

**FOUNDATION INVESTIGATION AND DESIGN REPORT
PICKEREL RIVER BRIDGE REPLACEMENT
HIGHWAY 11
DISTRICT OF RAINY RIVER, ONTARIO**

G.W.P. 6042-08-00, SITE No. 45-96

Geocres Number: 52B-16

Report to

Hatch Mott MacDonald

Thurber Engineering Ltd.
2010 Winston Park Drive, Suite 103
Oakville, Ontario
L6H 5R7
Phone: (905) 829 8666
Fax: (905) 829 1166

March 27, 2013
File: 19-1605-121

H:\19\1605\121 Bridge & Culvert Rehabs NWR\Reports &
Memos\Pickerel River\PICKERAL RIVER BRIDGE - FINAL
FIDR.doc

TABLE OF CONTENTS

PART 1 FACTUAL INFORMATION

1	INTRODUCTION.....	1
2	SITE DESCRIPTION.....	1
3	SITE INVESTIGATION AND FIELD TESTING	2
4	LABORATORY TESTING	3
5	DESCRIPTION OF SUBSURFACE CONDITIONS.....	3
5.1	Asphalt.....	4
5.2	Fill.....	4
5.3	Sand to Sandy Gravel	4
5.4	Clayey Silt	5
5.5	Silt to Sand and Silt	5
5.6	Sand	6
5.7	Water Levels.....	6
6	MISCELLANEOUS.....	8

PART 2 ENGINEERING DISCUSSION AND RECOMMENDATIONS

7	GENERAL	9
8	STRUCTURE FOUNDATIONS	9
8.1	Spread Footings on Native Soils.....	10
8.2	Drilled Shafts/Caissons.....	10
8.3	Driven Steel H-piles	11
8.3.1	Pile Installation.....	11
8.3.2	Downdrag.....	12
8.3.3	Lateral Resistance for H-piles	12
8.4	Recommended Foundation	13
8.5	Frost Cover	13
8.6	Impact of Pile Driving on Existing Bridge	13
9	SHEET PILE WALLS	14
10	EXCAVATION AND GROUNDWATER CONTROL	16
11	APPROACH EMBANKMENTS	16
11.1	Slope Stability.....	17

11.2 Settlement 17

12 EROSION PROTECTION 17

13 ROADWAY PROTECTION 18

14 SEISMIC CONSIDERATIONS..... 18

14.1 Seismic Design Parameters..... 18

15 CONSTRUCTION CONCERNS 19

16 CLOSURE..... 20

Appendices

Appendix A	Record of Borehole Sheets
Appendix B	Laboratory Test Results
Appendix C	Site Photographs
Appendix D	Foundation Comparison
Appendix E	Slope Stability Output
Appendix F	List of SPs and OPSS, and Suggested Text for NSSP
Appendix G	Borehole Locations and Soil Strata Drawings

**FOUNDATION INVESTIGATION AND DESIGN REPORT
PICKEREL RIVER BRIDGE REPLACEMENT
HIGHWAY 11
DISTRICT OF RAINY RIVER, ONTARIO**

G.W.P. 6042-08-00, SITE No. 45-96

Geocres Number: 52B-16

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the existing Pickerel River Bridge along Highway 11, in the District of Rainy River, Ontario.

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, a stratigraphic profile, laboratory test results and written descriptions of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to Hatch Mott MacDonald, under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0010.

2 SITE DESCRIPTION

The existing Pickerel River Bridge is located on Highway 11, approximately 43 km east of Atikokan. The Pickerel River flows from north to south, connecting Mink Lake at the north-east to French Lake at the south-west. The surrounding lands are undeveloped and heavily wooded. Quetico Provincial Park Entrance to Dawson Trail is located approximately 200m east from the bridge.

The existing bridge is a nine-span structure supported on eight timber bent piers and two abutments. The bridge is approximately 42.6 m long and 10.2 m wide. The approach embankments are approximately 5.0 m high. The river channel is approximately 10 m wide at the location of the bridge.

Photographs in Appendix C show the general nature of the site and the existing structure.

The site lies within the physiographic region known as the Quetico Subprovince of the Superior Province of the Canadian Shield. The site is underlain by Neo to Mesoarchean foliated tonalite to

granodiorite and massive granodiorite to granite igneous intrusive rocks. Diabase dikes of the Pigeon River and Pukaskwa swarms intrude at the east of the site. The bedrock is overlain by end moraine containing sand, gravel and boulders. Glaciolacustrine silt and clay deposits are present within deep depressions in the bedrock surface.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between August 29 and September 11, 2012. Due to limited site access under the bridge, several of the programmed boreholes were to be drilled from the bridge deck. It was observed that the existing timber deck suffered adverse impact during drilling of the first borehole through the deck and the investigation was adjusted thereafter following discussion with MTO. The borehole locations had to be shifted to avoid drilling through the bridge deck.

The investigation therefore comprised drilling and sampling five boreholes, identified as Boreholes PR-01, PR-02, PR-06, PR-09 and PR-10, and completing Borehole PR-06 with dynamic cone penetration testing (DCPT) below 15.8 m depth. The boreholes were advanced to depths of 9.8 m to 47.8 m below highway level.

Boreholes PR-01 and PR-10 were drilled on the west and east approaches respectively. Boreholes PR-02 and PR-09 were drilled at the existing west and east abutments respectively. Borehole PR-06 was drilled on the east bank of the Pickerel River from the bridge deck. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix G.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling. The coordinates and ground surface elevations for the boreholes were estimated from topographic plans provided by HMM.

A truck-mounted drill rig was used to advance the boreholes using a combination of hollow-stem augers, NW casing and NQ coring techniques. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

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

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Groundwater conditions observed after completion of drilling were not representative of site conditions as wash boring methods were used to drill the boreholes. Two standpipe piezometers were installed to monitor the groundwater level at the site. Completion details of the piezometers and boreholes were summarized in Table 3.1. The piezometers were decommissioned in general accordance with MOE Regulation 903 at the end of October 2012. Boreholes without piezometers were backfilled in general accordance with Regulation 903.

Table 3.1 – Borehole Abandonment Details

Foundation Unit	Borehole	Piezometer Tip Depth/ Elevation (m)	Abandonment Details
West Approach	PR-01	None installed	Borehole backfilled with sand and bentonite holeplug to 3.3 m, concrete from 3.3 m to 0.1 m, then asphalt cold patch to surface.
West Abutment	PR -02	43.8/ 369.7	Borehole backfilled with sand to 40.8 m, bentonite holeplug from 40.8 m to 37.3 m, bentonite holeplug and sand from 37.3 m to 0.3 m, sand from 0.3 m to 0.08 m, then asphalt cold patch to surface.
East Bank	PR -06	None installed	Borehole backfilled with bentonite holeplug and sand to ground surface, bridge deck backfilled with asphalt cold patch to bridge surface.
East Abutment	PR -09	43.2/ 370.9	Borehole backfilled with sand to 41.4 m, bentonite holeplug from 41.4 m to 39.9 m, bentonite holeplug and sand from 39.9 m to 0.5 m, then asphalt cold patch to surface.
East Approach	PR -10	None Installed	Borehole backfilled with bentonite holeplug and cuttings to 0.3 m, concrete from 0.3 m to 0.1 m, then asphalt cold patch to surface.

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and hydrometer). The results of this testing program are summarized on the Record of Borehole sheets included in Appendix A and on the figures presented in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing included in Appendix G. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions.

The site stratigraphy typically comprises cohesionless fill overlying a layer of native sand and gravel, underlain by a deep deposit of silt to sandy silt. Bedrock or refusal was not encountered in any of the boreholes within the depth of exploration of up to 47.8 m. More detailed descriptions of the individual strata are presented below.

5.1 Asphalt

Asphalt was encountered on the roadway surface in all boreholes drilled. The asphalt was between 65mm and 100mm thick. The asphalt overlies 160 mm of concrete at the bridge deck and 175mm to 250mm of concrete at the abutments.

5.2 Fill

Brown granular fill comprising sand, gravelly sand, sandy gravel, sand and gravel was encountered below the bridge in Borehole PR-06 and beneath the asphalt in all other boreholes. The thickness of fill encountered was 1.7 m to 5.8 m. The lower boundary of the fill layer was at depths of 2.9 m to 6.1 m (Elev. 407.8 to 411.2).

A thin layer of peat 50mm thick was encountered locally beneath the fill in Borehole PR-02. The peat is brown to black and fibrous.

SPT N-values recorded in the granular fill ranged from 8 to 42 blows for 0.3 m penetration, indicating a loose to dense condition, typically compact. Localized SPT N-values of 60 to 67 blows for less than 0.3 m penetration were recorded in Borehole PR-01 due to the presence of cobbles and boulders within the fill. Coring was required locally to advance the borehole through these cobbles and boulders. The moisture content ranged from 1% to 20%.

Four samples of the fill underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are shown on Figures B1 and B2 of Appendix B.

Soil Particles	Sand Fill (%)	Sand & Gravel Fill (%)
Gravel	9 to 19	44
Sand	70 to 88	48
Silt & Clay	2 to 11	8

5.3 Sand to Sandy Gravel

A brown to grey granular deposit was encountered beneath the fill in all boreholes. The deposit contained a mixture of sand, sand and gravel, sandy gravel and gravelly sand with trace silt and clay. Borehole PR-10 was terminated within this deposit at 9.8 m depth (Elev. 404.3). The thickness of the deposit in the remaining boreholes was between 1.6 m and 6.1 m, with its lower boundary at depths of 6.1 m to 12.2 m (Elev. 401.9 to 407.4).

SPT N-values measured ranged from 1 blow per 0.3 m penetration to 50 blows per 0.025 m penetration. The N-values in the sand were typically 5 to 12 blows per 0.3 m penetration, indicating loose to compact relative density, and greater than 26 blows per 0.3 m

penetration in the sand and gravel, indicating a compact to very dense relative density. Moisture contents in the deposit measured between 2% and 22%.

Grain size analysis testing was carried out on four samples of the granular deposit and the results are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are shown on Figures B3 and B4 of Appendix B.

