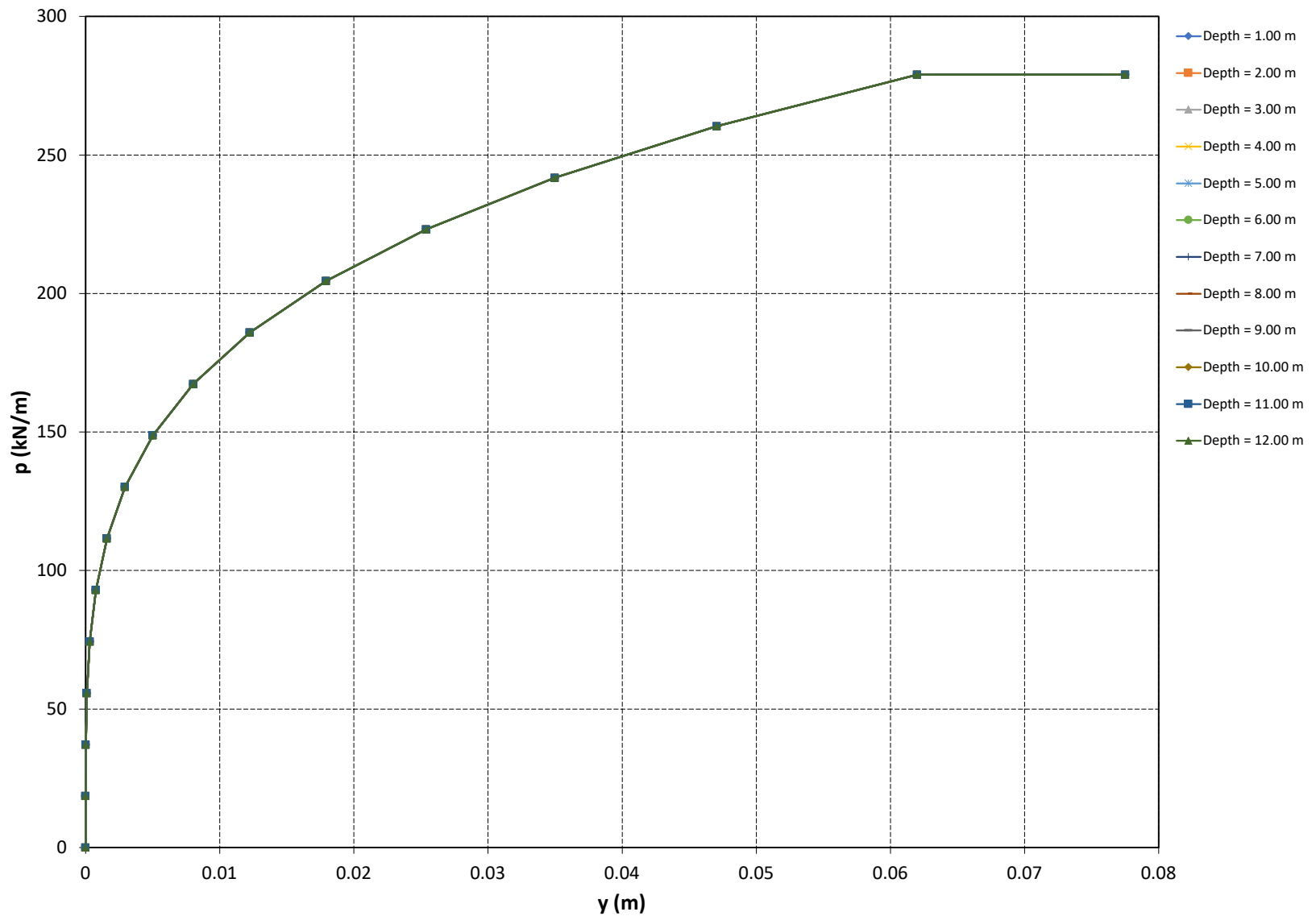


L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
West Abutment (BON19-2)
Static Conditions

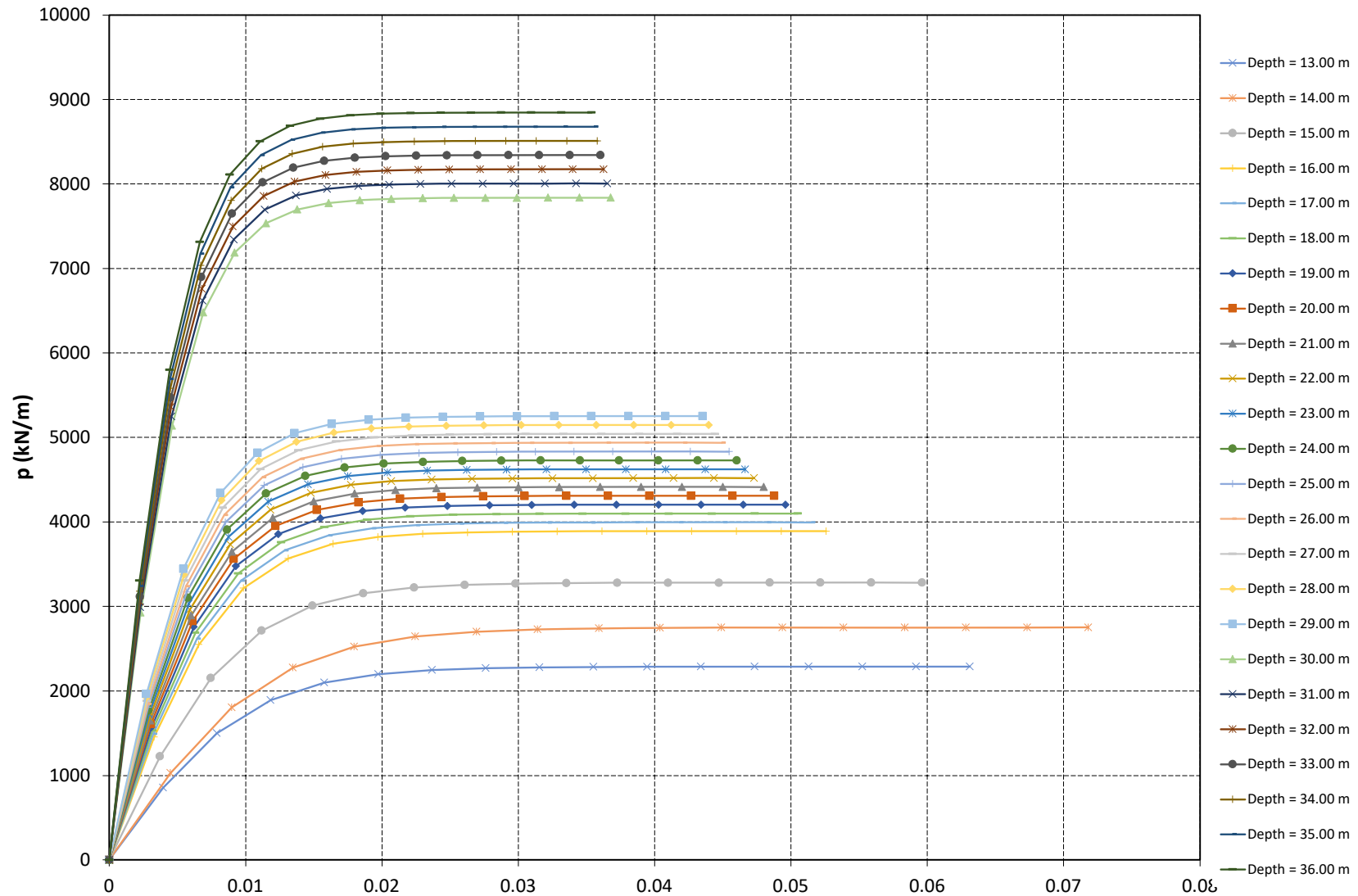
Soil Type	Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)	
Depth (m)	19		20		21		22		23		24		25		26		27	
Elev. (m)	80.7		79.7		78.7		77.7		76.7		75.7		74.7		73.7		72.7	
S T A T I C C o n d i t i o n s	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0031	1571.2	0.0030	1610.3	0.0030	1649.5	0.0030	1688.6	0.0029	1727.8	0.0029	1766.9	0.0028	1806.1	0.0028	1845.2	0.0028	1884.4
	0.0062	2757.3	0.0061	2826.0	0.0060	2894.7	0.0059	2963.5	0.0058	3032.2	0.0058	3100.9	0.0057	3169.6	0.0056	3238.3	0.0056	3307.0
	0.0093	3476.6	0.0091	3563.2	0.0090	3649.8	0.0089	3736.4	0.0087	3823.1	0.0086	3909.7	0.0085	3996.3	0.0084	4082.9	0.0083	4169.6
	0.0124	3856.2	0.0122	3952.3	0.0120	4048.4	0.0118	4144.5	0.0117	4240.6	0.0115	4336.7	0.0114	4432.8	0.0112	4528.8	0.0111	4624.9
	0.0155	4042.1	0.0152	4142.8	0.0150	4243.5	0.0148	4344.2	0.0146	4445.0	0.0144	4545.7	0.0142	4646.4	0.0140	4747.1	0.0139	4847.8
	0.0186	4129.7	0.0183	4232.6	0.0180	4335.5	0.0177	4438.4	0.0175	4541.3	0.0173	4644.2	0.0171	4747.1	0.0169	4850.0	0.0167	4952.9
	0.0217	4170.3	0.0213	4274.2	0.0210	4378.1	0.0207	4482.0	0.0204	4585.9	0.0201	4689.8	0.0199	4793.7	0.0197	4897.7	0.0194	5001.6
	0.0248	4188.9	0.0244	4293.3	0.0240	4397.7	0.0237	4502.0	0.0233	4606.4	0.0230	4710.8	0.0227	4815.2	0.0225	4919.5	0.0222	5023.9
	0.0279	4197.4	0.0274	4302.0	0.0270	4406.6	0.0266	4511.2	0.0262	4615.8	0.0259	4720.4	0.0256	4824.9	0.0253	4929.5	0.0250	5034.1
	0.0310	4201.3	0.0305	4306.0	0.0300	4410.7	0.0296	4515.4	0.0292	4620.1	0.0288	4724.7	0.0284	4829.4	0.0281	4934.1	0.0278	5038.8
	0.0341	4203.1	0.0335	4307.8	0.0330	4412.5	0.0325	4517.3	0.0321	4622.0	0.0317	4726.7	0.0313	4831.5	0.0309	4936.2	0.0305	5040.9
	0.0372	4203.9	0.0366	4308.6	0.0360	4413.4	0.0355	4518.1	0.0350	4622.9	0.0345	4727.6	0.0341	4832.4	0.0337	4937.1	0.0333	5041.9
	0.0403	4204.3	0.0396	4309.0	0.0390	4413.8	0.0384	4518.5	0.0379	4623.3	0.0374	4728.1	0.0369	4832.8	0.0365	4937.6	0.0361	5042.3
	0.0434	4204.4	0.0427	4309.2	0.0420	4414.0	0.0414	4518.7	0.0408	4623.5	0.0403	4728.2	0.0398	4833.0	0.0393	4937.8	0.0389	5042.5
	0.0465	4204.5	0.0457	4309.3	0.0450	4414.0	0.0443	4518.8	0.0437	4623.6	0.0432	4728.3	0.0426	4833.1	0.0421	4937.9	0.0417	5042.6
	0.0496	4204.6	0.0488	4309.3	0.0480	4414.1	0.0473	4518.8	0.0466	4623.6	0.0460	4728.4	0.0455	4833.1	0.0449	4937.9	0.0444	5042.7
Soil Type	Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)	
Depth (m)	28		29		30		31		32		33		34		35		36	
Elev. (m)	71.7		70.7		69.7		68.7		67.7		66.7		65.7		64.7		63.7	
S T A T I C C o n d i t i o n s	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0027	1923.5	0.0027	1962.7	0.0023	2929.0	0.0023	2991.9	0.0023	3054.7	0.0023	3117.5	0.0022	3180.3	0.0022	3243.1	0.0022	3305.9
	0.0055	3375.7	0.0054	3444.4	0.0046	5140.3	0.0046	5250.5	0.0045	5360.8	0.0045	5471.0	0.0045	5581.2	0.0044	5691.5	0.0044	5801.7
	0.0082	4256.2	0.0082	4342.8	0.0069	6481.1	0.0068	6620.1	0.0068	6759.1	0.0068	6898.0	0.0067	7037.0	0.0067	7176.0	0.0066	7315.0
	0.0110	4721.0	0.0109	4817.1	0.0092	7188.9	0.0091	7343.1	0.0091	7497.2	0.0090	7651.4	0.0090	7805.6	0.0089	7959.7	0.0088	8113.9
	0.0137	4948.5	0.0136	5049.3	0.0115	7535.4	0.0114	7697.0	0.0113	7858.6	0.0113	8020.2	0.0112	8181.8	0.0111	8343.4	0.0111	8505.0
	0.0165	5055.8	0.0163	5158.7	0.0138	7698.7	0.0137	7863.8	0.0136	8028.9	0.0135	8194.0	0.0134	8359.1	0.0133	8524.2	0.0133	8689.3
	0.0192	5105.5	0.0190	5209.4	0.0161	7774.3	0.0160	7941.0	0.0159	8107.8	0.0158	8274.5	0.0157	8441.2	0.0156	8607.9	0.0155	8774.7
	0.0220	5128.3	0.0218	5232.7	0.0184	7809.1	0.0183	7976.5	0.0181	8144.0	0.0180	8311.5	0.0179	8478.9	0.0178	8646.4	0.0177	8813.9
	0.0247	5138.7	0.0245	5243.3	0.0207	7824.9	0.0205	7992.7	0.0204	8160.6	0.0203	8328.4	0.0201	8496.2	0.0200	8664.0	0.0199	8831.8
	0.0275	5143.5	0.0272	5248.2	0.0230	7832.2	0.0228	8000.2	0.0227	8168.1	0.0225	8336.1	0.0224	8504.0	0.0222	8672.0	0.0221	8840.0
	0.0302	5145.6	0.0299	5250.4	0.0253	7835.5	0.0251	8003.5	0.0249	8171.6	0.0248	8339.6	0.0246	8507.6	0.0245	8675.7	0.0243	8843.7
	0.0330	5146.6	0.0326	5251.4	0.0276	7837.0	0.0274	8005.1	0.0272	8173.1	0.0270	8341.2	0.0269	8509.3	0.0267	8677.3	0.0265	8845.4
	0.0357	5147.1	0.0354	5251.8	0.0299	7837.7	0.0297	8005.8	0.0295	8173.9	0.0293	8341.9	0.0291	8510.0	0.0289	8678.1	0.0288	8846.2
	0.0385	5147.3	0.0381	5252.1	0.0322	7838.0	0.0320	8006.1	0.0317	8174.2	0.0315	8342.3	0.0313	8510.4	0.0311	8678.5	0.0310	8846.5
	0.0412	5147.4	0.0408	5252.2	0.0345	7838.2	0.0342	8006.2	0.0340	8174.3	0.0338	8342.4	0.0336	8510.5	0.0334	8678.6	0.0332	8846.7
	0.0440	5147.4	0.0435	5252.2	0.0368	7838.2	0.0365	8006.3	0.0363	8174.4	0.0360	8342.5	0.0358	8510.6	0.0356	8678.7	0.0354	8846.8



L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
West Abutment (BON19-2)
Static Conditions



L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
West Abutment (BON19-2)
Static Conditions





L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 1 (BON19-3)
Static Conditions

GENERAL NOTES

- The values P(kN/m) represent soil reaction per metre of pile length
- The values y(m) represent soil/pile deflection
- The underside of pile cap is at Elev. 97.5 m
- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)
- If lateral spacing between adjacent piles is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.22, C6.33, and C6.24 of the CHBDC (S6-19)

Soil Type	Clayey Silt		Clayey Silt		Clayey Silt		Clayey Silt		Clayey Silt		Clayey Silt		Clayey Silt		Sandy Silt		Sandy Silt	
Depth (m)	1		2		3		4		5		6		7		8		9	
Elev. (m)	96.5		95.5		94.5		93.5		92.5		91.5		90.5		89.5		88.5	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0000	18.6	0.0000	18.6	0.0000	18.6	0.0000	18.6	0.0000	18.6	0.0000	18.6	0.0046	713.3	0.0046	768.7	0.0046	824.2
	0.0000	37.2	0.0000	37.2	0.0000	37.2	0.0000	37.2	0.0000	37.2	0.0000	37.2	0.0093	1251.7	0.0092	1349.0	0.0092	1446.3
	0.0001	55.8	0.0001	55.8	0.0001	55.8	0.0001	55.8	0.0001	55.8	0.0001	55.8	0.0139	1578.2	0.0139	1700.9	0.0138	1823.6
	0.0003	74.4	0.0003	74.4	0.0003	74.4	0.0003	74.4	0.0003	74.4	0.0003	74.4	0.0185	1750.6	0.0185	1886.7	0.0185	2022.8
	0.0008	93.0	0.0008	93.0	0.0008	93.0	0.0008	93.0	0.0008	93.0	0.0008	93.0	0.0232	1835.0	0.0231	1977.6	0.0231	2120.2
	0.0016	111.6	0.0016	111.6	0.0016	111.6	0.0016	111.6	0.0016	111.6	0.0016	111.6	0.0278	1874.7	0.0277	2020.5	0.0277	2166.2
	0.0029	130.2	0.0029	130.2	0.0029	130.2	0.0029	130.2	0.0029	130.2	0.0029	130.2	0.0324	1893.2	0.0324	2040.3	0.0323	2187.5
	0.0050	148.8	0.0050	148.8	0.0050	148.8	0.0050	148.8	0.0050	148.8	0.0050	148.8	0.0371	1901.6	0.0370	2049.4	0.0369	2197.2
	0.0080	167.4	0.0080	167.4	0.0080	167.4	0.0080	167.4	0.0080	167.4	0.0080	167.4	0.0417	1905.5	0.0416	2053.6	0.0415	2201.7
	0.0122	186.0	0.0122	186.0	0.0122	186.0	0.0122	186.0	0.0122	186.0	0.0122	186.0	0.0463	1907.3	0.0462	2055.5	0.0461	2203.8
	0.0179	204.6	0.0179	204.6	0.0179	204.6	0.0179	204.6	0.0179	204.6	0.0179	204.6	0.0509	1908.1	0.0508	2056.4	0.0508	2204.7
	0.0254	223.2	0.0254	223.2	0.0254	223.2	0.0254	223.2	0.0254	223.2	0.0254	223.2	0.0556	1908.4	0.0555	2056.8	0.0554	2205.1
	0.0350	241.8	0.0350	241.8	0.0350	241.8	0.0350	241.8	0.0350	241.8	0.0350	241.8	0.0602	1908.6	0.0601	2057.0	0.0600	2205.3
	0.0470	260.4	0.0470	260.4	0.0470	260.4	0.0470	260.4	0.0470	260.4	0.0470	260.4	0.0648	1908.7	0.0647	2057.0	0.0646	2205.4
	0.0620	279.0	0.0620	279.0	0.0620	279.0	0.0620	279.0	0.0620	279.0	0.0620	279.0	0.0695	1908.7	0.0693	2057.1	0.0692	2205.4
	0.0775	279.0	0.0775	279.0	0.0775	279.0	0.0775	279.0	0.0775	279.0	0.0775	279.0	0.0741	1908.7	0.0740	2057.1	0.0738	2205.5

Soil Type	Sandy Silt		Sandy Silt		Sandy Silt		Sandy Silt		Sandy Silt (below WT)		Sandy Silt (below WT)		Sandy Silt (below WT)		Sandy Silt (below WT)		Silty Sand and Gravel (below WT)	
Depth (m)	10		11		12		13		14		15		16		17		18	
Elev. (m)	87.5		86.5		85.5		84.5		83.5		82.5		81.5		80.5		79.5	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0046	879.6	0.0046	935.0	0.0046	990.5	0.0046	1045.9	0.0062	1086.4	0.0061	1111.9	0.0059	1137.3	0.0058	1162.8	0.0046	1525.7
	0.0092	1543.6	0.0092	1640.9	0.0092	1738.2	0.0092	1835.5	0.0125	1906.5	0.0122	1951.2	0.0119	1995.9	0.0116	2040.6	0.0092	2677.6
	0.0138	1946.3	0.0138	2069.0	0.0138	2191.6	0.0138	2314.3	0.0187	2403.8	0.0182	2460.2	0.0178	2516.6	0.0174	2572.9	0.0138	3376.0
	0.0184	2158.8	0.0184	2294.9	0.0184	2431.0	0.0184	2567.1	0.0250	2666.4	0.0243	2728.9	0.0237	2791.4	0.0232	2853.9	0.0184	3744.7
	0.0230	2262.9	0.0230	2405.5	0.0230	2548.1	0.0229	2690.8	0.0312	2794.9	0.0304	2860.4	0.0296	2925.9	0.0290	2991.5	0.0230	3925.2
	0.0276	2311.9	0.0276	2457.7	0.0276	2603.4	0.0275	2749.1	0.0375	2855.4	0.0365	2922.4	0.0356	2989.4	0.0348	3056.3	0.0276	4010.3
	0.0322	2334.6	0.0322	2481.8	0.0322	2628.9	0.0321	2776.1	0.0437	2883.5	0.0425	2951.1	0.0415	3018.7	0.0405	3086.3	0.0322	4049.7
	0.0369	2345.1	0.0368	2492.9	0.0368	2640.7	0.0367	2788.5	0.0499	2896.4	0.0486	2964.3	0.0474	3032.2	0.0463	3100.1	0.0368	4067.7
	0.0415	2349.8	0.0414	2497.9	0.0413	2646.1	0.0413	2794.2	0.0562	2902.3	0.0547	2970.3	0.0534	3038.4	0.0521	3106.4	0.0414	4076.0
	0.0461	2352.0	0.0460	2500.3	0.0459	2648.5	0.0459	2796.8	0.0624	2905.0	0.0608	2973.1	0.0593	3041.2	0.0579	3109.3	0.0460	4079.8
	0.0507	2353.0	0.0506	2501.3	0.0505	2649.6	0.0505	2798.0	0.0687	2906.2	0.0669	2974.3	0.0652	3042.5	0.0637	3110.6	0.0506	4081.5
	0.0553	2353.5	0.0552	2501.8	0.0551	2650.1	0.0551	2798.5	0.0749	2906.7	0.0729	2974.9	0.0711	3043.1	0.0695	3111.2	0.0552	4082.3
	0.0599	2353.7	0.0598	2502.0	0.0597	2650.4	0.0597	2798.7	0.0812	2907.0	0.0790	2975.2	0.0771	3043.3	0.0753	3111.5	0.0598	4082.7
	0.0645	2353.8	0.0644	2502.1	0.0643	2650.5	0.0642	2798.8	0.0874	2907.1	0.0851	2975.3	0.0830	3043.4	0.0811	3111.6	0.0644	4082.8
	0.0691	2353.8	0.0690	2502.2	0.0689	2650.5	0.0688	2798.9	0.0937	2907.2	0.0912	2975.3	0.0889	3043.5	0.0869	3111.7	0.0690	4082.9
	0.0737	2353.8	0.0736	2502.2	0.0735	2650.6	0.0734	2798.9	0.0999	2907.2	0.0973	2975.4	0.0949	3043.5	0.0927	3111.7	0.0736	4082.9

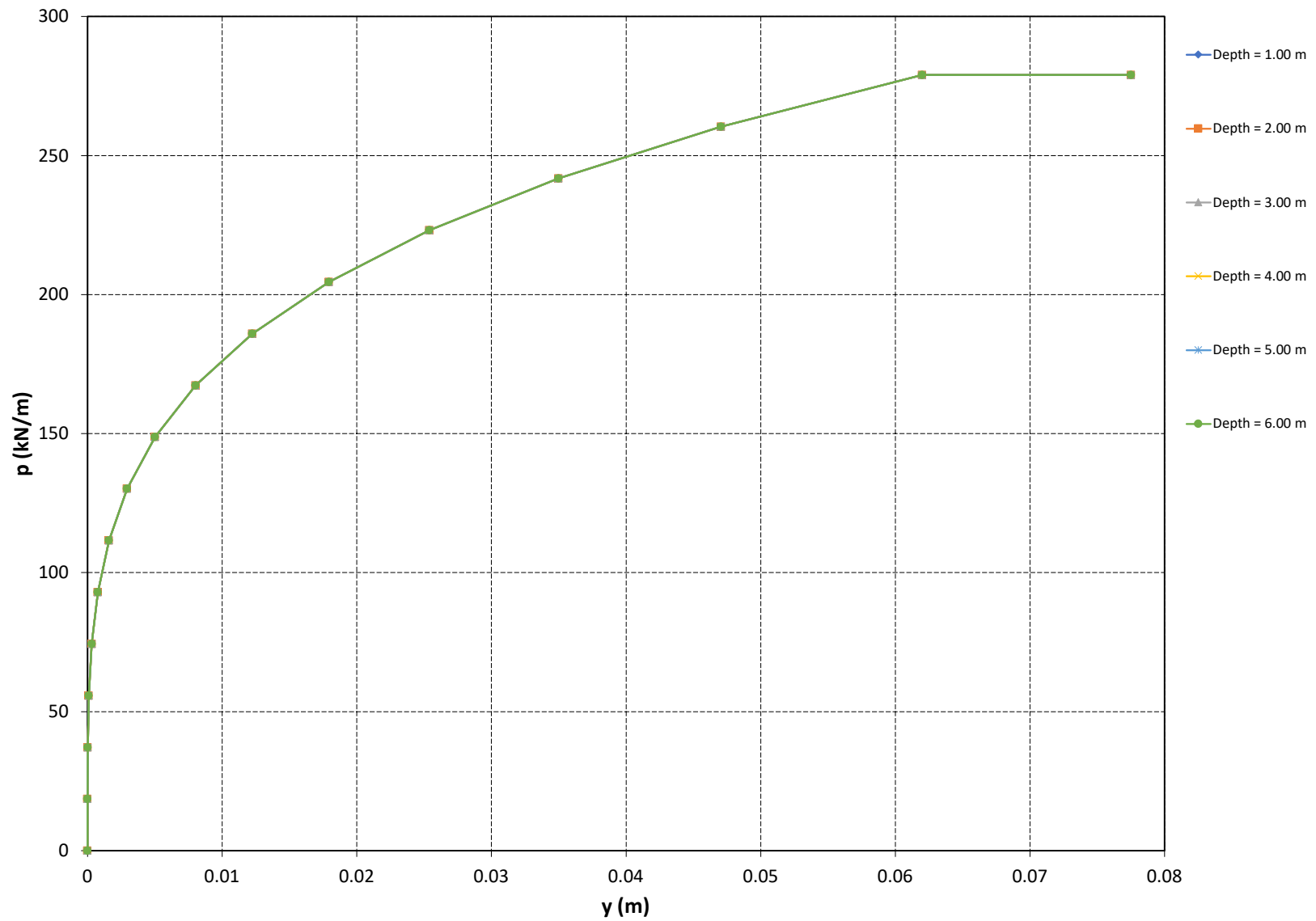


L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 1 (BON19-3)
Static Conditions

Soil Type	Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)	
Depth (m)	19		20		21		22		23		24		25		26		27	
Elev. (m)	78.5		77.5		76.5		75.5		74.5		73.5		72.5		71.5		70.5	
S T A T I C C o n d i t i o n s	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0045	1564.9	0.0045	1604.0	0.0044	1643.2	0.0043	1682.3	0.0043	1721.5	0.0042	1760.6	0.0042	1799.8	0.0041	1838.9	0.0041	1878.1
	0.0091	2746.3	0.0089	2815.0	0.0088	2883.7	0.0087	2952.4	0.0086	3021.1	0.0085	3089.8	0.0084	3158.5	0.0083	3227.2	0.0082	3295.9
	0.0136	3462.6	0.0134	3549.3	0.0132	3635.9	0.0130	3722.5	0.0128	3809.1	0.0127	3895.8	0.0125	3982.4	0.0124	4069.0	0.0123	4155.6
	0.0181	3840.8	0.0178	3936.9	0.0176	4033.0	0.0173	4129.0	0.0171	4225.1	0.0169	4321.2	0.0167	4417.3	0.0165	4513.4	0.0164	4609.5
	0.0226	4025.9	0.0223	4126.6	0.0220	4227.3	0.0217	4328.1	0.0214	4428.8	0.0211	4529.5	0.0209	4630.2	0.0207	4730.9	0.0205	4831.6
	0.0272	4113.2	0.0267	4216.1	0.0264	4319.0	0.0260	4421.9	0.0257	4524.8	0.0254	4627.7	0.0251	4730.6	0.0248	4833.5	0.0246	4936.4
	0.0317	4153.6	0.0312	4257.5	0.0308	4361.4	0.0303	4465.3	0.0300	4569.2	0.0296	4673.1	0.0293	4777.0	0.0290	4880.9	0.0287	4984.9
	0.0362	4172.1	0.0357	4276.5	0.0352	4380.9	0.0347	4485.2	0.0342	4589.6	0.0338	4694.0	0.0335	4798.4	0.0331	4902.7	0.0328	5007.1
	0.0407	4180.6	0.0401	4285.2	0.0395	4389.8	0.0390	4494.4	0.0385	4599.0	0.0381	4703.5	0.0376	4808.1	0.0372	4912.7	0.0369	5017.3
	0.0453	4184.5	0.0446	4289.2	0.0439	4393.9	0.0434	4498.5	0.0428	4603.2	0.0423	4707.9	0.0418	4812.6	0.0414	4917.3	0.0410	5022.0
	0.0498	4186.3	0.0490	4291.0	0.0483	4395.7	0.0477	4500.4	0.0471	4605.2	0.0465	4709.9	0.0460	4814.6	0.0455	4919.4	0.0450	5024.1
	0.0543	4187.1	0.0535	4291.8	0.0527	4396.6	0.0520	4501.3	0.0514	4606.1	0.0508	4710.8	0.0502	4815.5	0.0496	4920.3	0.0491	5025.0
	0.0588	4187.4	0.0580	4292.2	0.0571	4396.9	0.0564	4501.7	0.0556	4606.5	0.0550	4711.2	0.0544	4816.0	0.0538	4920.7	0.0532	5025.5
	0.0634	4187.6	0.0624	4292.4	0.0615	4397.1	0.0607	4501.9	0.0599	4606.6	0.0592	4711.4	0.0585	4816.2	0.0579	4920.9	0.0573	5025.7
	0.0679	4187.7	0.0669	4292.4	0.0659	4397.2	0.0650	4502.0	0.0642	4606.7	0.0634	4711.5	0.0627	4816.3	0.0621	4921.0	0.0614	5025.8
	0.0724	4187.7	0.0713	4292.5	0.0703	4397.2	0.0694	4502.0	0.0685	4606.8	0.0677	4711.5	0.0669	4816.3	0.0662	4921.1	0.0655	5025.8
Soil Type	Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)	
Depth (m)	28		29		30		31		32		33		34		35		36	
Elev. (m)	69.5		68.5		67.5		66.5		65.5		64.5		63.5		62.5		61.5	
S T A T I C C o n d i t i o n s	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0041	1917.2	0.0040	1956.4	0.0040	1995.5	0.0040	2034.7	0.0039	2073.8	0.0039	2113.0	0.0039	2152.1	0.0038	2191.3	0.0038	2230.4
	0.0081	3364.6	0.0080	3433.3	0.0080	3502.0	0.0079	3570.7	0.0078	3639.5	0.0078	3708.2	0.0077	3776.9	0.0077	3845.6	0.0076	3914.3
	0.0122	4242.3	0.0121	4328.9	0.0120	4415.5	0.0119	4502.1	0.0118	4588.8	0.0117	4675.4	0.0116	4762.0	0.0115	4848.6	0.0114	4935.3
	0.0162	4705.6	0.0161	4801.6	0.0159	4897.7	0.0158	4993.8	0.0157	5089.9	0.0156	5186.0	0.0154	5282.1	0.0153	5378.2	0.0152	5474.2
	0.0203	4932.4	0.0201	5033.1	0.0199	5133.8	0.0198	5234.5	0.0196	5335.2	0.0194	5435.9	0.0193	5536.7	0.0192	5637.4	0.0190	5738.1
	0.0243	5039.3	0.0241	5142.2	0.0239	5245.1	0.0237	5348.0	0.0235	5450.9	0.0233	5553.8	0.0232	5656.7	0.0230	5759.6	0.0229	5862.5
	0.0284	5088.8	0.0281	5192.7	0.0279	5296.6	0.0277	5400.5	0.0274	5504.4	0.0272	5608.3	0.0270	5712.2	0.0268	5816.1	0.0267	5920.1
	0.0324	5111.5	0.0321	5215.9	0.0319	5320.2	0.0316	5424.6	0.0314	5529.0	0.0311	5633.4	0.0309	5737.7	0.0307	5842.1	0.0305	5946.5
	0.0365	5121.9	0.0362	5226.5	0.0359	5331.1	0.0356	5435.7	0.0353	5540.2	0.0350	5644.8	0.0348	5749.4	0.0345	5854.0	0.0343	5958.6
	0.0406	5126.6	0.0402	5231.3	0.0398	5336.0	0.0395	5440.7	0.0392	5545.4	0.0389	5650.1	0.0386	5754.7	0.0383	5859.4	0.0381	5964.1
	0.0446	5128.8	0.0442	5233.5	0.0438	5338.3	0.0435	5443.0	0.0431	5547.7	0.0428	5652.4	0.0425	5757.2	0.0422	5861.9	0.0419	5966.6
	0.0487	5129.8	0.0482	5234.5	0.0478	5339.3	0.0474	5444.0	0.0470	5548.8	0.0467	5653.5	0.0463	5758.3	0.0460	5863.0	0.0457	5967.8
	0.0527	5130.2	0.0522	5235.0	0.0518	5339.8	0.0514	5444.5	0.0509	5549.3	0.0506	5654.0	0.0502	5758.8	0.0498	5863.5	0.0495	5968.3
	0.0568	5130.5	0.0563	5235.2	0.0558	5340.0	0.0553	5444.7	0.0549	5549.5	0.0545	5654.3	0.0541	5759.0	0.0537	5863.8	0.0533	5968.5
	0.0608	5130.5	0.0603	5235.3	0.0598	5340.1	0.0593	5444.8	0.0588	5549.6	0.0583	5654.4	0.0579	5759.1	0.0575	5863.9	0.0571	5968.7
	0.0649	5130.6	0.0643	5235.4	0.0637	5340.1	0.0632	5444.9	0.0627	5549.6	0.0622	5654.4	0.0618	5759.2	0.0614	5863.9	0.0609	5968.7

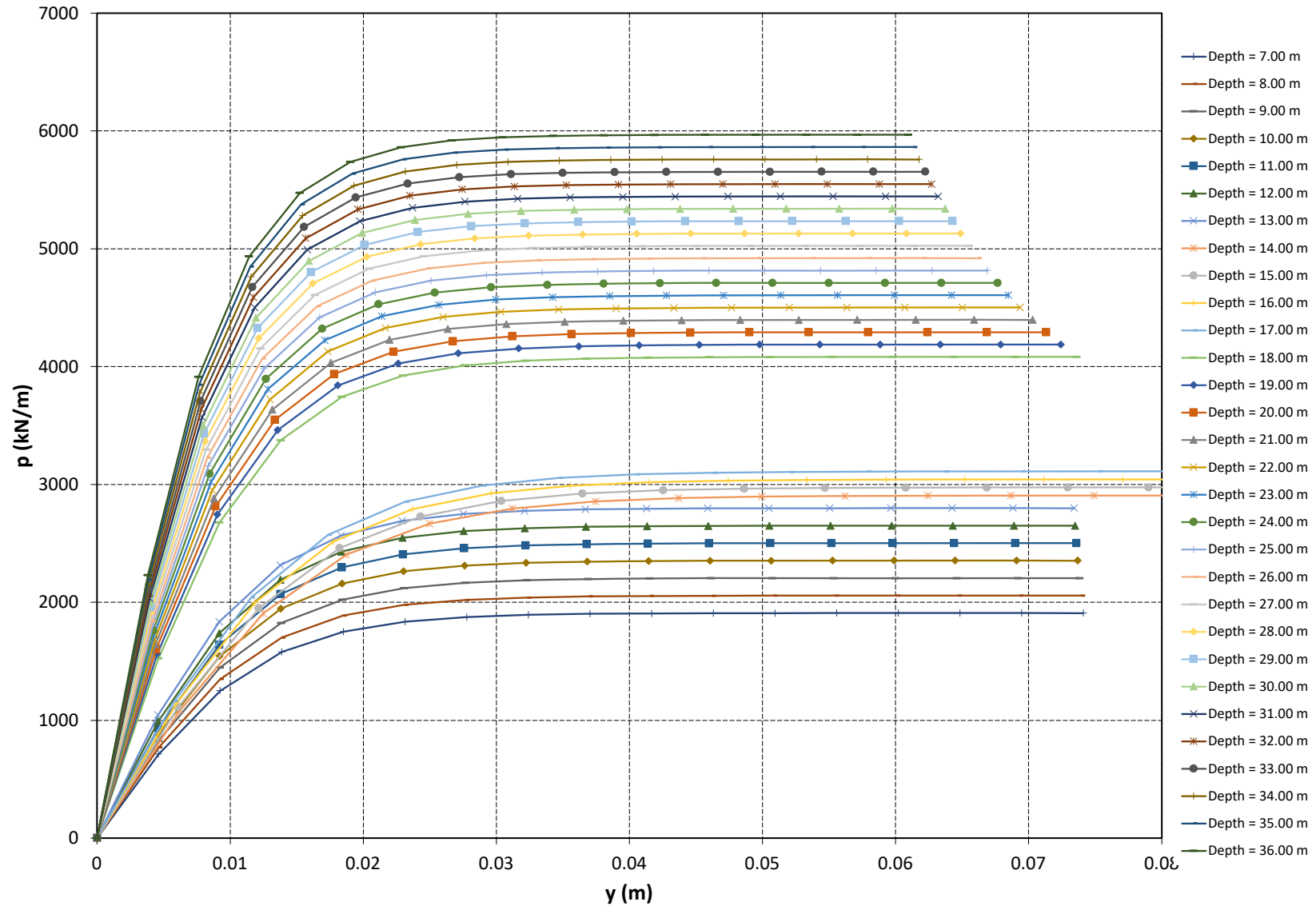


L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 1 (BON19-3)
Static Conditions





L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 1 (BON19-3)
Static Conditions



**L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 2 (BON-P1)
Static Conditions**

GENERAL NOTES

- The values P(kN/m) represent soil reaction per metre of pile length
- The values y(m) represent soil/pile deflection
- The underside of pile cap is at Elev. 83.4 m
- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)
- If lateral spacing between adjacent piles is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.22, C6.33, and C6.24 of the CHBDC (S6-19)