Soil Particles	Sand (%)	Sand and Gravel (%)
Gravel	17	36 to 49
Sand	81	48 to 61
Silt & Clay	2	3 to 7

5.4 Clayey Silt

Clayey silt with trace sand was encountered locally in Borehole PR-01 beneath the sand. The layer is 2.6 m in thickness with its lower boundary at a depth of 8.7 m (Elev. 404.8).

SPT N-values of 6 to 8 blows per 0.3 m penetration were recorded, indicating a firm consistency. The moisture content of the layer ranged from 24% to 27%.

Results of grain size analysis testing carried out on a clayey silt sample are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curve for this sample is shown on Figure B5 of Appendix B.

Soil Particles	Clayey Silt (%)
Gravel	0
Sand	9
Silt	70
Clay	21

5.5 Silt to Sand and Silt

A deep deposit of native grey silt to sandy silt was encountered beneath the sand and gravel deposits in all boreholes except Borehole PR-10. The silt deposit graded locally to sand and silt or silt and sand. The sampled portions of Boreholes PR-01, PR-06 and PR-09 were terminated in this deposit at depths of 11.3 to 44.8 m (Elev. 402.2 to 369.3), indicating a thickness of at least 2.6 to 32.6 m. Boreholes PR-06 and PR-09 were advanced a further 18.0 and 3.0 m by DCPT below the sampled portion, to total depths of 33.8 and 47.8 m (Elev. 380.1 and 366.3). In Borehole PR-02, the silt deposit was 26.1 m thick, with a lower boundary at 36.3 m depth (Elev. 377.2).

SPT N-values recorded typically ranged from 4 to 26 blows per 0.3 m penetration, indicating a loose to compact relative density. Moisture content of the silt and sand deposit measured between 15% and 35%.

Twelve samples of the deposit underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are shown on Figures B6, B7 and B8 of Appendix B.

Soil Particles	Silt (%)	Sandy Silt (%)	Silt and Sand (%)
Gravel	0	0	0 to 4
Sand	4 to 18	21 to 29	40 to 51
Silt & Clay	-	-	-
Silt	75 to 85	68 to 73	45 to 57
Clay	4 to 11	3 to 6	3 to 4

5.6 Sand

Sand with trace gravel and some silt and clay was encountered below the silt deposit at 36.3 m depth (Elev. 377.2) in Borehole PR-02. Cobbles and boulders were encountered below 42.5 m depth (Elev. 371.0) in this material, requiring coring methods to penetrate. Borehole PR-02 was terminated in the sand at 45.3 m depth (Elev. 368.2).

SPT N-values obtained in the sand ranged from 27 to 56 blows per 0.3 m penetration, indicating a compact to very dense condition. Moisture contents ranged from 15% to 19%.

The results of a grain size distribution analysis conducted on a sample of the sand are shown on the Record Borehole sheets in Appendix A and in Figure B3 of Appendix B. The results are as summarised below.

Soil Particles	Sand (%)
Gravel	4
Sand	80
Silt & Clay	16

5.7 Water Levels

Wash boring methods were used to advance the boreholes and therefore water levels were not measured in the open boreholes during and upon completion of drilling operations. Two standpipe piezometers were installed to monitor the groundwater level and the water levels observed are summarized in Table 5.2.

Table 5.2 – Water Level Measurements

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
PR-02	September 12, 2012	3.9	409.6	Piezometer
	October 27, 2012	2.4	411.1	
PR-09	September 12, 2012	1.1	413.0	Piezometer
	October 27, 2012	2.1	412.0	

The water level in the Pickerel River was measured at Elevation 409.0 on June 2, 2011. This information was provided by HMM.

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

6 MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. The co-ordinates and the ground surface elevations for the boreholes were established based on topographic survey information provided by HMM.

Thurber obtained utility clearances for the borehole locations prior to drilling.

Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied a truck mounted CME 75 drill rig and conducted the drilling, sampling and in-situ testing operations. The drilling operations were supervised by Mr. Ryan Kromer and Ms. Eckie Siu, of Thurber.

Overall supervision of the field program was conducted by Mr. Mark Farrant, P.Eng. Interpretation of the data and preparation of the report were carried out by Ms. Rocio Palomeque Reyna, P.Eng. and Ms. Mei Cheong, M.Phil.

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

Thurber Engineering Ltd

Mei Cheong, M.Phil.
Geotechnical Specialist



MAR 27, 2013

Murray R. Anderson, P.Eng., M.Eng
Senior Foundation Engineer



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



**FOUNDATION INVESTIGATION AND DESIGN REPORT
PICKEREL RIVER BRIDGE REPLACEMENT
HIGHWAY 11
DISTRICT OF RAINY RIVER, ONTARIO**

G.W.P. 6042-08-00, SITE No. 45-96

Geocres Number: 52B-16

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations for a new bridge, to replace the existing bridge on Highway 11 crossing Pickernel River in the District of Rainy River, Ontario.

The current Pickernel River Bridge is a nine-span structure supported on eight timber bent piers and two abutments. The bridge is approximately 42.6 m long and 10.2 m wide. Archive drawing TWP#: 5000-96-1-A shows that each pier and abutment is supported on eight timber piles varying in length between 7.6 m and 12.2 m. The bridge was originally constructed in the 1950s and the river was realigned eastwards during the bridge construction. In the early 2000s, a reinforced concrete deck was placed over the existing timber deck.

The preliminary General Arrangement drawing provided by HMM shows that the proposed replacement bridge will be a single span structure supported on steel H-piles. A sheet pile wall will be installed immediately behind the H-piles at the abutments to retain the approach fill, in lieu of a conventional abutment. The span of the structure will be 21 m and the width will be 12.6 m. The bridge replacement construction will be staged to maintain one lane of traffic.

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

8 STRUCTURE FOUNDATIONS

The subsurface conditions encountered at the site typically consist of pavement structure overlying 1.7 to 5.8 m of sand and gravel approach fill overlying a layer of native loose to very dense sand to sandy gravel and a deep deposit of loose to compact silt to sandy silt. Occasional cobbles and

boulders were encountered in the fill and sand/ gravel. Bedrock or refusal was not encountered in any of the boreholes within the depth of exploration of 9.8 m to 47.8 m.

The measured groundwater levels were at Elevation 409.6 to 411.1 at the west abutment and Elevation 412.0 to 413.0 at the east abutment based on piezometer readings. The preliminary GA drawing indicates a water level in the Pickerel River at Elevation 409.0 in June 2011.

Based on existing site conditions, initial consideration was given to the following foundation types:

- Spread footings on native soils
- Augered Caissons (drilled shafts)
- Driven steel H-piles

A comparison of the foundation alternatives based on advantages and disadvantages of each one is included in Appendix D.

8.1 Spread Footings on Native Soils

Consideration was given to supporting the structure on spread footings founded on native soils. However, this option is not recommended due to the following reasons:

- Low geotechnical capacities are available at this site in the native loose to compact gravels, sands and silts.
- Unacceptable settlements, larger than 25 mm, under footing loads may occur if footings are placed on the native soils.
- Suitable bearing stratum is not available within a reasonable and practical depth of excavation.
- Construction of footings would require excavation of the fill to native sand and gravel, below the water level, which will require temporary shoring and dewatering. Installation of temporary shoring (i.e. sheet pile cofferdam) will be difficult due to the presence of cobbles and boulders in the embankment fill and in the native soils.
- Temporary excavation for footing construction may have environmental impact on the river.
- Scour protection will be required for the footings.

In light of the above factors, the spread footings option was not further developed.

8.2 Drilled Shafts/Caissons

Caissons are not recommended at this site since suitable end bearing materials were not encountered within the borehole exploration depth of up to 47.8 m. Construction of

caissons in the cohesionless soils below the water table would require use of a steel liner to support the caisson sidewalls and measures such as drilling mud to prevent boiling/ heave at the caisson base. In addition, caisson base inspection will not be possible at this site.

This option, therefore, was not developed further.

8.3 Driven Steel H-piles

The subsurface conditions at the abutments are considered suitable for the design of foundations supported on steel H-piles. Driven steel H-piles will develop resistance to vertical loads primarily through frictional resistance along the sides of the H-piles within the upper sand/ gravel layer and underlying loose to compact silt to sandy silt.

The factored Geotechnical Resistances at ULS (per pile) and Geotechnical Reaction at SLS (25 mm settlement) estimated for two pile sections, HP 310x110 and HP 360x 132, driven to various depths into the native silts and sands are as indicated in Table 8.1.

Table 8.1 – Recommended Axial Resistances for Steel H-Piles

Foundation Unit	Pile length below underside of pile cap, m	Pile Tip Elevation	HP 310x110		HP 360x132	
			ULS _f (kN)	SLS (kN)	ULS _f (kN)	SLS (kN)
Abutments	15	397	180	150	200	180
	20	392	350	300	400	350
	25	387	550	450	650	550
	30	382	800	650	950	800
	35	377	1,100	900	1,400	1,150
	40	372	1,400	1,150	1,650	1,400

-Native gravel, sands and silts were contacted near elevations 408.9 and 408.0 at the west and east abutments, respectively.

-Based on GA drawing, the underside of pile cap is approximately at elevation 412.0.

8.3.1 Pile Installation

Pile installation should be in accordance with OPSS 903.

No pile shoe or tip protector should be used since the piles are designed as friction piles.

For friction piles driven into compact gravels, sands and silts, pile driving must be controlled by the Hiley Formula and an ultimate pile resistance to be specified by the designer in accordance with Clause 3.3.2 (b) Construction Stage of the Structural Manual. The Hiley formula need not be used until the piles are within 2.0 m of the design tip elevation. The appropriate pile driving note is “Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance of “R” kN per pile”. “R” must have a minimum value of twice the design load at ULS.

To facilitate pile installation, embankment fill through which piles will be driven must not contain oversize material, i.e. no particles exceeding 75 mm in size. It should be noted that cobbles and boulders were encountered in the fill forming the highway embankments. If such obstructions are encountered at the proposed location of the H-piles they will have to be removed to facilitate driving of H-piles.

The Contract Documents should contain a NSSP alerting the Bidders to the presence of cobbles and boulders within the highway embankment and native sand/gravel. A NSSP addressing this issue is included in Appendix F.

8.3.2 Downdrag

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

8.3.3 Lateral Resistance for H-piles

The lateral resistance of the piles within the native gravels, sands and silts at the abutments may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

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

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

where z = depth of embedment of pile in metres

D = pile width/diameter in metres

n_h = coefficient related to soil density
2,500 kN/m³ in native loose to compact
sand/silt below groundwater level
= 5,000 kN/m³ in native sand and gravel at east abutment

γ = unit weight
10 kN/m³ (buoyant unit weight below water table)

K_p = passive earth pressure coefficient
3.0 for native loose to compact silt/sand

The above equations and recommended parameters may be used to analyze the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant, K , for analysis may be obtained by the expression, $K = k_s \cdot L \cdot D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m³), D is the pile width/diameter (m) and L is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of pile, P_{ult} , may be obtained from the expression, $P_{ult} = p_{ult} \cdot L \cdot D$. This represents the ultimate load at which the pile

fails and will not support any additional load at greater displacements. It is recommended, however, that the total lateral resistance assumed in one pile be limited to no more than 110 kN at ULS and 40 kN at SLS for a pile section HP 310x110 and no more than 150 kN at ULS and 50 kN at SLS for a pile section HP 360x132.

For lateral soil/pile group interaction analysis, the modulus of subgrade reaction (k_s) may have to be reduced based on pile spacing.

Where a pile group is oriented *perpendicular* to the direction of loading, group action may be considered by reducing values for k_s by a reduction factor R as follows:

Pile Spacing Perpendicular to Direction of Loading	Horizontal Subgrade Reaction Reduction Factor, R
4 D*	1.00
1 D*	0.50

* D is the width of the pile, and spacing is measured centre to centre

Where a pile group is oriented *parallel* to the direction of loading, group action may be considered by reducing values for k_s by a reduction factor R as follows:

Pile Spacing Parallel to Direction of Loading	Horizontal Subgrade Reaction Reduction Factor, R
8 D	1.00
6 D	0.70
4 D	0.40
3 D	0.25

Intermediate values may be obtained by interpolation.

8.4 Recommended Foundation

From a geotechnical perspective, the recommended foundation alternative to support the bridge abutments at this site is driven steel H-piles. The pile lengths should be selected based on the abutment load demand.

8.5 Frost Cover

The design depth of frost penetration at this site is 2.3 m.

Frost protection should be provided for buried pile caps, if used, and should consist of a minimum of 2.3 m of soil cover.

8.6 Impact of Pile Driving on Existing Bridge

The abutment piles for the new bridge will be driven in between the existing timber bents. The distance between the proposed abutment locations and the nearest timber bents is within 0.5 m for the west abutment and ranged from 1.5 m to 2.0 m for the east abutment.

It is considered that the risk of settlement of the existing bridge foundations by adjacent pile driving is moderate at the west abutment and low at the east abutment. It is recommended that the contract documents include a monitoring program for the existing structure. As a minimum, this program should require the contractor to establish reference points over each abutment and each pile bent of the existing structure and to monitor movement of these points relative to known, fixed reference points on a regular basis during driving of the piles. Inspection of the existing pile bents should be conducted during pile driving to identify any movement.

The structural design team should assess the magnitude of settlement or horizontal displacement that would constitute a concern for the stability or serviceability of the existing structure and these limits should be incorporated into a monitoring program in the construction contract.

An NSSP addressing monitoring requirements of the existing bridge is included in Appendix F.

9 SHEET PILE WALLS

Steel sheet pile walls will be driven adjacent to the H-pile foundations at each abutment. The sheet piles will provide containment and resistance to lateral earth pressures from the approach fill. Alignment of the sheet pile walls should be carefully selected so that during installation of the sheet piles, they do not encounter the timber piles below the existing bents or the proposed steel H-piles for the new abutment.

Driving of the sheet piles through the existing approach fill may encounter cobbles and possible boulders. The Contract Documents should contain a NSSP alerting the Bidders to the possibility of some sheet piles meeting refusal on the cobbles or a large boulder, and the need to remove or otherwise penetrate these obstructions. Suggested text for the NSSP is included in Appendix F. Sheet piles should be provided with sheet pile tip protection to minimize any tip damage.

Any visible boulders along the sides of the embankment should be removed prior to driving the sheet piles.

Backfill to the sheet pile walls should be in accordance with OPSS 902. Granular backfill should be placed to the extents shown in OPSD 3101.150. All granular material should meet the specifications of OPSS 1010 as amended by Special Provision 110S13. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS 501.

Earth pressures acting on the sheet pile walls may be assumed to be triangular and to be governed by the characteristics of the abutment backfill and the underlying native soils. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p_h = K^*(\gamma h + q)$$

Where:

p_h = horizontal pressure on the wall at depth h (kPa)

K = earth pressure coefficient (see Table 9.1)

γ = unit weight of retained soil (see Table 9.1)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 9.1.

Table 9.1 – Earth Pressure Coefficient (K)

Condition	Earth Pressure Coefficient (K)						
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ$, $\gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ$, $\gamma = 21.2 \text{ kN/m}^3$		Native Gravel/Sand $\phi = 30^\circ$, $\gamma = 20 \text{ kN/m}^3$		
	Horizontal Surface	Sloping Surface in front of Wall (2H:1V)	Horizontal Surface	Sloping Surface in front of Wall (2H:1V)	Horizontal Surface	Sloping Surface in front of Wall (2H:1V)	Surface in front of Wall (3H:1V)
Active (Unrestrained Wall)	0.27	0.38	0.31	0.46	0.33	0.54	0.40
At rest (Restrained Wall)	0.43	0.43	0.47	0.47	0.50	0.50	0.50
Passive (Movement Towards Soil Mass)	3.7	2.1	3.3	1.7	3.0	1.5	2.3

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the wall.

The factors in Table 9.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.16 in the Commentary to the Canadian Highway Bridge Design Code.

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

10 EXCAVATION AND GROUNDWATER CONTROL

If any earth excavation is required, it must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the native soils within the probable depth of excavation at this site may be classed as Type 3 soils above the water table and Type 4 soils below the water table.

The excavation must be carried out in accordance with OPSS 902.

Piezometric readings indicate that the water level is near Elevations 409.6 to 411.1 at the west abutment and Elevations 412.0 to 413.0 at the east abutment. The GA drawing indicates a water level in Pickerel River at Elevation 409.0 in June 2011.

Based on the preliminary GA for the bridge structure and the use of pile foundations, it is not expected that work at the abutments will require excavation below the river/groundwater level.

It is recommended that excavation for removal of existing structures be maintained above the water level in the river. Any excavation below the groundwater level/river level without prior dewatering is not recommended since the inflow of groundwater will make it difficult to maintain a dry, sound base on which to work.

In general, the design of the dewatering system should be the responsibility of the Contractor and the Contract Documents should alert him to this responsibility.

11 APPROACH EMBANKMENTS

Based on site observations and GA drawing provided by HMM, it was estimated that the existing approach embankments are approximately 4.5 m to 5.0 m high with forward slopes near inclinations of about 2H:1V to 3H:1V. Locally, the slopes may be inclined at up to 1.5H:1V in the river channel. The foundation soils governing stability of the approach embankments consist generally of native loose to compact gravels, sands and silts.

Communication with HMM indicates that a grade raise between 400mm and 700mm is anticipated at the bridge location on the existing Highway 11.

It is understood that additional fill will be required between the existing abutment and the new sheet pile wall. This new fill is expected to have a maximum thickness of about 3.2 m to 4.2 m. The sides of the new approach fill will be contained by sheet pile walls. Prior to placement of new fill, all topsoil, organics or other unsuitable materials must be stripped from the subgrade.

Comments regarding stability of embankment slopes and settlement of the foundations soils are provided in the following sections.

11.1 Slope Stability

The existing embankments bearing on the foundation soils at this site appear to be performing satisfactorily under the existing conditions.

The additional approach fill (approximately 3.2 m to 4.2 m) to be placed behind the new abutment will be supported within a sheet pile enclosure and therefore the stability of the new approach will be governed by the sheet pile wall design. A global slope stability analysis was conducted to assess the embedment requirements for a sheet pile supporting the new approach fill behind the sheet pile walls. The analyses were carried out using the Morgenstern-Price method of slope stability analysis.

The results of the analyses indicate that an adequate factor of safety of 1.5 is achieved for the long term conditions if the sheet pile is driven to or below elevation 407.0 at the west abutment and to or below elevation 406.5 at the east abutment. The slope stability computation outputs are included in Figures E1 and E2 of Appendix E.

The stability of the embankments was not checked under seismic loading as the zonal acceleration at this site is 0.0g.

11.2 Settlement

The placement of approximately 3.2 m to 4.2 m of new fill behind the sheet pile abutments will induce immediate (elastic) settlement in the existing non-cohesive fill and the underlying native gravel, sand and silt layers.

The total immediate settlement was assessed using elastic methods theory. Based on these analyses, the settlement at the bridge approaches under the weight of the additional approach fill is estimated to be in the order of 30 mm to 35 mm.

Due to the non-cohesive nature of the foundation soils, these settlements will be immediate and essentially completed when construction of the bridge is completed.

12 EROSION PROTECTION

The native sands and silts at this site are susceptible to erosion. It is recommended that the potential for erosion be investigated by the bridge designer. River bank erosion in front of the sheet piles must be prevented by providing rock protection.

A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS 804.

13 ROADWAY PROTECTION

The bridge construction will be done in stages in order to keep at least one highway lane operational. Roadway protection will be required to facilitate staging of removals and support the existing Highway 11.

Roadway protection should be provided in accordance with OPSS 539 and designed for Performance Level 2.

Continuous sheet piles or conventional steel soldier pile and timber lagging walls are two options to provide temporary support to the roadway during excavation. Timber lagging boards should be installed as soon as the soil face is exposed and properly prepared.

The following parameters apply for design of the temporary shoring system:

γ	=	21 kN/m ³	(bulk unit weight)
γ_w	=	11 kN/m ³	(submerged unit weight under groundwater table)
K_a	=	0.33	(Active pressure coefficient for: road embankment sand fill and native gravel/sand/silt)
K_p	=	3.0	(Passive pressure coefficient for: road embankment sand fill and native gravel/ sand/silt)
h_w	=	411 m	(design groundwater level at this site)

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.