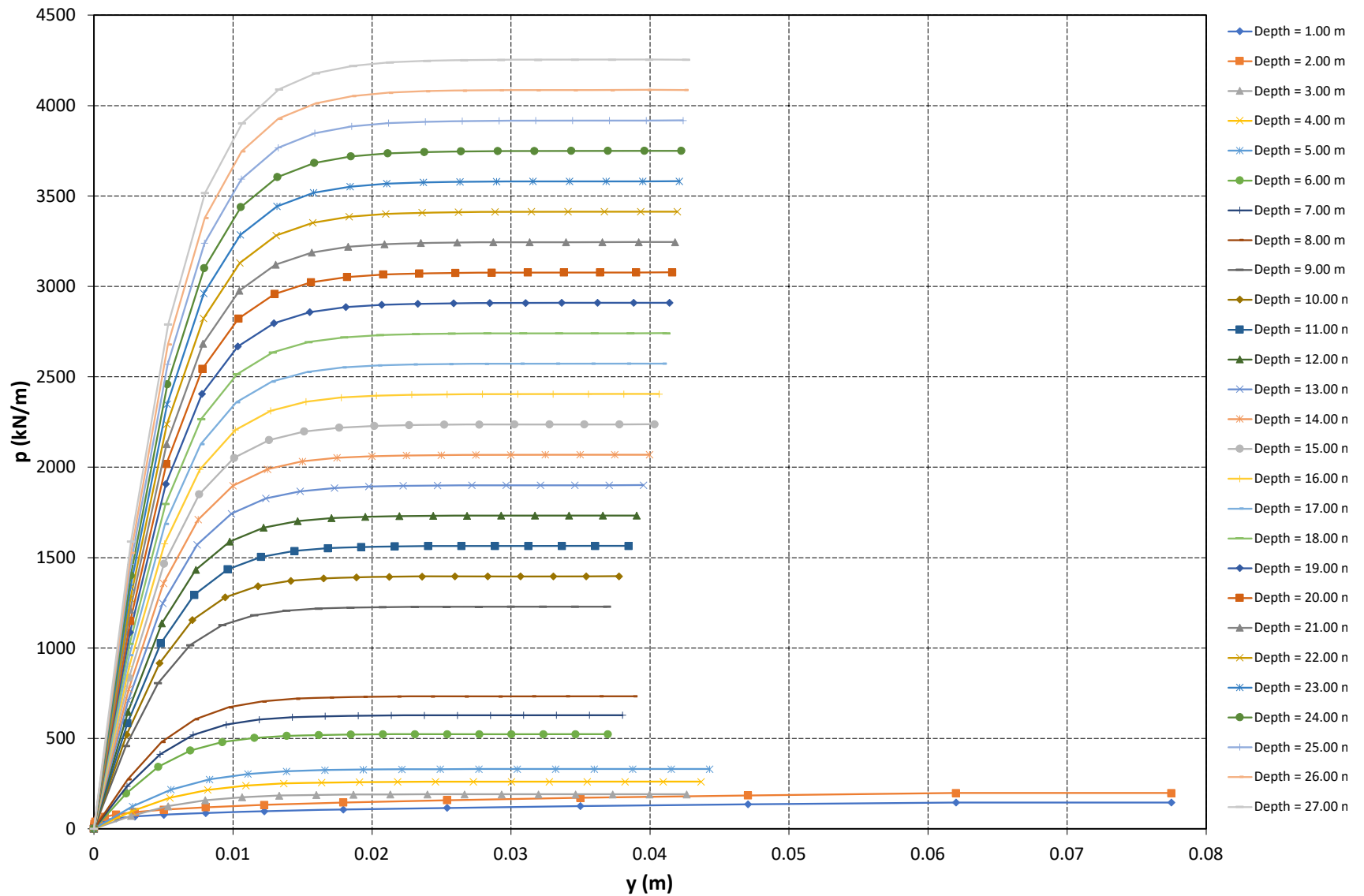
Soil Type	Silty Clay to Clayey Silt (below WT)		Silty Clay to Clayey Silt (below WT)		Silt and Sand (below WT)		Silt and Sand (below WT)		Silt and Sand (below WT)		Compact Sand (below WT)		Compact Sand (below WT)		Compact Sand (below WT)		Dense Sand & Gravel (below WT)	
Depth (m)	1		2		3		4		5		6		7		8		9	
Elev. (m)	82.4		81.4		80.4		79.4		78.4		77.4		76.4		75.4		74.4	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0000	9.7	0.0000	13.2	0.0027	71.3	0.0027	97.4	0.0028	123.5	0.0023	195.6	0.0024	234.7	0.0024	273.9	0.0023	459.0
	0.0000	19.4	0.0000	26.4	0.0053	125.2	0.0055	170.9	0.0055	216.7	0.0046	343.2	0.0048	411.9	0.0049	480.6	0.0046	805.6
	0.0001	29.1	0.0001	39.6	0.0080	157.8	0.0082	215.5	0.0083	273.2	0.0069	432.7	0.0071	519.3	0.0073	606.0	0.0069	1015.7
	0.0003	38.8	0.0003	52.7	0.0107	175.1	0.0109	239.1	0.0111	303.0	0.0092	480.0	0.0095	576.0	0.0097	672.1	0.0092	1126.7
	0.0008	48.5	0.0008	65.9	0.0133	183.5	0.0136	250.6	0.0138	317.7	0.0115	503.1	0.0119	603.8	0.0121	704.5	0.0115	1181.0
	0.0016	58.2	0.0016	79.1	0.0160	187.5	0.0164	256.0	0.0166	324.5	0.0139	514.0	0.0143	616.9	0.0146	719.8	0.0138	1206.6
	0.0029	67.8	0.0029	92.3	0.0187	189.3	0.0191	258.5	0.0194	327.7	0.0162	519.0	0.0166	623.0	0.0170	726.9	0.0161	1218.4
	0.0050	77.5	0.0050	105.5	0.0213	190.2	0.0218	259.7	0.0221	329.2	0.0185	521.4	0.0190	625.7	0.0194	730.1	0.0185	1223.9
	0.0080	87.2	0.0080	118.7	0.0240	190.5	0.0246	260.2	0.0249	329.9	0.0208	522.4	0.0214	627.0	0.0218	731.6	0.0208	1226.3
	0.0122	96.9	0.0122	131.8	0.0266	190.7	0.0273	260.4	0.0277	330.2	0.0231	522.9	0.0238	627.6	0.0243	732.3	0.0231	1227.5
	0.0179	106.6	0.0179	145.0	0.0293	190.8	0.0300	260.6	0.0304	330.3	0.0254	523.1	0.0261	627.9	0.0267	732.6	0.0254	1228.0
	0.0254	116.3	0.0254	158.2	0.0320	190.8	0.0327	260.6	0.0332	330.4	0.0277	523.2	0.0285	628.0	0.0291	732.7	0.0277	1228.2
	0.0350	126.0	0.0350	171.4	0.0346	190.9	0.0355	260.6	0.0360	330.4	0.0300	523.3	0.0309	628.0	0.0315	732.8	0.0300	1228.3
	0.0470	135.7	0.0470	184.6	0.0373	190.9	0.0382	260.6	0.0387	330.4	0.0323	523.3	0.0333	628.1	0.0340	732.8	0.0323	1228.4
	0.0620	145.4	0.0620	197.8	0.0400	190.9	0.0409	260.6	0.0415	330.4	0.0346	523.3	0.0356	628.1	0.0364	732.8	0.0346	1228.4
	0.0775	145.4	0.0775	197.8	0.0426	190.9	0.0437	260.6	0.0443	330.4	0.0370	523.3	0.0380	628.1	0.0388	732.8	0.0369	1228.4
Soil Type	Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)	
Depth (m)	10		11		12		13		14		15		16		17		18	
Elev. (m)	73.4		72.4		71.4		70.4		69.4		68.4		67.4		66.4		65.4	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0024	521.9	0.0024	584.7	0.0024	647.5	0.0025	710.3	0.0025	773.1	0.0025	835.9	0.0025	898.7	0.0026	961.6	0.0026	1024.4
	0.0047	915.8	0.0048	1026.1	0.0049	1136.3	0.0049	1246.5	0.0050	1356.8	0.0050	1467.0	0.0051	1577.2	0.0051	1687.5	0.0051	1797.7
	0.0071	1154.7	0.0072	1293.7	0.0073	1432.7	0.0074	1571.7	0.0075	1710.7	0.0076	1849.7	0.0076	1988.7	0.0077	2127.6	0.0077	2266.6
	0.0094	1280.8	0.0096	1435.0	0.0098	1589.2	0.0099	1743.3	0.0100	1897.5	0.0101	2051.7	0.0102	2205.8	0.0102	2360.0	0.0103	2514.2
	0.0118	1342.6	0.0120	1504.2	0.0122	1665.8	0.0124	1827.4	0.0125	1989.0	0.0126	2150.6	0.0127	2312.1	0.0128	2473.7	0.0129	2635.3
	0.0142	1371.7	0.0144	1536.8	0.0146	1701.9	0.0148	1867.0	0.0150	2032.1	0.0151	2197.2	0.0152	2362.3	0.0153	2527.4	0.0154	2692.5
	0.0165	1385.1	0.0168	1551.9	0.0171	1718.6	0.0173	1885.3	0.0175	2052.0	0.0176	2218.7	0.0178	2385.5	0.0179	2552.2	0.0180	2718.9
	0.0189	1391.3	0.0192	1558.8	0.0195	1726.3	0.0198	1893.7	0.0200	2061.2	0.0202	2228.7	0.0203	2396.1	0.0205	2563.6	0.0206	2731.1
	0.0212	1394.2	0.0216	1562.0	0.0220	1729.8	0.0222	1897.6	0.0225	2065.4	0.0227	2233.2	0.0229	2401.0	0.0230	2568.8	0.0232	2736.6
	0.0236	1395.4	0.0240	1563.4	0.0244	1731.4	0.0247	1899.3	0.0250	2067.3	0.0252	2235.3	0.0254	2403.2	0.0256	2571.2	0.0257	2739.2
	0.0260	1396.0	0.0264	1564.1	0.0268	1732.1	0.0272	1900.1	0.0275	2068.2	0.0277	2236.2	0.0279	2404.2	0.0281	2572.3	0.0283	2740.3
	0.0283	1396.3	0.0288	1564.4	0.0293	1732.4	0.0296	1900.5	0.0300	2068.6	0.0302	2236.6	0.0305	2404.7	0.0307	2572.8	0.0309	2740.8
	0.0307	1396.4	0.0312	1564.5	0.0317	1732.6	0.0321	1900.7	0.0325	2068.8	0.0328	2236.8	0.0330	2404.9	0.0332	2573.0	0.0335	2741.1
	0.0330	1396.5	0.0336	1564.6	0.0342	1732.7	0.0346	1900.7	0.0350	2068.8	0.0353	2236.9	0.0356	2405.0	0.0358	2573.1	0.0360	2741.2
	0.0354	1396.5	0.0361	1564.6	0.0366	1732.7	0.0371	1900.8	0.0375	2068.9	0.0378	2237.0	0.0381	2405.1	0.0384	2573.1	0.0386	2741.2
	0.0378	1396.5	0.0385	1564.6	0.0390	1732.7	0.0395	1900.8	0.0400	2068.9	0.0403	2237.0	0.0406	2405.1	0.0409	2573.2	0.0412	2741.3



L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 2 (BON-P1)
Static Conditions

Soil Type	Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)	
Depth (m)	19		20		21		22		23		24		25		26		27	
Elev. (m)	64.4		63.4		62.4		61.4		60.4		59.4		58.4		57.4		56.4	
S T A T I C C o n d i t i o n s	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0026	1087.2	0.0026	1150.0	0.0026	1212.8	0.0026	1275.6	0.0026	1338.4	0.0026	1401.3	0.0026	1464.1	0.0027	1526.9	0.0027	1589.7
	0.0052	1908.0	0.0052	2018.2	0.0052	2128.4	0.0052	2238.7	0.0053	2348.9	0.0053	2459.1	0.0053	2569.4	0.0053	2679.6	0.0053	2789.8
	0.0078	2405.6	0.0078	2544.6	0.0078	2683.6	0.0079	2822.6	0.0079	2961.6	0.0079	3100.6	0.0079	3239.5	0.0080	3378.5	0.0080	3517.5
	0.0103	2668.3	0.0104	2822.5	0.0104	2976.7	0.0105	3130.8	0.0105	3285.0	0.0106	3439.2	0.0106	3593.3	0.0106	3747.5	0.0106	3901.7
	0.0129	2796.9	0.0130	2958.5	0.0131	3120.1	0.0131	3281.7	0.0132	3443.3	0.0132	3604.9	0.0132	3766.5	0.0133	3928.1	0.0133	4089.7
	0.0155	2857.6	0.0156	3022.7	0.0157	3187.8	0.0157	3352.9	0.0158	3518.0	0.0158	3683.1	0.0159	3848.2	0.0159	4013.3	0.0160	4178.4
	0.0181	2885.6	0.0182	3052.4	0.0183	3219.1	0.0184	3385.8	0.0184	3552.5	0.0185	3719.3	0.0185	3886.0	0.0186	4052.7	0.0186	4219.4
	0.0207	2898.5	0.0208	3066.0	0.0209	3233.5	0.0210	3400.9	0.0211	3568.4	0.0211	3735.9	0.0212	3903.3	0.0212	4070.8	0.0213	4238.3
	0.0233	2904.4	0.0234	3072.2	0.0235	3240.0	0.0236	3407.8	0.0237	3575.7	0.0238	3743.5	0.0238	3911.3	0.0239	4079.1	0.0240	4246.9
	0.0259	2907.1	0.0260	3075.1	0.0261	3243.0	0.0262	3411.0	0.0263	3579.0	0.0264	3746.9	0.0265	3914.9	0.0266	4082.9	0.0266	4250.8
	0.0285	2908.3	0.0286	3076.4	0.0287	3244.4	0.0288	3412.4	0.0289	3580.5	0.0290	3748.5	0.0291	3916.5	0.0292	4084.6	0.0293	4252.6
	0.0310	2908.9	0.0312	3077.0	0.0313	3245.0	0.0315	3413.1	0.0316	3581.2	0.0317	3749.2	0.0318	3917.3	0.0319	4085.4	0.0319	4253.4
	0.0336	2909.2	0.0338	3077.2	0.0339	3245.3	0.0341	3413.4	0.0342	3581.5	0.0343	3749.6	0.0344	3917.6	0.0345	4085.7	0.0346	4253.8
	0.0362	2909.3	0.0364	3077.4	0.0366	3245.5	0.0367	3413.5	0.0368	3581.6	0.0370	3749.7	0.0371	3917.8	0.0372	4085.9	0.0373	4254.0
	0.0388	2909.3	0.0390	3077.4	0.0392	3245.5	0.0393	3413.6	0.0395	3581.7	0.0396	3749.8	0.0397	3917.9	0.0398	4086.0	0.0399	4254.1
	0.0414	2909.4	0.0416	3077.4	0.0418	3245.5	0.0420	3413.6	0.0421	3581.7	0.0422	3749.8	0.0424	3917.9	0.0425	4086.0	0.0426	4254.1

L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 2 (BON-P1)
Static Conditions





L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 3 (BON-P2)
Static Conditions

GENERAL NOTES

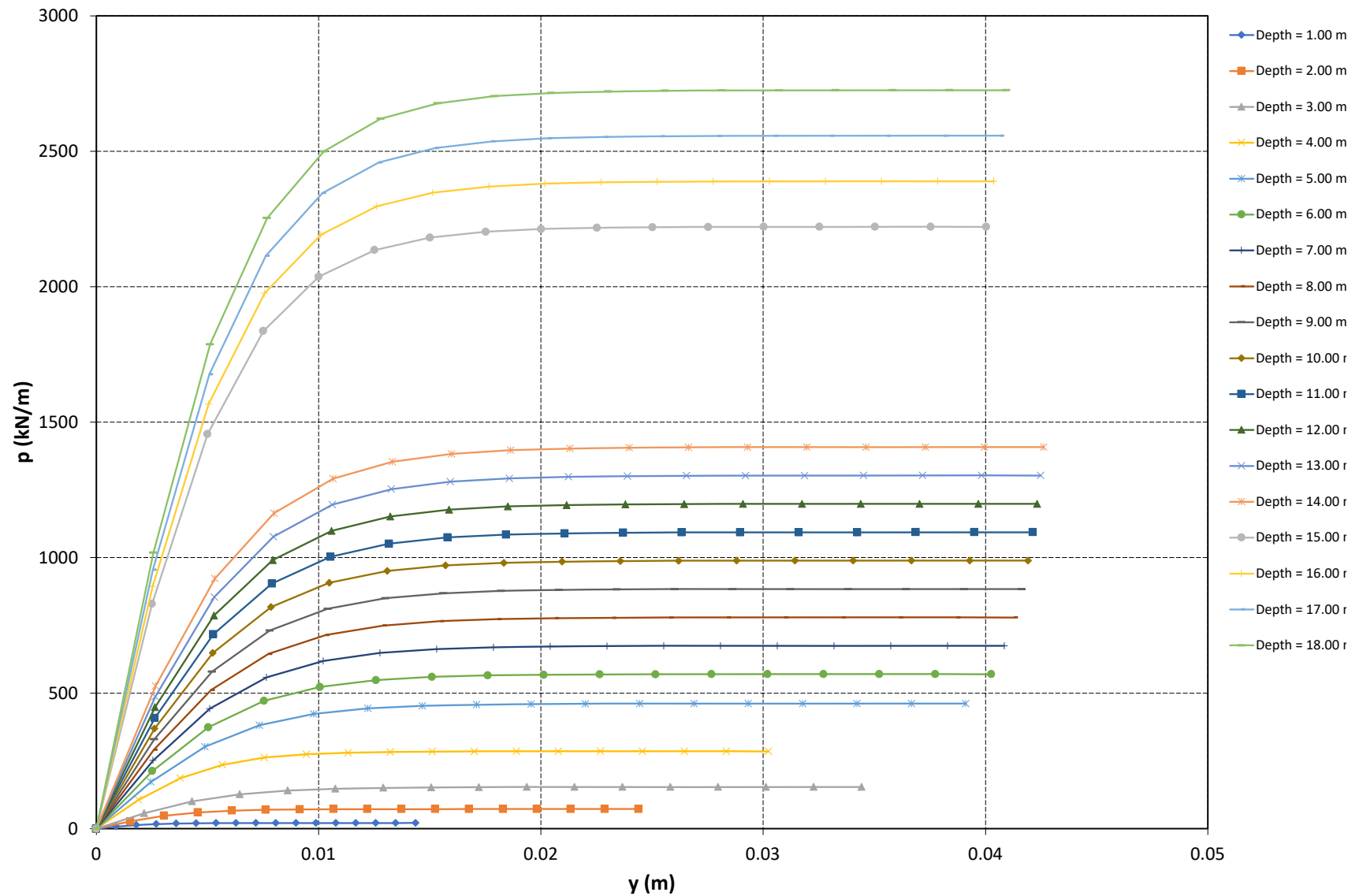
- The values P(kN/m) represent soil reaction per metre of pile length
- The values y(m) represent soil/pile deflection
- The underside of pile cap is at Elev. 82 m
- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)
- If lateral spacing between adjacent piles is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.22, C6.33, and C6.24 of the CHBDC (S6-19)

Soil Type	Silty Sand - Sand (below WT)		Silty Sand - Sand (below WT)		Silty Sand - Sand (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)	
Depth (m)	1		2		3		4		5		6		7		8		9	
Elev. (m)	81		80		79		78		77		76		75		74		73	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0009	8.0	0.0015	27.2	0.0022	57.6	0.0019	106.7	0.0024	172.5	0.0025	213.0	0.0026	252.2	0.0026	291.3	0.0026	330.5
	0.0018	14.1	0.0030	47.8	0.0043	101.1	0.0038	187.2	0.0049	302.7	0.0050	373.8	0.0051	442.5	0.0052	511.2	0.0052	579.9
	0.0027	17.7	0.0046	60.2	0.0065	127.4	0.0057	236.0	0.0073	381.6	0.0075	471.3	0.0077	558.0	0.0077	644.6	0.0078	731.2
	0.0036	19.7	0.0061	66.8	0.0086	141.4	0.0076	261.8	0.0098	423.3	0.0101	522.8	0.0102	618.9	0.0103	715.0	0.0104	811.1
	0.0045	20.6	0.0076	70.0	0.0108	148.2	0.0094	274.4	0.0122	443.7	0.0126	548.0	0.0128	648.7	0.0129	749.5	0.0130	850.2
	0.0054	21.1	0.0091	71.5	0.0129	151.4	0.0113	280.3	0.0147	453.3	0.0151	559.9	0.0153	662.8	0.0155	765.7	0.0156	868.6
	0.0063	21.3	0.0107	72.2	0.0151	152.9	0.0132	283.1	0.0171	457.8	0.0176	565.4	0.0179	669.3	0.0181	773.2	0.0182	877.1
	0.0072	21.4	0.0122	72.5	0.0172	153.6	0.0151	284.4	0.0196	459.8	0.0201	567.9	0.0204	672.3	0.0206	776.7	0.0208	881.0
	0.0081	21.4	0.0137	72.7	0.0194	153.9	0.0170	284.9	0.0220	460.8	0.0226	569.1	0.0230	673.7	0.0232	778.3	0.0234	882.8
	0.0090	21.4	0.0152	72.8	0.0215	154.0	0.0189	285.2	0.0244	461.2	0.0252	569.6	0.0255	674.3	0.0258	779.0	0.0260	883.7
	0.0099	21.4	0.0168	72.8	0.0237	154.1	0.0208	285.3	0.0269	461.4	0.0277	569.8	0.0281	674.6	0.0284	779.3	0.0286	884.0
	0.0108	21.4	0.0183	72.8	0.0258	154.1	0.0227	285.4	0.0293	461.5	0.0302	570.0	0.0306	674.7	0.0310	779.5	0.0312	884.2
	0.0117	21.4	0.0198	72.8	0.0280	154.1	0.0246	285.4	0.0318	461.5	0.0327	570.0	0.0332	674.8	0.0335	779.5	0.0338	884.3
	0.0126	21.4	0.0213	72.8	0.0301	154.1	0.0265	285.4	0.0342	461.5	0.0352	570.0	0.0357	674.8	0.0361	779.6	0.0364	884.3
	0.0135	21.4	0.0229	72.8	0.0323	154.1	0.0283	285.4	0.0367	461.6	0.0377	570.0	0.0383	674.8	0.0387	779.6	0.0390	884.3
	0.0144	21.4	0.0244	72.8	0.0344	154.1	0.0302	285.4	0.0391	461.6	0.0403	570.0	0.0408	674.8	0.0413	779.6	0.0416	884.3

Soil Type	Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)	
Depth (m)	10		11		12		13		14		15		16		17		18	
Elev. (m)	72		71		70		69		68		67		66		65		64	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0026	369.6	0.0026	408.8	0.0026	447.9	0.0027	487.1	0.0027	526.2	0.0025	830.0	0.0025	892.9	0.0025	955.7	0.0026	1018.5
	0.0052	648.7	0.0053	717.4	0.0053	786.1	0.0053	854.8	0.0053	923.5	0.0050	1456.7	0.0050	1566.9	0.0051	1677.1	0.0051	1787.4
	0.0079	817.8	0.0079	904.5	0.0079	991.1	0.0080	1077.7	0.0080	1164.3	0.0075	1836.6	0.0076	1975.6	0.0076	2114.6	0.0077	2253.6
	0.0105	907.2	0.0105	1003.2	0.0106	1099.3	0.0106	1195.4	0.0107	1291.5	0.0100	2037.2	0.0101	2191.4	0.0102	2345.6	0.0102	2499.7
	0.0131	950.9	0.0132	1051.6	0.0132	1152.3	0.0133	1253.0	0.0133	1353.8	0.0125	2135.4	0.0126	2297.0	0.0127	2458.6	0.0128	2620.2
	0.0157	971.5	0.0158	1074.4	0.0159	1177.3	0.0159	1280.2	0.0160	1383.1	0.0150	2181.7	0.0151	2346.8	0.0153	2511.9	0.0154	2677.0
	0.0183	981.0	0.0184	1084.9	0.0185	1188.9	0.0186	1292.8	0.0186	1396.7	0.0175	2203.1	0.0177	2369.8	0.0178	2536.6	0.0179	2703.3
	0.0210	985.4	0.0211	1089.8	0.0212	1194.2	0.0212	1298.5	0.0213	1402.9	0.0200	2213.0	0.0202	2380.4	0.0203	2547.9	0.0205	2715.4
	0.0236	987.4	0.0237	1092.0	0.0238	1196.6	0.0239	1301.2	0.0240	1405.8	0.0225	2217.5	0.0227	2385.3	0.0229	2553.1	0.0230	2720.9
	0.0262	988.3	0.0263	1093.0	0.0265	1197.7	0.0266	1302.4	0.0266	1407.1	0.0250	2219.5	0.0252	2387.5	0.0254	2555.4	0.0256	2723.4
	0.0288	988.8	0.0290	1093.5	0.0291	1198.2	0.0292	1302.9	0.0293	1407.7	0.0275	2220.5	0.0278	2388.5	0.0280	2556.5	0.0281	2724.6
	0.0314	988.9	0.0316	1093.7	0.0317	1198.4	0.0319	1303.2	0.0320	1407.9	0.0300	2220.9	0.0303	2388.9	0.0305	2557.0	0.0307	2725.1
	0.0341	989.0	0.0342	1093.8	0.0344	1198.5	0.0345	1303.3	0.0346	1408.1	0.0325	2221.1	0.0328	2389.2	0.0330	2557.2	0.0333	2725.3
	0.0367	989.1	0.0369	1093.8	0.0370	1198.6	0.0372	1303.4	0.0373	1408.1	0.0350	2221.2	0.0353	2389.3	0.0356	2557.3	0.0358	2725.4
	0.0393	989.1	0.0395	1093.9	0.0397	1198.6	0.0398	1303.4	0.0400	1408.1	0.0375	2221.2	0.0379	2389.3	0.0381	2557.4	0.0384	2725.5
	0.0419	989.1	0.0421	1093.9	0.0423	1198.6	0.0425	1303.4	0.0426	1408.2	0.0400	2221.2	0.0404	2389.3	0.0407	2557.4	0.0409	2725.5



L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 3 (BON-P2)
Static Conditions





L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 4 (BON-P3)
Static Conditions

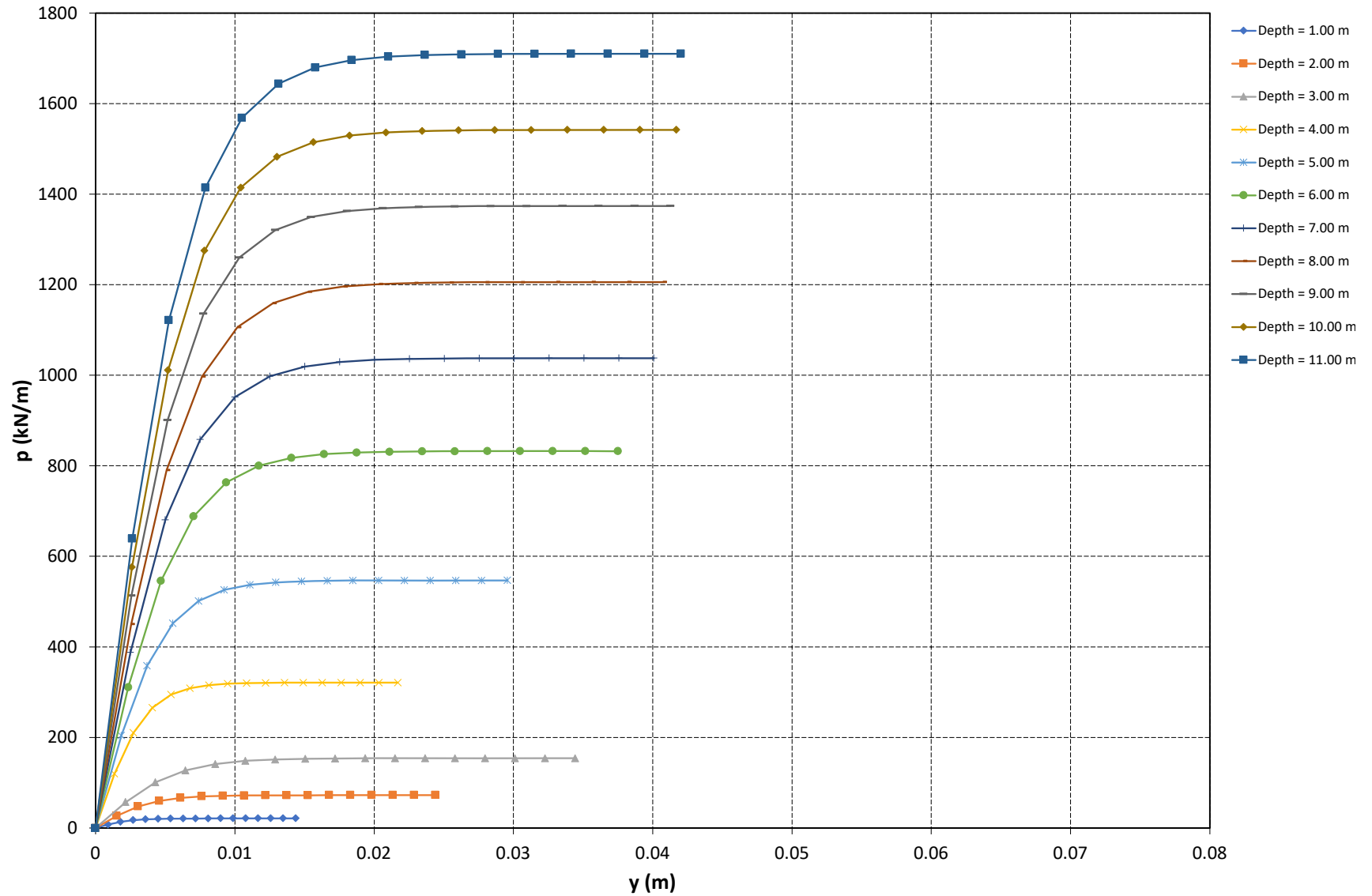
GENERAL NOTES

- The values P(kN/m) represent soil reaction per metre of pile length
- The values y(m) represent soil/pile deflection
- The underside of pile cap is at Elev. 83.4 m
- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)
- If lateral spacing between adjacent piles is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.22, C6.33, and C6.24 of the CHBDC (S6-19)

Soil Type	Compact Sand and Gravel (below WT)		Compact Sand and Gravel (below WT)		Compact Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)	
Depth (m)	1		2		3		4		5		6		7		8		9	
Elev. (m)	82.4		81.4		80.4		79.4		78.4		77.4		76.4		75.4		74.4	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0009	8.0	0.0015	27.2	0.0022	57.6	0.0014	120.0	0.0018	204.4	0.0023	311.1	0.0025	387.8	0.0025	450.6	0.0026	513.4
	0.0018	14.1	0.0030	47.8	0.0043	101.1	0.0027	210.6	0.0037	358.6	0.0047	545.9	0.0050	680.6	0.0051	790.8	0.0052	901.1
	0.0027	17.7	0.0046	60.2	0.0065	127.4	0.0041	265.5	0.0055	452.2	0.0070	688.3	0.0075	858.1	0.0076	997.1	0.0077	1136.1
	0.0036	19.7	0.0061	66.8	0.0086	141.4	0.0054	294.6	0.0074	501.6	0.0094	763.5	0.0100	951.8	0.0102	1106.0	0.0103	1260.2
	0.0045	20.6	0.0076	70.0	0.0108	148.2	0.0068	308.7	0.0092	525.7	0.0117	800.3	0.0125	997.7	0.0127	1159.3	0.0129	1320.9
	0.0054	21.1	0.0091	71.5	0.0129	151.4	0.0081	315.4	0.0111	537.1	0.0141	817.6	0.0150	1019.3	0.0153	1184.4	0.0155	1349.6
	0.0063	21.3	0.0107	72.2	0.0151	152.9	0.0095	318.5	0.0129	542.4	0.0164	825.7	0.0175	1029.4	0.0178	1196.1	0.0181	1362.8
	0.0072	21.4	0.0122	72.5	0.0172	153.6	0.0109	320.0	0.0148	544.8	0.0188	829.4	0.0200	1034.0	0.0204	1201.4	0.0206	1368.9
	0.0081	21.4	0.0137	72.7	0.0194	153.9	0.0122	320.6	0.0166	546.0	0.0211	831.0	0.0225	1036.1	0.0229	1203.9	0.0232	1371.7
	0.0090	21.4	0.0152	72.8	0.0215	154.0	0.0136	320.9	0.0185	546.5	0.0234	831.8	0.0251	1037.0	0.0255	1205.0	0.0258	1373.0
	0.0099	21.4	0.0168	72.8	0.0237	154.1	0.0149	321.0	0.0203	546.7	0.0258	832.2	0.0276	1037.5	0.0280	1205.5	0.0284	1373.5
	0.0108	21.4	0.0183	72.8	0.0258	154.1	0.0163	321.1	0.0222	546.8	0.0281	832.3	0.0301	1037.7	0.0306	1205.7	0.0310	1373.8
	0.0117	21.4	0.0198	72.8	0.0280	154.1	0.0176	321.1	0.0240	546.8	0.0305	832.4	0.0326	1037.8	0.0331	1205.8	0.0335	1373.9
	0.0126	21.4	0.0213	72.8	0.0301	154.1	0.0190	321.1	0.0259	546.9	0.0328	832.4	0.0351	1037.8	0.0357	1205.9	0.0361	1374.0
	0.0135	21.4	0.0229	72.8	0.0323	154.1	0.0204	321.2	0.0277	546.9	0.0352	832.4	0.0376	1037.8	0.0382	1205.9	0.0387	1374.0
	0.0144	21.4	0.0244	72.8	0.0344	154.1	0.0217	321.2	0.0296	546.9	0.0375	832.5	0.0401	1037.8	0.0408	1205.9	0.0413	1374.0

Soil Type	Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)	
Depth (m)	10		11	
Elev. (m)	73.4		72.4	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0
	0.0026	576.3	0.0026	639.1
	0.0052	1011.3	0.0053	1121.5
	0.0078	1275.1	0.0079	1414.1
	0.0104	1414.4	0.0105	1568.5
	0.0130	1482.5	0.0131	1644.1
	0.0156	1514.7	0.0158	1679.8
	0.0182	1529.5	0.0184	1696.3
	0.0208	1536.4	0.0210	1703.8
	0.0235	1539.5	0.0236	1707.3
	0.0261	1540.9	0.0263	1708.9
	0.0287	1541.6	0.0289	1709.6
	0.0313	1541.9	0.0315	1709.9
	0.0339	1542.0	0.0342	1710.1
	0.0365	1542.1	0.0368	1710.1
	0.0391	1542.1	0.0394	1710.2
	0.0417	1542.1	0.0420	1710.2

L-Pile Data for P-Y Curves (310x110)
 Bonnechere River Bridge
 Pier 4 (BON-P3)
 Static Conditions





L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
East Abutment (BON19-5)
Static Conditions

GENERAL NOTES

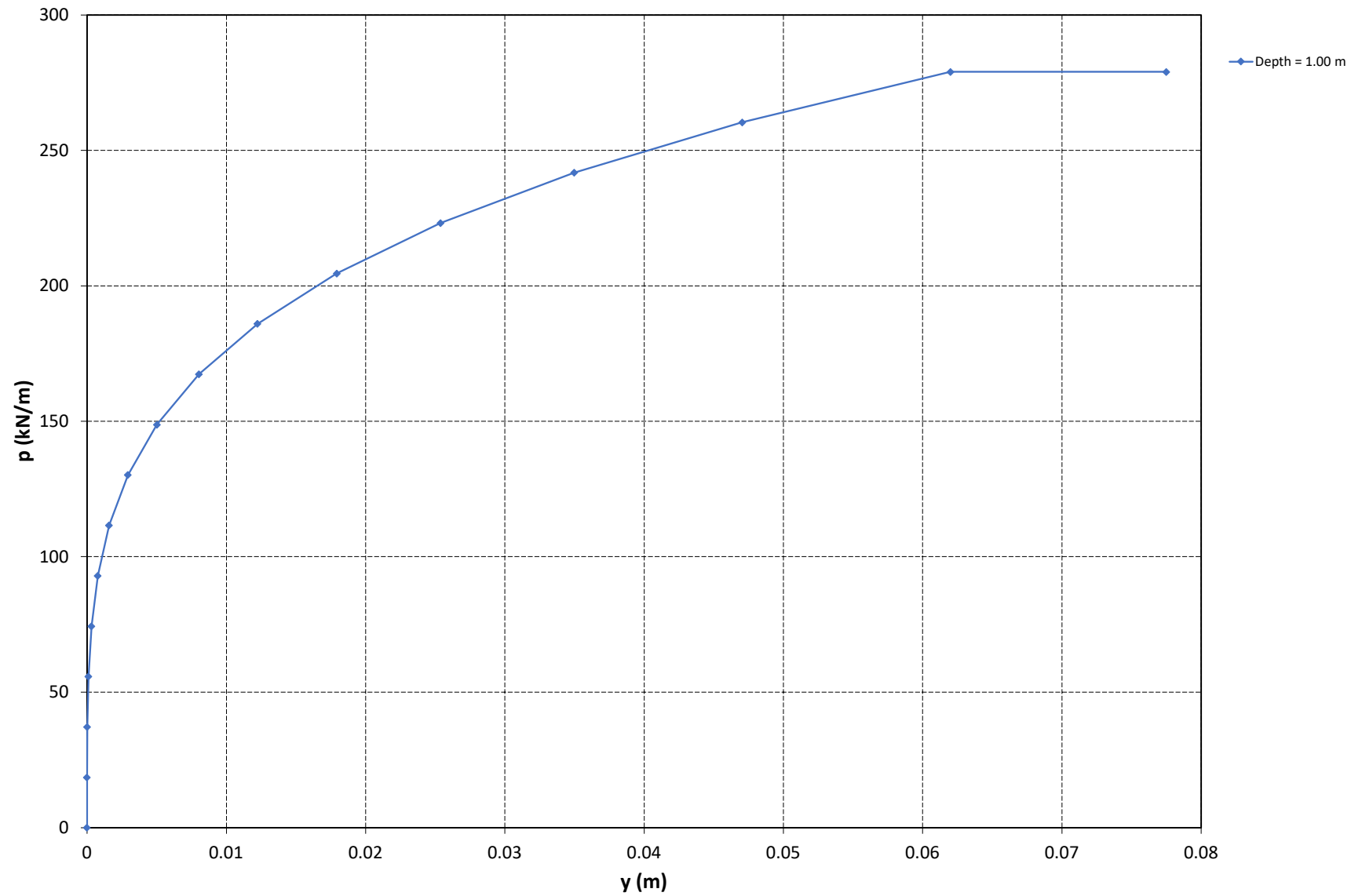
- The values P(kN/m) represent soil reaction per metre of pile length
- The values y(m) represent soil/pile deflection
- The underside of pile cap is at Elev. 98 m
- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)
- If lateral spacing between adjacent piles is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.22, C6.33, and C6.24 of the CHBDC (S6-19)