Temporary groundwater and surface water control measures may be required during construction.

The design of roadway protection should be the responsibility of the Contractor. All shoring systems should be designed by a Professional Engineer experienced in such designs.

14 SEISMIC CONSIDERATIONS

14.1 Seismic Design Parameters

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.0
- Acceleration Related Seismic Zone 0
- Zonal Acceleration Ratio 0.0

- Peak Horizontal Acceleration 0.011g

The soil profile type at this site has been classified as Type IV. Therefore, according to Clause 4.4.6.1 Table 4.4 of the CHBDC, a Site Coefficient “S” (ground motion amplification factor) of 2.0 should be used in seismic design.

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

Table 14.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)		
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ$ $\gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I $\phi = 32^\circ$, $\gamma = 21.2 \text{ kN/m}^3$	Native Gravel/Sand/Silt $\phi = 30^\circ$, $\gamma = 20 \text{ kN/m}^3$
Active (K_{AE})*	0.28	0.32	0.33
Passive (K_{PE})	3.7	3.2	3.0
At Rest (K_{OE})**	0.45	0.50	0.50

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

** After Woods

The potential for liquefaction of the foundations soils was assessed using the Seed and Idriss (1971) method for cohesionless soils.

Using the method, it is estimated that under the existing conditions, the foundation soils at the abutments are not prone to liquefaction.

15 CONSTRUCTION CONCERNS

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

- Cobbles and possible boulders are present within the existing embankment fill and underlying sand/ gravel layers. The Contractor must be prepared to remove, drill through or otherwise penetrate these obstructions if H-piles or sheet piles meet refusal above the design tip depth.
- As indicated in the report, the risk of settlement of the foundations of the existing structure by adjacent pile driving is considered to be moderate to low. A monitoring program for

the existing structure should be implemented at this site before and during construction of the new bridge.

16 CLOSURE

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

Thurber Engineering Ltd.

Mei Cheong M.Phil.
Geotechnical Specialist



MAR 27, 2013

Murray R. Anderson, P.Eng., M.Eng.
Senior Foundation Engineer



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



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level
 Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE No PR-01

1 OF 2

METRIC

W.P. 6042-08-00 LOCATION Pickerel River Bridge N 5 393 639.5 E 221 881.2 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.09.09 - 2012.09.09 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
413.5							20	40	60	80	100								
0.0	ASPHALT: (75mm)																		
0.1																			
	SAND and GRAVEL, trace silt and clay		1	GS															
	Very Dense																		
	Brown																		
	Damp		1	SS	67/														
	(FILL)				0.175														
	Occasional cobbles and boulders at 1.1m																		
	Compact		2	SS	16														
	Light Brown																		
	Boulders (175mm) at 2.2m																		
			3	SS	42														
	Poor recovery																		
	Cobbles, granitic		4	SS	60/														
	White/Grey				0.175														
409.0																			
4.5	SAND, trace gravel																		
	Loose																		
	Grey		5	SS	7														
	Moist																		
407.4																			
6.1	Clayey SILT, trace sand																		
	Firm																		
	Grey		6	SS	8														
	Wet to Moist																		

Continued Next Page

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

RECORD OF BOREHOLE No PR-01

2 OF 2

METRIC

W.P. 6042-08-00 LOCATION Pickerel River Bridge N 5 393 639.5 E 221 881.2 ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2012.09.09 - 2012.09.09 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
	Continued From Previous Page																
402.2	Some sand		9	SS	4		403						o				
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE BACKFILLED WITH SAND AND BENTONITE HOLEPLUG TO 3.3m, CONCRETE TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.																

RECORD OF BOREHOLE No PR-02

1 OF 5

METRIC

W.P. 6042-08-00 LOCATION Pickering River Bridge N 5 393 641.4 E 221 890.7 ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2012.08.29 - 2012.09.09 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
413.5								20	40	60	80	100						
0.0	ASPHALT: (100mm)																	
0.1																		
413.1	CONCRETE: (250mm)																	
0.4	Gravelly SAND to Sandy GRAVEL Compact to Loose Brown Moist (FILL)		1	SS	19		413											
	Poor recovery		2	SS	20		412											
	Coring from 2.1m to 2.7m Cobbles and boulders, granitic White/grey		3	SS	8		411											
							410											
408.9							409											
408.9	PEAT, coarse, fibrous Dark Brown/Black Moist		4	SS	5		408											
4.6	SAND, some gravel, trace silt and clay Loose Grey Wet						407											
	No recovery		5	SS	10		406											
	Compact						405											
			6	SS	12		404											
	Very Loose		7	SS	1													

Continued Next Page

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

RECORD OF BOREHOLE No PR-02

2 OF 5

METRIC

W.P. 6042-08-00 LOCATION Pickerel River Bridge N 5 393 641.4 E 221 890.7 ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2012.08.29 - 2012.09.09 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m 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										
403.3																					
10.2	SILT, some sand, trace clay Loose Grey Wet																				
			8	SS	8		403														
							402														
			9	SS	8		401														
							400														
			10	SS	7		399														
			11	SS	5		398														
396.7																					
16.8	SILT and SAND, trace clay Loose Grey Wet																				
			12	SS	4		397														
							396														
			13	SS	9		395														
394.1																					
19.4	SILT, trace to some sand, trace to some clay Loose to Compact Grey																				
							394														

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No PR-02

3 OF 5

METRIC

W.P. 6042-08-00 LOCATION Pickerel River Bridge N 5 393 641.4 E 221 890.7 ORIGINATED BY RK
HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2012.08.29 - 2012.09.09 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	20 40 60			
	Continued From Previous Page													
	SILT, trace to some sand, trace to some clay Loose to Compact Grey Wet		14	SS	8		393							0 4 85 11
							392							
							391							
			15	SS	10		390							
							389							
							388							
			16	SS	12		387							
							386							
							385							
			17	SS	16		384							

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 PR-02

5 OF 5

METRIC

W.P. 6042-08-00 LOCATION Pickerel River Bridge N 5 393 641.4 E 221 890.7 ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2012.08.29 - 2012.09.09 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
	Continued From Previous Page																
	Occasional cobbles and boulders (330mm)		22	SS	56											4 80 16 (SI+CL)	
	Coring from 43.3m to 43.8m																
	Coring from 43.8m to 45.3m																
368.2																	
45.3	END OF BOREHOLE AT 45.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Sep. 12/12 3.9 409.6 Oct. 27/12 2.4 411.1																

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 2/14/13

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 C
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60	W _P W W _L				
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			WATER CONTENT (%)			
413.9 0.0 0.1 0.2 413.4 0.5	ASPHALT: (65mm) CONCRETE: (160mm) WOOD DECK Air gap between underside of bridge deck and ground surface						414							
							413							
							412							
							411							
							410							
409.5 4.4	SAND, coarse grained, some gravel, occasional cobbles Compact Brown Wet (FILL) Poor recovery Cobbles, granitic White/grey/pink		1	SS	10		409							
			2	SS	31									
407.8 6.1	SAND and GRAVEL, occasional cobble Dense Brown/Orange Wet Poor recovery at 6.1m		3	SS	32		408							
			4	SS	33		407							
			5	SS	31		406							
405.2 8.7	SILT, some sand, trace gravel Loose Grey Moist		6	SS	8		405							

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No PR-06

2 OF 4

METRIC

W.P. 6042-08-00 LOCATION Pickerel River Bridge N 5 393 625.6 E 221 918.5 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.09.06 - 2012.09.06 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								20 40 60 80 100										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
Continued From Previous Page							20 40 60 80 100			PLASTIC LIMIT W P			NATURAL MOISTURE CONTENT W			LIQUID LIMIT W L		
403.7							404											
10.2	Sandy SILT , trace clay Compact Grey Moist		7	SS	12		403											
							402											
	Loose		8	SS	8		401											0 24 70 6
							400											
	Silty		9	SS	9		399											
	Compact		10	SS	15													0 16 79 5
398.1							398											
15.8	End of sampling at 15.8m and start of DCPT						397											
							396											
							395											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No PR-06

3 OF 4

METRIC

W.P. 6042-08-00 LOCATION Pickerel River Bridge N 5 393 625.6 E 221 918.5 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.09.06 - 2012.09.06 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 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						394	20 40 60 80 100	20 40 60					
							393							
							392							
							391							
							390							
							389							
							388							
							387							
							386							
							385							
							384							

Continued Next Page

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

RECORD OF BOREHOLE No PR-06

4 OF 4

METRIC

W.P. 6042-08-00 LOCATION Pickerel River Bridge N 5 393 625.6 E 221 918.5 ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2012.09.06 - 2012.09.06 CHECKED BY RPR





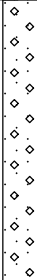
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60					
380.1							383							
							382							
							381							
33.8	END OF BOREHOLE AT 33.8m UPON DCPT REFUSAL. BOREHOLE BACKFILLED WITH SAND AND BENTONITE HOLEPLUG TO GROUND SURFACE AND BRIDGE DECK BACKFILLED WITH ASPHALT COLD PATCH TO BRIDGE SURFACE.													

RECORD OF BOREHOLE No PR-09

1 OF 5

METRIC

W.P. 6042-08-00 LOCATION Pickerel River Bridge N 5 393 610.7 E 221 931.9 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Casing COMPILED BY AN
 DATUM Geodetic DATE 2012.09.10 - 2012.09.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m 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										
414.1								20	40	60	80	100							
0.0																			
419.8	ASPHALT: (75mm)																		
0.3	CONCRETE: (175mm)																		
	SAND, coarse grained, trace to some gravel, trace silt and clay Compact Brown Moist (FILL)		1	SS	12									○					
			2	SS	12									○					
			3	SS	12									○					
	Occasional cobbles and boulders		4	SS	26									○					
	Cobbles		5	SS	31									○					
408.0																			
6.1	SAND and GRAVEL, trace silt and clay Compact Brown/Grey Wet		6	SS	14									○					
406.5																			
7.6	Sandy GRAVEL, occasional cobbles Compact Brown/Orange Wet Poor recovery		7	SS	29														
			8	SS	26									○					

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 2/14/13

RECORD OF BOREHOLE No PR-09

3 OF 5

METRIC

W.P. 6042-08-00 LOCATION Pickerel River Bridge N 5 393 610.7 E 221 931.9 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Casing COMPILED BY AN
 DATUM Geodetic DATE 2012.09.10 - 2012.09.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m 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					
	Continued From Previous Page															
	Sandy SILT, trace clay Compact Grey Moist		15	SS	13		394									
							393									
							392									
			16	SS	10		391									
							390									
							389									
			17	SS	11		388								0 29 68 3	
							387									
							386									
			18	SS	14		385									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No PR-09

4 OF 5

METRIC

W.P. 6042-08-00 LOCATION Pickerel River Bridge N 5 393 610.7 E 221 931.9 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Casing COMPILED BY AN
 DATUM Geodetic DATE 2012.09.10 - 2012.09.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m 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																	
383.6	SILT , some sand, trace clay Compact Grey Moist						384								0 18 78 4		
30.5							383										
				19	SS		18	382				○					
								381									
								380									
				20	SS		16	379				○					
							378										
377.5	SAND and SILT , trace clay Compact Grey Moist						377										
36.6							376				○						
				21	SS		21										
							375										

Continued Next Page

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

RECORD OF BOREHOLE No PR-09

5 OF 5

METRIC

W.P. 6042-08-00 LOCATION Pickerel River Bridge N 5 393 610.7 E 221 931.9 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Casing COMPILED BY AN
 DATUM Geodetic DATE 2012.09.10 - 2012.09.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 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													
			22	SS	25		374							
							373							0 51 45 4
							372							
							371							
			23	SS	26		370							
							369							
							368							
							367							
366.3 47.8	END OF BOREHOLE AT 47.8m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Sep. 12/12 1.1 413.0 Oct. 27/12 2.1 412.0													

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 2/14/13

RECORD OF BOREHOLE No PR-10

1 OF 2

METRIC

W.P. 6042-08-00 LOCATION Pickerel River Bridge N 5 393 613.7 E 221 939.4 ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.08.29 - 2012.08.29 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
414.1								20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No PR-10

2 OF 2

METRIC

W.P. 6042-08-00 LOCATION Pickering River Bridge N 5 393 613.7 E 221 939.4 ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.08.29 - 2012.08.29 CHECKED BY RPR

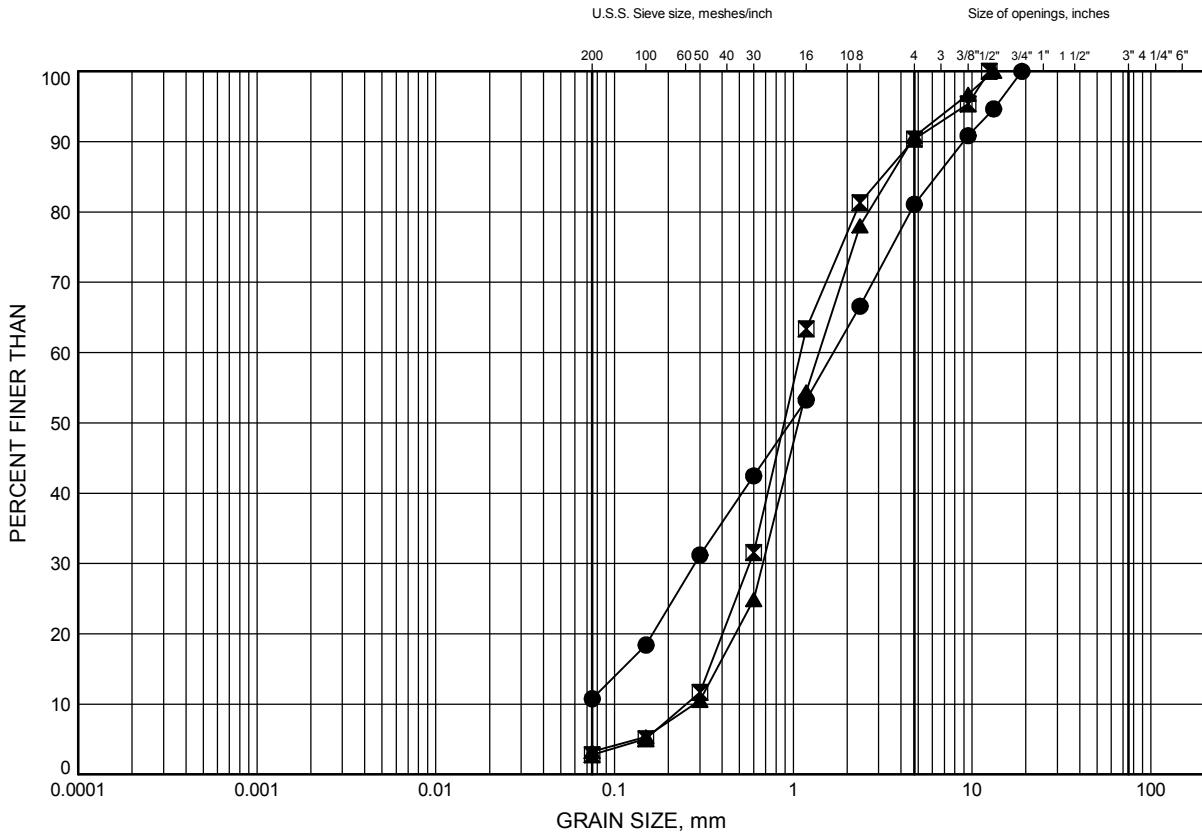
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					20 40 60 W P W W L					
	Continued From Previous Page																
	BOREHOLE CAVED TO 2.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.3m, CONCRETE TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.																

Appendix B
Laboratory Test Results

Pickerel River Bridge
GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PR-02	3.05	410.45
⊠	PR-09	2.59	411.51
▲	PR-10	2.59	411.51

Date January 2013
W.P. 6042-08-00

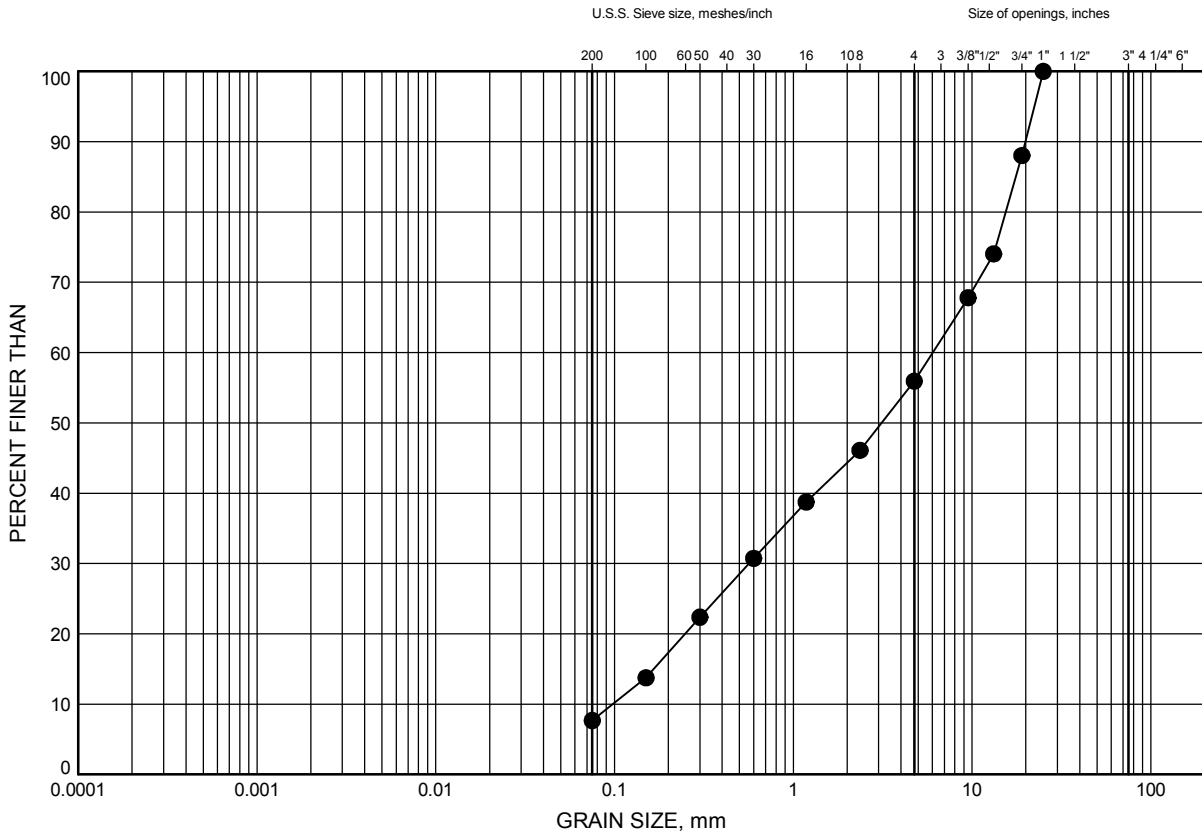


Prep'd AN
Chkd. MC

Pickerel River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND AND GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PR-01	1.83	411.67