Soil Type	Clayey Silt [WC]		Compact Silty Sand		Compact Silty Sand		Compact Silty Sand		Compact Silty Sand		Compact Silty Sand		Sand & Gravel		Sand & Gravel		Sand & Gravel	
Depth (m)	1		2		3		4		5		6		7		8		9	
Elev. (m)	97		96		95		94		93		92		91		90		89	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0000	18.6	0.0048	293.9	0.0047	350.9	0.0047	406.4	0.0047	461.8	0.0047	517.3	0.0029	1076.0	0.0029	1193.7	0.0030	1311.5
	0.0000	37.2	0.0095	515.7	0.0095	615.9	0.0094	713.2	0.0094	810.5	0.0093	907.8	0.0058	1888.3	0.0059	2095.0	0.0059	2301.6
	0.0001	55.8	0.0143	650.3	0.0142	776.5	0.0141	899.2	0.0141	1021.9	0.0140	1144.6	0.0088	2380.8	0.0088	2641.4	0.0089	2902.0
	0.0003	74.4	0.0191	721.3	0.0190	861.3	0.0188	997.4	0.0187	1133.5	0.0187	1269.6	0.0117	2640.8	0.0118	2929.9	0.0119	3218.9
	0.0008	93.0	0.0239	756.0	0.0237	902.8	0.0236	1045.5	0.0234	1188.1	0.0233	1330.7	0.0146	2768.1	0.0147	3071.1	0.0148	3374.1
	0.0016	111.6	0.0286	772.4	0.0285	922.4	0.0283	1068.1	0.0281	1213.9	0.0280	1359.6	0.0175	2828.1	0.0177	3137.6	0.0178	3447.2
	0.0029	130.2	0.0334	780.0	0.0332	931.5	0.0330	1078.6	0.0328	1225.8	0.0327	1372.9	0.0205	2855.9	0.0206	3168.5	0.0208	3481.1
	0.0050	148.8	0.0382	783.5	0.0380	935.6	0.0377	1083.4	0.0375	1231.3	0.0373	1379.1	0.0234	2868.6	0.0236	3182.6	0.0237	3496.6
	0.0080	167.4	0.0429	785.1	0.0427	937.5	0.0424	1085.6	0.0422	1233.8	0.0420	1381.9	0.0263	2874.5	0.0265	3189.1	0.0267	3503.7
	0.0122	186.0	0.0477	785.8	0.0475	938.4	0.0471	1086.7	0.0469	1234.9	0.0467	1383.2	0.0292	2877.1	0.0295	3192.1	0.0297	3507.0
	0.0179	204.6	0.0525	786.1	0.0522	938.8	0.0518	1087.1	0.0515	1235.4	0.0513	1383.7	0.0321	2878.3	0.0324	3193.4	0.0327	3508.5
	0.0254	223.2	0.0573	786.3	0.0570	939.0	0.0565	1087.3	0.0562	1235.7	0.0560	1384.0	0.0351	2878.9	0.0354	3194.0	0.0356	3509.1
	0.0350	241.8	0.0620	786.4	0.0617	939.1	0.0613	1087.4	0.0609	1235.8	0.0606	1384.1	0.0380	2879.1	0.0383	3194.3	0.0386	3509.4
	0.0470	260.4	0.0668	786.4	0.0665	939.1	0.0660	1087.5	0.0656	1235.8	0.0653	1384.2	0.0409	2879.3	0.0413	3194.4	0.0416	3509.6
	0.0620	279.0	0.0716	786.4	0.0712	939.1	0.0707	1087.5	0.0703	1235.8	0.0700	1384.2	0.0438	2879.3	0.0442	3194.5	0.0445	3509.7
	0.0775	279.0	0.0763	786.4	0.0760	939.1	0.0754	1087.5	0.0750	1235.9	0.0746	1384.2	0.0468	2879.3	0.0472	3194.5	0.0475	3509.7

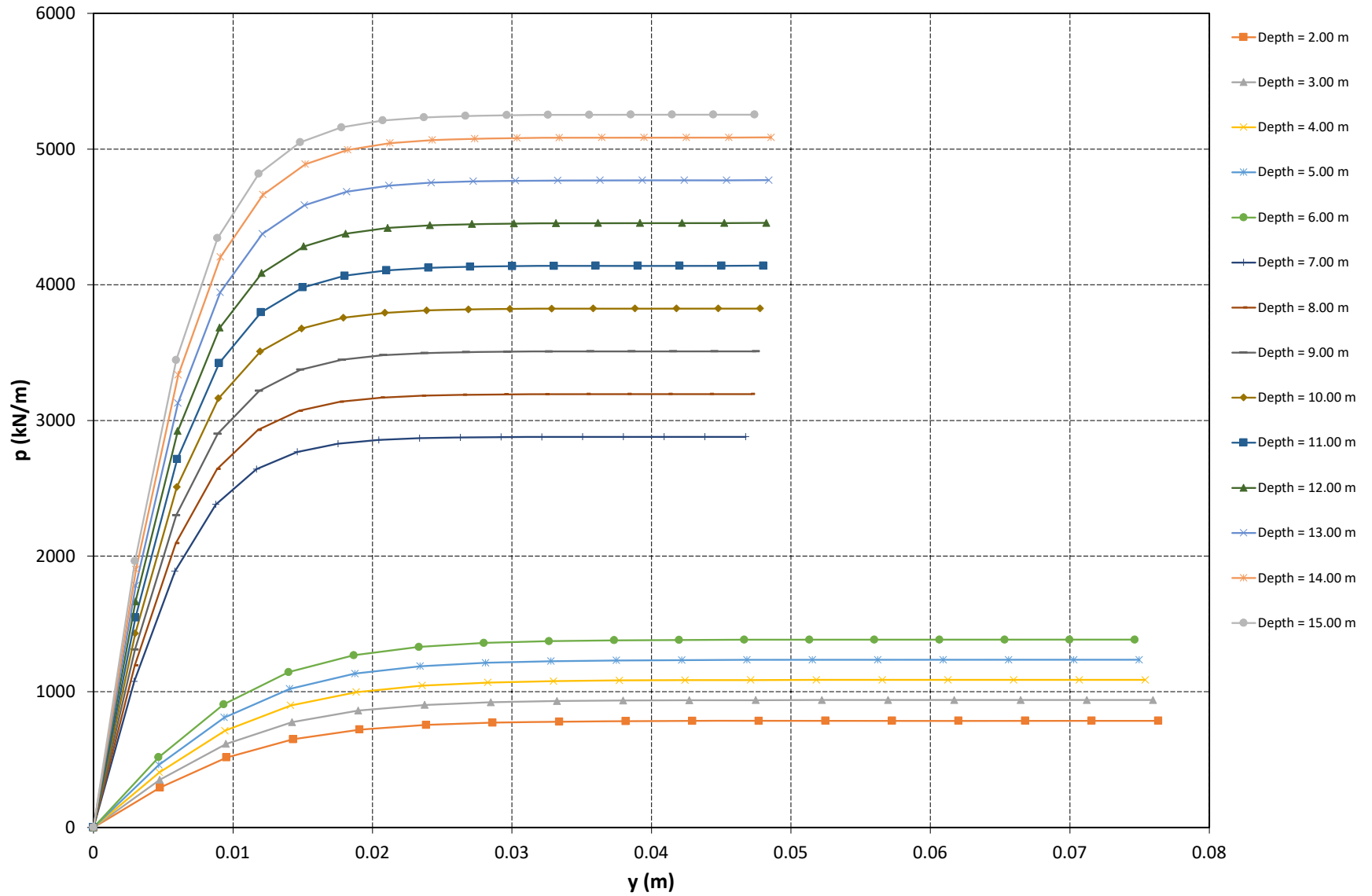
Soil Type	Sand & Gravel		Sand & Gravel		Sand & Gravel		Sand & Gravel		Sand & Gravel		Sand & Gravel (below WT)	
Depth (m)	10		11		12		13		14		15	
Elev. (m)	88		87		86		85		84		83	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0
	0.0030	1429.3	0.0030	1547.1	0.0030	1664.9	0.0030	1782.6	0.0030	1900.4	0.0030	1963.2
	0.0060	2508.3	0.0060	2715.0	0.0060	2921.7	0.0061	3128.4	0.0061	3335.1	0.0059	3445.3
	0.0090	3162.6	0.0090	3423.2	0.0090	3683.8	0.0091	3944.4	0.0091	4205.0	0.0089	4344.0
	0.0119	3508.0	0.0120	3797.1	0.0121	4086.1	0.0121	4375.2	0.0121	4664.3	0.0119	4818.4
	0.0149	3677.1	0.0150	3980.1	0.0151	4283.1	0.0151	4586.1	0.0152	4889.1	0.0148	5050.7
	0.0179	3756.8	0.0180	4066.3	0.0181	4375.9	0.0182	4685.5	0.0182	4995.0	0.0178	5160.1
	0.0209	3793.7	0.0210	4106.3	0.0211	4418.9	0.0212	4731.5	0.0213	5044.1	0.0207	5210.8
	0.0239	3810.6	0.0240	4124.6	0.0241	4438.6	0.0242	4752.6	0.0243	5066.6	0.0237	5234.1
	0.0269	3818.4	0.0270	4133.0	0.0271	4447.7	0.0272	4762.3	0.0273	5076.9	0.0267	5244.7
	0.0299	3821.9	0.0300	4136.8	0.0301	4451.8	0.0303	4766.7	0.0304	5081.6	0.0296	5249.6
	0.0329	3823.5	0.0330	4138.6	0.0332	4453.7	0.0333	4768.7	0.0334	5083.8	0.0326	5251.8
	0.0358	3824.3	0.0360	4139.4	0.0362	4454.5	0.0363	4769.6	0.0364	5084.8	0.0356	5252.8
	0.0388	3824.6	0.0390	4139.8	0.0392	4454.9	0.0393	4770.1	0.0395	5085.2	0.0385	5253.3
	0.0418	3824.8	0.0420	4139.9	0.0422	4455.1	0.0424	4770.3	0.0425	5085.4	0.0415	5253.5
	0.0448	3824.8	0.0450	4140.0	0.0452	4455.2	0.0454	4770.3	0.0455	5085.5	0.0444	5253.6
	0.0478	3824.9	0.0480	4140.0	0.0482	4455.2	0.0484	4770.4	0.0486	5085.6	0.0474	5253.6



L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
East Abutment (BON19-5)
Static Conditions



L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
East Abutment (BON19-5)
Static Conditions





L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
West Abutment (BON19-2)
Static Conditions

GENERAL NOTES

- The values P(kN/m) represent soil reaction per metre of pile length
- The values y(m) represent soil/pile deflection
- The underside of pile cap is at Elev. 99.7 m
- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)
- If lateral spacing between adjacent piles is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.22, C6.33, and C6.24 of the CHBDC (S6-19)

Soil Type	Silty Clay [WC]		Silty Clay [WC]		Silty Clay [WC]		Silty Clay [WC]		Clayey Silt		Clayey Silt		Clayey Silt		Clayey Silt		Clayey Silt	
Depth (m)	1		2		3		4		5		6		7		8		9	
Elev. (m)	98.7		97.7		96.7		95.7		94.7		93.7		92.7		91.7		90.7	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0000	62.4	0.0000	67.5	0.0000	72.5	0.0000	77.6	0.0000	83.0	0.0000	88.0	0.0000	90.0	0.0000	90.0	0.0000	90.0
	0.0001	124.8	0.0001	135.0	0.0001	145.1	0.0001	155.2	0.0001	165.9	0.0001	176.1	0.0001	180.0	0.0001	180.0	0.0001	180.0
	0.0005	187.2	0.0005	202.4	0.0005	217.6	0.0005	232.9	0.0005	248.9	0.0005	264.1	0.0005	270.0	0.0005	270.0	0.0005	270.0
	0.0015	249.6	0.0015	269.9	0.0015	290.2	0.0015	310.5	0.0015	331.8	0.0015	352.1	0.0015	360.0	0.0015	360.0	0.0015	360.0
	0.0037	312.1	0.0037	337.4	0.0037	362.7	0.0037	388.1	0.0037	414.8	0.0037	440.1	0.0037	450.0	0.0037	450.0	0.0037	450.0
	0.0077	374.5	0.0077	404.9	0.0077	435.3	0.0077	465.7	0.0077	497.7	0.0077	528.2	0.0077	540.0	0.0077	540.0	0.0077	540.0
	0.0142	436.9	0.0142	472.3	0.0142	507.8	0.0142	543.3	0.0142	580.7	0.0142	616.2	0.0142	630.0	0.0142	630.0	0.0142	630.0
	0.0243	499.3	0.0243	539.8	0.0243	580.4	0.0243	620.9	0.0243	663.6	0.0243	704.2	0.0243	720.0	0.0243	720.0	0.0243	720.0
	0.0389	561.7	0.0389	607.3	0.0389	652.9	0.0389	698.6	0.0389	746.6	0.0389	792.3	0.0389	810.0	0.0389	810.0	0.0389	810.0
	0.0593	624.1	0.0593	674.8	0.0593	725.5	0.0593	776.2	0.0593	829.5	0.0593	880.3	0.0593	900.0	0.0593	900.0	0.0593	900.0
	0.0868	686.5	0.0868	742.2	0.0868	798.0	0.0868	853.8	0.0868	912.5	0.0868	968.3	0.0868	990.0	0.0868	990.0	0.0868	990.0
	0.1229	748.9	0.1229	809.7	0.1229	870.5	0.1229	931.4	0.1229	995.5	0.1229	1056.4	0.1229	1080.0	0.1229	1080.0	0.1229	1080.0
	0.1693	811.4	0.1693	877.2	0.1693	943.1	0.1693	1009.0	0.1693	1078.4	0.1693	1144.4	0.1693	1170.0	0.1693	1170.0	0.1693	1170.0
	0.2277	873.8	0.2277	944.7	0.2277	1015.6	0.2277	1086.7	0.2277	1161.4	0.2277	1232.4	0.2277	1260.0	0.2277	1260.0	0.2277	1260.0
	0.3000	936.2	0.3000	1012.1	0.3000	1088.2	0.3000	1164.3	0.3000	1244.3	0.3000	1320.4	0.3000	1350.0	0.3000	1350.0	0.3000	1350.0
	0.3750	936.2	0.3750	1012.1	0.3750	1088.2	0.3750	1164.3	0.3750	1244.3	0.3750	1320.4	0.3750	1350.0	0.3750	1350.0	0.3750	1350.0

Soil Type	Clayey Silt		Clayey Silt		Clayey Silt		Silt - Clayey Silt		Silt - Clayey Silt		Silt - Clayey Silt		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)	
Depth (m)	10		11		12		13		14		15		16		17		18	
Elev. (m)	89.7		88.7		87.7		86.7		85.7		84.7		83.7		82.7		81.7	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0000	90.0	0.0000	90.0	0.0000	90.0	0.0086	1857.1	0.0095	2167.2	0.0074	2434.9	0.0104	3031.5	0.0111	3388.7	0.0118	3762.5
	0.0001	180.0	0.0001	180.0	0.0001	180.0	0.0171	3259.2	0.0189	3803.3	0.0148	4273.1	0.0209	5320.0	0.0222	5947.0	0.0236	6603.0
	0.0005	270.0	0.0005	270.0	0.0005	270.0	0.0257	4109.3	0.0284	4795.4	0.0222	5387.7	0.0313	6707.7	0.0334	7498.2	0.0354	8325.3
	0.0015	360.0	0.0015	360.0	0.0015	360.0	0.0343	4558.1	0.0378	5319.1	0.0296	5976.1	0.0417	7440.2	0.0445	8317.1	0.0472	9234.6
	0.0037	450.0	0.0037	450.0	0.0037	450.0	0.0428	4777.8	0.0473	5575.4	0.0370	6264.2	0.0521	7798.8	0.0556	8718.0	0.0590	9679.6
	0.0077	540.0	0.0077	540.0	0.0077	540.0	0.0514	4881.3	0.0567	5696.3	0.0444	6400.0	0.0626	7967.9	0.0667	8906.9	0.0708	9889.5
	0.0142	630.0	0.0142	630.0	0.0142	630.0	0.0600	4929.3	0.0662	5752.2	0.0518	6462.8	0.0730	8046.1	0.0778	8994.4	0.0826	9986.6
	0.0243	720.0	0.0243	720.0	0.0243	720.0	0.0685	4951.3	0.0757	5777.9	0.0592	6491.7	0.0834	8082.1	0.0889	9034.6	0.0944	10031.2
	0.0389	810.0	0.0389	810.0	0.0389	810.0	0.0771	4961.4	0.0851	5789.7	0.0666	6504.9	0.0939	8098.5	0.1001	9053.0	0.1062	10051.6
	0.0593	900.0	0.0593	900.0	0.0593	900.0	0.0857	4965.9	0.0946	5795.0	0.0740	6510.9	0.1043	8106.0	0.1112	9061.4	0.1180	10060.9
	0.0868	990.0	0.0868	990.0	0.0868	990.0	0.0942	4968.0	0.1040	5797.5	0.0814	6513.7	0.1147	8109.4	0.1223	9065.2	0.1298	10065.2
	0.1229	1080.0	0.1229	1080.0	0.1229	1080.0	0.1028	4969.0	0.1135	5798.6	0.0888	6514.9	0.1251	8111.0	0.1334	9067.0	0.1416	10067.1
	0.1693	1170.0	0.1693	1170.0	0.1693	1170.0	0.1113	4969.4	0.1230	5799.1	0.0962	6515.5	0.1356	8111.7	0.1445	9067.8	0.1534	10068.0
	0.2277	1260.0	0.2277	1260.0	0.2277	1260.0	0.1199	4969.6	0.1324	5799.3	0.1036	6515.8	0.1460	8112.0	0.1557	9068.1	0.1652	10068.4
	0.3000	1350.0	0.3000	1350.0	0.3000	1350.0	0.1285	4969.7	0.1419	5799.5	0.1110	6515.9	0.1564	8112.2	0.1668	9068.3	0.1770	10068.6
	0.3750	1350.0	0.3750	1350.0	0.3750	1350.0	0.1370	4969.8	0.1513	5799.5	0.1184	6515.9	0.1669	8112.3	0.1779	9068.4	0.1888	10068.7



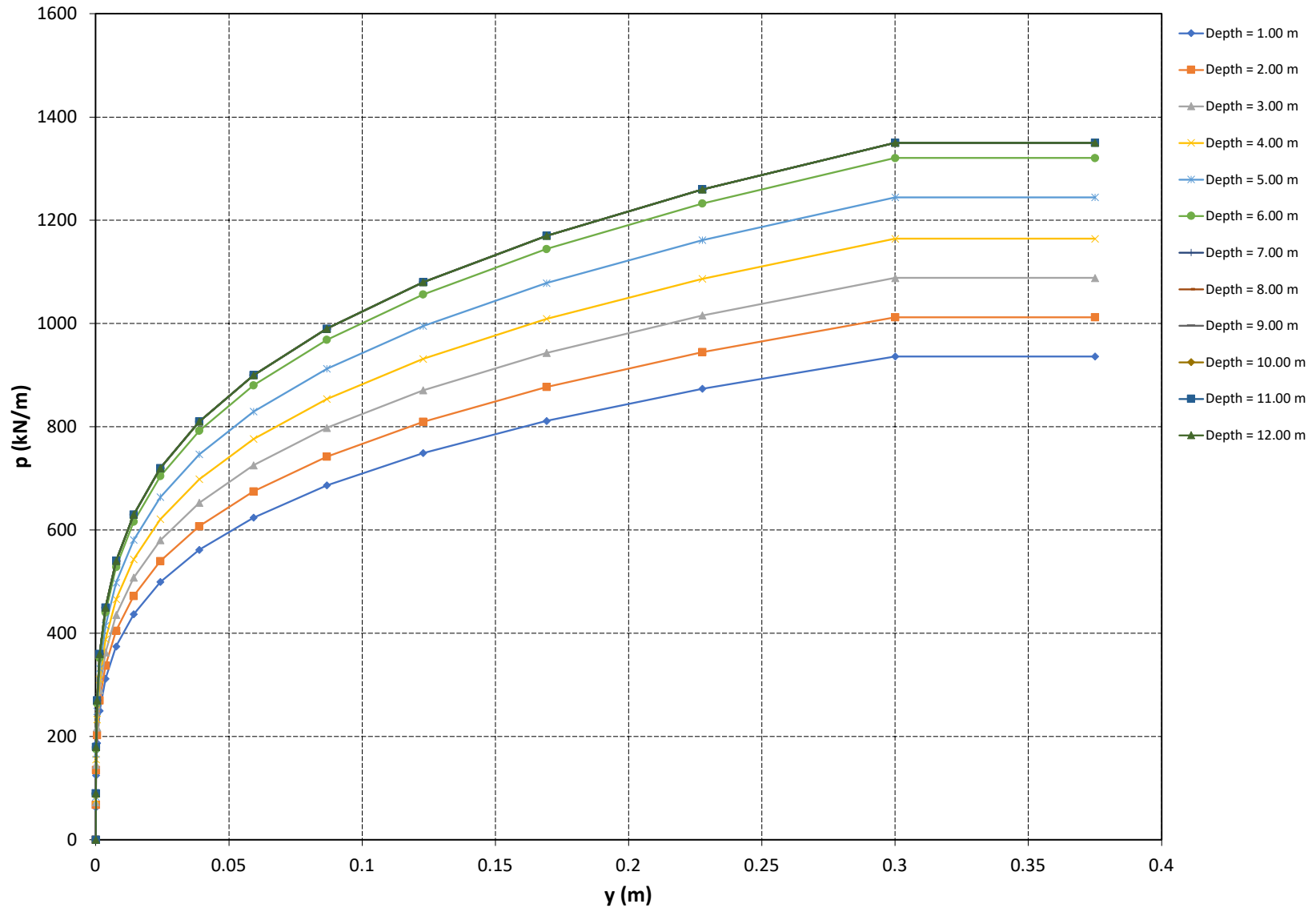
L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
West Abutment (BON19-2)
Static Conditions

Soil Type	Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)	
Depth (m)	19		20		21		22		23		24		25		26		27	
Elev. (m)	80.7		79.7		78.7		77.7		76.7		75.7		74.7		73.7		72.7	
S T A T I C C o n d i t i o n s	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0125	4152.8	0.0131	4559.3	0.0138	4982.1	0.0144	5421.1	0.0151	5876.1	0.0157	6347.3	0.0164	6834.5	0.0170	7337.6	0.0176	7856.8
	0.0249	7287.8	0.0263	8001.3	0.0276	8743.3	0.0289	9513.6	0.0302	10312.3	0.0315	11139.1	0.0327	11994.1	0.0340	12877.1	0.0352	13788.2
	0.0374	9188.8	0.0394	10088.3	0.0414	11023.8	0.0433	11995.1	0.0453	13002.1	0.0472	14044.6	0.0491	15122.6	0.0510	16236.0	0.0529	17384.7
	0.0499	10192.3	0.0525	11190.1	0.0552	12227.8	0.0578	13305.1	0.0604	14422.1	0.0629	15578.5	0.0655	16774.2	0.0680	18009.1	0.0705	19283.3
	0.0624	10683.5	0.0657	11729.4	0.0690	12817.1	0.0722	13946.4	0.0754	15117.2	0.0786	16329.3	0.0818	17582.6	0.0850	18877.1	0.0881	20212.6
	0.0748	10915.1	0.0788	11983.7	0.0828	13094.9	0.0867	14248.7	0.0905	15444.8	0.0944	16683.2	0.0982	17963.7	0.1020	19286.3	0.1057	20650.8
	0.0873	11022.3	0.0919	12101.4	0.0965	13223.6	0.1011	14388.7	0.1056	15596.6	0.1101	16847.1	0.1145	18140.2	0.1190	19475.7	0.1233	20853.6
	0.0998	11071.6	0.1051	12155.4	0.1103	13282.6	0.1155	14452.9	0.1207	15666.2	0.1258	16922.4	0.1309	18221.2	0.1360	19562.7	0.1410	20946.8
	0.1122	11094.1	0.1182	12180.2	0.1241	13309.6	0.1300	14482.3	0.1358	15698.1	0.1416	16956.8	0.1473	18258.3	0.1529	19602.5	0.1586	20989.4
	0.1247	11104.4	0.1313	12191.5	0.1379	13322.0	0.1444	14495.8	0.1509	15712.6	0.1573	16972.5	0.1636	18275.2	0.1699	19620.7	0.1762	21008.8
	0.1372	11109.1	0.1445	12196.6	0.1517	13327.6	0.1589	14501.9	0.1660	15719.3	0.1730	16979.7	0.1800	18282.9	0.1869	19629.0	0.1938	21017.7
	0.1496	11111.2	0.1576	12199.0	0.1655	13330.2	0.1733	14504.7	0.1811	15722.3	0.1887	16982.9	0.1964	18286.5	0.2039	19632.8	0.2114	21021.8
	0.1621	11112.2	0.1707	12200.0	0.1793	13331.3	0.1878	14506.0	0.1961	15723.7	0.2045	16984.4	0.2127	18288.1	0.2209	19634.5	0.2291	21023.6
	0.1746	11112.6	0.1839	12200.5	0.1931	13331.9	0.2022	14506.5	0.2112	15724.3	0.2202	16985.1	0.2291	18288.8	0.2379	19635.3	0.2467	21024.4
	0.1871	11112.8	0.1970	12200.7	0.2069	13332.1	0.2166	14506.8	0.2263	15724.6	0.2359	16985.4	0.2454	18289.1	0.2549	19635.6	0.2643	21024.8
	0.1995	11112.9	0.2102	12200.8	0.2207	13332.2	0.2311	14506.9	0.2414	15724.7	0.2516	16985.6	0.2618	18289.3	0.2719	19635.8	0.2819	21025.0

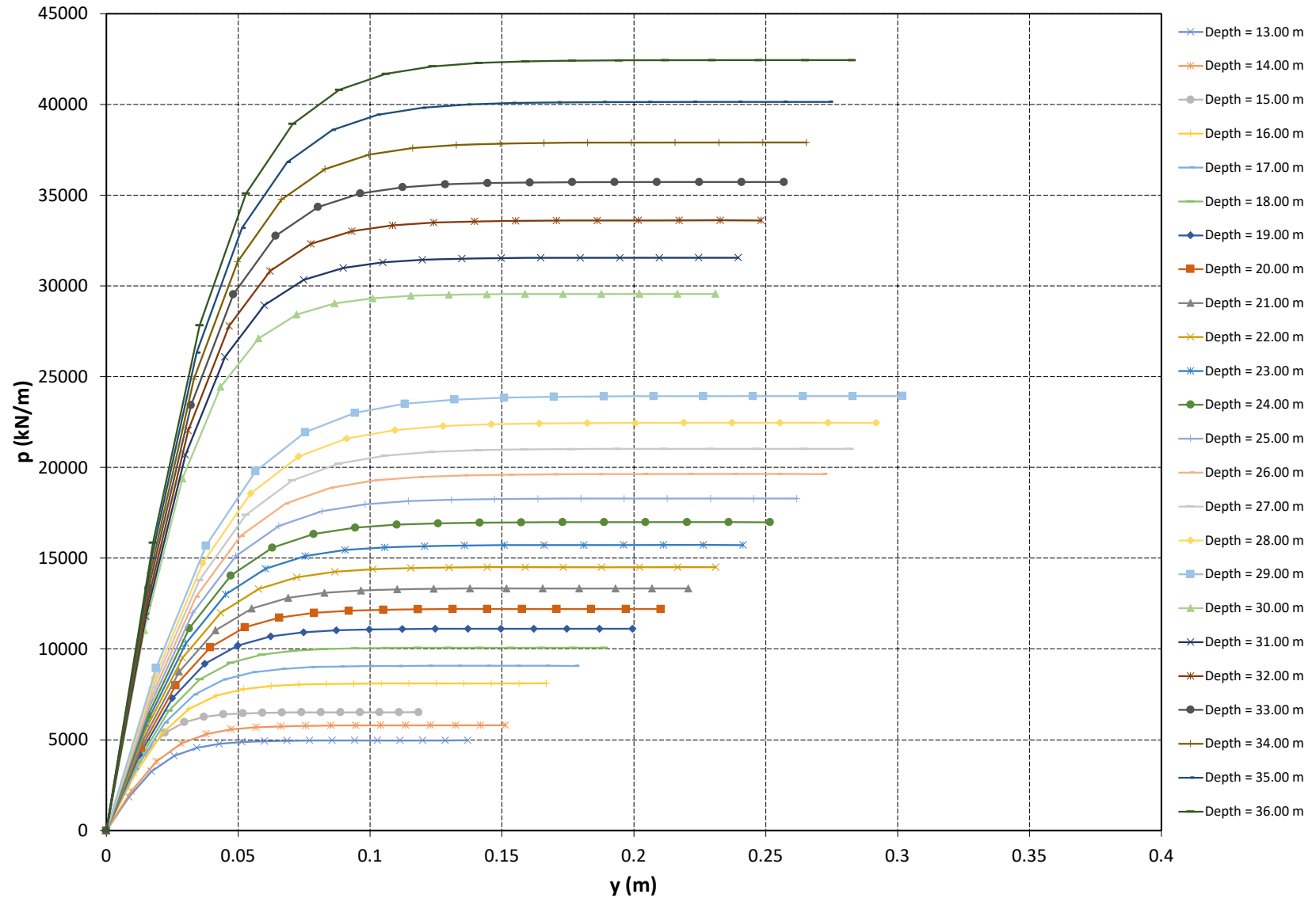
Soil Type	Compact to Dense Sand and Gravel (below WT)		Compact to Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)	
Depth (m)	28		29		30		31		32		33		34		35		36	
Elev. (m)	71.7		70.7		69.7		68.7		67.7		66.7		65.7		64.7		63.7	
S T A T I C C o n d i t i o n s	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0182	8391.8	0.0189	8942.8	0.0144	11045.6	0.0150	11791.2	0.0155	12559.6	0.0161	13350.7	0.0166	14164.4	0.0171	15000.7	0.0177	15859.7
	0.0365	14727.2	0.0377	15694.1	0.0289	19384.3	0.0300	20692.9	0.0310	22041.4	0.0321	23429.6	0.0332	24857.6	0.0343	26325.4	0.0353	27832.8
	0.0547	18568.6	0.0566	19787.7	0.0433	24440.5	0.0449	26090.4	0.0466	27790.6	0.0482	29540.9	0.0498	31341.4	0.0514	33192.0	0.0530	35092.7
	0.0730	20596.5	0.0754	21948.8	0.0577	27109.7	0.0599	28939.8	0.0621	30825.6	0.0642	32767.2	0.0664	34764.3	0.0685	36817.0	0.0707	38925.2
	0.0912	21589.2	0.0943	23006.6	0.0722	28416.3	0.0749	30334.6	0.0776	32311.3	0.0803	34346.4	0.0830	36439.8	0.0856	38591.4	0.0883	40801.2
	0.1095	22057.1	0.1132	23505.3	0.0866	29032.2	0.0899	30992.1	0.0931	33011.7	0.0963	35090.9	0.0996	37229.6	0.1028	39427.9	0.1060	41685.6
	0.1277	22273.8	0.1320	23736.2	0.1010	29317.4	0.1048	31296.6	0.1086	33336.0	0.1124	35435.6	0.1162	37595.4	0.1199	39815.2	0.1236	42095.1
	0.1459	22373.3	0.1509	23842.2	0.1155	29448.4	0.1198	31436.4	0.1241	33484.9	0.1284	35593.9	0.1327	37763.3	0.1370	39993.1	0.1413	42283.1
	0.1642	22418.8	0.1698	23890.7	0.1299	29508.3	0.1348	31500.3	0.1397	33553.0	0.1445	35666.3	0.1493	37840.1	0.1542	40074.4	0.1590	42369.1
	0.1824	22439.6	0.1886	23912.9	0.1444	29535.6	0.1498	31529.5	0.1552	33584.1	0.1606	35699.3	0.1659	37875.2	0.1713	40111.5	0.1766	42408.4
	0.2007	22449.1	0.2075	23923.0	0.1588	29548.1	0.1647	31542.8	0.1707	33598.3	0.1766	35714.4	0.1825	37891.2	0.1884	40128.5	0.1943	42426.3
	0.2189	22453.4	0.2263	23927.6	0.1732	29553.8	0.1797	31548.9	0.1862	33604.7	0.1927	35721.3	0.1991	37898.5	0.2055	40136.2	0.2120	42434.5
	0.2372	22455.4	0.2452	23929.7	0.1877	29556.4	0.1947	31551.7	0.2017	33607.7	0.2087	35724.4	0.2157	37901.8	0.2227	40139.7	0.2296	42438.2
	0.2554	22456.3	0.2641	23930.6	0.2021	29557.6	0.2097	31552.9	0.2172	33609.0	0.2248	35725.9	0.2323	37903.3	0.2398	40141.4	0.2473	42439.9
	0.2736	22456.7	0.2829	23931.1	0.2165	29558.1	0.2247	31553.5	0.2328	33609.7	0.2408	35726.5	0.2489	37904.0	0.2569	40142.1	0.2650	42440.7
	0.2919	22456.9	0.3018	23931.3	0.2310	29558.4	0.2396	31553.8	0.2483	33609.9	0.2569	35726.8	0.2655	37904.3	0.2741	40142.4	0.2826	42441.1



L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
West Abutment (BON19-2)
Static Conditions



L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
West Abutment (BON19-2)
Static Conditions





L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 1 (BON19-3)
Static Conditions

GENERAL NOTES

- The values P(kN/m) represent soil reaction per metre of pile length
- The values y(m) represent soil/pile deflection
- The underside of pile cap is at Elev. 97.5 m
- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)
- If lateral spacing between adjacent piles is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.22, C6.33, and C6.24 of the CHBDC (S6-19)

Soil Type	Clayey Silt		Clayey Silt		Clayey Silt		Clayey Silt		Clayey Silt		Clayey Silt		Clayey Silt		Sandy Silt		Sandy Silt	
Depth (m)	1		2		3		4		5		6		7		8		9	
Elev. (m)	96.5		95.5		94.5		93.5		92.5		91.5		90.5		89.5		88.5	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0000	70.5	0.0000	75.6	0.0000	80.6	0.0000	85.7	0.0000	90.0	0.0000	90.0	0.0087	1346.0	0.0097	1612.9	0.0107	1903.5
	0.0001	141.1	0.0001	151.2	0.0001	161.3	0.0001	171.4	0.0001	180.0	0.0001	180.0	0.0175	2362.2	0.0194	2830.5	0.0213	3340.6
	0.0005	211.6	0.0005	226.7	0.0005	241.9	0.0005	257.1	0.0005	270.0	0.0005	270.0	0.0262	2978.3	0.0291	3568.8	0.0320	4211.9
	0.0015	282.2	0.0015	302.3	0.0015	322.5	0.0015	342.8	0.0015	360.0	0.0015	360.0	0.0350	3303.6	0.0388	3958.6	0.0426	4671.9
	0.0037	352.7	0.0037	377.9	0.0037	403.2	0.0037	428.5	0.0037	450.0	0.0037	450.0	0.0437	3462.8	0.0485	4149.3	0.0533	4897.1
	0.0077	423.2	0.0077	453.5	0.0077	483.8	0.0077	514.2	0.0077	540.0	0.0077	540.0	0.0524	3537.9	0.0582	4239.3	0.0639	5003.2
	0.0142	493.8	0.0142	529.1	0.0142	564.4	0.0142	599.9	0.0142	630.0	0.0142	630.0	0.0612	3572.6	0.0679	4280.9	0.0746	5052.4
	0.0243	564.3	0.0243	604.7	0.0243	645.1	0.0243	685.6	0.0243	720.0	0.0243	720.0	0.0699	3588.6	0.0776	4300.0	0.0852	5074.9
	0.0389	634.9	0.0389	680.2	0.0389	725.7	0.0389	771.2	0.0389	810.0	0.0389	810.0	0.0787	3595.9	0.0873	4308.8	0.0959	5085.3
	0.0593	705.4	0.0593	755.8	0.0593	806.4	0.0593	856.9	0.0593	900.0	0.0593	900.0	0.0874	3599.2	0.0970	4312.8	0.1066	5090.0
	0.0868	775.9	0.0868	831.4	0.0868	887.0	0.0868	942.6	0.0868	990.0	0.0868	990.0	0.0961	3600.8	0.1067	4314.6	0.1172	5092.1
	0.1229	846.5	0.1229	907.0	0.1229	967.6	0.1229	1028.3	0.1229	1080.0	0.1229	1080.0	0.1049	3601.5	0.1164	4315.4	0.1279	5093.1
	0.1693	917.0	0.1693	982.6	0.1693	1048.3	0.1693	1114.0	0.1693	1170.0	0.1693	1170.0	0.1136	3601.8	0.1261	4315.8	0.1385	5093.6
	0.2277	987.6	0.2277	1058.2	0.2277	1128.9	0.2277	1199.7	0.2277	1260.0	0.2277	1260.0	0.1224	3601.9	0.1358	4316.0	0.1492	5093.8
	0.3000	1058.1	0.3000	1133.7	0.3000	1209.5	0.3000	1285.4	0.3000	1350.0	0.3000	1350.0	0.1311	3602.0	0.1455	4316.1	0.1598	5093.8
	0.3750	1058.1	0.3750	1133.7	0.3750	1209.5	0.3750	1285.4	0.3750	1350.0	0.3750	1350.0	0.1399	3602.0	0.1552	4316.1	0.1705	5093.9