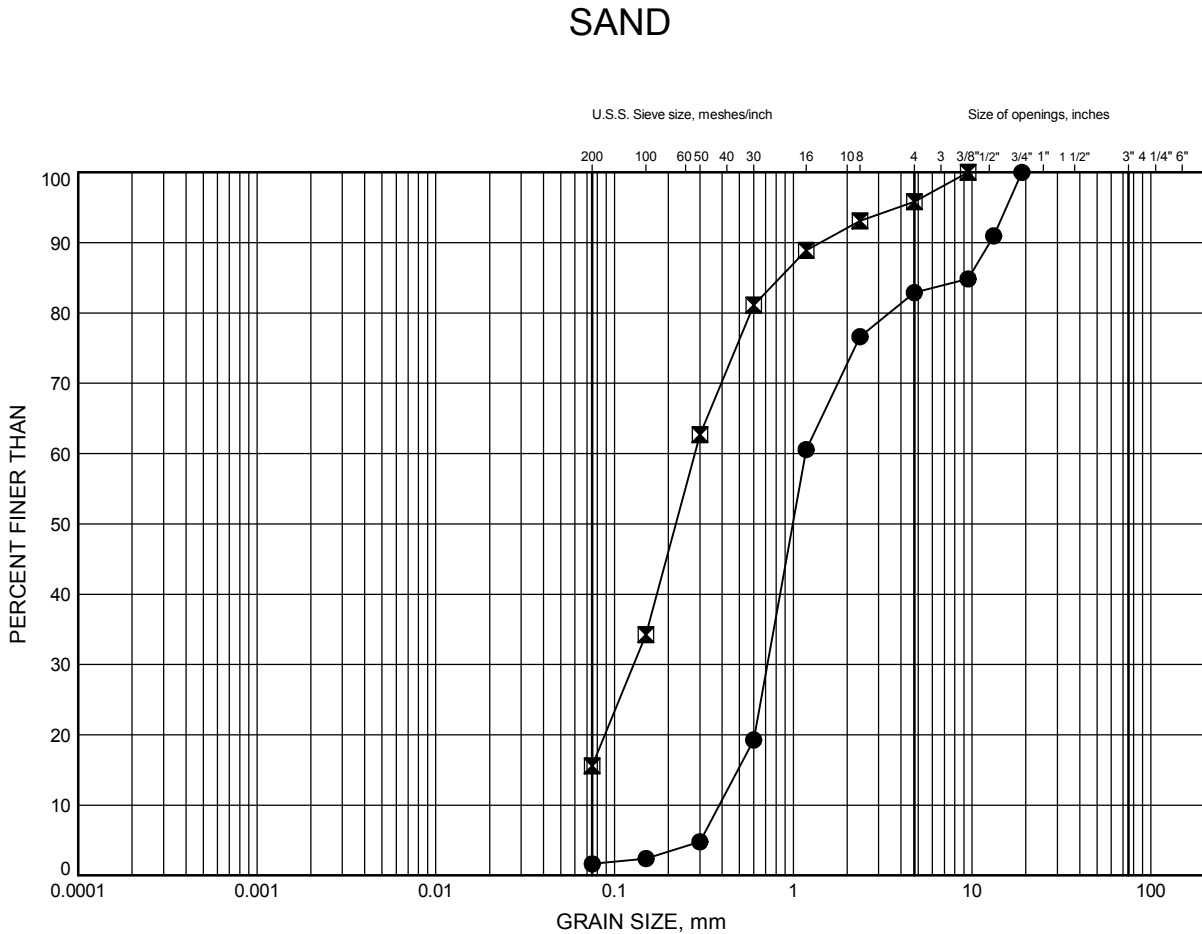
Date January 2013
W.P. 6042-08-00



Prep'd AN
Chkd. MC

Pickerel River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B3



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PR-02	7.92	405.58
⊠	PR-02	42.96	370.54

Date February 2013
W.P. 6042-08-00

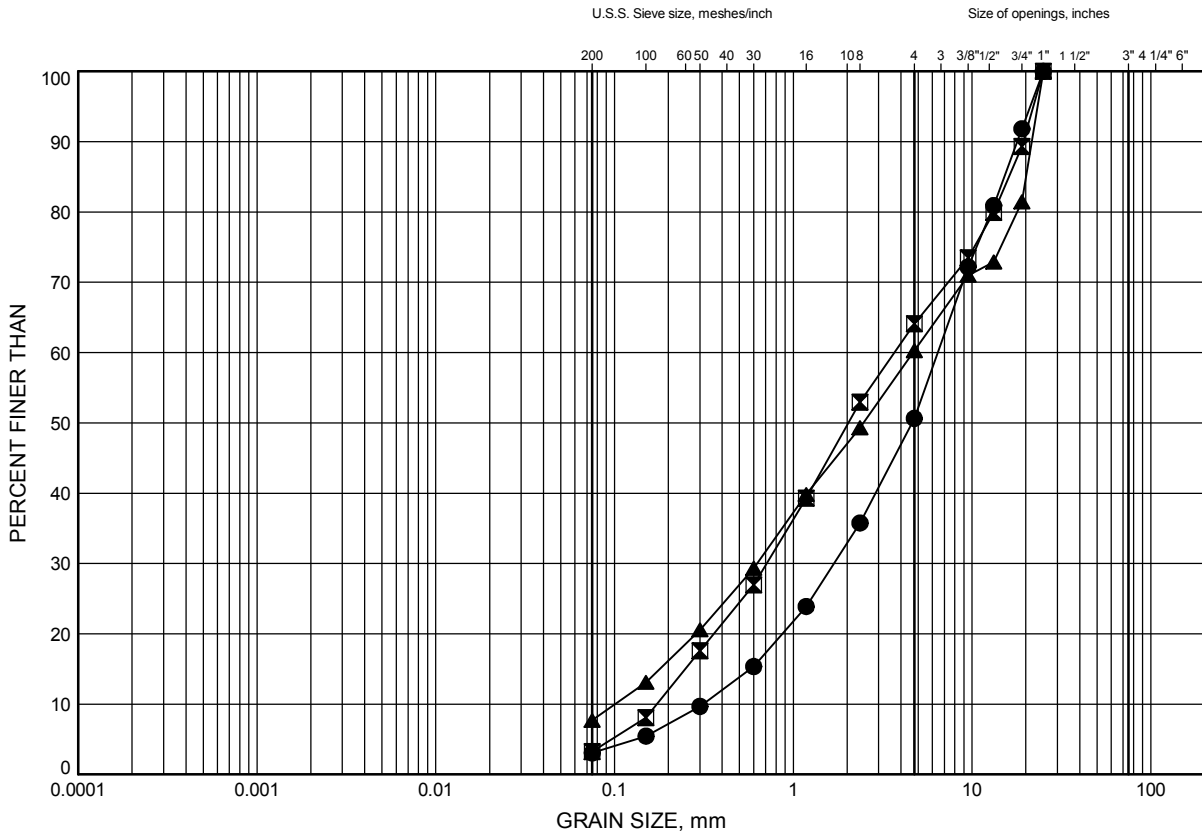


Prep'd AN
Chkd. MC

Pickrel River Bridge
GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND AND GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PR-09	6.40	407.70
⊠	PR-10	6.40	407.70
▲	PR-10	9.45	404.65

Date January 2013
W.P. 6042-08-00

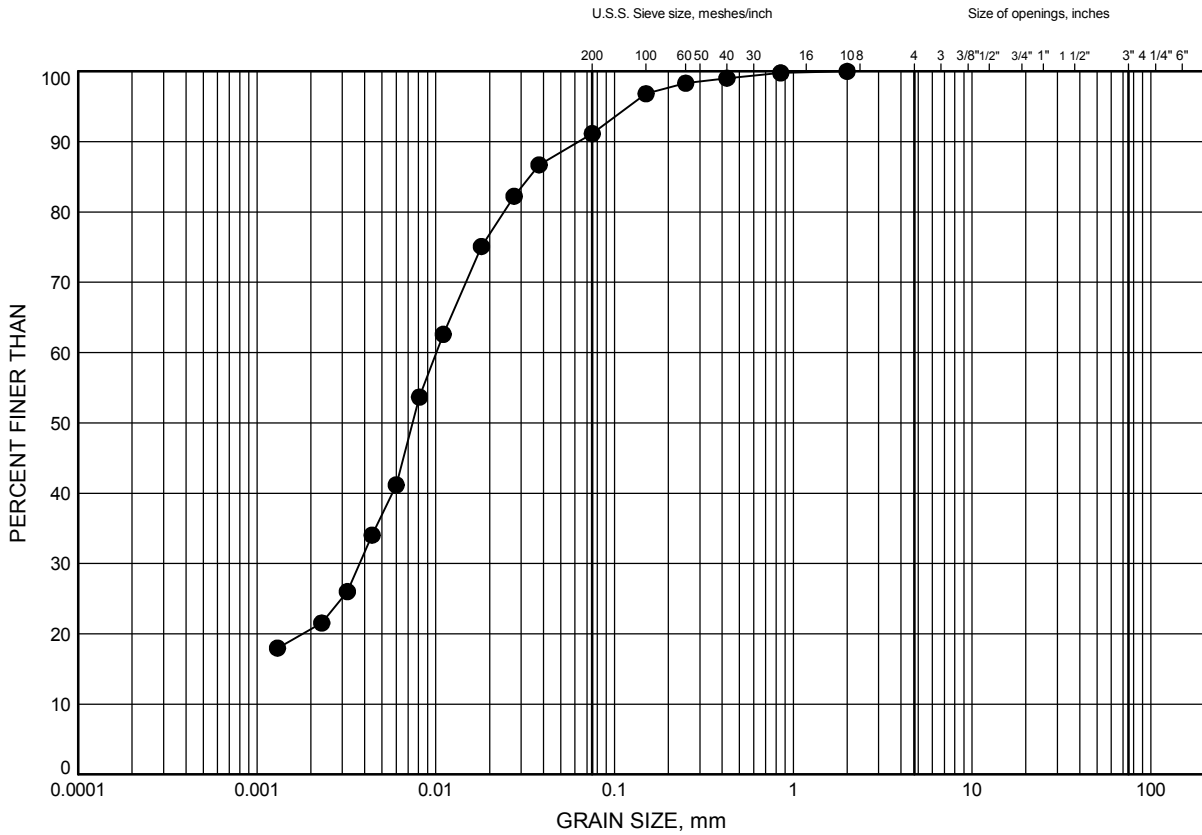


Prep'd AN
Chkd. MC

Pickrel River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B5

CLAYEY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PR-01	6.40	407.10

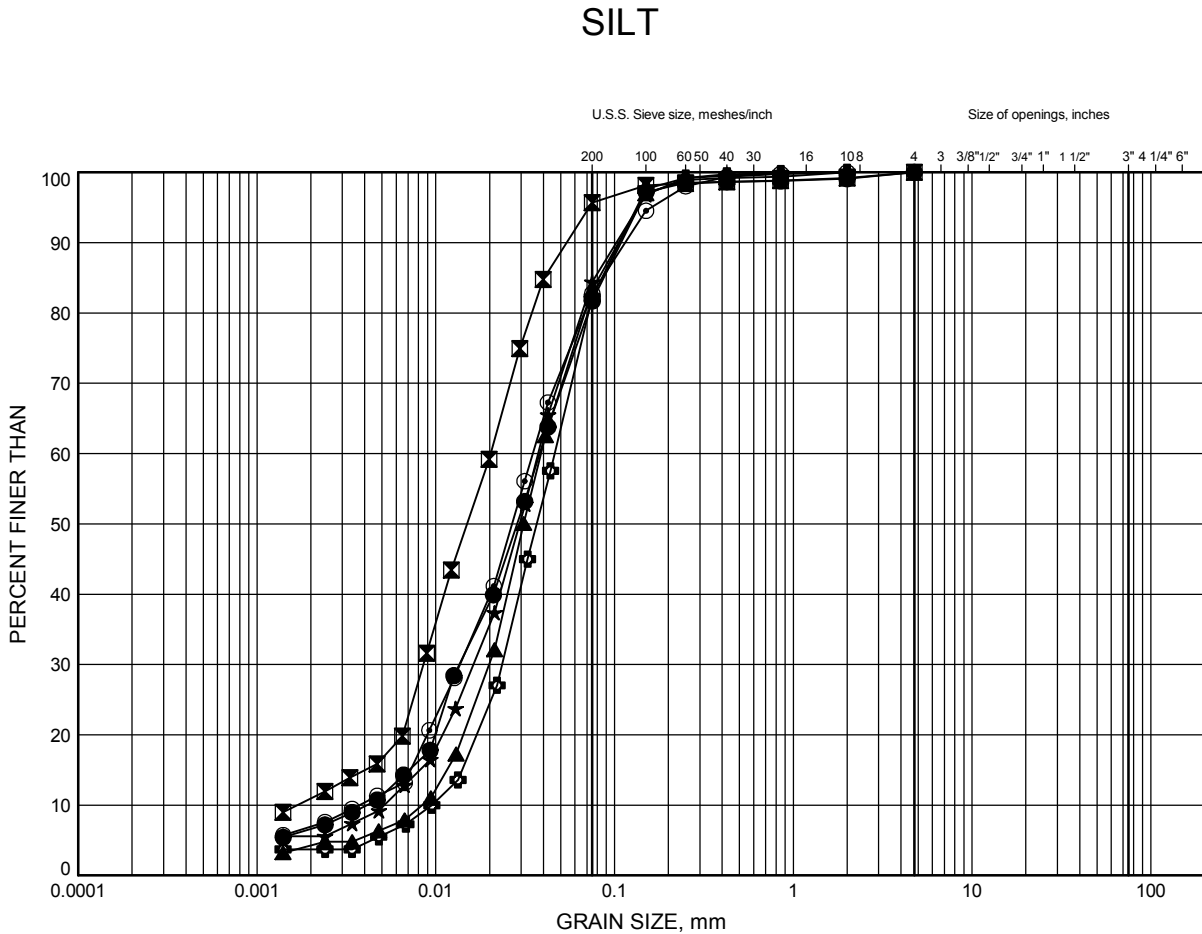
Date January 2013
W.P. 6042-08-00



Prep'd AN
Chkd. MC

Pickerel River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B6



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PR-02	14.02	399.48
⊠	PR-02	20.12	393.38
▲	PR-02	32.31	381.19
★	PR-06	15.54	398.36
⊙	PR-09	12.50	401.60
⊕	PR-09	32.31	381.79

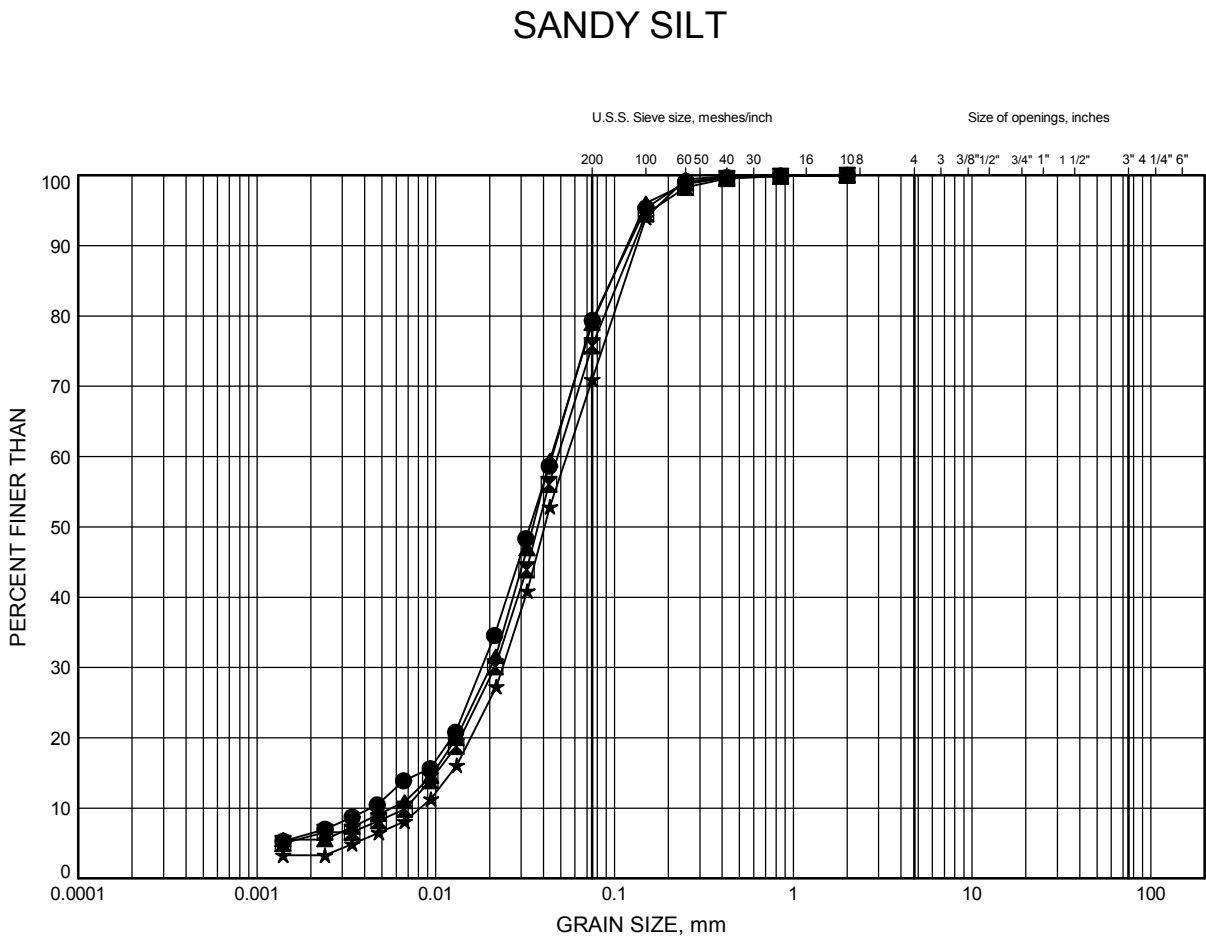
Date February 2013
W.P. 6042-08-00



Prep'd AN
Chkd. MC

Pickerel River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B7



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PR-01	9.45	404.05
⊠	PR-06	12.50	401.40
▲	PR-09	18.59	395.51
★	PR-09	26.21	387.89