Soil Type	Sandy Silt		Sandy Silt		Sandy Silt		Sandy Silt		Sandy Silt (below WT)		Sandy Silt (below WT)		Sandy Silt (below WT)		Sandy Silt (below WT)		Silty Sand and Gravel (below WT)	
Depth (m)	10		11		12		13		14		15		16		17		18	
Elev. (m)	87.5		86.5		85.5		84.5		83.5		82.5		81.5		80.5		79.5	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0116	2218.0	0.0126	2556.2	0.0135	2918.2	0.0145	3304.1	0.0211	3675.2	0.0219	3998.3	0.0226	4332.5	0.0233	4677.6	0.0170	5630.9
	0.0232	3892.4	0.0252	4486.0	0.0271	5121.3	0.0290	5798.4	0.0422	6449.7	0.0437	7016.8	0.0452	7603.2	0.0466	8208.9	0.0340	9881.9
	0.0348	4907.7	0.0377	5656.1	0.0406	6457.2	0.0435	7310.9	0.0634	8132.1	0.0656	8847.1	0.0677	9586.4	0.0699	10350.1	0.0509	12459.4
	0.0465	5443.7	0.0503	6273.8	0.0541	7162.4	0.0580	8109.3	0.0845	9020.2	0.0874	9813.3	0.0903	10633.4	0.0932	11480.4	0.0679	13820.1
	0.0581	5706.0	0.0629	6576.2	0.0677	7507.6	0.0725	8500.2	0.1056	9454.9	0.1093	10286.2	0.1129	11145.8	0.1165	12033.8	0.0849	14486.2
	0.0697	5829.7	0.0755	6718.7	0.0812	7670.3	0.0870	8684.4	0.1267	9659.9	0.1311	10509.2	0.1355	11387.4	0.1398	12294.6	0.1019	14800.2
	0.0813	5887.0	0.0880	6784.7	0.0948	7745.7	0.1015	8769.7	0.1479	9754.8	0.1530	10612.4	0.1581	11499.3	0.1631	12415.4	0.1189	14945.6
	0.0929	5913.3	0.1006	6815.0	0.1083	7780.2	0.1160	8808.9	0.1690	9798.3	0.1749	10659.8	0.1807	11550.7	0.1864	12470.8	0.1358	15012.4
	0.1045	5925.3	0.1132	6828.9	0.1218	7796.1	0.1305	8826.8	0.1901	9818.3	0.1967	10681.5	0.2032	11574.2	0.2097	12496.2	0.1528	15042.9
	0.1162	5930.8	0.1258	6835.2	0.1354	7803.3	0.1450	8835.0	0.2112	9827.4	0.2186	10691.4	0.2258	11584.9	0.2330	12507.8	0.1698	15056.8
	0.1278	5933.3	0.1383	6838.1	0.1489	7806.6	0.1595	8838.7	0.2323	9831.5	0.2404	10695.9	0.2484	11589.8	0.2563	12513.1	0.1868	15063.2
	0.1394	5934.4	0.1509	6839.4	0.1624	7808.1	0.1740	8840.4	0.2535	9833.4	0.2623	10698.0	0.2710	11592.0	0.2796	12515.5	0.2038	15066.1
	0.1510	5935.0	0.1635	6840.0	0.1760	7808.8	0.1885	8841.2	0.2746	9834.3	0.2842	10698.9	0.2936	11593.0	0.3029	12516.6	0.2208	15067.4
	0.1626	5935.2	0.1761	6840.3	0.1895	7809.1	0.2030	8841.6	0.2957	9834.7	0.3060	10699.4	0.3162	11593.5	0.3262	12517.1	0.2377	15068.0
	0.1742	5935.3	0.1886	6840.4	0.2030	7809.2	0.2175	8841.7	0.3168	9834.9	0.3279	10699.6	0.3387	11593.7	0.3495	12517.3	0.2547	15068.3
	0.1858	5935.4	0.2012	6840.5	0.2166	7809.3	0.2320	8841.8	0.3379	9834.9	0.3497	10699.6	0.3613	11593.8	0.3728	12517.4	0.2717	15068.4

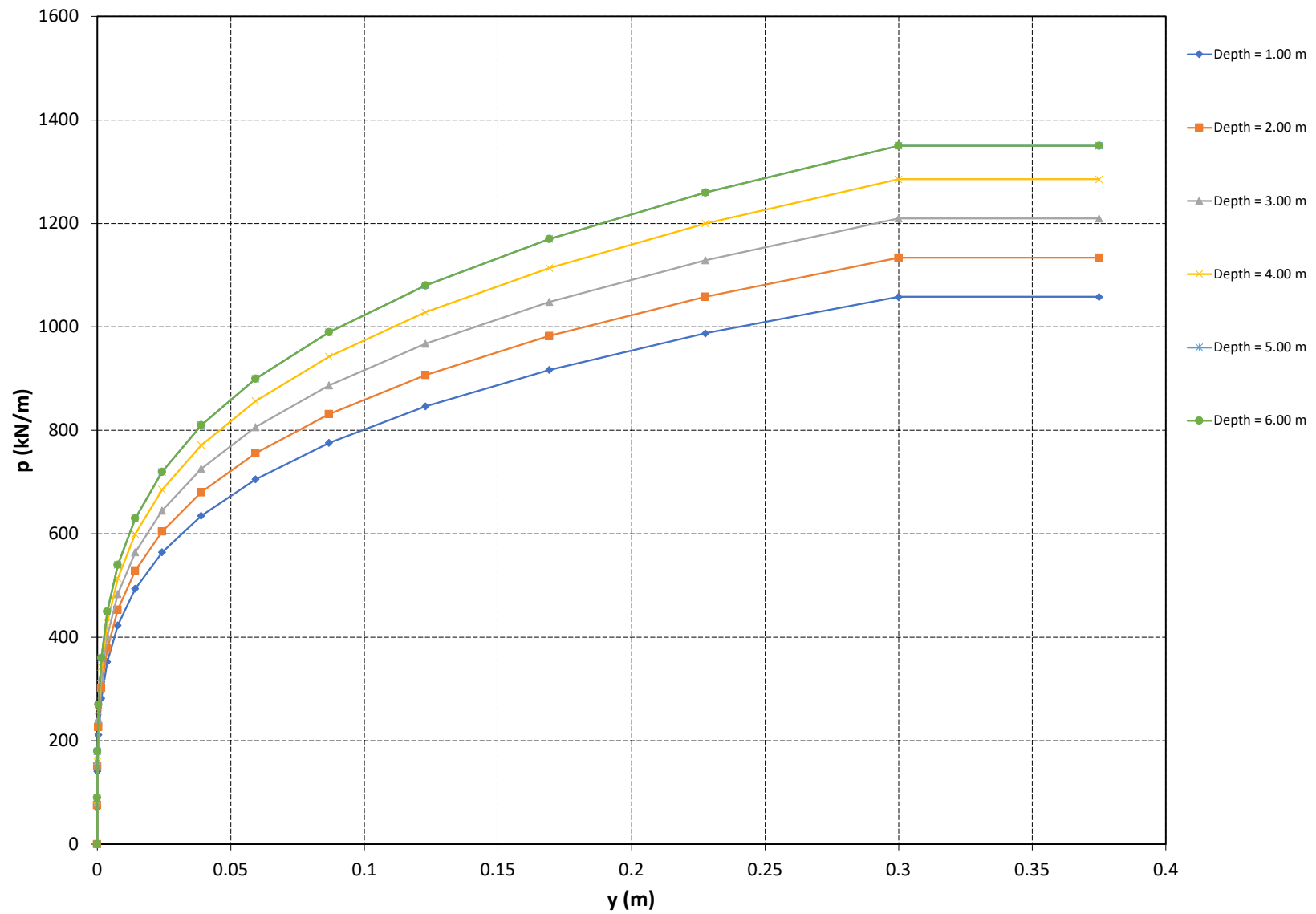


L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 1 (BON19-3)
Static Conditions

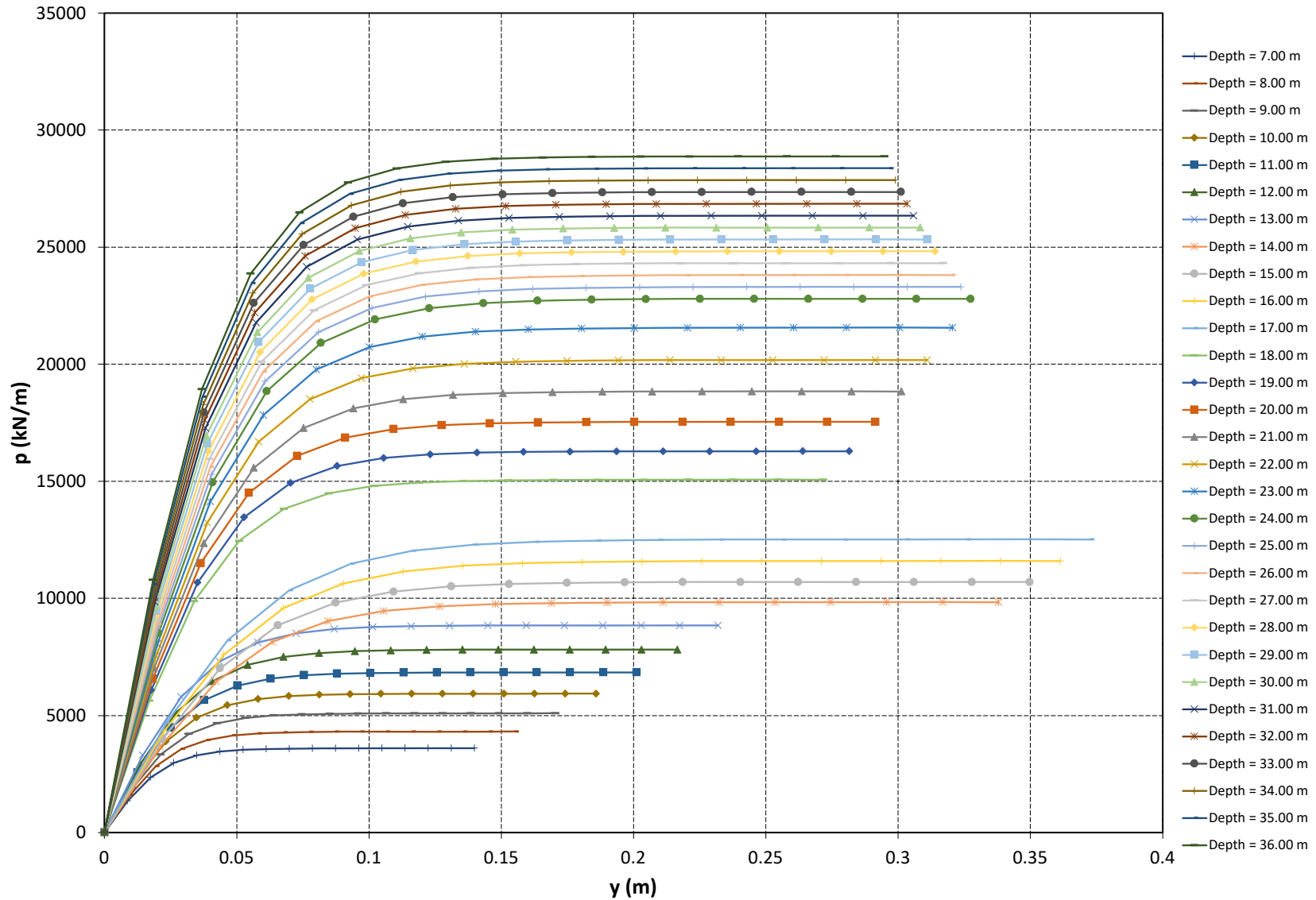
Soil Type	Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)	
Depth (m)	19		20		21		22		23		24		25		26		27	
Elev. (m)	78.5		77.5		76.5		75.5		74.5		73.5		72.5		71.5		70.5	
S T A T I C C o n d i t i o n s	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0176	6084.9	0.0182	6554.7	0.0188	7040.2	0.0194	7541.4	0.0200	8058.3	0.0205	8519.2	0.0202	8708.7	0.0200	8898.1	0.0198	9087.5
	0.0352	10678.6	0.0364	11503.0	0.0377	12355.0	0.0389	13234.7	0.0401	14141.9	0.0409	14950.7	0.0405	15283.2	0.0400	15615.6	0.0396	15948.0
	0.0528	13464.0	0.0546	14503.4	0.0565	15577.7	0.0583	16686.8	0.0601	17830.6	0.0614	18850.4	0.0607	19269.6	0.0601	19688.7	0.0594	20107.9
	0.0704	14934.4	0.0729	16087.4	0.0753	17279.0	0.0777	18509.2	0.0802	19778.0	0.0819	20909.1	0.0809	21374.1	0.0801	21839.0	0.0793	22303.9
	0.0880	15654.2	0.0911	16862.7	0.0941	18111.8	0.0972	19401.2	0.1002	20731.2	0.1023	21916.9	0.1012	22404.2	0.1001	22891.5	0.0991	23378.9
	0.1056	15993.5	0.1093	17228.3	0.1130	18504.3	0.1166	19821.8	0.1202	21180.5	0.1228	22391.9	0.1214	22889.8	0.1201	23387.7	0.1189	23885.6
	0.1232	16150.6	0.1275	17397.5	0.1318	18686.1	0.1360	20016.5	0.1403	21388.6	0.1433	22611.9	0.1416	23114.7	0.1401	23617.5	0.1387	24120.3
	0.1408	16222.8	0.1457	17475.2	0.1506	18769.6	0.1555	20105.9	0.1603	21484.1	0.1637	22712.9	0.1619	23217.9	0.1602	23723.0	0.1585	24228.0
	0.1584	16255.8	0.1639	17510.7	0.1694	18807.8	0.1749	20146.8	0.1803	21527.8	0.1842	22759.1	0.1821	23265.2	0.1802	23771.2	0.1783	24277.3
	0.1760	16270.9	0.1822	17527.0	0.1883	18825.2	0.1943	20165.5	0.2004	21547.8	0.2047	22780.2	0.2024	23286.7	0.2002	23793.3	0.1982	24299.8
	0.1936	16277.7	0.2004	17534.4	0.2071	18833.1	0.2138	20174.0	0.2204	21556.9	0.2251	22789.8	0.2226	23296.6	0.2202	23803.3	0.2180	24310.1
	0.2112	16280.9	0.2186	17537.8	0.2259	18836.8	0.2332	20177.9	0.2405	21561.1	0.2456	22794.2	0.2428	23301.0	0.2402	23807.9	0.2378	24314.7
	0.2288	16282.3	0.2368	17539.3	0.2448	18838.4	0.2526	20179.7	0.2605	21562.9	0.2661	22796.2	0.2631	23303.1	0.2602	23810.0	0.2576	24316.9
	0.2464	16282.9	0.2550	17540.0	0.2636	18839.2	0.2721	20180.5	0.2805	21563.8	0.2865	22797.1	0.2833	23304.0	0.2803	23810.9	0.2774	24317.8
	0.2640	16283.2	0.2732	17540.3	0.2824	18839.5	0.2915	20180.8	0.3006	21564.2	0.3070	22797.5	0.3035	23304.4	0.3003	23811.4	0.2972	24318.3
	0.2816	16283.4	0.2915	17540.5	0.3012	18839.7	0.3110	20181.0	0.3206	21564.4	0.3275	22797.7	0.3238	23304.6	0.3203	23811.6	0.3171	24318.5
Soil Type	Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)		Silty Sand and Gravel (below WT)	
Depth (m)	28		29		30		31		32		33		34		35		36	
Elev. (m)	69.5		68.5		67.5		66.5		65.5		64.5		63.5		62.5		61.5	
S T A T I C C o n d i t i o n s	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0196	9276.9	0.0194	9466.4	0.0193	9655.8	0.0191	9845.2	0.0190	10034.7	0.0188	10224.1	0.0187	10413.5	0.0186	10603.0	0.0184	10792.4
	0.0393	16280.5	0.0389	16612.9	0.0386	16945.4	0.0382	17277.8	0.0379	17610.2	0.0376	17942.7	0.0374	18275.1	0.0371	18607.6	0.0369	18940.0
	0.0589	20527.1	0.0583	20946.2	0.0578	21365.4	0.0573	21784.5	0.0569	22203.7	0.0565	22622.8	0.0561	23042.0	0.0557	23461.1	0.0553	23880.3
	0.0785	22768.9	0.0778	23233.8	0.0771	23698.7	0.0765	24163.6	0.0759	24628.6	0.0753	25093.5	0.0747	25558.4	0.0742	26023.4	0.0737	26488.3
	0.0981	23866.2	0.0972	24353.6	0.0964	24840.9	0.0956	25328.2	0.0948	25815.6	0.0941	26302.9	0.0934	26790.3	0.0928	27277.6	0.0921	27764.9
	0.1178	24383.5	0.1167	24881.4	0.1157	25379.3	0.1147	25877.2	0.1138	26375.1	0.1129	26873.0	0.1121	27370.9	0.1113	27868.8	0.1106	28366.7
	0.1374	24623.1	0.1361	25125.9	0.1349	25628.6	0.1338	26131.4	0.1327	26634.2	0.1317	27137.0	0.1308	27639.8	0.1299	28142.6	0.1290	28645.4
	0.1570	24733.0	0.1556	25238.1	0.1542	25743.1	0.1529	26248.2	0.1517	26753.2	0.1506	27258.2	0.1495	27763.3	0.1484	28268.3	0.1474	28773.4
	0.1766	24783.4	0.1750	25289.4	0.1735	25795.5	0.1720	26301.6	0.1707	26807.6	0.1694	27313.7	0.1682	27819.8	0.1670	28325.8	0.1659	28831.9
	0.1963	24806.3	0.1945	25312.9	0.1928	25819.4	0.1912	26325.9	0.1896	26832.5	0.1882	27339.0	0.1868	27845.5	0.1855	28352.1	0.1843	28858.6
	0.2159	24816.8	0.2139	25323.6	0.2120	25830.3	0.2103	26337.1	0.2086	26843.8	0.2070	27350.6	0.2055	27857.3	0.2041	28364.1	0.2027	28870.8
	0.2355	24821.6	0.2333	25328.4	0.2313	25835.3	0.2294	26342.1	0.2276	26849.0	0.2258	27355.8	0.2242	27862.7	0.2226	28369.5	0.2212	28876.4
	0.2551	24823.8	0.2528	25330.7	0.2506	25837.5	0.2485	26344.4	0.2465	26851.3	0.2447	27358.2	0.2429	27865.1	0.2412	28372.0	0.2396	28878.9
	0.2748	24824.8	0.2722	25331.7	0.2699	25838.6	0.2676	26345.5	0.2655	26852.4	0.2635	27359.3	0.2616	27866.2	0.2597	28373.1	0.2580	28880.1
	0.2944	24825.2	0.2917	25332.1	0.2891	25839.1	0.2867	26346.0	0.2845	26852.9	0.2823	27359.8	0.2803	27866.7	0.2783	28373.7	0.2764	28880.6
	0.3140	24825.4	0.3111	25332.3	0.3084	25839.3	0.3058	26346.2	0.3034	26853.1	0.3011	27360.0	0.2989	27867.0	0.2969	28373.9	0.2949	28880.8



L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 1 (BON19-3)
Static Conditions



L-Pile Data for P-Y Curves (310x110)
Bonnechere River Bridge
Pier 1 (BON19-3)
Static Conditions





L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
Pier 2 (BON-P1)
Static Conditions

GENERAL NOTES

- The values P(kN/m) represent soil reaction per metre of pile length
- The values y(m) represent soil/pile deflection
- The underside of pile cap is at Elev. 83.4 m
- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)
- If lateral spacing between adjacent piles is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.22, C6.33, and C6.24 of the CHBDC (S6-19)

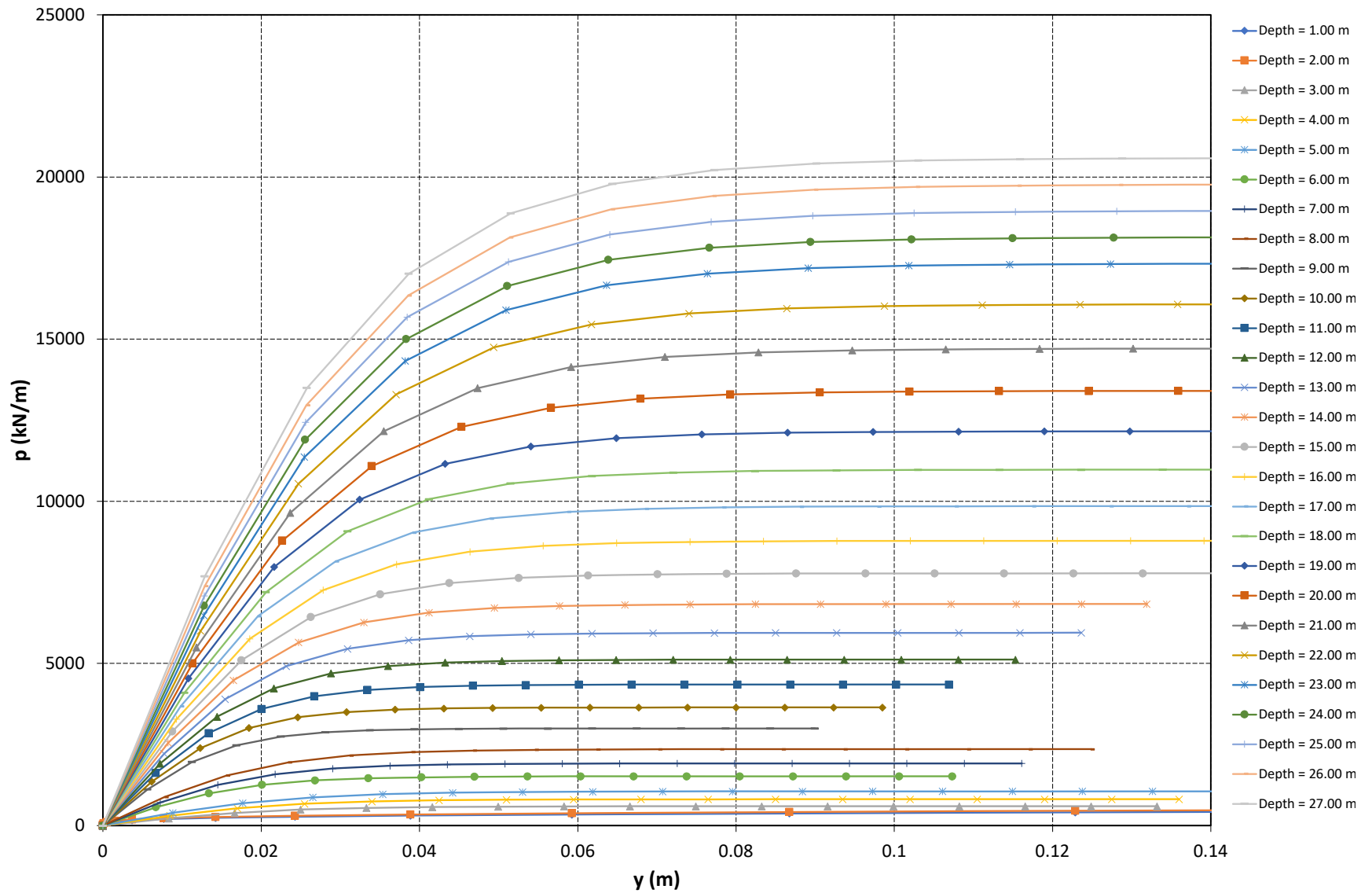
Soil Type	Silty Clay to Clayey Silt (below WT)		Silty Clay to Clayey Silt (below WT)		Silt and Sand (below WT)		Silt and Sand (below WT)		Silt and Sand (below WT)		Compact Sand (below WT)		Compact Sand (below WT)		Compact Sand (below WT)		Dense Sand & Gravel (below WT)	
Depth (m)	1		2		3		4		5		6		7		8		9	
Elev. (m)	82.4		81.4		80.4		79.4		78.4		77.4		76.4		75.4		74.4	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0000	34.1	0.0000	38.2	0.0083	222.9	0.0085	303.4	0.0088	394.5	0.0067	568.0	0.0073	716.9	0.0078	880.9	0.0056	1119.2
	0.0001	68.2	0.0001	76.4	0.0167	391.1	0.0170	532.4	0.0177	692.3	0.0134	996.8	0.0145	1258.1	0.0156	1545.9	0.0112	1964.2
	0.0005	102.3	0.0005	114.6	0.0250	493.1	0.0255	671.3	0.0265	872.9	0.0201	1256.9	0.0218	1586.2	0.0234	1949.2	0.0169	2476.5
	0.0015	136.4	0.0015	152.8	0.0333	547.0	0.0340	744.6	0.0354	968.2	0.0268	1394.1	0.0290	1759.5	0.0312	2162.0	0.0225	2747.0
	0.0037	170.5	0.0037	191.0	0.0416	573.3	0.0425	780.5	0.0442	1014.9	0.0335	1461.3	0.0363	1844.3	0.0390	2266.2	0.0281	2879.4
	0.0077	204.6	0.0077	229.2	0.0500	585.8	0.0510	797.4	0.0531	1036.9	0.0403	1493.0	0.0435	1884.3	0.0468	2315.4	0.0337	2941.8
	0.0142	238.7	0.0142	267.4	0.0583	591.5	0.0595	805.2	0.0619	1047.0	0.0470	1507.6	0.0508	1902.8	0.0546	2338.1	0.0394	2970.7
	0.0243	272.8	0.0243	305.7	0.0666	594.2	0.0680	808.8	0.0707	1051.7	0.0537	1514.4	0.0581	1911.3	0.0624	2348.6	0.0450	2983.9
	0.0389	306.9	0.0389	343.9	0.0749	595.4	0.0765	810.5	0.0796	1053.9	0.0604	1517.5	0.0653	1915.1	0.0702	2353.3	0.0506	2990.0
	0.0593	341.0	0.0593	382.1	0.0833	595.9	0.0850	811.2	0.0884	1054.8	0.0671	1518.9	0.0726	1916.9	0.0780	2355.5	0.0562	2992.8
	0.0868	375.1	0.0868	420.3	0.0916	596.2	0.0935	811.6	0.0973	1055.3	0.0738	1519.5	0.0798	1917.7	0.0858	2356.5	0.0619	2994.1
	0.1229	409.2	0.1229	458.5	0.0999	596.3	0.1020	811.7	0.1061	1055.5	0.0805	1519.8	0.0871	1918.1	0.0936	2357.0	0.0675	2994.6
	0.1693	443.3	0.1693	496.7	0.1082	596.3	0.1105	811.8	0.1149	1055.6	0.0872	1519.9	0.0944	1918.3	0.1014	2357.2	0.0731	2994.9
	0.2277	477.4	0.2277	534.9	0.1166	596.4	0.1190	811.8	0.1238	1055.6	0.0939	1520.0	0.1016	1918.3	0.1092	2357.3	0.0787	2995.0
	0.3000	511.6	0.3000	573.1	0.1249	596.4	0.1275	811.9	0.1326	1055.6	0.1006	1520.0	0.1089	1918.4	0.1171	2357.3	0.0843	2995.1
	0.3750	511.6	0.3750	573.1	0.1332	596.4	0.1360	811.9	0.1415	1055.6	0.1073	1520.0	0.1161	1918.4	0.1249	2357.3	0.0900	2995.1
Soil Type	Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)	
Depth (m)	10		11		12		13		14		15		16		17		18	
Elev. (m)	73.4		72.4		71.4		70.4		69.4		68.4		67.4		66.4		65.4	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0062	1361.4	0.0067	1625.8	0.0072	1912.5	0.0077	2221.5	0.0082	2552.8	0.0088	2906.4	0.0093	3282.3	0.0098	3680.6	0.0103	4101.3
	0.0123	2389.2	0.0134	2853.2	0.0144	3356.3	0.0155	3898.6	0.0165	4479.9	0.0175	5100.5	0.0186	5760.3	0.0196	6459.3	0.0206	7197.5
	0.0185	3012.4	0.0201	3597.4	0.0216	4231.8	0.0232	4915.5	0.0247	5648.5	0.0263	6430.9	0.0278	7262.8	0.0294	8144.1	0.0309	9074.8
	0.0246	3341.4	0.0267	3990.3	0.0288	4693.9	0.0309	5452.3	0.0330	6265.4	0.0350	7133.3	0.0371	8056.0	0.0392	9033.5	0.0412	10065.9
	0.0308	3502.4	0.0334	4182.6	0.0360	4920.2	0.0386	5715.1	0.0412	6567.3	0.0438	7477.1	0.0464	8444.2	0.0490	9468.9	0.0515	10551.0
	0.0369	3578.3	0.0401	4273.3	0.0432	5026.8	0.0464	5838.9	0.0495	6709.7	0.0526	7639.1	0.0557	8627.3	0.0587	9674.1	0.0618	10779.7
	0.0431	3613.5	0.0468	4315.3	0.0504	5076.2	0.0541	5896.3	0.0577	6775.6	0.0613	7714.2	0.0649	8712.0	0.0685	9769.2	0.0721	10885.6
	0.0492	3629.6	0.0535	4334.6	0.0577	5098.9	0.0618	5922.6	0.0660	6805.9	0.0701	7748.6	0.0742	8750.9	0.0783	9812.8	0.0824	10934.3
	0.0554	3637.0	0.0602	4343.4	0.0649	5109.2	0.0695	5934.7	0.0742	6819.7	0.0789	7764.4	0.0835	8768.7	0.0881	9832.8	0.0927	10956.5
	0.0616	3640.4	0.0668	4347.4	0.0721	5114.0	0.0773	5940.2	0.0825	6826.0	0.0876	7771.6	0.0928	8776.9	0.0979	9841.9	0.1030	10966.7
	0.0677	3641.9	0.0735	4349.2	0.0793	5116.1	0.0850	5942.7	0.0907	6828.9	0.0964	7774.9	0.1020	8780.6	0.1077	9846.0	0.1133	10971.3
	0.0739	3642.6	0.0802	4350.1	0.0865	5117.1	0.0927	5943.8	0.0989	6830.2	0.1051	7776.4	0.1113	8782.3	0.1175	9847.9	0.1236	10973.4
	0.0800	3642.9	0.0869	4350.5	0.0937	5117.6	0.1005	5944.4	0.1072	6830.8	0.1139	7777.0	0.1206	8783.0	0.1273	9848.8	0.1339	10974.4
	0.0862	3643.1	0.0936	4350.6	0.1009	5117.8	0.1082	5944.6	0.1154	6831.1	0.1227	7777.4	0.1299	8783.4	0.1371	9849.2	0.1442	10974.8
	0.0923	3643.1	0.1003	4350.7	0.1081	5117.9	0.1159	5944.7	0.1237	6831.2	0.1314	7777.5	0.1391	8783.5	0.1469	9849.4	0.1545	10975.0
	0.0985	3643.2	0.1069	4350.8	0.1153	5117.9	0.1236	5944.7	0.1319	6831.3	0.1402	7777.6	0.1484	8783.6	0.1566	9849.5	0.1648	10975.1



L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
Pier 2 (BON-P1)
Static Conditions

Soil Type	Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)		Dense Sand & Gravel (below WT)	
Depth (m)	19		20		21		22		23		24		25		26		27	
Elev. (m)	64.4		63.4		62.4		61.4		60.4		59.4		58.4		57.4		56.4	
S T A T I C C o n d i t i o n s	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0108	4544.2	0.0113	5009.6	0.0118	5497.3	0.0123	6007.4	0.0127	6476.3	0.0128	6780.3	0.0128	7084.2	0.0128	7388.2	0.0129	7692.1
	0.0216	7974.9	0.0227	8791.5	0.0237	9647.4	0.0247	10542.6	0.0255	11365.6	0.0255	11899.0	0.0256	12432.4	0.0257	12965.8	0.0258	13499.2
	0.0324	10055.0	0.0340	11084.7	0.0355	12163.9	0.0370	13292.5	0.0382	14330.2	0.0383	15002.7	0.0384	15675.2	0.0385	16347.8	0.0386	17020.3
	0.0433	11153.2	0.0453	12295.3	0.0473	13492.3	0.0494	14744.2	0.0509	15895.2	0.0511	16641.2	0.0513	17387.1	0.0514	18133.1	0.0515	18879.1
	0.0541	11690.7	0.0566	12887.9	0.0592	14142.6	0.0617	15454.8	0.0637	16661.3	0.0639	17443.2	0.0641	18225.1	0.0642	19007.1	0.0644	19789.0
	0.0649	11944.1	0.0680	13167.2	0.0710	14449.1	0.0741	15789.8	0.0764	17022.4	0.0766	17821.3	0.0769	18620.2	0.0771	19419.1	0.0773	20217.9
	0.0757	12061.4	0.0793	13296.6	0.0829	14591.1	0.0864	15944.9	0.0891	17189.7	0.0894	17996.4	0.0897	18803.1	0.0899	19609.8	0.0902	20416.5
	0.0865	12115.3	0.0906	13356.0	0.0947	14656.2	0.0988	16016.1	0.1019	17266.4	0.1022	18076.8	0.1025	18887.1	0.1028	19697.4	0.1031	20507.7
	0.0973	12139.9	0.1019	13383.1	0.1065	14686.0	0.1111	16048.7	0.1146	17301.6	0.1150	18113.5	0.1153	18925.5	0.1156	19737.5	0.1159	20549.4
	0.1081	12151.2	0.1133	13395.5	0.1184	14699.7	0.1235	16063.6	0.1273	17317.6	0.1277	18130.3	0.1281	18943.0	0.1285	19755.8	0.1288	20568.5
	0.1190	12156.3	0.1246	13401.2	0.1302	14705.9	0.1358	16070.4	0.1401	17324.9	0.1405	18138.0	0.1409	18951.0	0.1413	19764.1	0.1417	20577.2
	0.1298	12158.7	0.1359	13403.8	0.1420	14708.7	0.1482	16073.4	0.1528	17328.2	0.1533	18141.5	0.1538	18954.7	0.1542	19767.9	0.1546	20581.1
	0.1406	12159.7	0.1472	13404.9	0.1539	14710.0	0.1605	16074.9	0.1655	17329.8	0.1661	18143.1	0.1666	18956.4	0.1670	19769.7	0.1675	20583.0
	0.1514	12160.2	0.1586	13405.5	0.1657	14710.6	0.1729	16075.5	0.1783	17330.5	0.1788	18143.8	0.1794	18957.1	0.1799	19770.4	0.1804	20583.8
	0.1622	12160.5	0.1699	13405.7	0.1776	14710.8	0.1852	16075.8	0.1910	17330.8	0.1916	18144.1	0.1922	18957.5	0.1927	19770.8	0.1932	20584.2
	0.1730	12160.6	0.1812	13405.8	0.1894	14711.0	0.1976	16075.9	0.2037	17330.9	0.2044	18144.3	0.2050	18957.6	0.2056	19771.0	0.2061	20584.3

L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
Pier 2 (BON-P1)
Static Conditions





L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
Pier 3 (BON-P2)
Static Conditions

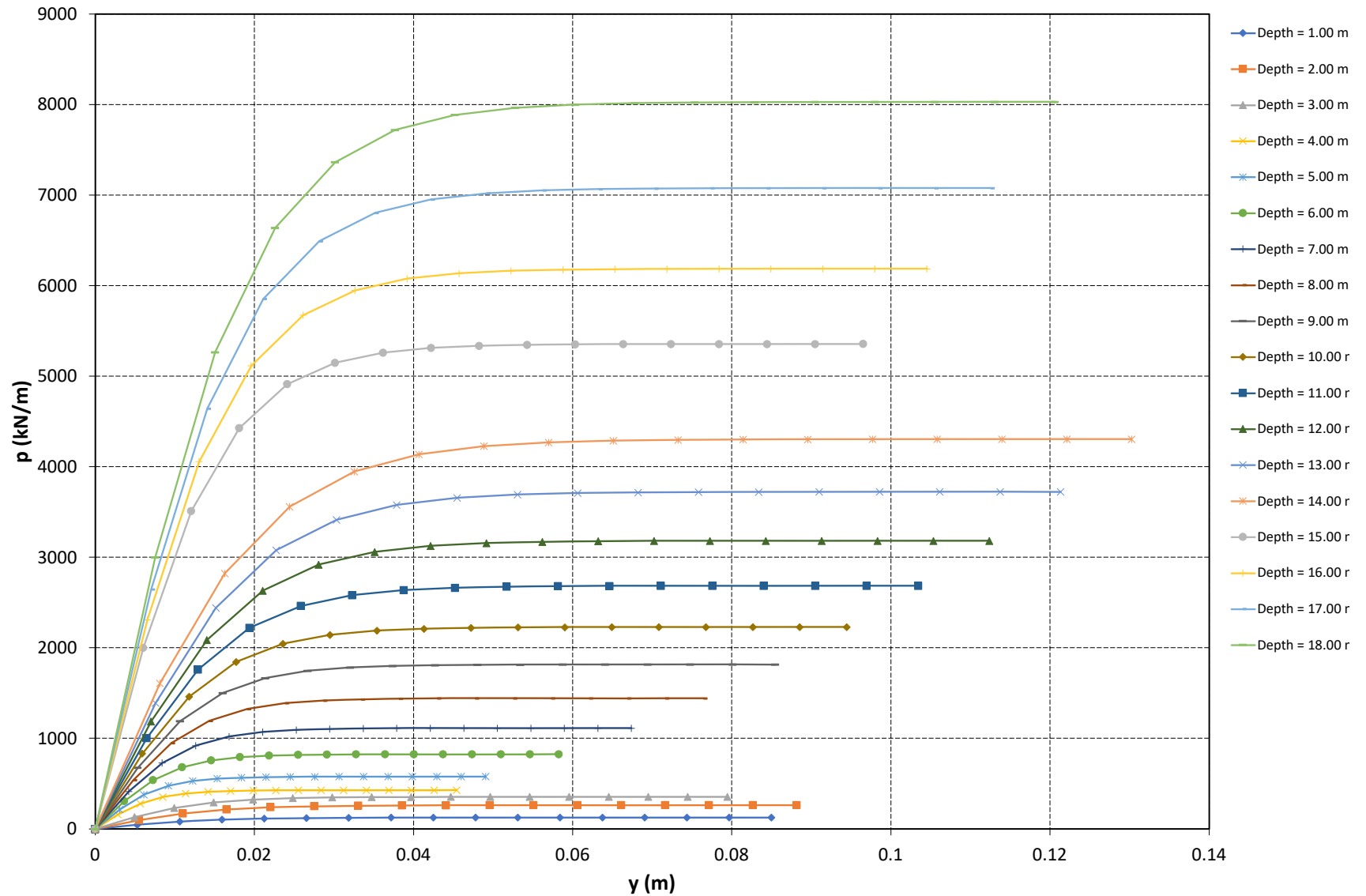
GENERAL NOTES

- The values P(kN/m) represent soil reaction per metre of pile length
- The values y(m) represent soil/pile deflection
- The underside of pile cap is at Elev. 82 m
- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)
- If lateral spacing between adjacent piles is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.22, C6.33, and C6.24 of the CHBDC (S6-19)

Soil Type	Silty Sand - Sand (below WT)		Silty Sand - Sand (below WT)		Silty Sand - Sand (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)	
Depth (m)	1		2		3		4		5		6		7		8		9	
Elev. (m)	81		80		79		78		77		76		75		74		73	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0053	47.4	0.0055	98.3	0.0050	132.9	0.0028	160.3	0.0031	216.4	0.0036	308.4	0.0042	416.1	0.0048	539.5	0.0053	678.5
	0.0106	83.2	0.0110	172.6	0.0099	233.3	0.0057	281.3	0.0061	379.8	0.0073	541.2	0.0084	730.2	0.0096	946.7	0.0107	1190.7
	0.0159	104.9	0.0165	217.6	0.0149	294.1	0.0085	354.6	0.0092	478.8	0.0109	682.4	0.0126	920.7	0.0143	1193.7	0.0160	1501.3
	0.0213	116.4	0.0220	241.4	0.0199	326.3	0.0114	393.4	0.0123	531.1	0.0146	757.0	0.0169	1021.3	0.0191	1324.0	0.0214	1665.2
	0.0266	122.0	0.0276	253.0	0.0248	342.0	0.0142	412.3	0.0153	556.7	0.0182	793.4	0.0211	1070.5	0.0239	1387.8	0.0267	1745.5
	0.0319	124.6	0.0331	258.5	0.0298	349.4	0.0170	421.3	0.0184	568.8	0.0219	810.6	0.0253	1093.7	0.0287	1417.9	0.0321	1783.3
	0.0372	125.8	0.0386	261.0	0.0348	352.8	0.0199	425.4	0.0215	574.4	0.0255	818.6	0.0295	1104.4	0.0335	1431.8	0.0374	1800.8
	0.0425	126.4	0.0441	262.2	0.0397	354.4	0.0227	427.3	0.0245	576.9	0.0291	822.3	0.0337	1109.4	0.0382	1438.2	0.0427	1808.9
	0.0478	126.6	0.0496	262.7	0.0447	355.1	0.0256	428.2	0.0276	578.1	0.0328	823.9	0.0379	1111.6	0.0430	1441.2	0.0481	1812.5
	0.0531	126.8	0.0551	263.0	0.0497	355.4	0.0284	428.6	0.0307	578.6	0.0364	824.7	0.0421	1112.7	0.0478	1442.5	0.0534	1814.2
	0.0584	126.8	0.0606	263.1	0.0546	355.6	0.0312	428.8	0.0337	578.9	0.0401	825.0	0.0463	1113.1	0.0526	1443.1	0.0588	1815.0
	0.0638	126.8	0.0661	263.1	0.0596	355.7	0.0341	428.8	0.0368	579.0	0.0437	825.2	0.0506	1113.3	0.0573	1443.4	0.0641	1815.3
	0.0691	126.9	0.0716	263.2	0.0646	355.7	0.0369	428.9	0.0399	579.0	0.0474	825.3	0.0548	1113.4	0.0621	1443.5	0.0695	1815.5
	0.0744	126.9	0.0772	263.2	0.0695	355.7	0.0398	428.9	0.0429	579.1	0.0510	825.3	0.0590	1113.5	0.0669	1443.6	0.0748	1815.6
	0.0797	126.9	0.0827	263.2	0.0745	355.7	0.0426	428.9	0.0460	579.1	0.0546	825.3	0.0632	1113.5	0.0717	1443.6	0.0801	1815.6
	0.0850	126.9	0.0882	263.2	0.0795	355.7	0.0454	428.9	0.0491	579.1	0.0583	825.3	0.0674	1113.5	0.0765	1443.6	0.0855	1815.6

Soil Type	Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)		Sand & Gravel (below WT)	
Depth (m)	10		11		12		13		14		15		16		17		18	
Elev. (m)	72		71		70		69		68		67		66		65		64	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0059	833.1	0.0065	1003.5	0.0070	1189.5	0.0076	1391.1	0.0081	1608.4	0.0060	2001.2	0.0065	2311.8	0.0070	2644.8	0.0075	3000.2
	0.0118	1462.1	0.0129	1761.0	0.0140	2087.4	0.0152	2441.3	0.0163	2822.6	0.0121	3512.0	0.0131	4057.1	0.0141	4641.5	0.0151	5265.2
	0.0177	1843.5	0.0194	2220.4	0.0211	2631.9	0.0228	3078.1	0.0244	3558.9	0.0181	4428.0	0.0196	5115.4	0.0211	5852.2	0.0226	6638.6
	0.0236	2044.8	0.0259	2462.9	0.0281	2919.3	0.0303	3414.2	0.0326	3947.6	0.0241	4911.6	0.0261	5674.0	0.0281	6491.4	0.0301	7363.6
	0.0295	2143.4	0.0323	2581.6	0.0351	3060.1	0.0379	3578.8	0.0407	4137.8	0.0302	5148.4	0.0327	5947.5	0.0352	6804.2	0.0377	7718.5
	0.0354	2189.8	0.0388	2637.5	0.0421	3126.4	0.0455	3656.4	0.0489	4227.5	0.0362	5260.0	0.0392	6076.4	0.0422	6951.7	0.0452	7885.8
	0.0413	2211.4	0.0453	2663.4	0.0492	3157.1	0.0531	3692.3	0.0570	4269.0	0.0422	5311.6	0.0457	6136.1	0.0492	7020.0	0.0528	7963.3
	0.0472	2221.2	0.0517	2675.3	0.0562	3171.2	0.0607	3708.8	0.0651	4288.1	0.0483	5335.4	0.0523	6163.5	0.0563	7051.3	0.0603	7998.8
	0.0531	2225.7	0.0582	2680.8	0.0632	3177.6	0.0683	3716.3	0.0733	4296.8	0.0543	5346.2	0.0588	6176.1	0.0633	7065.7	0.0678	8015.1
	0.0590	2227.8	0.0646	2683.3	0.0702	3180.6	0.0758	3719.8	0.0814	4300.8	0.0603	5351.2	0.0653	6181.8	0.0703	7072.2	0.0754	8022.5
	0.0649	2228.8	0.0711	2684.4	0.0773	3181.9	0.0834	3721.3	0.0896	4302.6	0.0664	5353.4	0.0719	6184.4	0.0774	7075.2	0.0829	8025.9
	0.0709	2229.2	0.0776	2684.9	0.0843	3182.5	0.0910	3722.1	0.0977	4303.4	0.0724	5354.5	0.0784	6185.6	0.0844	7076.6	0.0904	8027.5
	0.0768	2229.4	0.0840	2685.2	0.0913	3182.8	0.0986	3722.4	0.1058	4303.8	0.0784	5354.9	0.0849	6186.1	0.0915	7077.2	0.0980	8028.2
	0.0827	2229.5	0.0905	2685.3	0.0983	3183.0	0.1062	3722.5	0.1140	4304.0	0.0845	5355.1	0.0915	6186.4	0.0985	7077.5	0.1055	8028.5
	0.0886	2229.5	0.0970	2685.3	0.1054	3183.0	0.1138	3722.6	0.1221	4304.1	0.0905	5355.2	0.0980	6186.5	0.1055	7077.6	0.1131	8028.6
	0.0945	2229.5	0.1034	2685.3	0.1124	3183.0	0.1213	3722.6	0.1303	4304.1	0.0965	5355.3	0.1045	6186.5	0.1126	7077.7	0.1206	8028.7

L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
Pier 3 (BON-P2)
Static Conditions





L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
Pier 4 (BON-P2)
Static Conditions

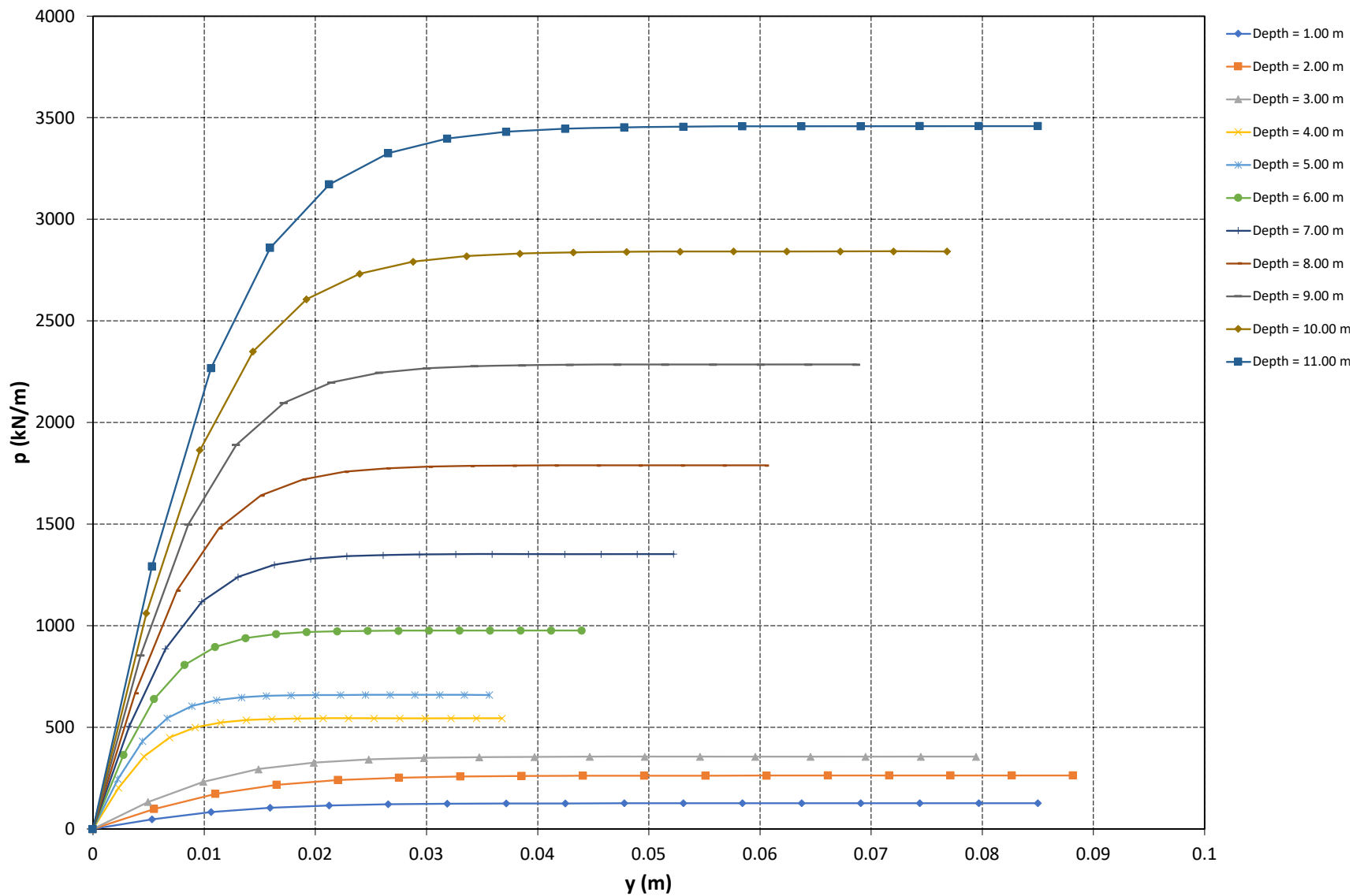
GENERAL NOTES

- The values P(kN/m) represent soil reaction per metre of pile length
- The values y(m) represent soil/pile deflection
- The underside of pile cap is at Elev. 83.4 m
- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)
- If lateral spacing between adjacent piles is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.22, C6.33, and C6.24 of the CHBDC (S6-19)

Soil Type	Compact Sand and Gravel (below WT)		Compact Sand and Gravel (below WT)		Compact Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)	
Depth (m)	1		2		3		4		5		6		7		8		9	
Elev. (m)	82.4		81.4		80.4		79.4		78.4		77.4		76.4		75.4		74.4	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0053	47.4	0.0055	98.3	0.0050	132.9	0.0023	203.5	0.0022	246.4	0.0027	364.7	0.0033	505.5	0.0038	668.6	0.0043	854.1
	0.0106	83.2	0.0110	172.6	0.0099	233.3	0.0046	357.1	0.0045	432.5	0.0055	640.1	0.0065	887.0	0.0076	1173.4	0.0086	1499.0
	0.0159	104.9	0.0165	217.6	0.0149	294.1	0.0069	450.3	0.0067	545.3	0.0082	807.0	0.0098	1118.4	0.0113	1479.4	0.0129	1890.0
	0.0213	116.4	0.0220	241.4	0.0199	326.3	0.0092	499.5	0.0089	604.9	0.0110	895.2	0.0131	1240.6	0.0151	1641.0	0.0172	2096.4
	0.0266	122.0	0.0276	253.0	0.0248	342.0	0.0115	523.6	0.0111	634.0	0.0137	938.3	0.0163	1300.4	0.0189	1720.1	0.0215	2197.4
	0.0319	124.6	0.0331	258.5	0.0298	349.4	0.0138	534.9	0.0134	647.7	0.0165	958.7	0.0196	1328.5	0.0227	1757.4	0.0257	2245.0
	0.0372	125.8	0.0386	261.0	0.0348	352.8	0.0161	540.2	0.0156	654.1	0.0192	968.1	0.0229	1341.6	0.0265	1774.6	0.0300	2267.1
	0.0425	126.4	0.0441	262.2	0.0397	354.4	0.0184	542.6	0.0178	657.0	0.0220	972.4	0.0261	1347.6	0.0302	1782.5	0.0343	2277.2
	0.0478	126.6	0.0496	262.7	0.0447	355.1	0.0207	543.7	0.0201	658.4	0.0247	974.4	0.0294	1350.3	0.0340	1786.2	0.0386	2281.9
	0.0531	126.8	0.0551	263.0	0.0497	355.4	0.0230	544.2	0.0223	659.0	0.0275	975.3	0.0327	1351.6	0.0378	1787.8	0.0429	2284.0
	0.0584	126.8	0.0606	263.1	0.0546	355.6	0.0253	544.4	0.0245	659.3	0.0302	975.7	0.0359	1352.2	0.0416	1788.6	0.0472	2284.9
	0.0638	126.8	0.0661	263.1	0.0596	355.7	0.0276	544.5	0.0267	659.4	0.0330	975.9	0.0392	1352.4	0.0453	1788.9	0.0515	2285.4
	0.0691	126.9	0.0716	263.2	0.0646	355.7	0.0299	544.6	0.0290	659.4	0.0357	976.0	0.0424	1352.5	0.0491	1789.1	0.0558	2285.6
	0.0744	126.9	0.0772	263.2	0.0695	355.7	0.0322	544.6	0.0312	659.5	0.0385	976.0	0.0457	1352.6	0.0529	1789.2	0.0601	2285.7
	0.0797	126.9	0.0827	263.2	0.0745	355.7	0.0345	544.6	0.0334	659.5	0.0412	976.0	0.0490	1352.6	0.0567	1789.2	0.0644	2285.7
	0.0850	126.9	0.0882	263.2	0.0795	355.7	0.0368	544.6	0.0357	659.5	0.0440	976.0	0.0522	1352.6	0.0605	1789.2	0.0687	2285.7

Soil Type	Dense Sand and Gravel (below WT)		Dense Sand and Gravel (below WT)	
Depth (m)	10		11	
Elev. (m)	73.4		72.4	
S T A T I C C o n d i t i o n	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0
	0.0048	1062.1	0.0053	1292.4
	0.0096	1863.9	0.0106	2268.1
	0.0144	2350.1	0.0159	2859.7
	0.0192	2606.7	0.0213	3172.1
	0.0240	2732.4	0.0266	3324.9
	0.0288	2791.6	0.0319	3397.0
	0.0336	2819.0	0.0372	3430.4
	0.0384	2831.6	0.0425	3445.7
	0.0432	2837.4	0.0478	3452.7
	0.0480	2840.0	0.0531	3455.9
	0.0528	2841.2	0.0584	3457.4
	0.0576	2841.8	0.0638	3458.0
	0.0624	2842.0	0.0691	3458.3
	0.0672	2842.1	0.0744	3458.5
	0.0720	2842.2	0.0797	3458.5
	0.0768	2842.2	0.0850	3458.6

L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
Pier 4 (BON-P2)
Static Conditions



L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
East Abutment (BON19-5)
Static Conditions

GENERAL NOTES

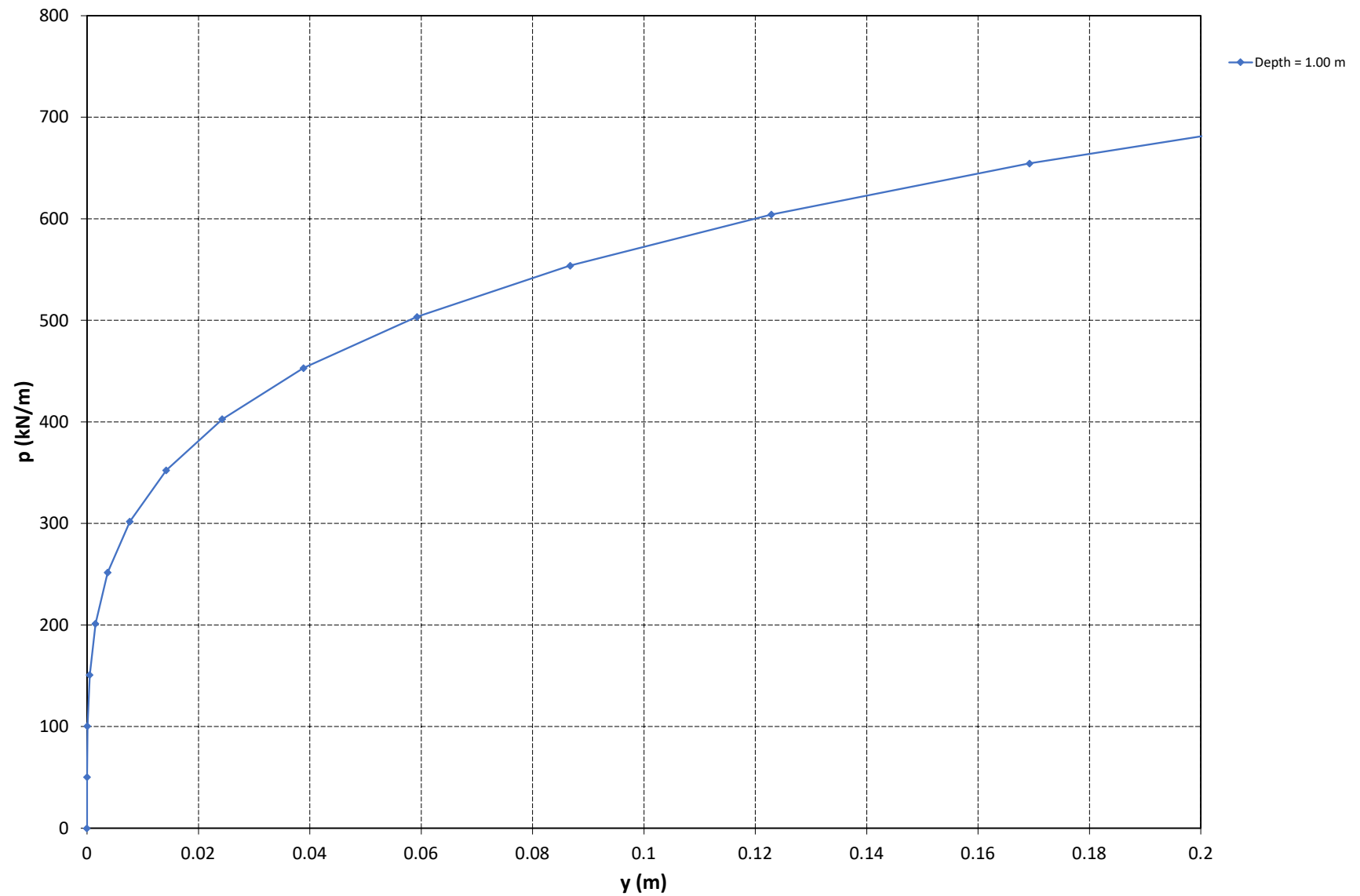
- The values P(kN/m) represent soil reaction per metre of pile length
- The values y(m) represent soil/pile deflection
- The underside of pile cap is at Elev. 98 m
- The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (ϕ_{gu} and ϕ_{gs}) provided in Table 6.2 of the CHBDC (S6-19)
- If lateral spacing between adjacent piles is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.22, C6.33, and C6.24 of the CHBDC (S6-19)

Soil Type	Clayey Silt [WC]		Compact Silty Sand		Compact Silty Sand		Compact Silty Sand		Compact Silty Sand		Compact Silty Sand		Sand & Gravel		Sand & Gravel		Sand & Gravel	
Depth (m)	1		2		3		4		5		6		7		8		9	
Elev. (m)	97		96		95		94		93		92		91		90		89	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.0000	50.3	0.0076	466.2	0.0085	628.3	0.0094	814.3	0.0104	1024.0	0.0113	1257.6	0.0048	1769.6	0.0054	2177.2	0.0059	2626.7
	0.0001	100.7	0.0151	818.1	0.0170	1102.7	0.0189	1429.0	0.0208	1797.1	0.0227	2207.0	0.0096	3105.6	0.0108	3820.8	0.0119	4609.6
	0.0005	151.0	0.0227	1031.5	0.0255	1390.3	0.0283	1801.7	0.0312	2265.9	0.0340	2782.6	0.0144	3915.6	0.0161	4817.4	0.0178	5812.0
	0.0015	201.4	0.0303	1144.1	0.0340	1542.1	0.0378	1998.5	0.0416	2513.3	0.0454	3086.5	0.0192	4343.2	0.0215	5343.5	0.0238	6446.8
	0.0037	251.7	0.0378	1199.3	0.0425	1616.4	0.0472	2094.8	0.0520	2634.5	0.0567	3235.3	0.0240	4552.6	0.0269	5601.0	0.0297	6757.5
	0.0077	302.1	0.0454	1225.2	0.0510	1651.5	0.0567	2140.2	0.0623	2691.6	0.0681	3305.4	0.0288	4651.2	0.0323	5722.4	0.0357	6903.9
	0.0142	352.4	0.0530	1237.3	0.0595	1667.7	0.0661	2161.3	0.0727	2718.0	0.0794	3337.9	0.0336	4696.9	0.0376	5778.6	0.0416	6971.8
	0.0243	402.8	0.0605	1242.8	0.0680	1675.1	0.0755	2170.9	0.0831	2730.1	0.0907	3352.8	0.0385	4717.9	0.0430	5804.5	0.0476	7002.9
	0.0389	453.1	0.0681	1245.3	0.0765	1678.6	0.0850	2175.3	0.0935	2735.7	0.1021	3359.6	0.0433	4727.5	0.0484	5816.3	0.0535	7017.1
	0.0593	503.5	0.0757	1246.5	0.0850	1680.1	0.0944	2177.4	0.1039	2738.2	0.1134	3362.7	0.0481	4731.9	0.0538	5821.7	0.0595	7023.7
	0.0868	553.8	0.0832	1247.0	0.0935	1680.8	0.1039	2178.3	0.1143	2739.4	0.1248	3364.1	0.0529	4733.9	0.0591	5824.1	0.0654	7026.6
	0.1229	604.2	0.0908	1247.3	0.1020	1681.1	0.1133	2178.7	0.1247	2739.9	0.1361	3364.8	0.0577	4734.8	0.0645	5825.2	0.0713	7028.0
	0.1693	654.5	0.0984	1247.4	0.1105	1681.3	0.1228	2178.9	0.1351	2740.2	0.1474	3365.1	0.0625	4735.2	0.0699	5825.7	0.0773	7028.6
	0.2277	704.9	0.1059	1247.4	0.1190	1681.4	0.1322	2179.0	0.1455	2740.3	0.1588	3365.2	0.0673	4735.4	0.0753	5826.0	0.0832	7028.9
	0.3000	755.2	0.1135	1247.4	0.1275	1681.4	0.1416	2179.0	0.1559	2740.3	0.1701	3365.3	0.0721	4735.5	0.0806	5826.1	0.0892	7029.0
	0.3750	755.2	0.1211	1247.5	0.1360	1681.4	0.1511	2179.0	0.1662	2740.3	0.1815	3365.3	0.0769	4735.5	0.0860	5826.1	0.0951	7029.1

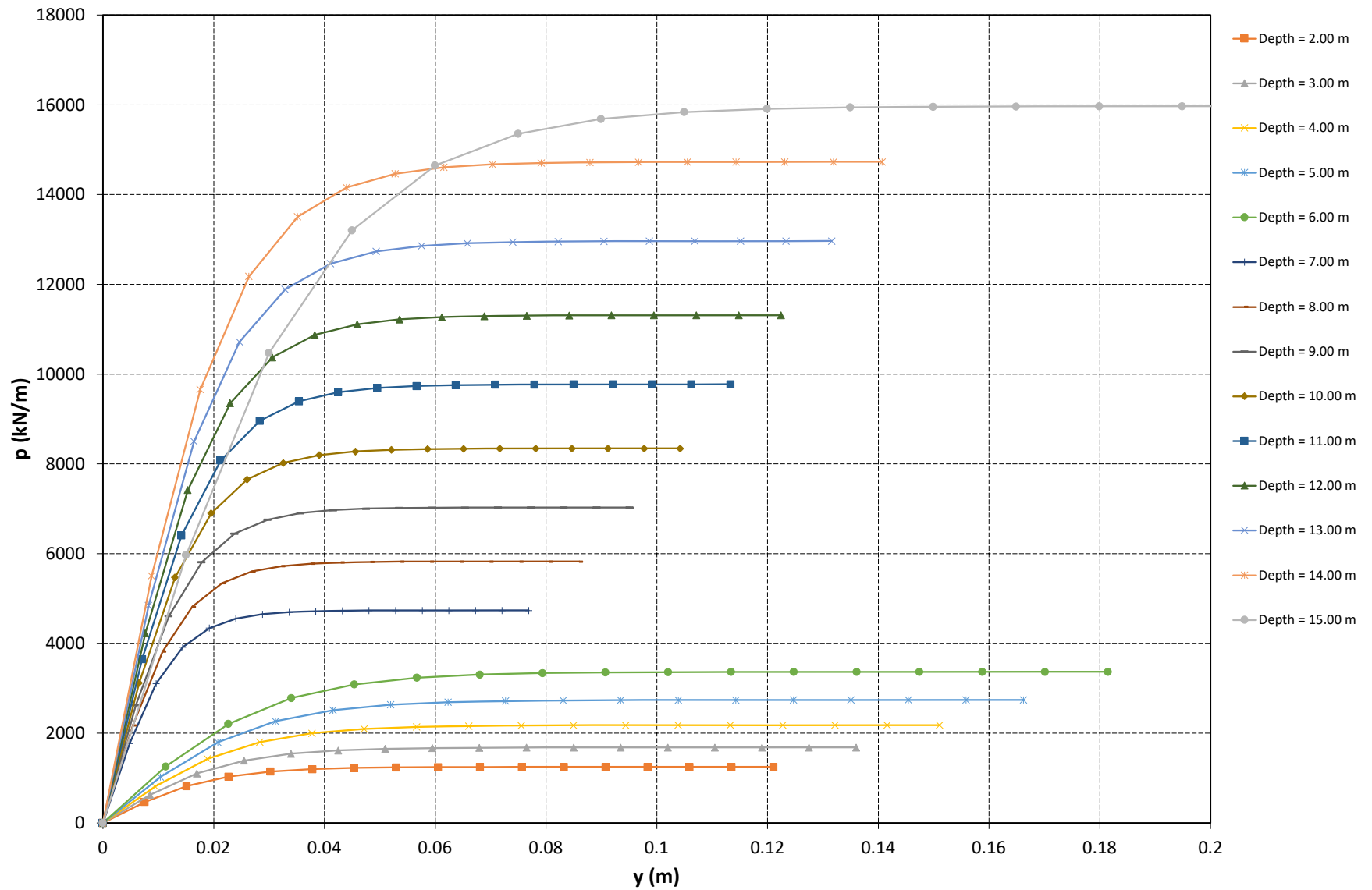
Soil Type	Sand & Gravel		Sand & Gravel		Sand & Gravel		Sand & Gravel		Sand & Gravel		Sand & Gravel (below WT)	
Depth (m)	10		11		12		13		14		15	
Elev. (m)	88		87		86		85		84		83	
S T A T I C	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0	0	0	0	0	0	0	0	0	0	0	0
	0.0065	3118.2	0.0071	3651.6	0.0077	4227.0	0.0082	4844.4	0.0088	5503.8	0.0150	5967.5
	0.0130	5472.2	0.0142	6408.4	0.0153	7418.2	0.0164	8501.7	0.0176	9658.8	0.0300	10472.6
	0.0195	6899.5	0.0213	8079.9	0.0230	9353.2	0.0247	10719.3	0.0264	12178.2	0.0450	13204.3
	0.0261	7653.0	0.0283	8962.3	0.0306	10374.6	0.0329	11889.9	0.0352	13508.2	0.0600	14646.4
	0.0326	8021.9	0.0354	9394.3	0.0383	10874.7	0.0411	12463.0	0.0440	14159.2	0.0750	15352.3
	0.0391	8195.8	0.0425	9597.9	0.0459	11110.4	0.0493	12733.1	0.0528	14466.2	0.0899	15685.0
	0.0456	8276.3	0.0496	9692.2	0.0536	11219.5	0.0576	12858.2	0.0616	14608.3	0.1049	15839.1
	0.0521	8313.3	0.0567	9735.5	0.0612	11269.6	0.0658	12915.6	0.0704	14673.5	0.1199	15909.9
	0.0586	8330.2	0.0638	9755.3	0.0689	11292.5	0.0740	12941.9	0.0791	14703.4	0.1349	15942.2
	0.0652	8337.9	0.0708	9764.3	0.0765	11303.0	0.0822	12953.9	0.0879	14717.0	0.1499	15957.0
	0.0717	8341.4	0.0779	9768.5	0.0842	11307.8	0.0905	12959.4	0.0967	14723.2	0.1649	15963.7
	0.0782	8343.0	0.0850	9770.3	0.0919	11310.0	0.0987	12961.9	0.1055	14726.0	0.1799	15966.8
	0.0847	8343.7	0.0921	9771.2	0.0995	11311.0	0.1069	12963.0	0.1143	14727.3	0.1949	15968.2
	0.0912	8344.1	0.0992	9771.6	0.1072	11311.4	0.1151	12963.5	0.1231	14727.9	0.2099	15968.8
	0.0977	8344.2	0.1063	9771.8	0.1148	11311.6	0.1234	12963.8	0.1319	14728.2	0.2249	15969.1
	0.1042	8344.3	0.1134	9771.9	0.1225	11311.7	0.1316	12963.9	0.1407	14728.3	0.2399	15969.3



L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
East Abutment (BON19-5)
Static Conditions



L-Pile Data for P-Y Curves (1.5m Dia. Caisson)
Bonnechere River Bridge
East Abutment (BON19-5)
Static Conditions





Appendix I.

Slope Stability Analysis Figures

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

CONT No
WP No 4068-09-00

HIGHWAY 17 TWINNING
BONNECHERE RIVER
BRIDGE
ASSESSED SLOPE SECTION LOCATIONS

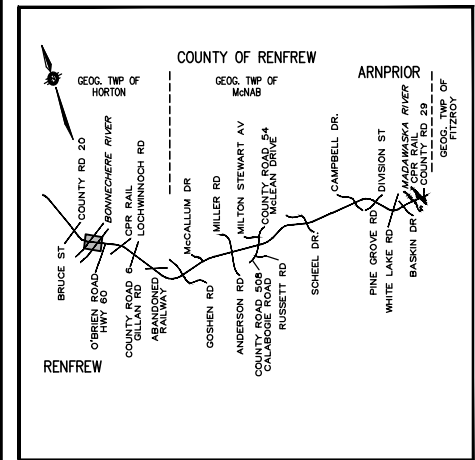


SHEET

Ontario



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 Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
BON19-1	107.1	5 038 613.9	292 296.7
BON19-2	103.0	5 038 599.4	292 321.5
BON19-3	103.0	5 038 587.0	292 358.5
BON19-4	98.9	5 038 442.4	292 616.2
BON19-5	98.9	5 038 435.7	292 610.5
BON19-6	116.9	5 038 422.9	292 651.3
BON19-7	118.0	5 038 407.3	292 674.7
BON19-8	117.7	5 038 384.8	292 718.9
BON19-9	117.8	5 038 365.0	292 751.0
BON-P1	87.9	5 038 552.4	292 418.8
BON-P2	86.1	5 038 497.3	292 506.7
BON-P3	89.2	5 038 469.0	292 562.5

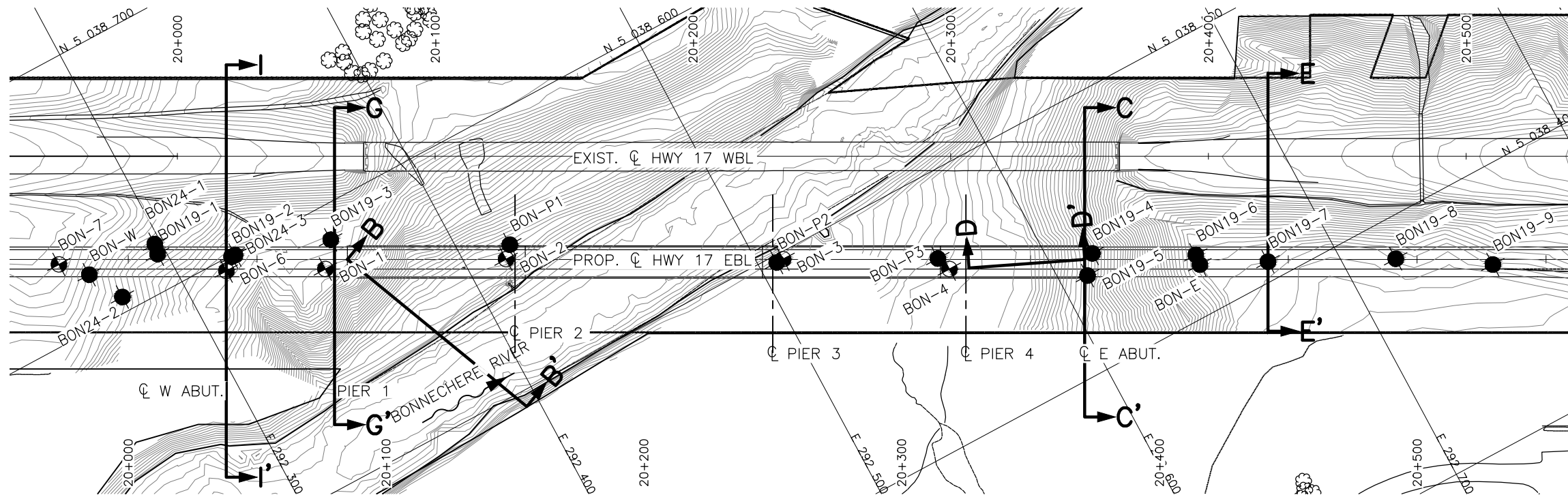
-NOTES-

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

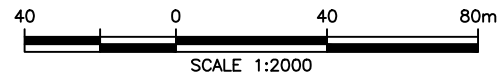
GEORES No. 31F-236

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	JG	CHK	MJK
DRAWN	MFA	CHK	JG
CODE	LOAD	DATE	AUG 2024
SITE	STRUCT	DWG	I1

FILENAME: H:\Drafting\24000\24726\TED-24726-BHPP-BRB.dwg
PLOTDATE: 8/26/2024 12:17 PM

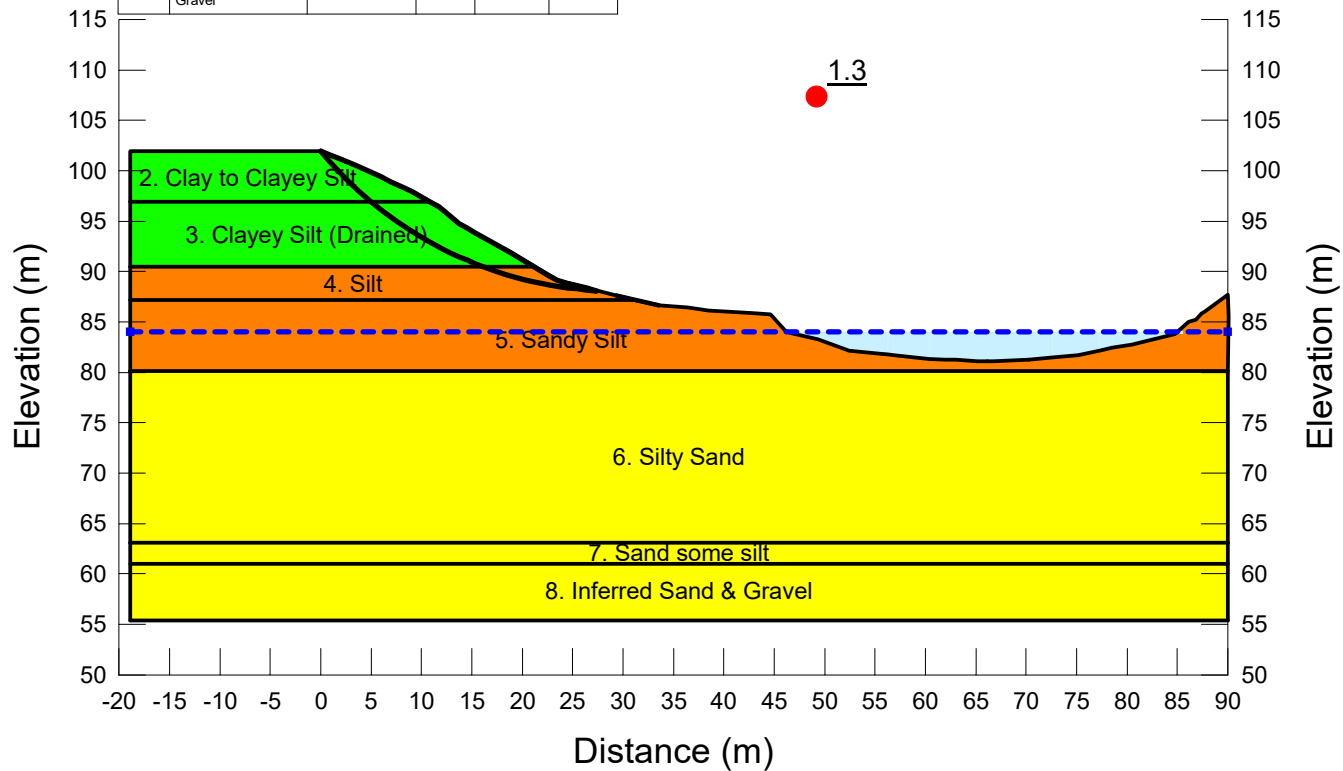


PLAN



BON-E	116.9	5 038 418.8	292 650.9
BON-W	112.0	5 038 619.4	292 269.6
BON-1	102.4	5 038 578.0	292 351.3
BON-2	87.2	5 038 548.1	292 414.8
BON-3	86.1	5 038 497.2	292 509.5
BON-4	89.7	5 038 463.3	292 564.5
BON-6	103.0	5 038 595.5	292 317.1
BON-7	113.0	5 038 628.5	292 261.1
BON24-1	107.8	5 038 617.8	292 297.6
BON24-2	108.5	5 038 605.7	292 276.8
BON24-3	104.0	5 038 599.3	292 323.0

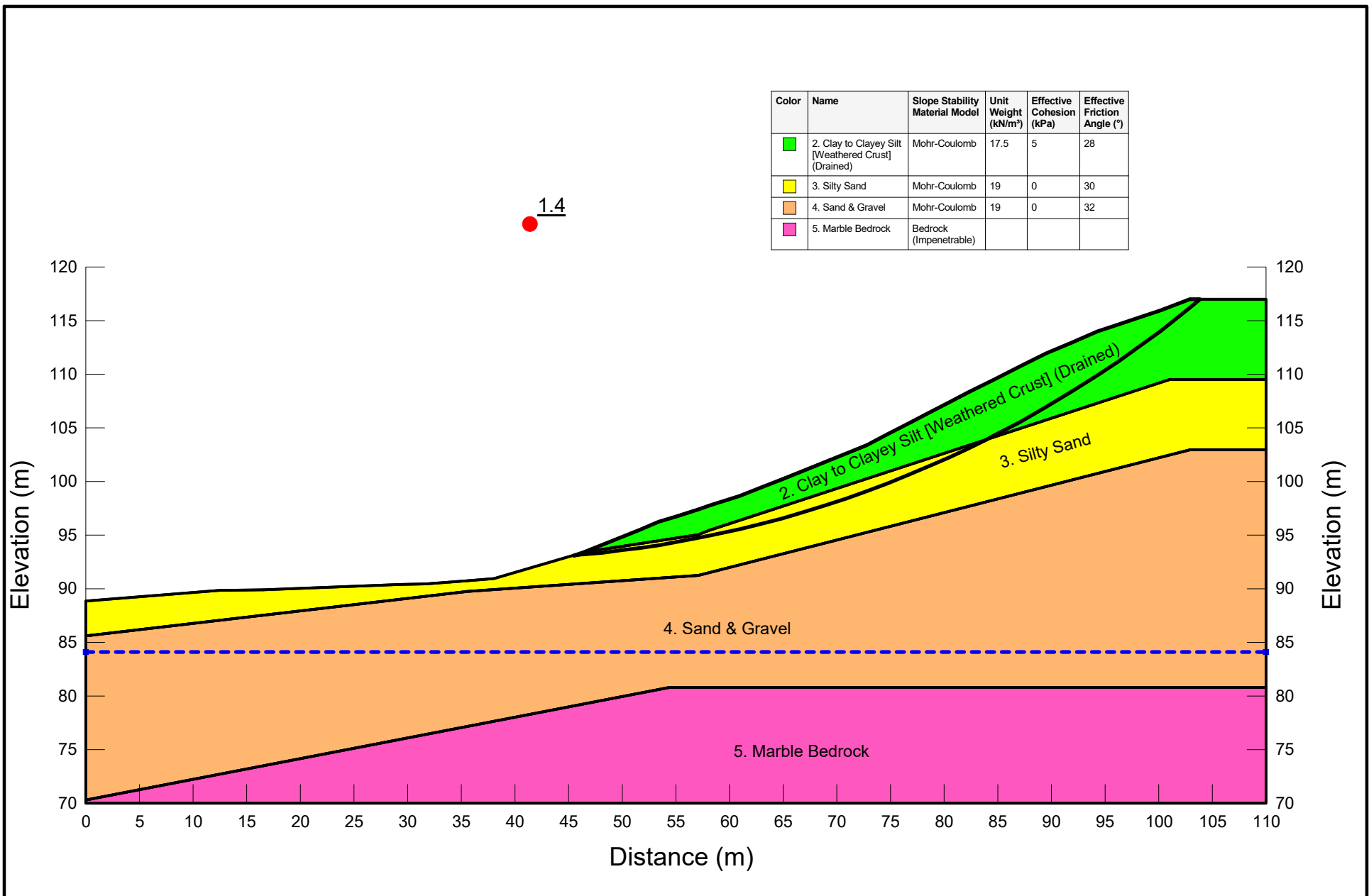
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	2. Clay to Clayey Silt [Weathered Crust] (Drained)	Mohr-Coulomb	17.5	5	28
■	3. Clayey Silt (Drained)	Mohr-Coulomb	17.5	5	28
■	4. Silt	Mohr-Coulomb	21	0	30
■	5. Sandy Silt	Mohr-Coulomb	21	0	30
■	6. Silty Sand	Mohr-Coulomb	21	0	32
■	7. Sand some silt	Mohr-Coulomb	21	0	32
■	8. Inferred Sand & Gravel	Mohr-Coulomb	21	0	35



Project		
Bonnechere River Bridge, West Bank, Sta. 20+085		
Analysis		
1.1 Permanent (Long Term)		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2023/09/06, 03:27:41 PM	1:750

Additional Details
 Name: Riverbank Slope, Existing (B-B')
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (0, 101.92) m, Exit: (27.351068, 88.090285) m
 Center: (29.591484, 126.48216) m, Radius: 38.457195 m

Figure I1.1




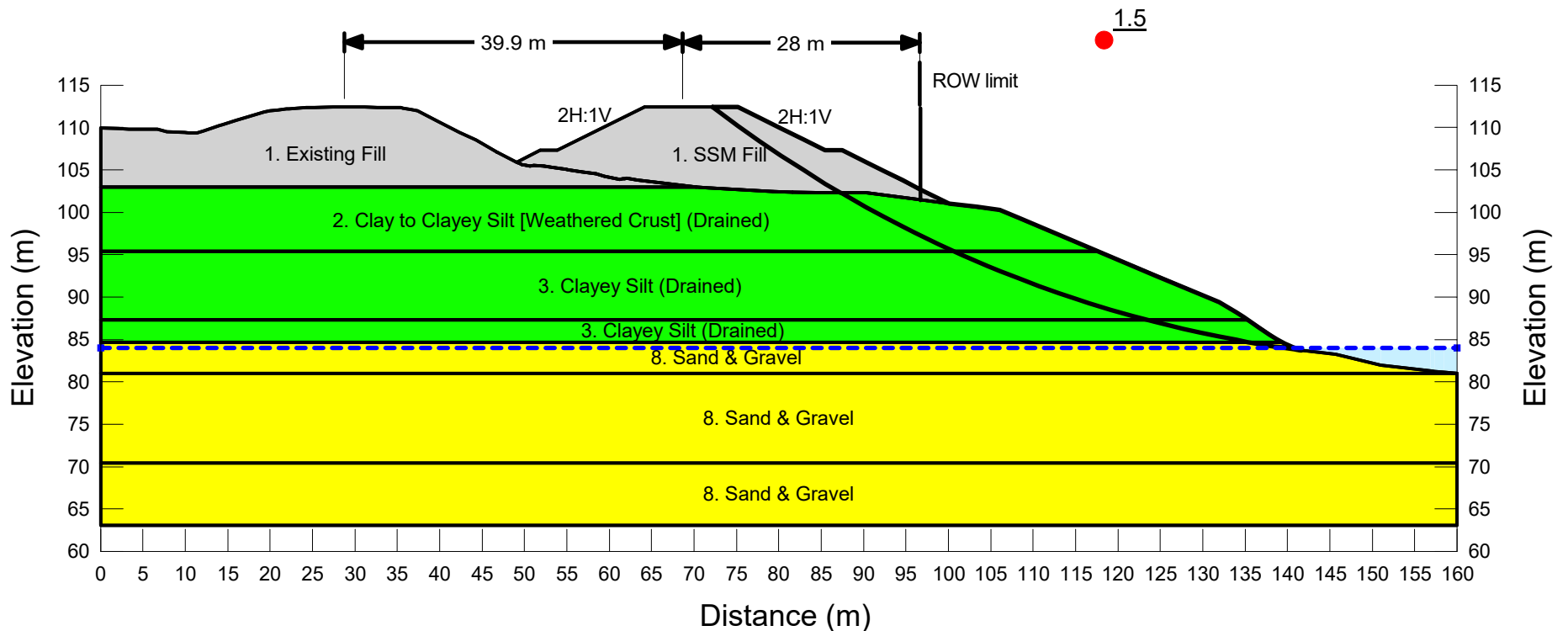
	Project			Additional Details		
	Bonnechere River Bridge, East Abut., Sta. 20+371			Name: Existing Slope (D-D')		
	Analysis			Comments: Slope Stability Assessment		
	1. Permanent (Long Term)			Method: Morgenstern-Price, Half-Sine		
	Seismic Coefficient			Minimum Slip Surface Depth: 1.52 m		
	H: 0g, V: 0g		Last Run		Entry: (103.84667, 116.956) m, Exit: (45.50209, 93.099106) m	
			2023/09/06, 03:32:52 PM		Center: (36.976744, 197.22113) m, Radius: 104.47047 m	
			Scale		1:500	

Figure I1.2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	1. Existing Fill	Mohr-Coulomb	21	0	32
■	1. SSM Fill	Mohr-Coulomb	21	0	32
■	2. Clay to Clayey Silt [Weathered Crust] (Drained)	Mohr-Coulomb	17.5	5	28
■	3. Clayey Silt (Drained)	Mohr-Coulomb	17.5	5	28
■	8. Sand & Gravel	Mohr-Coulomb	21	0	35



Project		
Bonnechere River Bridge, West Abut., Sta. 20+038		
Analysis		
1. Permanent (Long Term) (SSM)		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	06/15/2022, 12:34:24 PM	1:750

Additional Details

Name: 2H:1V SSM Embankment Side Slope (I-I')

Comments: Slope Stability Assessment






Method: Morgenstern-Price, Half-Sine

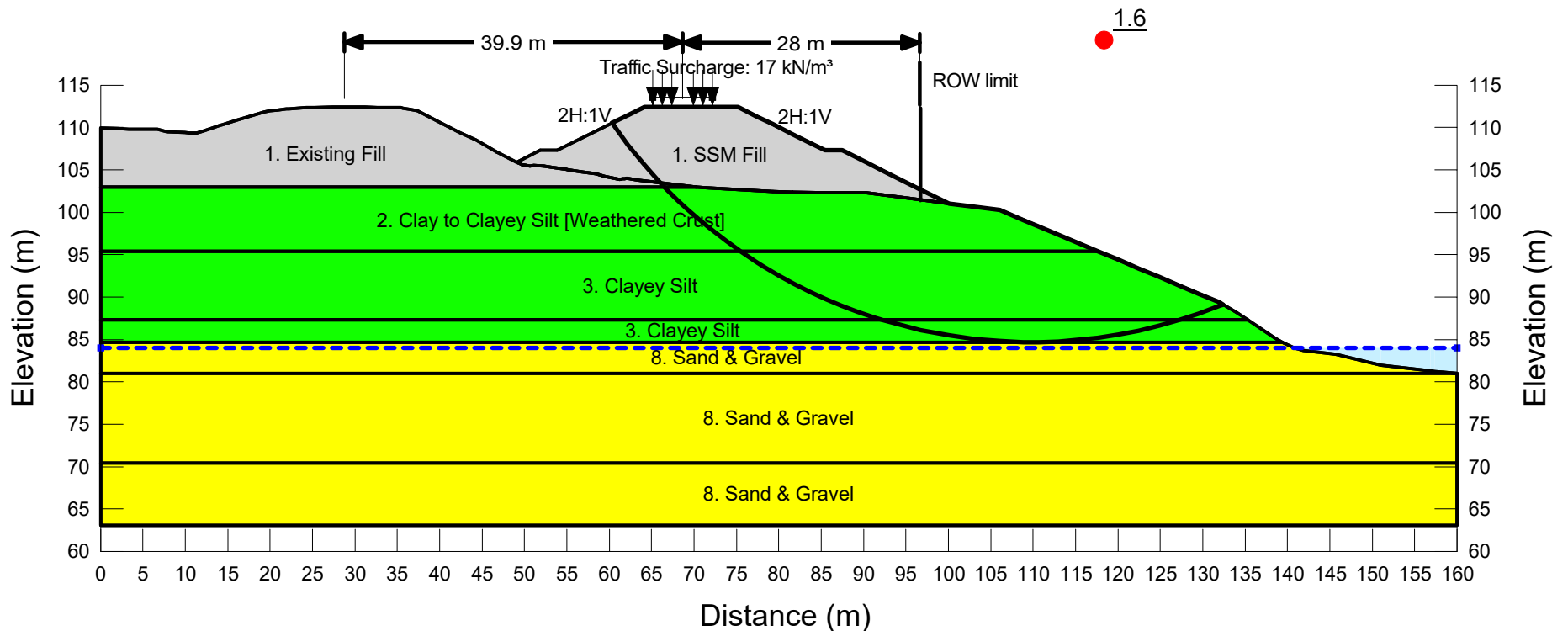
Minimum Slip Surface Depth: 1.52 m

Entry: (72.15, 112.443) m, Exit: (141.65087, 83.731525) m

Center: (160.53884, 227.92787) m, Radius: 145.42813 m

Figure I2.1

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1. Existing Fill	Mohr-Coulomb	21	0	32
	1. SSM Fill	Mohr-Coulomb	21	0	32
	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
	3. Clayey Silt	Mohr-Coulomb	17.5	100	0
	8. Sand & Gravel	Mohr-Coulomb	21	0	35



Project		
Bonnechere River Bridge, West Abut., Sta. 20+038		
Analysis		
2. Temp (Short Term) Traffic (SSM)		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	06/15/2022, 12:34:42 PM	1:750

Additional Details

Name: 2H:1V SSM Embankment Side Slope (I-I')

Comments: Slope Stability Assessment






Method: Morgenstern-Price, Half-Sine

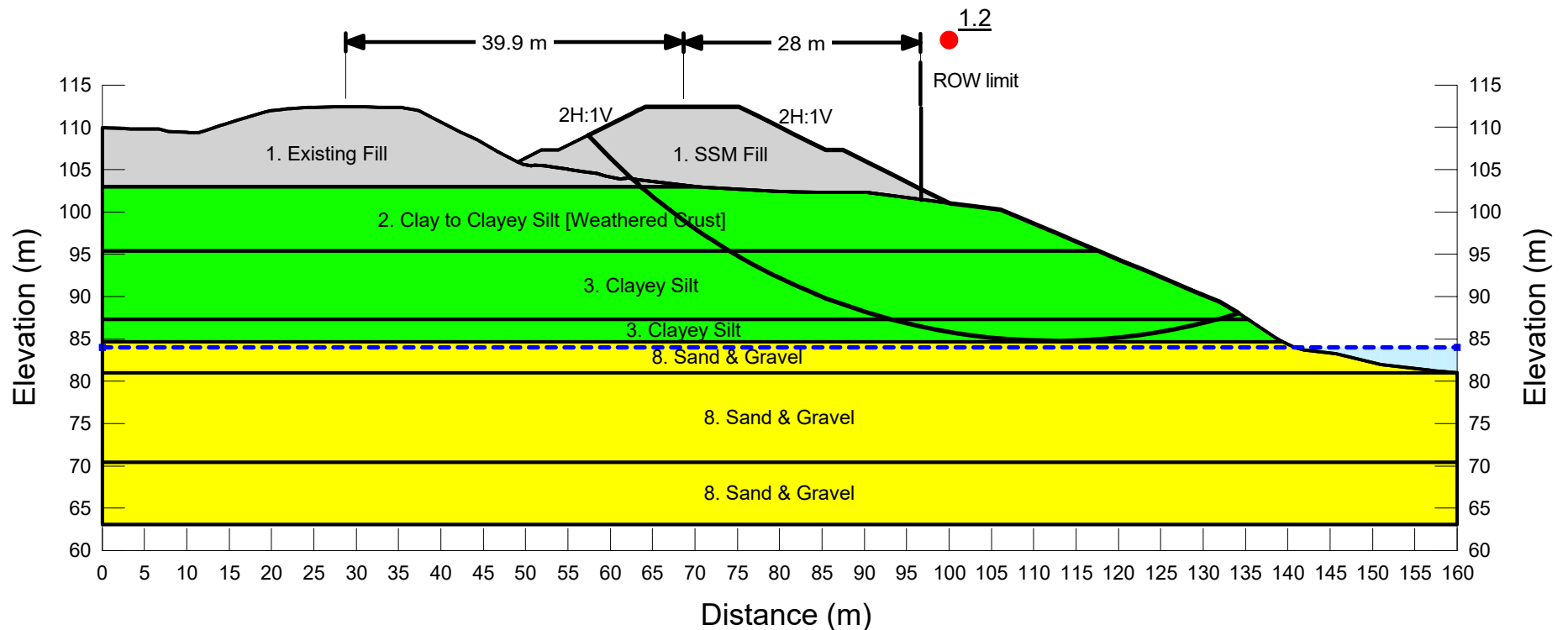
Minimum Slip Surface Depth: 1.52 m

Entry: (60.306343, 110.52533) m, Exit: (132.37506, 89.118111) m

Center: (109.72476, 144.87998) m, Radius: 60.186556 m

Figure I2.2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1. Existing Fill	Mohr-Coulomb	21	0	32
	1. SSM Fill	Mohr-Coulomb	21	0	32
	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
	3. Clayey Silt	Mohr-Coulomb	17.5	100	0
	8. Sand & Gravel	Mohr-Coulomb	21	0	35



Project		
Bonnechere River Bridge, West Abut., Sta. 20+038		
Analysis		
3. Temp (Short Term) Pseudo-Static (2,475 yr EQ) (SSM)		
Seismic Coefficient	Last Run	Scale
H: 0.13g, V: 0g	06/15/2022, 12:34:42 PM	1:750

Additional Details

Name: 2H:1V SSM Embankment Side Slope (I-I')

Comments: Slope Stability Assessment






Method: Morgenstern-Price, Half-Sine

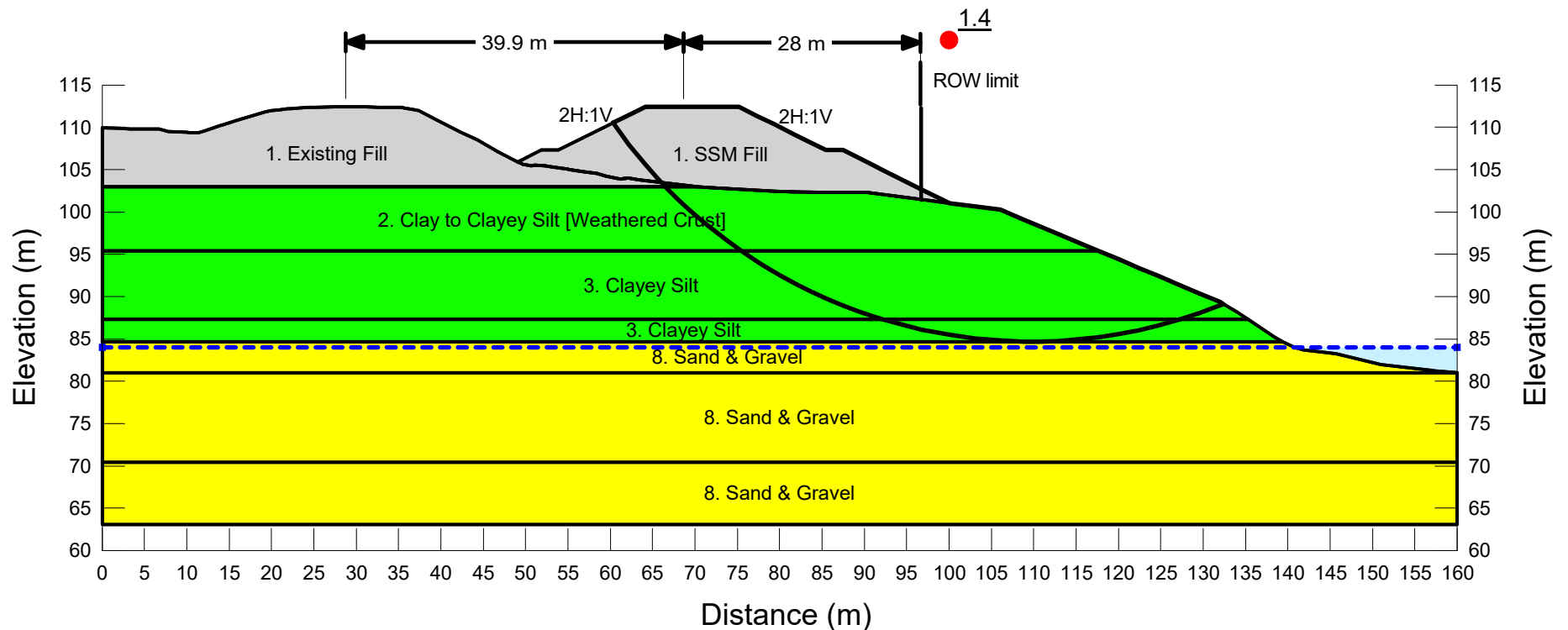
Minimum Slip Surface Depth: 1.52 m

Entry: (57.372303, 109.06187) m, Exit: (134.17119, 88.037411) m

Center: (112.37516, 159.19918) m, Radius: 74.424893 m

Figure I2.3

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1. Existing Fill	Mohr-Coulomb	21	0	32
	1. SSM Fill	Mohr-Coulomb	21	0	32
	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
	3. Clayey Silt	Mohr-Coulomb	17.5	100	0
	8. Sand & Gravel	Mohr-Coulomb	21	0	35



Project		
Bonnechere River Bridge, West Abut., Sta. 20+038		
Analysis		
4. Temp (Short Term) Pseudo-Static (475 yr EQ) (SSM)		
Seismic Coefficient	Last Run	Scale
H: 0.05g, V: 0g	06/15/2022, 12:34:43 PM	1:750

Additional Details

Name: 2H:1V SSM Embankment Side Slope (I-I')

Comments: Slope Stability Assessment






Method: Morgenstern-Price, Half-Sine

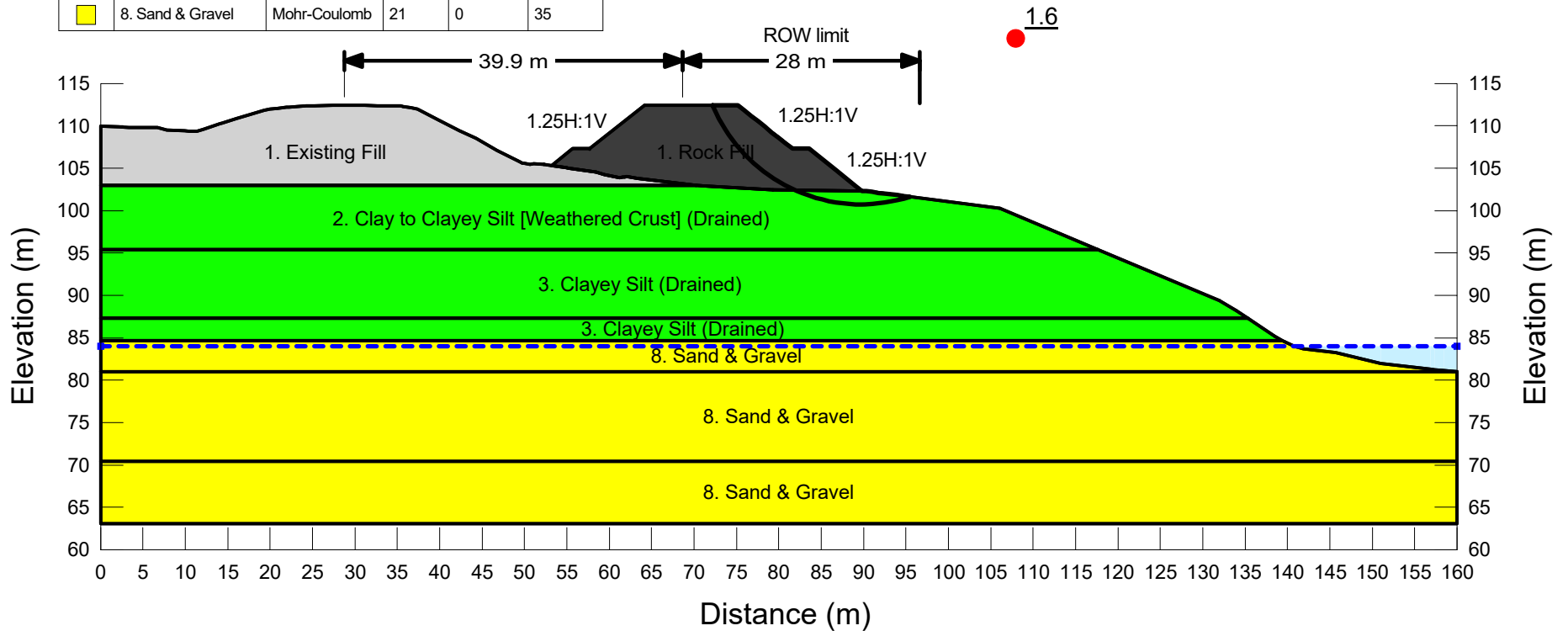
Minimum Slip Surface Depth: 1.52 m

Entry: (60.306343, 110.52533) m, Exit: (132.37506, 89.118111) m

Center: (109.72476, 144.87998) m, Radius: 60.186556 m

Figure I2.4






Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1. Existing Fill	Mohr-Coulomb	21	0	32
	1. Rock Fill	Mohr-Coulomb	20	0	42
	2. Clay to Clayey Silt [Weathered Crust] (Drained)	Mohr-Coulomb	17.5	5	28
	3. Clayey Silt (Drained)	Mohr-Coulomb	17.5	5	28
	8. Sand & Gravel	Mohr-Coulomb	21	0	35

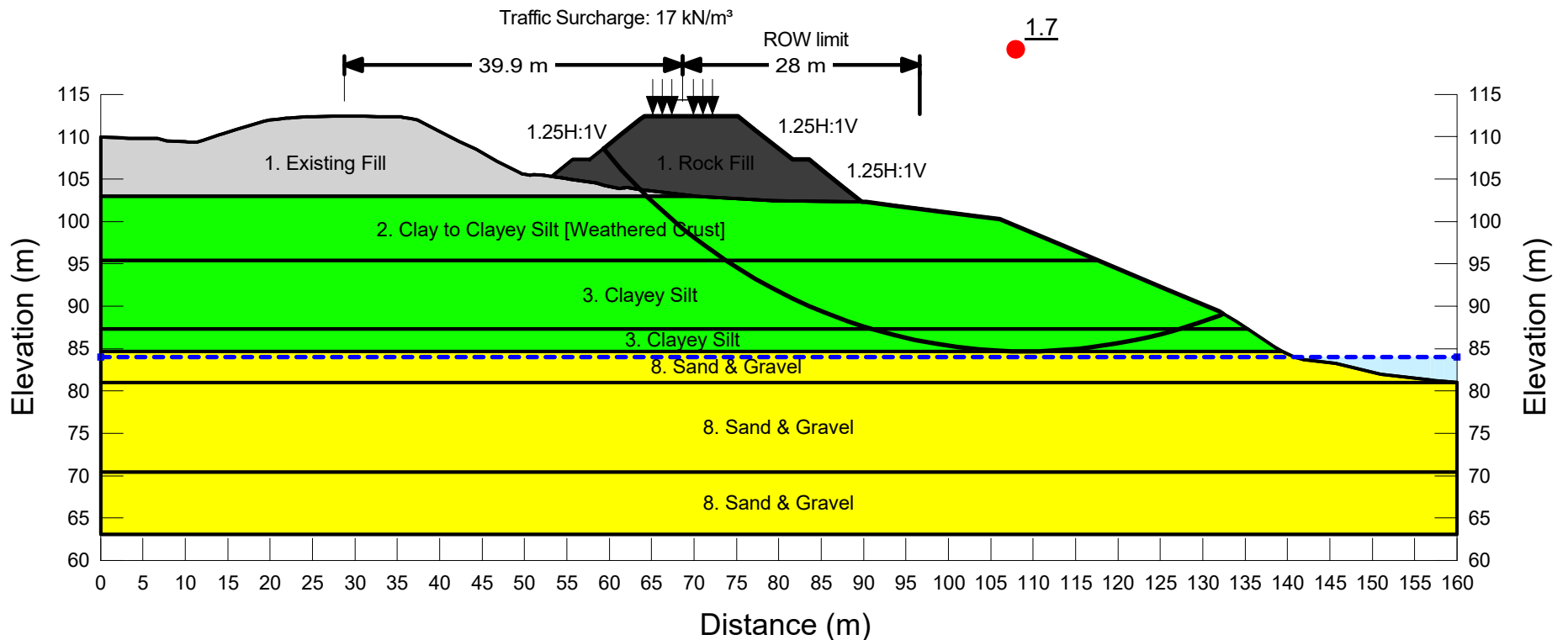


Project		
Bonnechere River Bridge, West Abut., Sta. 20+038		
Analysis		
1. Permanent (Long Term) (RF)		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2022-05-13, 03:16:01 PM	1:750

Additional Details	
Name: 1.25H:1V Rock Fill Embankment Side Slope (I-I')	
Comments: Slope Stability Assessment	
Method: Morgenstern-Price, Half-Sine	
Minimum Slip Surface Depth: 1.52 m	
Entry: (72.15, 112.443) m, Exit: (95.510327, 101.62708) m	
Center: (89.7397, 119.79851) m, Radius: 19.065704 m	

Figure I3.1






Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1. Existing Fill	Mohr-Coulomb	21	0	32
	1. Rock Fill	Mohr-Coulomb	20	0	42
	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
	3. Clayey Silt	Mohr-Coulomb	17.5	100	0
	8. Sand & Gravel	Mohr-Coulomb	21	0	35

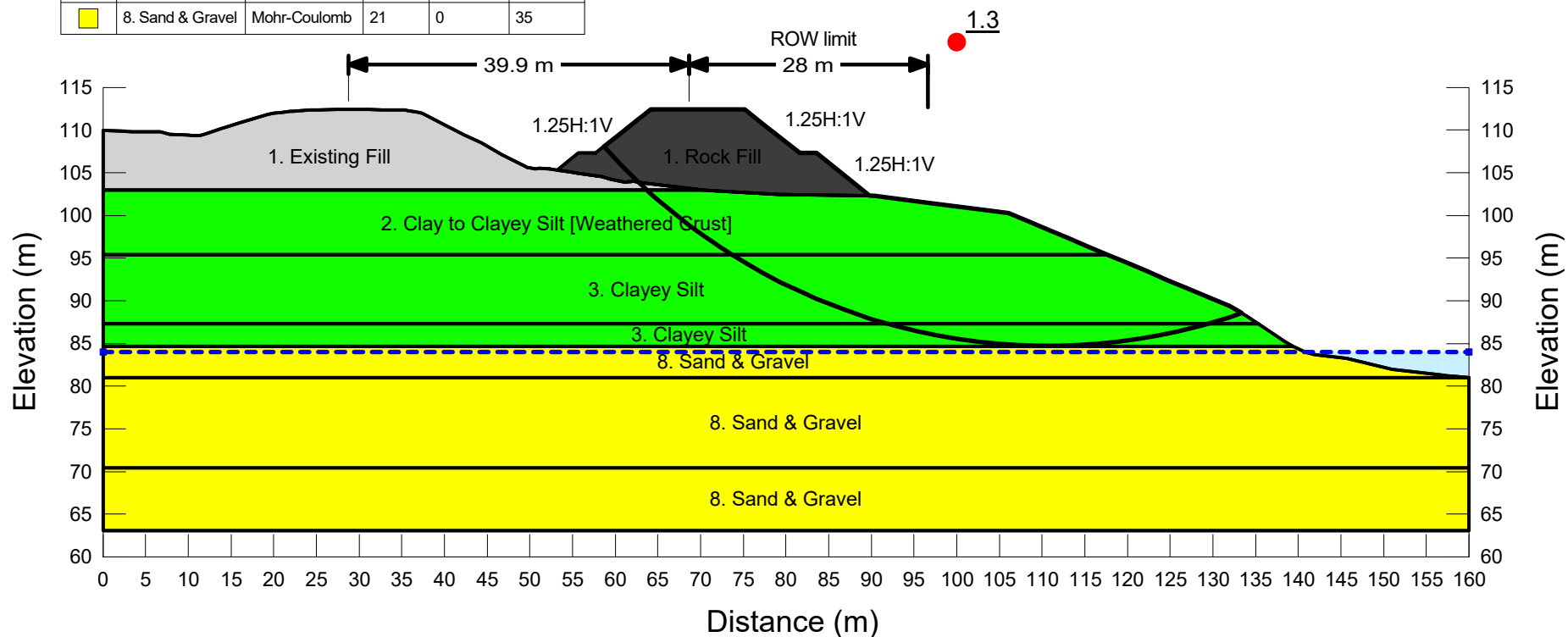


Project Bonnechere River Bridge, West Abut., Sta. 20+038		
Analysis 2. Temp (Short Term) Traffic (RF)		
Seismic Coefficient H: 0g, V: 0g	Last Run 2022-05-13, 03:18:00 PM	Scale 1:750

Additional Details
 Name: 1.25H:1V Rock Fill Embankment Side Slope (I-I')
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (59.34529, 108.59753) m, Exit: (132.41605, 89.093746) m
 Center: (109.10979, 148.40842) m, Radius: 63.729211 m

Figure I3.2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1. Existing Fill	Mohr-Coulomb	21	0	32
	1. Rock Fill	Mohr-Coulomb	20	0	42
	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
	3. Clayey Silt	Mohr-Coulomb	17.5	100	0
	8. Sand & Gravel	Mohr-Coulomb	21	0	35

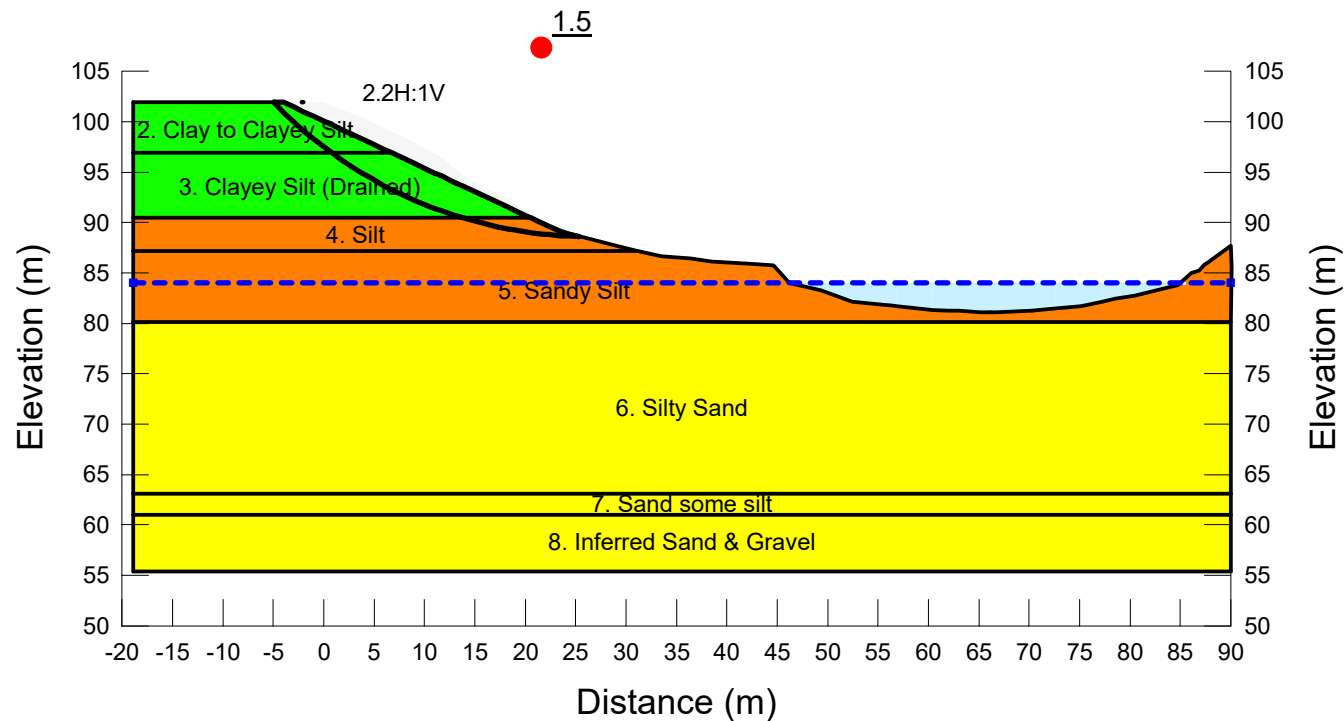


Project		
Bonnechere River Bridge, West Abut., Sta. 20+038		
Analysis		
3. Temp (Short Term) Pseudo-Static (2,475 yr EQ) (RF)		
Seismic Coefficient	Last Run	Scale
H: 0.13g, V: 0g	2022-05-13, 03:18:00 PM	1:750

Additional Details	
Name: 1.25H:1V Rock Fill Embankment Side Slope (I-I')	
Comments: Slope Stability Assessment	
Method: Morgenstern-Price, Half-Sine	
Minimum Slip Surface Depth: 1.52 m	
Entry: (58.675514, 108.06159) m, Exit: (133.35374, 88.536385) m	
Center: (110.66376, 154.32767) m, Radius: 69.594022 m	

Figure I3.3

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	2. Clay to Clayey Silt [Weathered Crust] (Drained)	Mohr-Coulomb	17.5	5	28
■	3. Clayey Silt (Drained)	Mohr-Coulomb	17.5	5	28
■	4. Silt	Mohr-Coulomb	21	0	30
■	5. Sandy Silt	Mohr-Coulomb	21	0	30
■	6. Silty Sand	Mohr-Coulomb	21	0	32
■	7. Sand some silt	Mohr-Coulomb	21	0	32
■	8. Inferred Sand & Gravel	Mohr-Coulomb	21	0	35

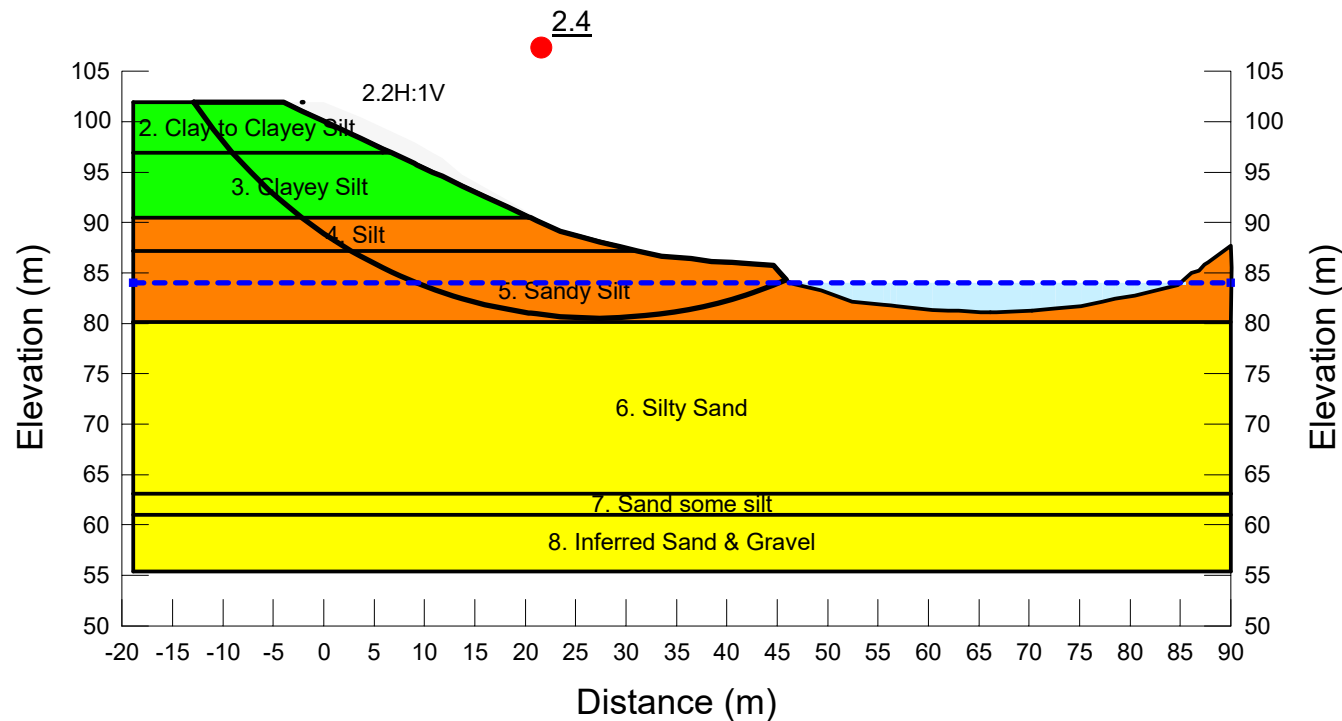


Project		
Bonnechere River Bridge, West Bank, Sta. 20+085		
Analysis		
2.1 Permanent (Long Term)		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2023/09/06, 03:27:44 PM	1:750

Additional Details
 Name: Riverbank Slope, Flattened (B-B')
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (-4.9916, 101.92) m, Exit: (25.317654, 88.610461) m
 Center: (26.378323, 132.19164) m, Radius: 43.594087 m

Figure I4.1

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
■	3. Clayey Silt	Mohr-Coulomb	17.5	100	0
■	4. Silt	Mohr-Coulomb	21	0	30
■	5. Sandy Silt	Mohr-Coulomb	21	0	30
■	6. Silty Sand	Mohr-Coulomb	21	0	32
■	7. Sand some silt	Mohr-Coulomb	21	0	32
■	8. Inferred Sand & Gravel	Mohr-Coulomb	21	0	35

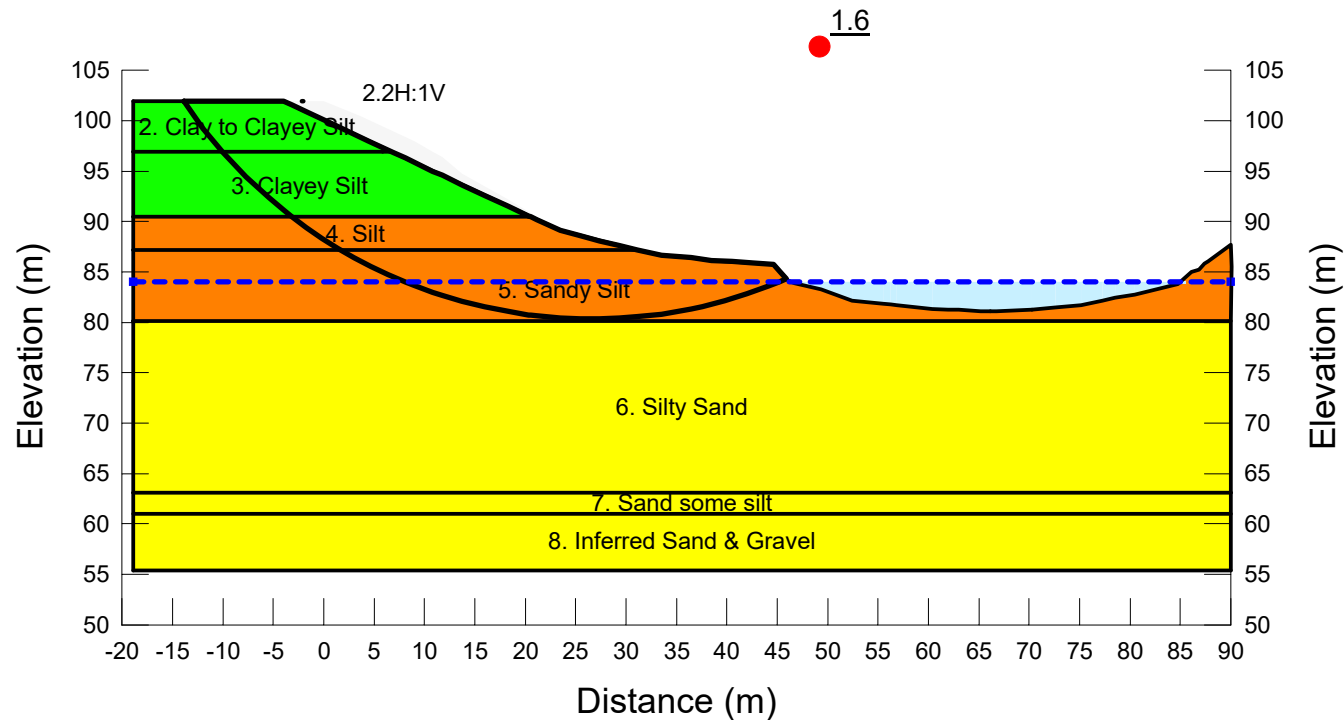


Project		
Bonnechere River Bridge, West Bank, Sta. 20+085		
Analysis		
2.2 Temp (Short Term) Traffic		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2023/09/06, 03:27:49 PM	1:750

Additional Details
 Name: Riverbank Slope, Flattened (B-B')
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (-12.9244, 101.92) m, Exit: (45.90603, 84.3) m
 Center: (27.18761, 128.82493) m, Radius: 48.29957 m

Figure I4.2






Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
■	3. Clayey Silt	Mohr-Coulomb	17.5	100	0
■	4. Silt	Mohr-Coulomb	21	0	30
■	5. Sandy Silt	Mohr-Coulomb	21	0	30
■	6. Silty Sand	Mohr-Coulomb	21	0	32
■	7. Sand some silt	Mohr-Coulomb	21	0	32
■	8. Inferred Sand & Gravel	Mohr-Coulomb	21	0	35

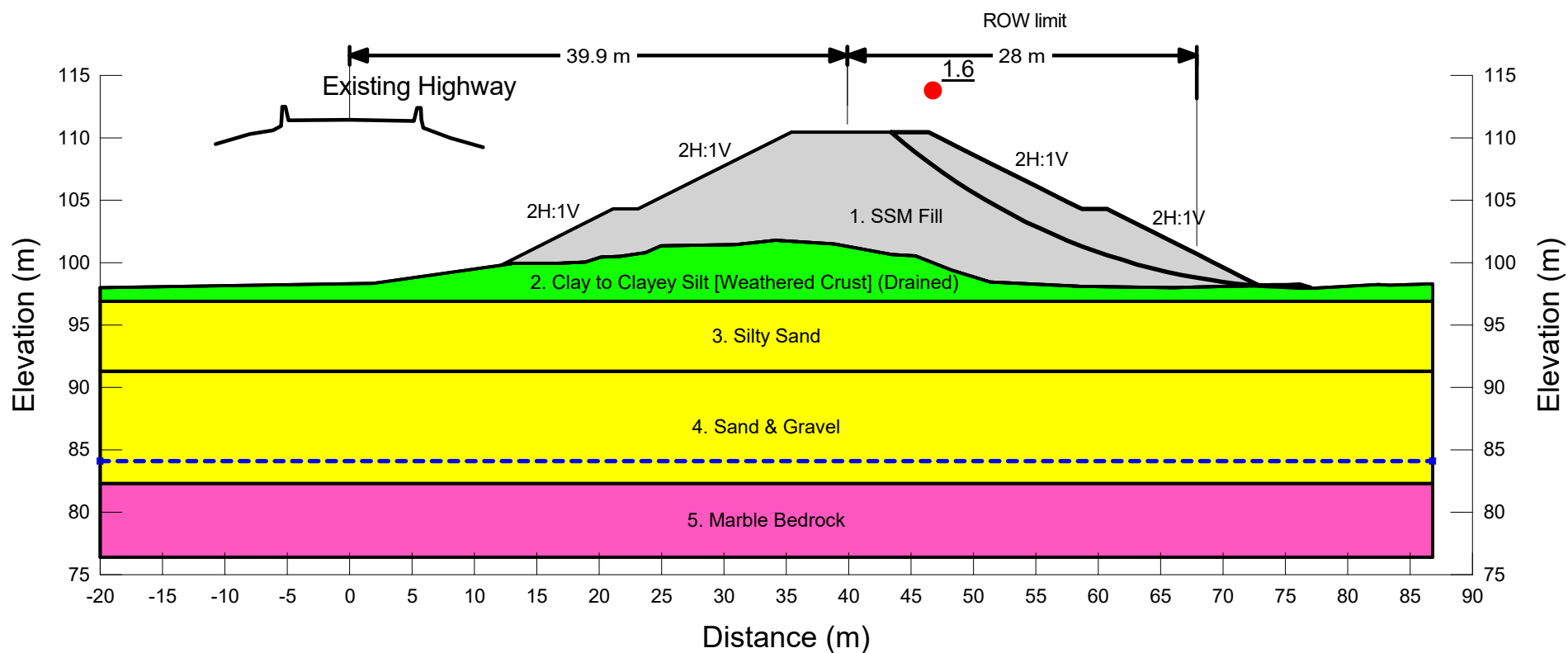


Project		
Bonnechere River Bridge, West Bank, Sta. 20+085		
Analysis		
2.3 Temp (Short Term) Pseudo-Static (2,475 yr EQ)		
Seismic Coefficient	Last Run	Scale
H: 0.13g, V: 0g	2023/09/06, 03:27:49 PM	1:750

Additional Details	
Name: Riverbank Slope, Flattened (B-B')	
Comments: Slope Stability Assessment	
Method: Morgenstern-Price, Half-Sine	
Minimum Slip Surface Depth: 1.52 m	
Entry: (-13.916, 101.92) m, Exit: (45.90603, 84.3) m	
Center: (26.625981, 129.20341) m, Radius: 48.867544 m	

Figure I4.3

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1. SSM Fill	Mohr-Coulomb	21	0	32
	2. Clay to Clayey Silt [Weathered Crust] (Drained)	Mohr-Coulomb	17.5	5	28
	3. Silty Sand	Mohr-Coulomb	19	0	30
	4. Sand & Gravel	Mohr-Coulomb	19	0	35
	5. Marble Bedrock	Bedrock (Impenetrable)			



Project		
Bonnechere River Bridge, East Abut., Sta. 21+371		
Analysis		
1. Permanent (Long Term) (SSM)		
Seismic Coefficient	Last Run	
H: 0g, V: 0g	06/15/2022, 01:05:49 PM	
	1:500	

Additional Details

Name: 2H:1V SSM Embankment Side Slope (C-C')

Comments: Slope Stability Assessment

Method: Morgenstern-Price, Half-Sine

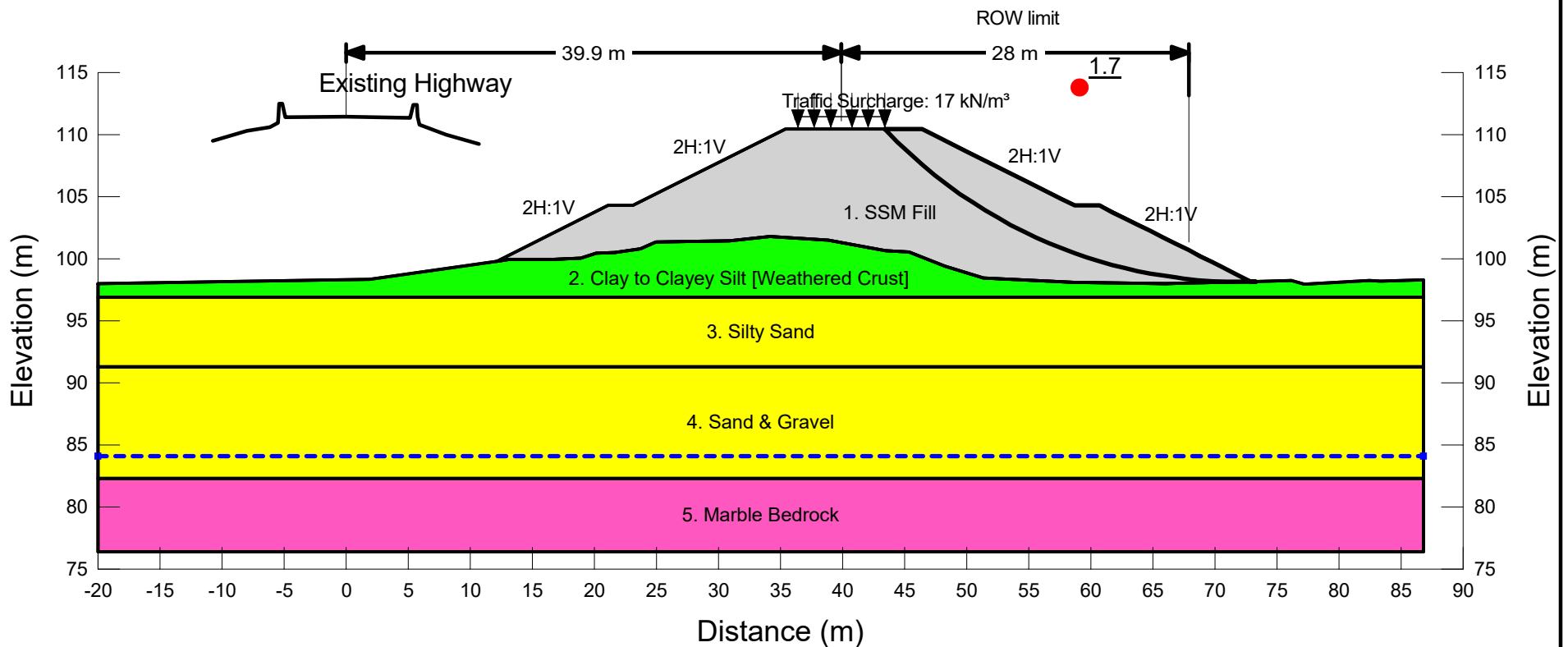
Minimum Slip Surface Depth: 1.52 m

Entry: (43.4, 110.42) m, Exit: (77.017272, 97.981021) m

Center: (76.780538, 148.98732) m, Radius: 51.006847 m

Figure I5.1

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
Grey	1. SSM Fill	Mohr-Coulomb	21	0	32
Green	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
Yellow	3. Silty Sand	Mohr-Coulomb	19	0	30
Yellow	4. Sand & Gravel	Mohr-Coulomb	19	0	35
Pink	5. Marble Bedrock	Bedrock (Impenetrable)			



Project		
Bonnechere River Bridge, East Abut., Sta. 21+371		
Analysis		
2. Temp (Short Term) Traffic (SSM)		
Seismic Coefficient	Last Run	
H: 0g, V: 0g	06/15/2022, 01:07:32 PM	
	1:500	

Additional Details

Name: 2H:1V SSM Embankment Side Slope (C-C')

Comments: Slope Stability Assessment

Method: Morgenstern-Price, Half-Sine

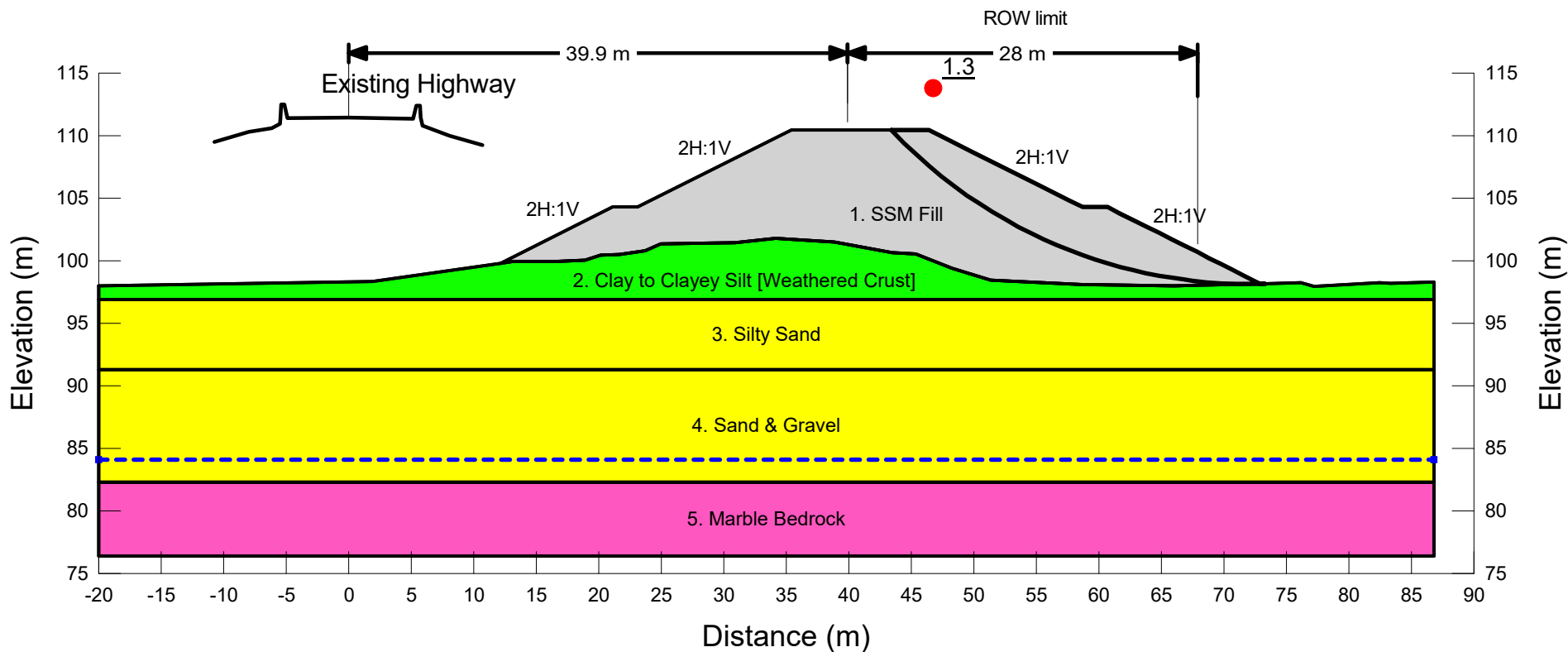
Minimum Slip Surface Depth: 1.52 m

Entry: (43.4, 110.42) m, Exit: (73.3, 98.145025) m

Center: (71.995065, 137.51985) m, Radius: 39.39644 m

Figure I5.2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
Grey	1. SSM Fill	Mohr-Coulomb	21	0	32
Green	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
Yellow	3. Silty Sand	Mohr-Coulomb	19	0	30
Yellow	4. Sand & Gravel	Mohr-Coulomb	19	0	35
Pink	5. Marble Bedrock	Bedrock (Impenetrable)			

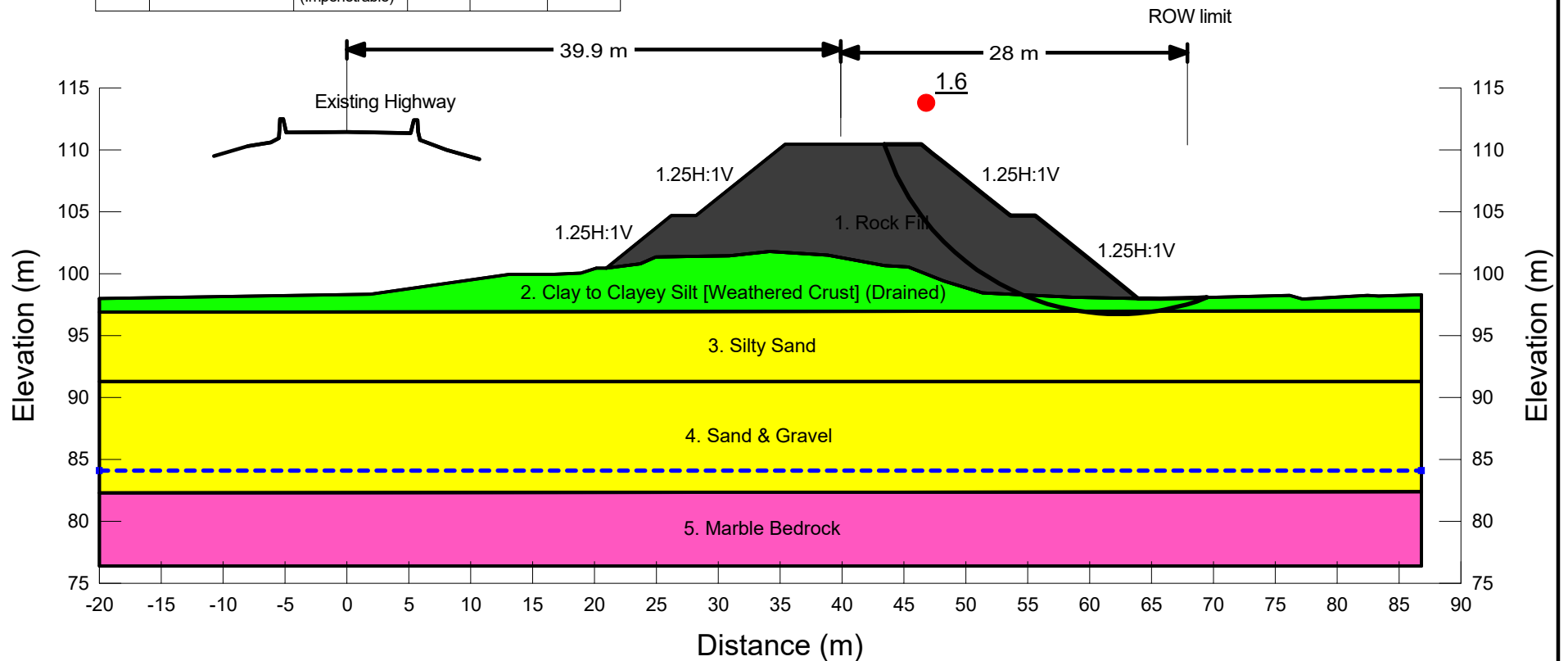


Project Bonnechere River Bridge, East Abut., Sta. 21+371		
Analysis 3. Temp (Short Term) Pseudo-Static (2,475 yr EQ) (SSM)		
Seismic Coefficient H: 0.13g, V: 0g	Last Run 06/15/2022, 01:07:33 PM	1:500

Additional Details
 Name: 2H:1V SSM Embankment Side Slope (C-C')
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (43.4, 110.42) m, Exit: (73.3, 98.145025) m
 Center: (71.995065, 137.51985) m, Radius: 39.39644 m

Figure I5.3

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	1. Rock Fill	Mohr-Coulomb	20	0	42
■	2. Clay to Clayey Silt [Weathered Crust] (Drained)	Mohr-Coulomb	17.5	5	28
■	3. Silty Sand	Mohr-Coulomb	19	0	30
■	4. Sand & Gravel	Mohr-Coulomb	19	0	35
■	5. Marble Bedrock	Bedrock (Impenetrable)			



Project		
Bonnechere River Bridge, East Abut., Sta. 20+371		
Analysis		
1. Permanent (Long Term) (RF)		
Seismic Coefficient	Last Run	
H: 0g, V: 0g	2022-04-26, 03:46:20 PM	
	1:500	

Additional Details

Name: 1.25H:1V Rock Fill Embankment Side Slope (C-C')

Comments: Slope Stability Assessment

Method: Morgenstern-Price, Half-Sine

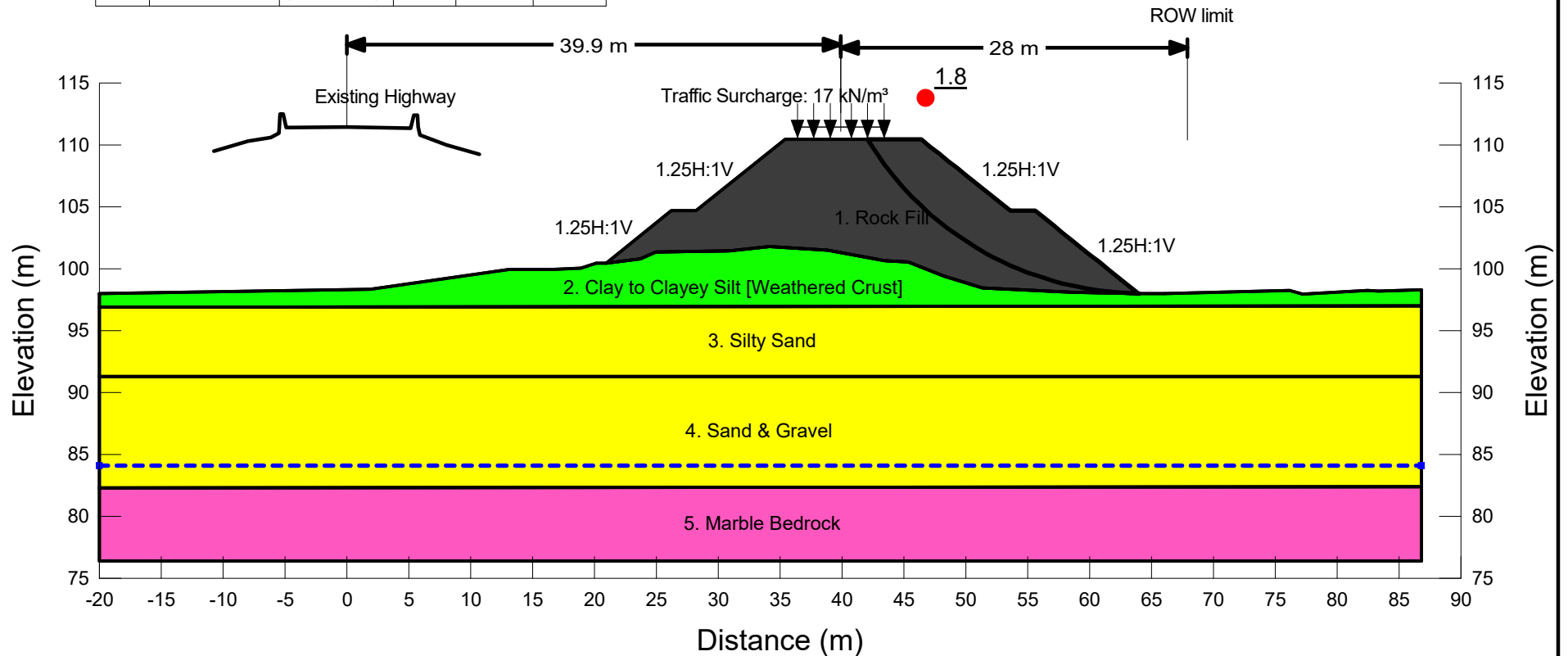
Minimum Slip Surface Depth: 1.52 m

Entry: (43.4, 110.42) m, Exit: (69.4905, 98.057965) m

Center: (62.298117, 116.59166) m, Radius: 19.880348 m

Figure I6.1

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	1. Rock Fill	Mohr-Coulomb	20	0	42
■	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
■	3. Silty Sand	Mohr-Coulomb	19	0	30
■	4. Sand & Gravel	Mohr-Coulomb	19	0	35
■	5. Marble Bedrock	Bedrock (Impenetrable)			



Project		
Bonnechere River Bridge, East Abut., Sta. 20+371		
Analysis		
2. Temp (Short Term) Traffic (RF)		
Seismic Coefficient	Last Run	
H: 0g, V: 0g	2022-04-26, 03:47:24 PM	
	1:500	

Additional Details

Name: 1.25H:1V Rock Fill Embankment Side Slope (C-C')

Comments: Slope Stability Assessment

Method: Morgenstern-Price, Half-Sine

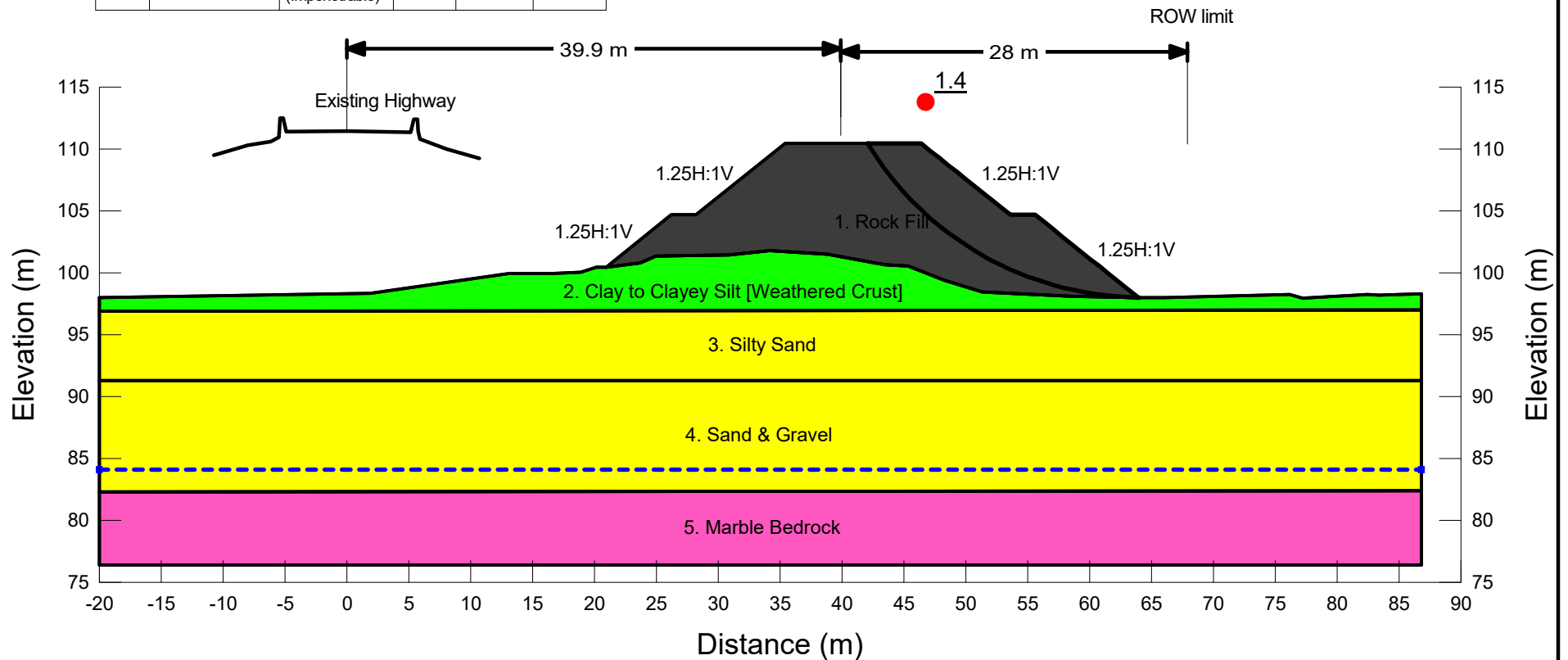
Minimum Slip Surface Depth: 1.52 m

Entry: (42.058438, 110.42) m, Exit: (64.01, 97.999025) m

Center: (64.16592, 123.88254) m, Radius: 25.883987 m

Figure I6.2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	1. Rock Fill	Mohr-Coulomb	20	0	42
■	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
■	3. Silty Sand	Mohr-Coulomb	19	0	30
■	4. Sand & Gravel	Mohr-Coulomb	19	0	35
■	5. Marble Bedrock	Bedrock (Impenetrable)			

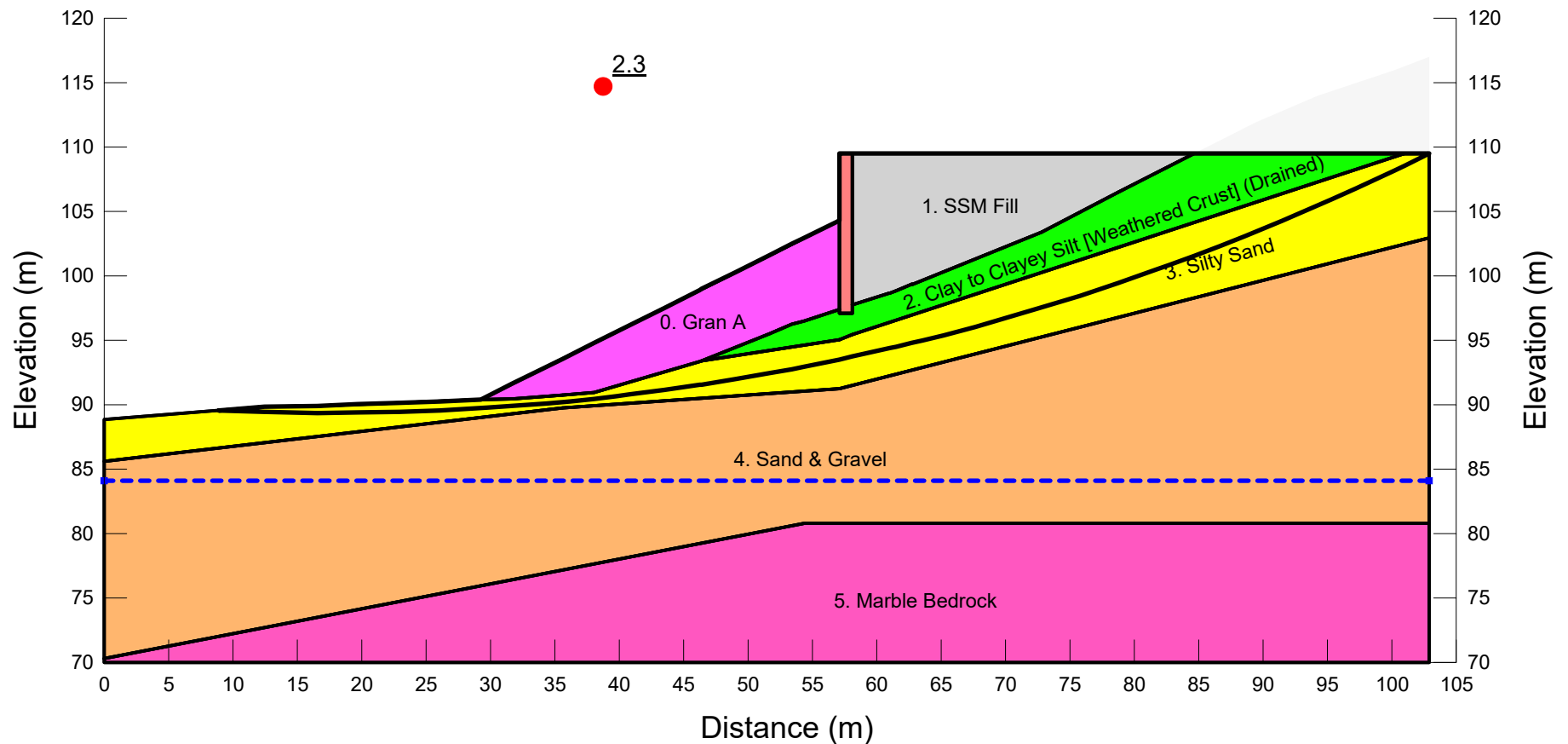


Project		
Bonnechere River Bridge, East Abut., Sta. 20+371		
Analysis		
3. Temp (Short Term) Pseudo-Static (2,475 yr EQ) (RF)		
Seismic Coefficient	Last Run	
H: 0.13g, V: 0g	2022-04-26, 03:47:58 PM	
	1:500	

Additional Details
Name: 1.25H:1V Rock Fill Embankment Side Slope (C-C')
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (42.058438, 110.42) m, Exit: (64.01, 97.999025) m
Center: (64.16592, 123.88254) m, Radius: 25.883987 m

Figure I6.3

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	0. Abt. Wall	Mohr-Coulomb	24	1,000	0
	0. Gran A	Mohr-Coulomb	22.8	0	40
	1. SSM Fill	Mohr-Coulomb	21	0	32
	2. Clay to Clayey Silt [Weathered Crust] (Drained)	Mohr-Coulomb	17.5	5	28
	3. Silty Sand	Mohr-Coulomb	19	0	30
	4. Sand & Gravel	Mohr-Coulomb	19	0	32
	5. Marble Bedrock	Bedrock (Impenetrable)			

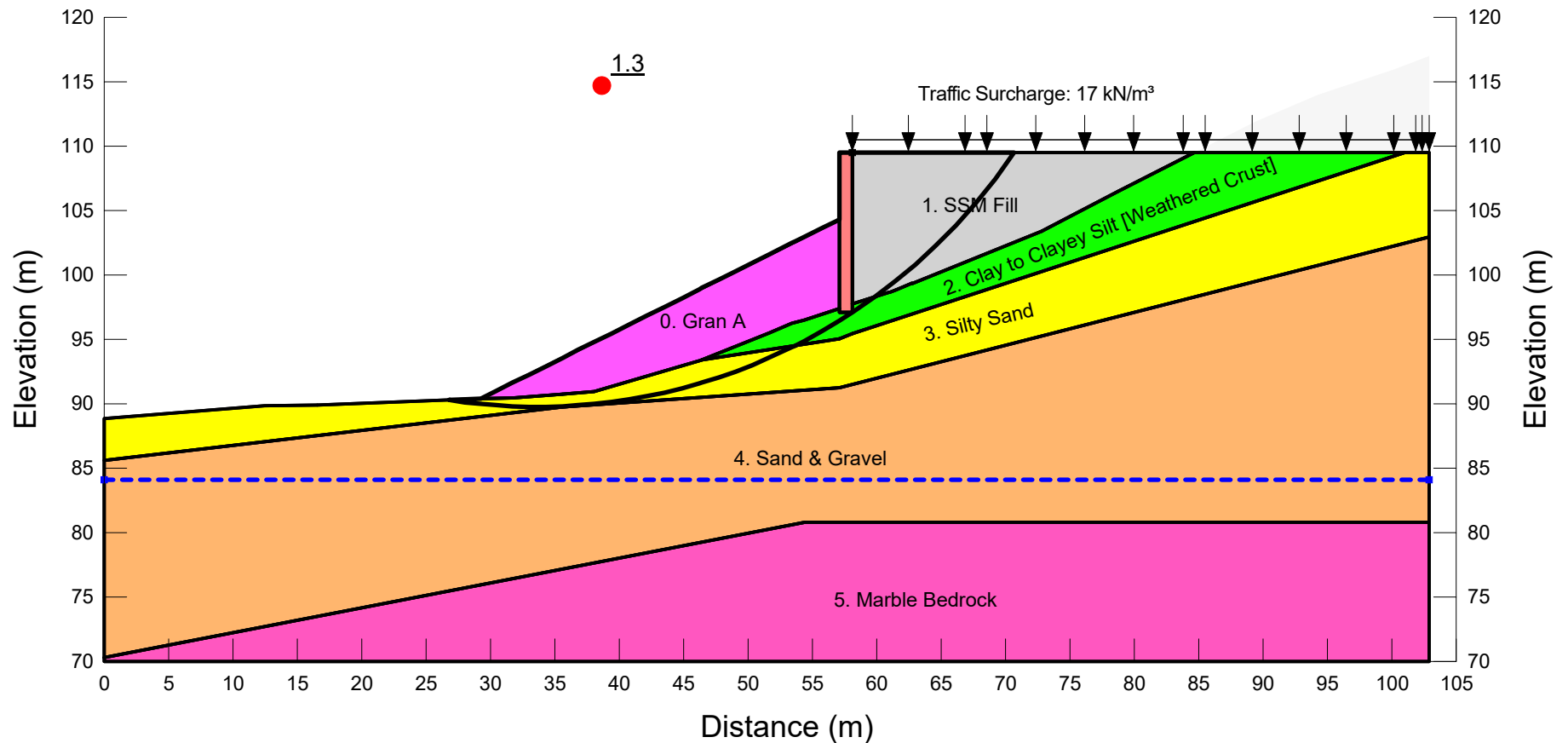


Project Bonnechere River Bridge, East Abut., Sta. 20+371		
Analysis 1. Permanent (Long Term) (SSM)		
Seismic Coefficient H: 0g, V: 0g	Last Run 2022-05-17, 11:09:30 AM	Scale 1:500

Additional Details
 Name: Abutment Foreslope Paving (D-D')
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (102.9, 109.5) m, Exit: (8.9056988, 89.542463) m
 Center: (17.554064, 280.13307) m, Radius: 190.78672 m

Figure I7.1

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	0. Abt. Wall	Mohr-Coulomb	24	1,000	0
	0. Gran A	Mohr-Coulomb	22.8	0	40
	1. SSM Fill	Mohr-Coulomb	21	0	32
	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
	3. Silty Sand	Mohr-Coulomb	19	0	30
	4. Sand & Gravel	Mohr-Coulomb	19	0	32
	5. Marble Bedrock	Bedrock (Impenetrable)			

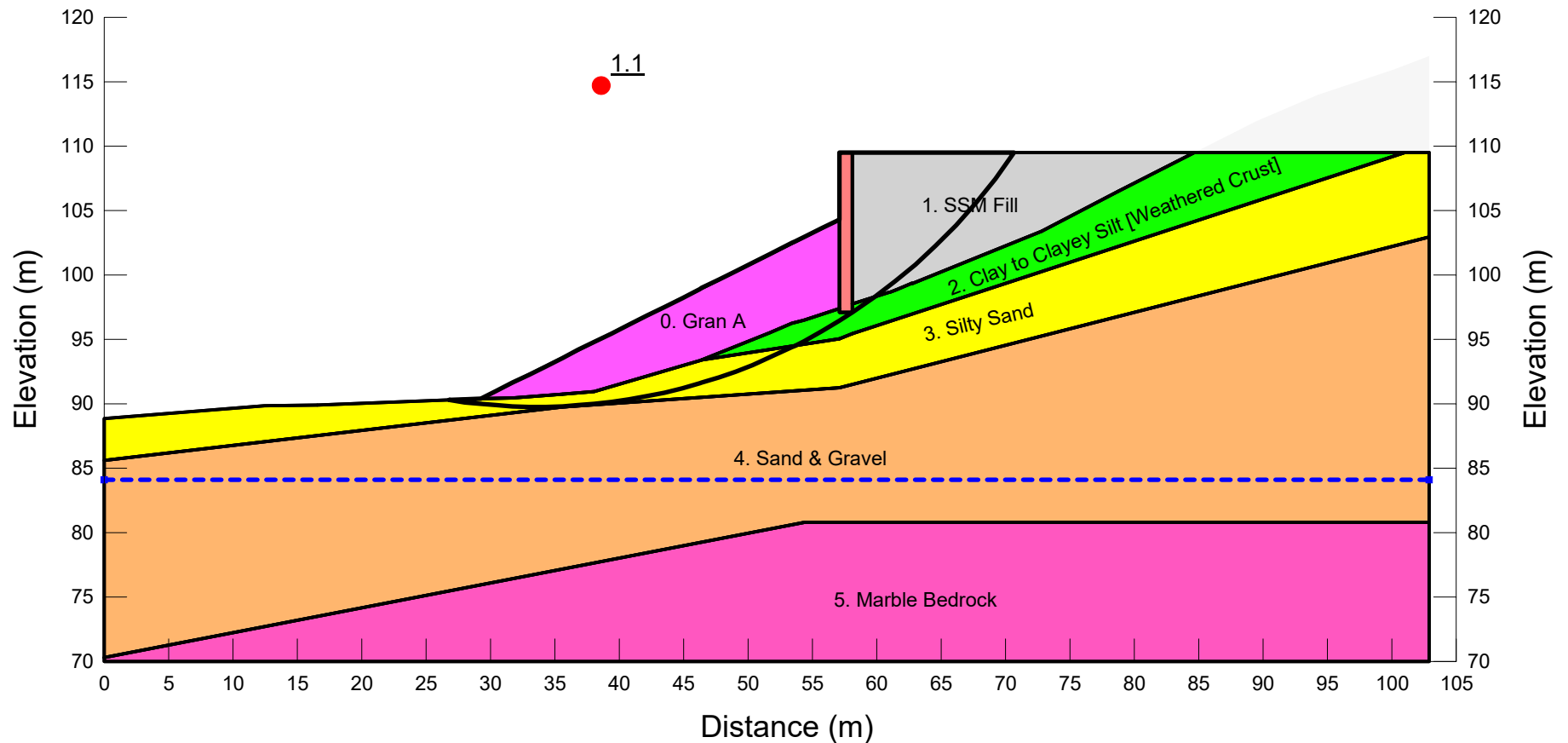


Project Bonnechere River Bridge, East Abut., Sta. 20+371		
Analysis 2. Temp (Short Term) Traffic (SSM)		
Seismic Coefficient H: 0g, V: 0g	Last Run 2022-05-17, 11:11:20 AM	Scale 1:500

Additional Details
 Name: Abutment Foreslope Paving (D-D')
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (70.644, 109.5) m, Exit: (26.77153, 90.269691) m
 Center: (33.614856, 134.31816) m, Radius: 44.576881 m

Figure I7.2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	0. Abt. Wall	Mohr-Coulomb	24	1,000	0
	0. Gran A	Mohr-Coulomb	22.8	0	40
	1. SSM Fill	Mohr-Coulomb	21	0	32
	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
	3. Silty Sand	Mohr-Coulomb	19	0	30
	4. Sand & Gravel	Mohr-Coulomb	19	0	32
	5. Marble Bedrock	Bedrock (Impenetrable)			

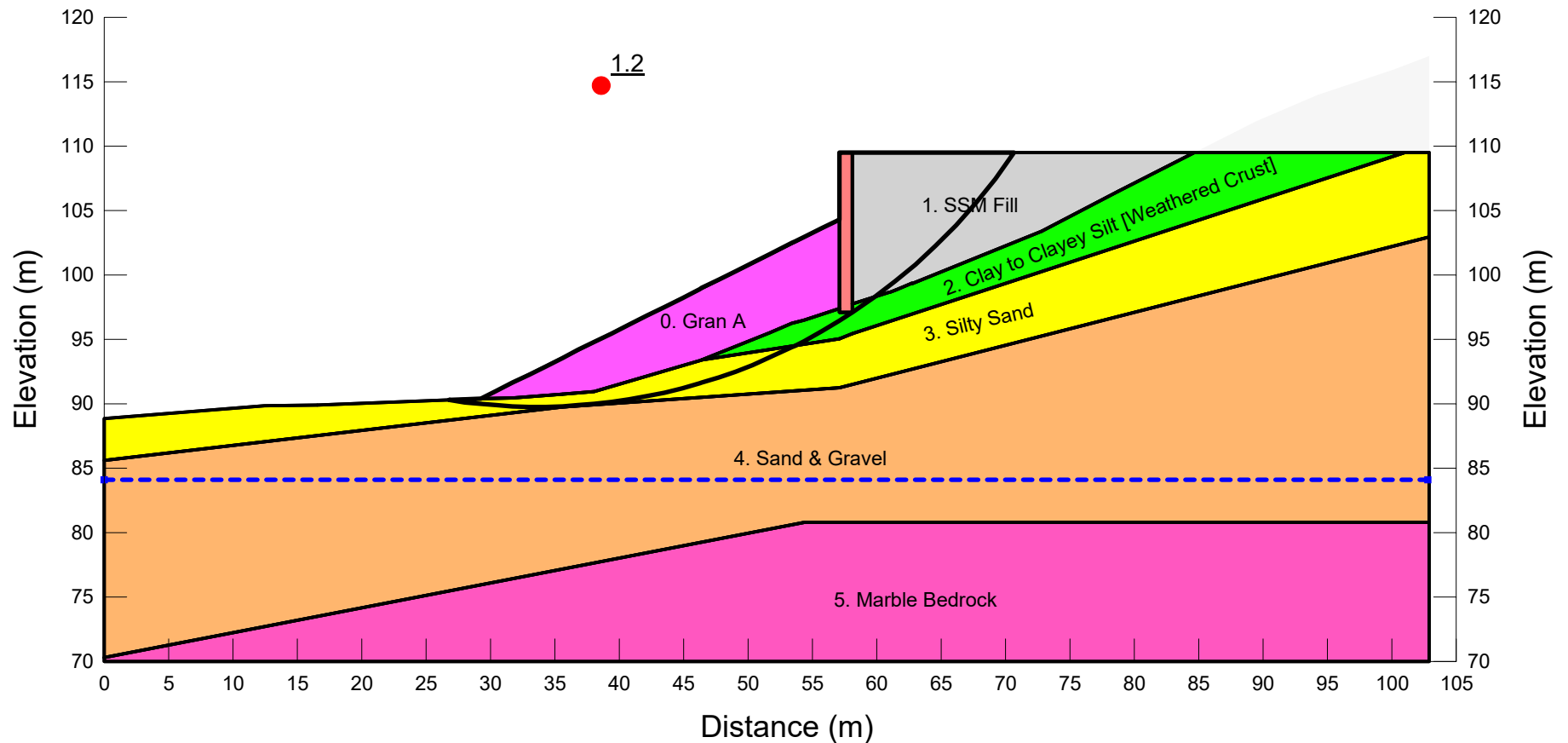


Project		
Bonnechere River Bridge, East Abut., Sta. 20+371		
Analysis		
3. Temp (Short Term) Pseudo-Static (2,475 yr EQ) (SSM)		
Seismic Coefficient	Last Run	Scale
H: 0.13g, V: 0g	2022-05-17, 11:14:26 AM	1:500

Additional Details
 Name: Abutment Foreslope Paving (D-D')
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (70.644, 109.5) m, Exit: (26.77153, 90.269691) m
 Center: (33.614856, 134.31816) m, Radius: 44.576881 m

Figure I7.3

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	0. Abt. Wall	Mohr-Coulomb	24	1,000	0
	0. Gran A	Mohr-Coulomb	22.8	0	40
	1. SSM Fill	Mohr-Coulomb	21	0	32
	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
	3. Silty Sand	Mohr-Coulomb	19	0	30
	4. Sand & Gravel	Mohr-Coulomb	19	0	32
	5. Marble Bedrock	Bedrock (Impenetrable)			

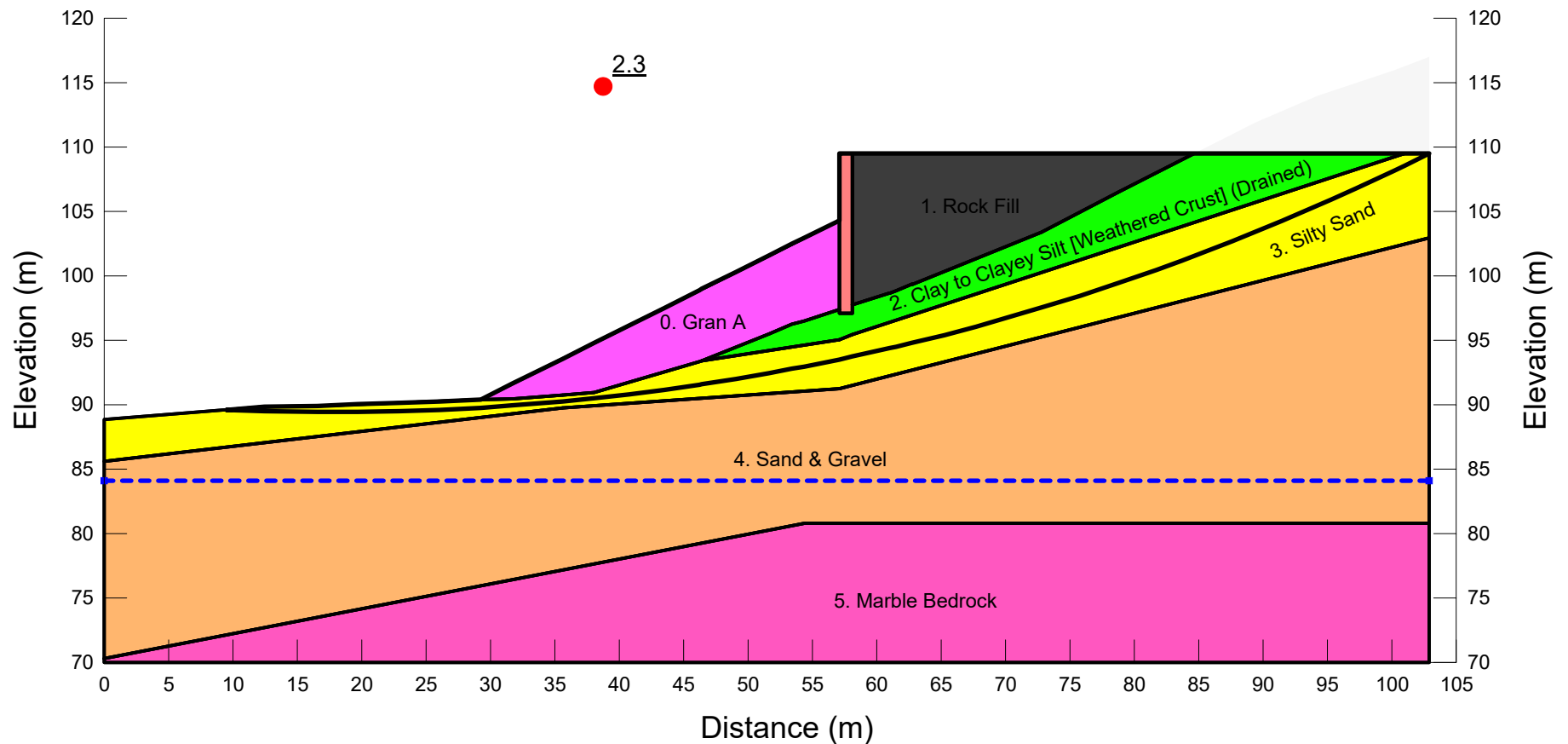


Project Bonnechere River Bridge, East Abut., Sta. 20+371		
Analysis 4. Temp (Short Term) Pseudo-Static (475 yr EQ) (SSM)		
Seismic Coefficient H: 0.05g, V: 0g	Last Run 2022-05-17, 11:14:26 AM	Scale 1:500

Additional Details
 Name: Abutment Foreslope Paving (D-D')
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (70.644, 109.5) m, Exit: (26.77153, 90.269691) m
 Center: (33.614856, 134.31816) m, Radius: 44.576881 m

Figure I7.4

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	0. Abt. Wall	Mohr-Coulomb	24	1,000	0
	0. Gran A	Mohr-Coulomb	22.8	0	40
	1. Rock Fill	Mohr-Coulomb	20	0	42
	2. Clay to Clayey Silt [Weathered Crust] (Drained)	Mohr-Coulomb	17.5	5	28
	3. Silty Sand	Mohr-Coulomb	19	0	30
	4. Sand & Gravel	Mohr-Coulomb	19	0	32
	5. Marble Bedrock	Bedrock (Impenetrable)			

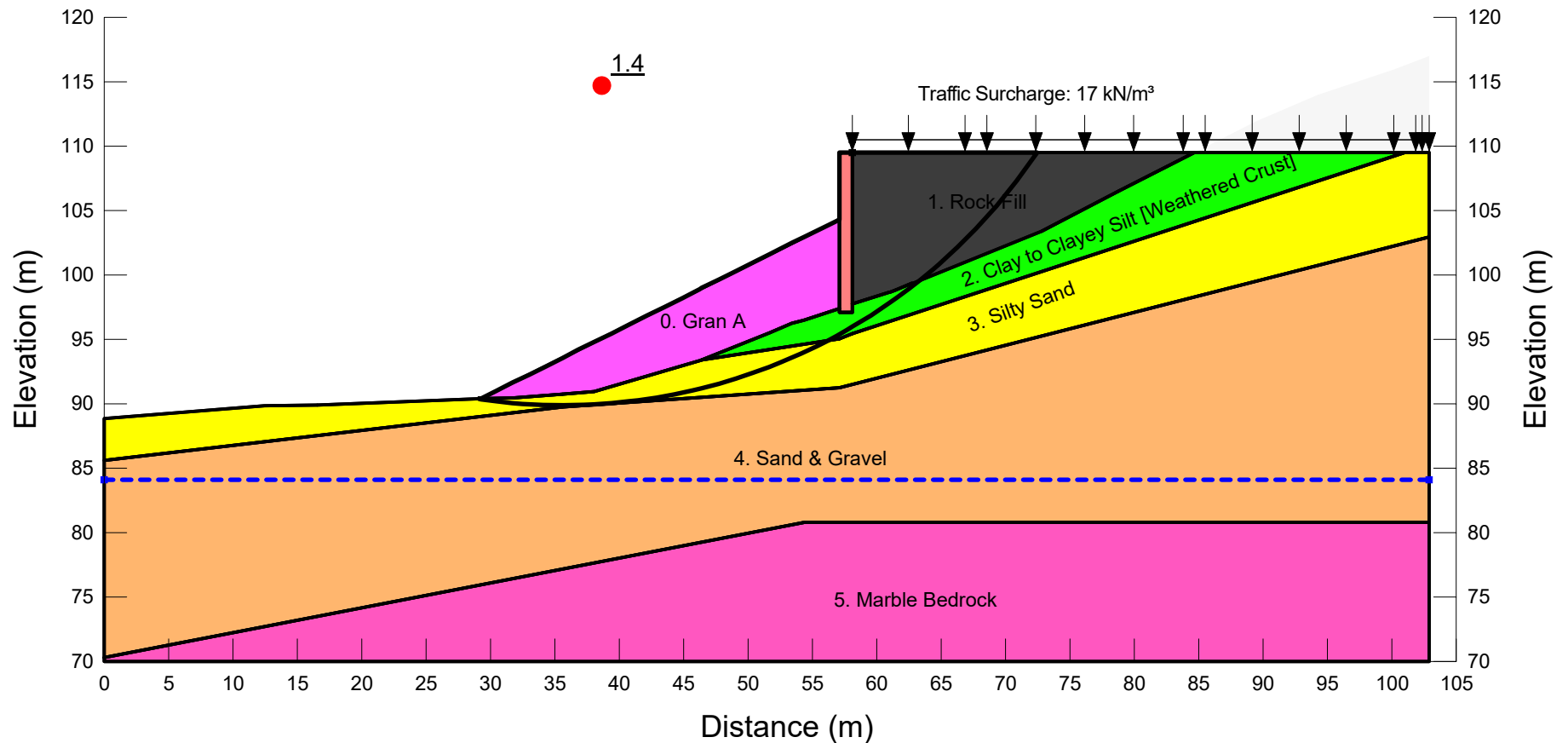


Project Bonnechere River Bridge, East Abut., Sta. 20+371		
Analysis 1. Permanent (Long Term) (RF)		
Seismic Coefficient H: 0g, V: 0g	Last Run 2022-05-17, 11:11:22 AM	Scale 1:500

Additional Details
 Name: Abutment Foreslope Paving (D-D') (2)
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (102.9, 109.5) m, Exit: (9.4860788, 89.589481) m
 Center: (17.903039, 279.18943) m, Radius: 189.78669 m

Figure I8.1

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	0. Abt. Wall	Mohr-Coulomb	24	1,000	0
	0. Gran A	Mohr-Coulomb	22.8	0	40
	1. Rock Fill	Mohr-Coulomb	20	0	42
	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
	3. Silty Sand	Mohr-Coulomb	19	0	30
	4. Sand & Gravel	Mohr-Coulomb	19	0	32
	5. Marble Bedrock	Bedrock (Impenetrable)			



Project		
Bonnechere River Bridge, East Abut., Sta. 20+371		
Analysis		
2. Temp (Short Term) Traffic (RF)		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2022-05-17, 11:14:28 AM	1:500

Additional Details

Name: Abutment Foreslope Paving (D-D') (2)

Comments: Slope Stability Assessment

Method: Morgenstern-Price, Half-Sine

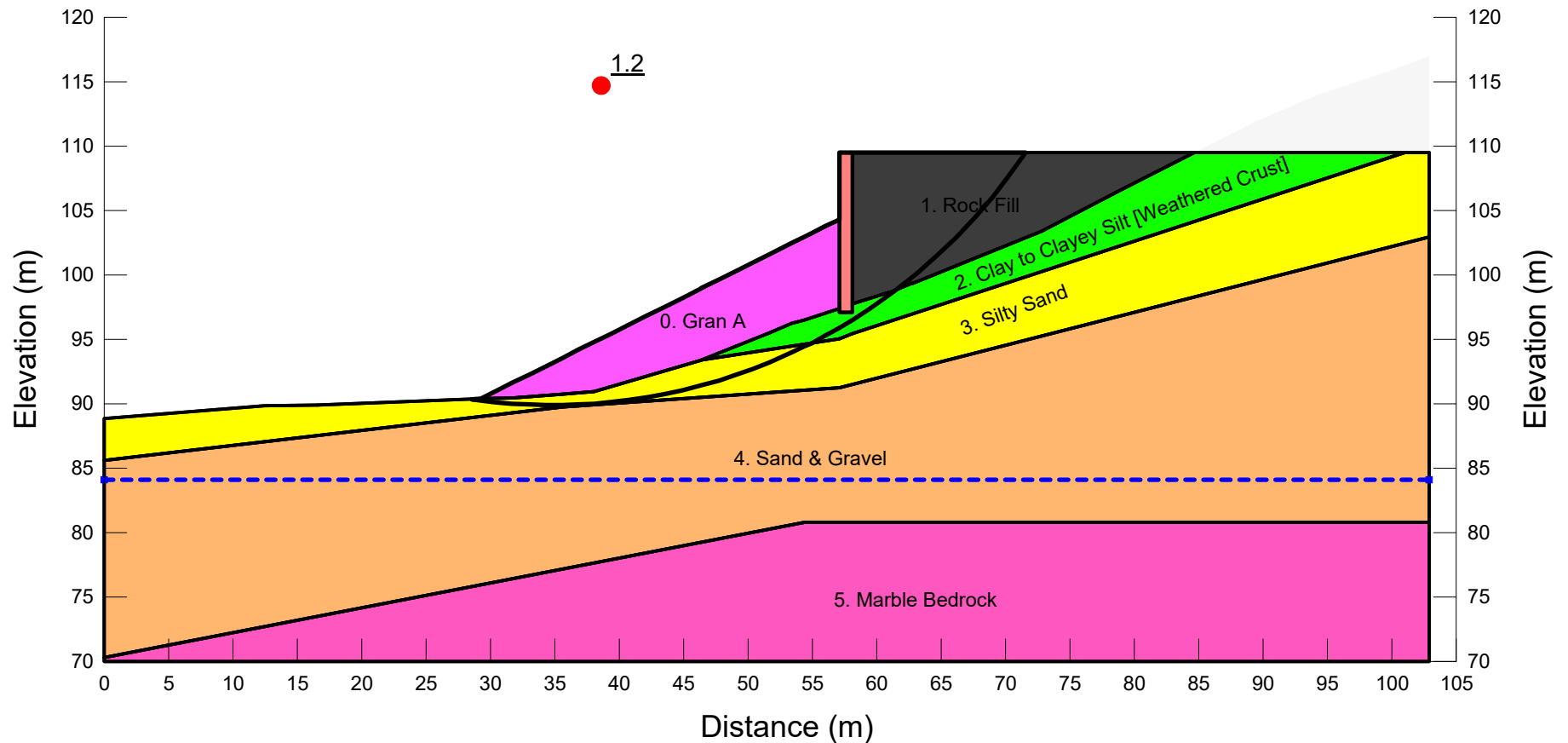
Minimum Slip Surface Depth: 1.52 m

Entry: (72.436, 109.5) m, Exit: (29.09341, 90.354065) m

Center: (35.682301, 134.0706) m, Radius: 44.210277 m

Figure I8.2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	0. Abt. Wall	Mohr-Coulomb	24	1,000	0
	0. Gran A	Mohr-Coulomb	22.8	0	40
	1. Rock Fill	Mohr-Coulomb	20	0	42
	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
	3. Silty Sand	Mohr-Coulomb	19	0	30
	4. Sand & Gravel	Mohr-Coulomb	19	0	32
	5. Marble Bedrock	Bedrock (Impenetrable)			

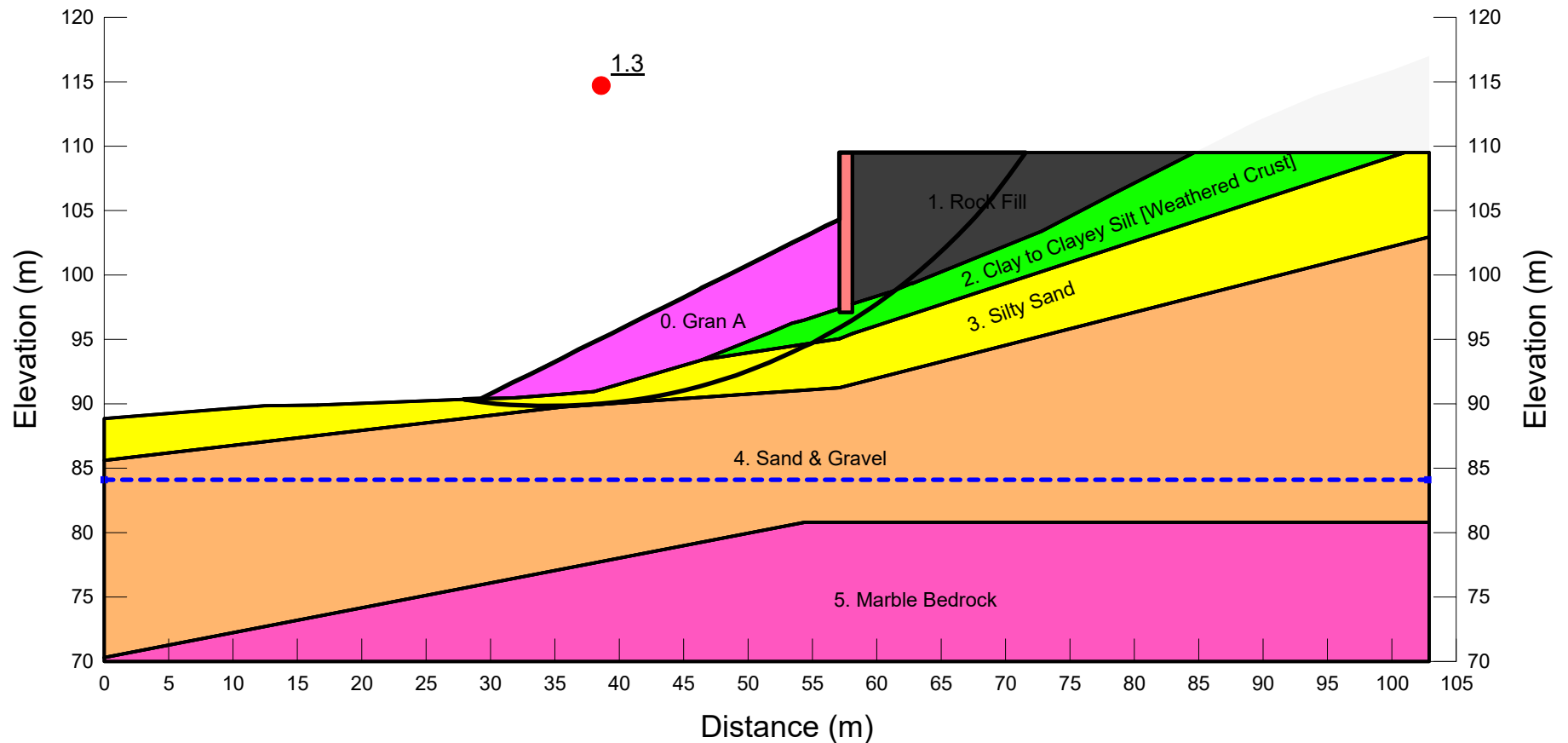


Project		
Bonnechere River Bridge, East Abut., Sta. 20+371		
Analysis		
3. Temp (Short Term) Pseudo-Static (2,475 yr EQ) (RF)		
Seismic Coefficient	Last Run	Scale
H: 0.13g, V: 0g	2022-05-17, 11:14:29 AM	1:500

Additional Details
 Name: Abutment Foreslope Paving (D-D') (2)
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (71.54, 109.5) m, Exit: (28.51294, 90.332971) m
 Center: (34.866392, 133.94855) m, Radius: 44.075902 m

Figure I8.3

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	0. Abt. Wall	Mohr-Coulomb	24	1,000	0
	0. Gran A	Mohr-Coulomb	22.8	0	40
	1. Rock Fill	Mohr-Coulomb	20	0	42
	2. Clay to Clayey Silt [Weathered Crust]	Mohr-Coulomb	17.5	100	0
	3. Silty Sand	Mohr-Coulomb	19	0	30
	4. Sand & Gravel	Mohr-Coulomb	19	0	32
	5. Marble Bedrock	Bedrock (Impenetrable)			

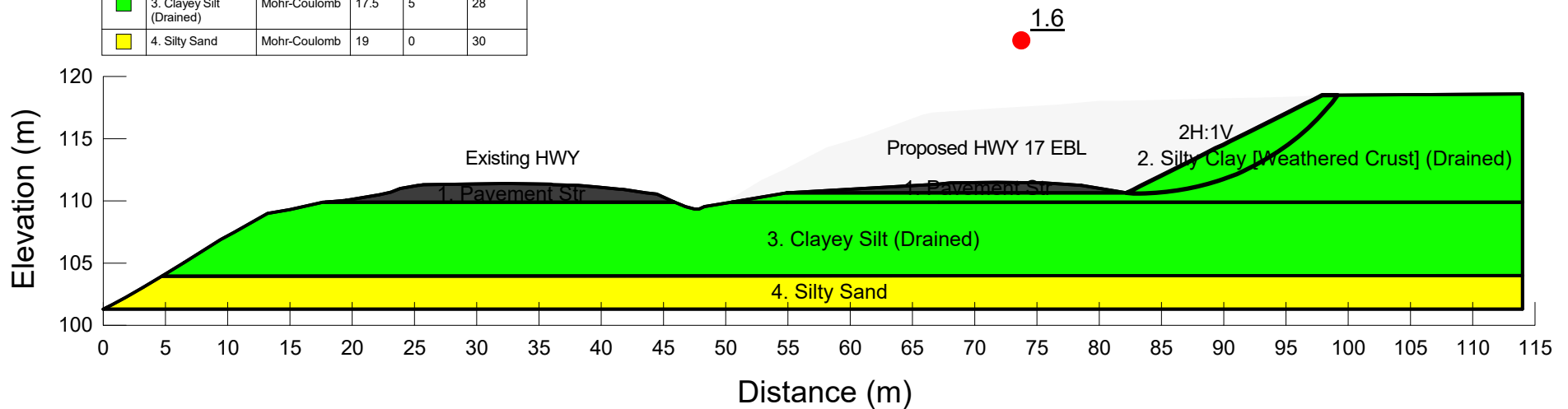


Project		
Bonnechere River Bridge, East Abut., Sta. 20+371		
Analysis		
4. Temp (Short Term) Pseudo-Static (475 yr EQ) (RF)		
Seismic Coefficient	Last Run	Scale
H: 0.05g, V: 0g	2022-05-17, 11:14:29 AM	1:500

Additional Details
 Name: Abutment Foreslope Paving (D-D') (2)
 Comments: Slope Stability Assessment
 Method: Morgenstern-Price, Half-Sine
 Minimum Slip Surface Depth: 1.52 m
 Entry: (71.54, 109.5) m, Exit: (27.93247, 90.311878) m
 Center: (34.648696, 134.19435) m, Radius: 44.393461 m

Figure I8.4

Color	Name	Slope Stability Material Model	Unit Weight (kN/m ³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	1. Pavement Str	Mohr-Coulomb	20	0	32
■	2. Silty Clay [Weathered Crust] (Drained)	Mohr-Coulomb	17.5	5	28
■	3. Clayey Silt (Drained)	Mohr-Coulomb	17.5	5	28
■	4. Silty Sand	Mohr-Coulomb	19	0	30



Project
Bonnechere River Bridge, East Approach, Sta. 20+441

Analysis
1. Permanent (Long Term)

Seismic Coefficient
H: 0g, V: 0g

Last Run
2022-05-11, 10:33:12 AM

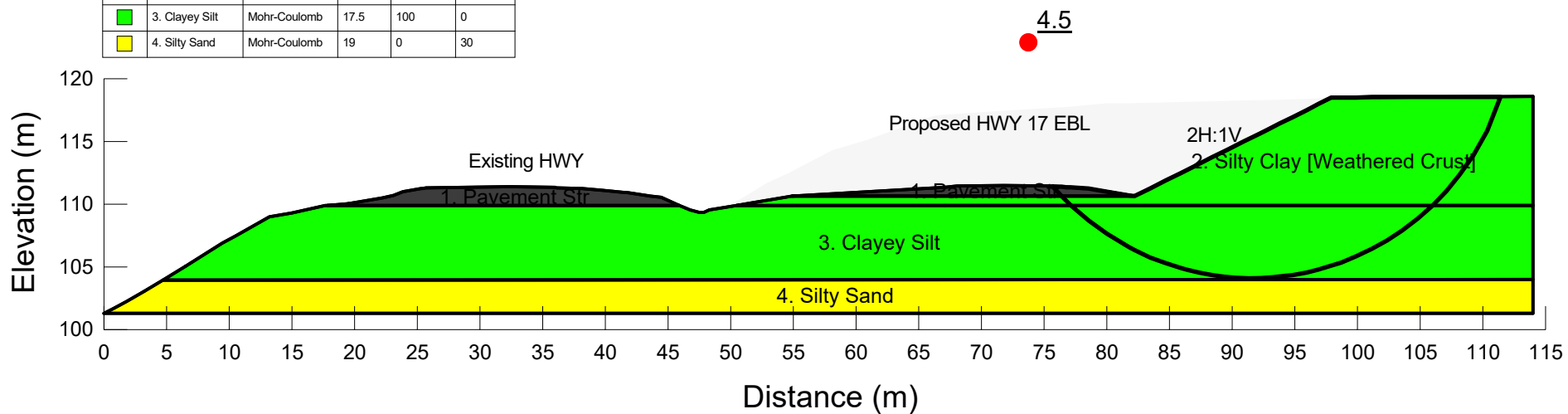
Scale
1:500

Additional Details

Name: Earth Cut (E-E')
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (99.174377, 118.51374) m, Exit: (82.21, 110.635) m
Center: (83.311132, 130.46714) m, Radius: 19.862684 m

Figure I9.1

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	1. Pavement Str	Mohr-Coulomb	20	0	32
■	2. Silty Clay [Weathered Crust]	Mohr-Coulomb	17.5	100	0
■	3. Clayey Silt	Mohr-Coulomb	17.5	100	0
■	4. Silty Sand	Mohr-Coulomb	19	0	30



Project
Bonnechere River Bridge, East Approach, Sta. 20+441

Analysis
2. Temp (Short Term) Traffic

Seismic Coefficient
H: 0g, V: 0g

Last Run
2022-05-11, 10:33:50 AM

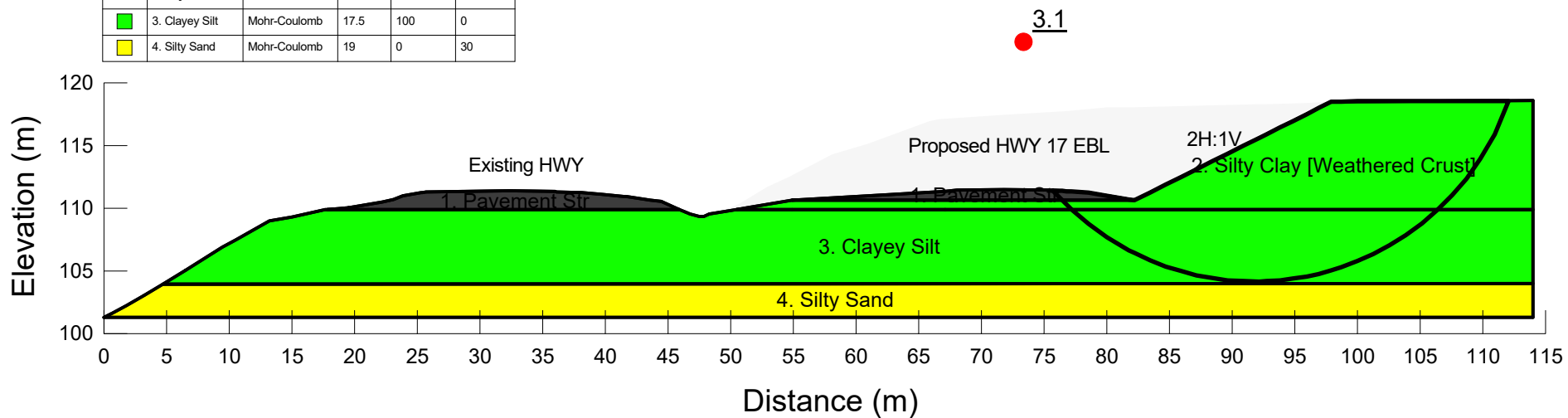
Scale
1:500

Additional Details

Name: Earth Cut (E-E')
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (111.42163, 118.55856) m, Exit: (75.719012, 111.41486) m
Center: (91.575697, 124.95539) m, Radius: 20.851391 m

Figure I9.2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	1. Pavement Str	Mohr-Coulomb	20	0	32
■	2. Silty Clay [Weathered Crust]	Mohr-Coulomb	17.5	100	0
■	3. Clayey Silt	Mohr-Coulomb	17.5	100	0
■	4. Silty Sand	Mohr-Coulomb	19	0	30



Project		
Bonnechere River Bridge, East Approach, Sta. 20+441		
Analysis		
3. Temp (Short Term) Pseudo-Static (2,475 yr EQ)		
Seismic Coefficient	Last Run	Scale
H: 0.13g, V: 0g	2022-05-11, 10:33:51 AM	1:500

Additional Details
Name: Earth Cut (E-E')
Comments: Slope Stability Assessment
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (112.06622, 118.56092) m, Exit: (75.719012, 111.41486) m
Center: (91.806629, 125.59791) m, Radius: 21.446919 m

Figure I9.3



Appendix J.

List of Referenced Specifications Non-Standard Special Provisions



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

OPSD 3090.101	Foundation Frost Depths for Southern Ontario
OPSD 3101.150	Walls Abutment, Backfill Minimum Granular Requirement
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS.PROV 902	Construction Specification for Excavating and Backfilling Structures
OPSS.PROV 903	Construction Specification for Deep Foundations
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
SP 110S06	Amendment to OPSS 1010 - Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
SP 517F01	Amendment to OPSS 517 - Construction Specification for Dewatering

2. Suggested wording for NSSPs

“Structural Backfill”

Structural backfill for the abutments and retaining walls shall consist of OPSS Granular B Type II or Quarry Sourced OPSS Granular A material.

“Notice to Contractor: Obstructions”

The Contractor is hereby notified that cobbles and boulders were observed in the soils underlying the project limits. Considerations of these potential obstructions must be made in the selection of appropriate equipment and procedures for excavations, installations of deep foundations, cofferdams and temporary protection systems.