Date February 2013
W.P. 6042-08-00

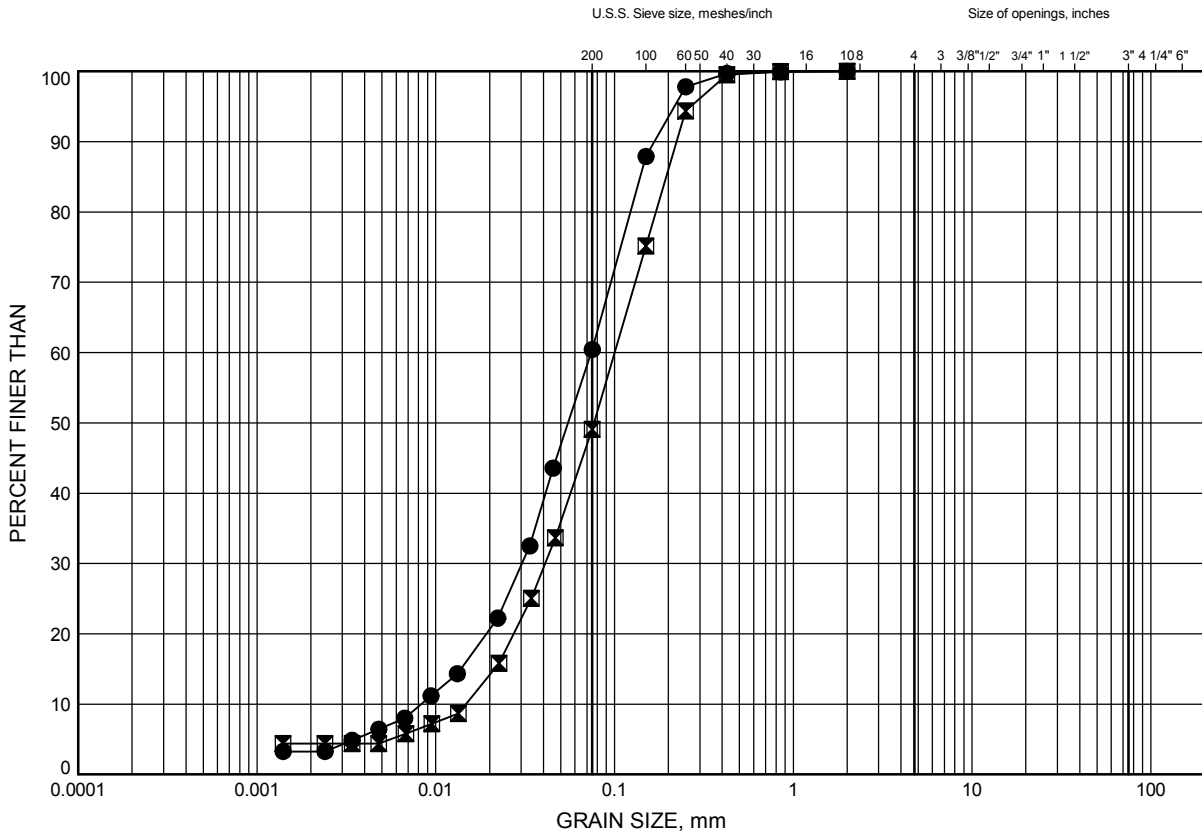


Prep'd AN
Chkd. MC

Pickerel River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B8

SILT AND SAND



Appendix C
Site Photographs



Photograph 1 – North elevation of the bridge, looking west



Photograph 2 – South elevation of the bridge, looking west



Photograph 3 – East abutment and bents, looking east



Photograph 4 – East abutment, looking north

Appendix D
Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR ABUTMENTS

Footing on Native Soil	Augered Caissons (drilled shafts)	Driven Piles into native gravel/sand/silt
<p><i>Advantages:</i></p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. 	<p><i>Advantages:</i></p> <ul style="list-style-type: none"> i. Construction of caissons could continue in freezing weather. ii. Subexcavation of fill not required. 	<p><i>Advantages:</i></p> <ul style="list-style-type: none"> i. Piles will develop geotechnical resistance by shaft friction in loose to compact silt/sand. ii. Installation of piles could continue in freezing weather. iii. Independent of groundwater conditions. iv. Excavation for foundation construction is not required. v. Readily installed.
<p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> i. Low available geotechnical resistance in native soils. ii. Potential for settlements. iii. Scour protection required. iv. Will require excavation in cohesionless soils below the water level. v. Potential disturbance of river banks during construction 	<p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> i. Suitable bearing stratum was not encountered within the borehole depth of exploration ii. Higher unit cost compared to spread footings. iii. Specialized installation measures such as temporary liners and drilling mud will be required to install caissons in cohesionless soils under the water table. iv. Potential difficulty in cleaning and inspecting bases. 	<p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> i. Higher unit costs than footings. ii. Relatively low axial and lateral resistance available.
NOT RECOMMENDED	NOT RECOMMENDED	RECOMMENDED

Appendix E
Slope Stability Output

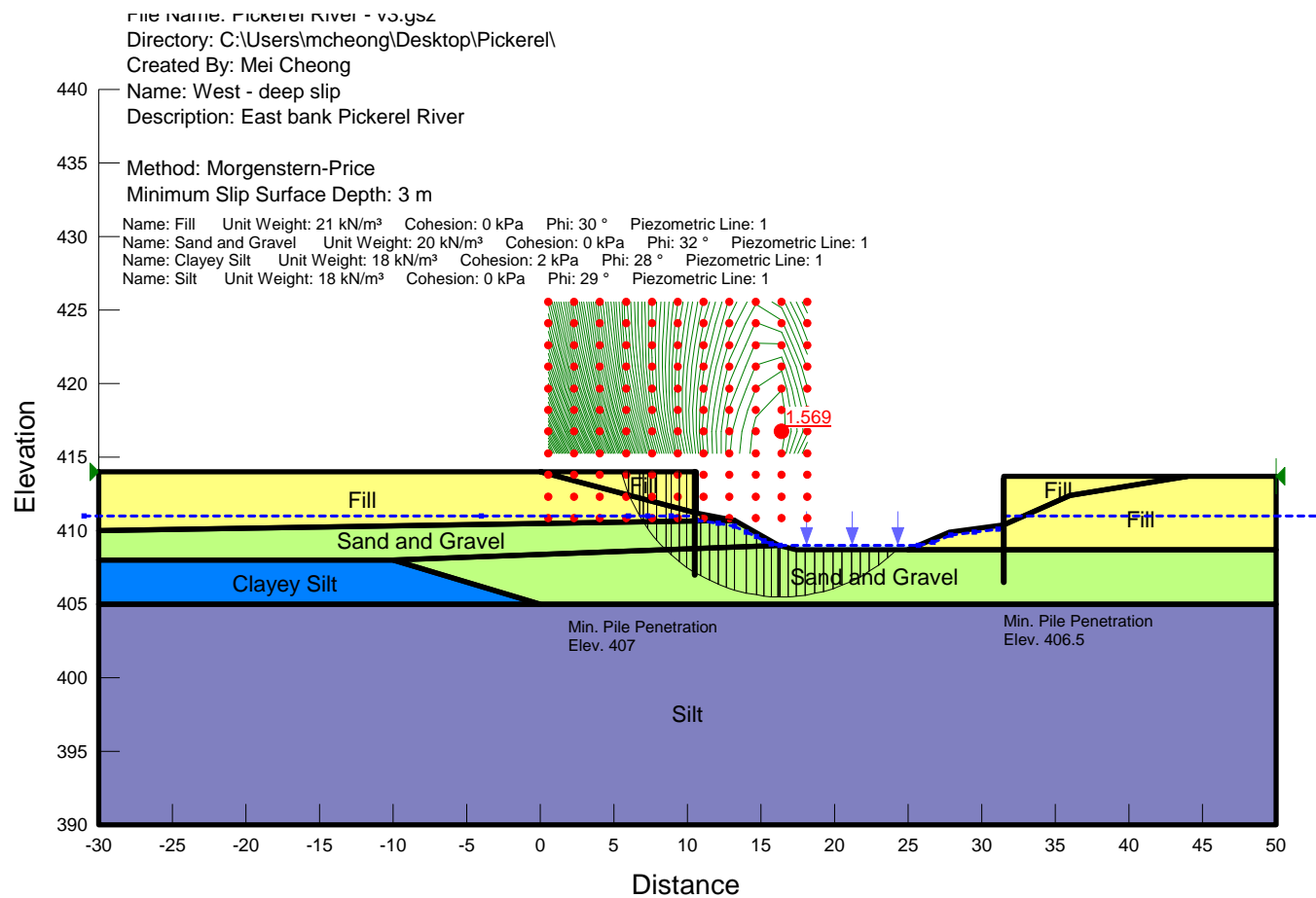


FIGURE E1

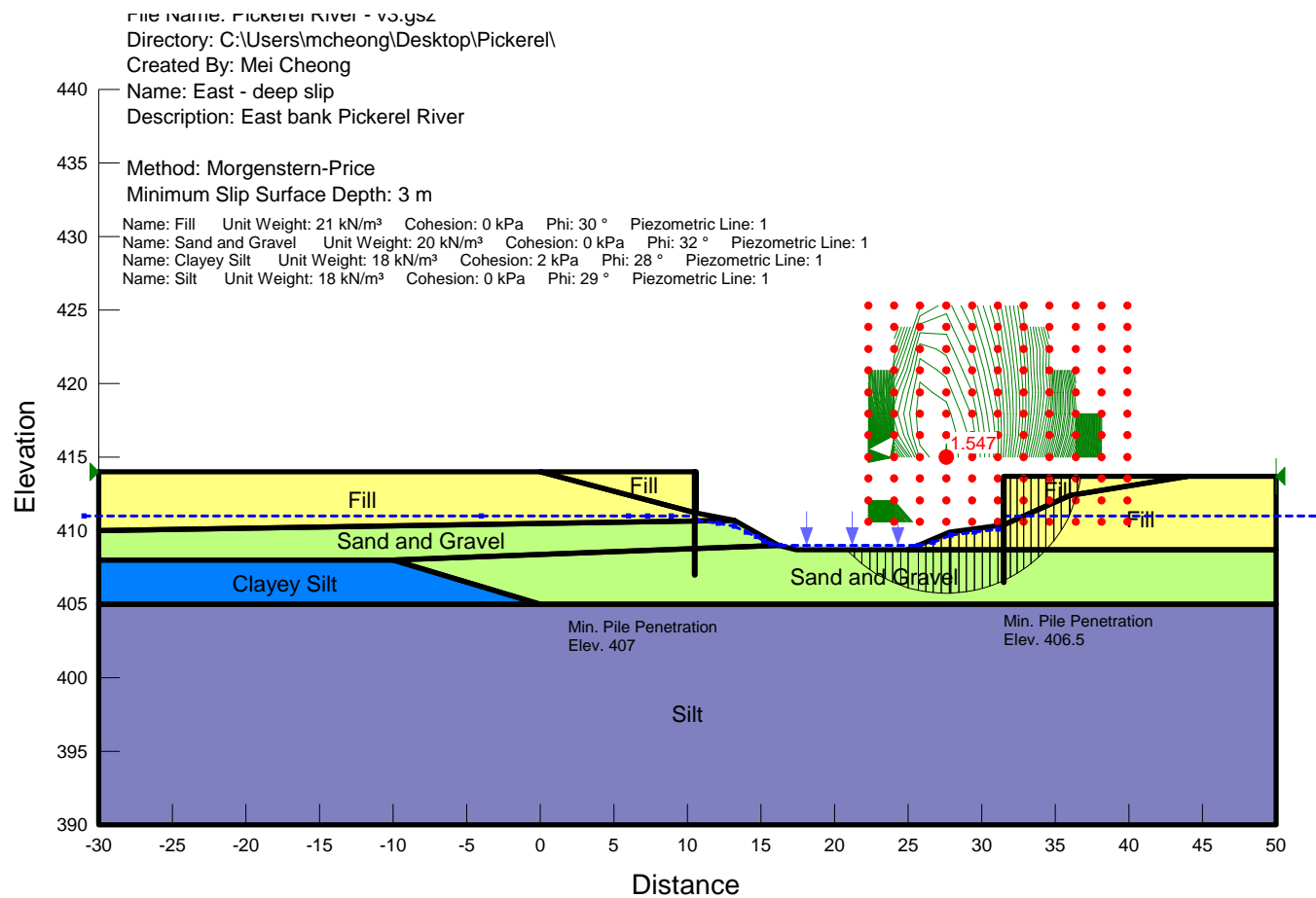


FIGURE E2

Appendix F

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

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

- OPSS 501
- OPSS 539
- OPSS 804
- OPSS 902
- OPSS 903
- OPSD 3101.150
- Special Provision 110S13 “Amendment to OPSS 1010, April 2004”.

2. Suggested text for a NSSP on Steel Sheet Pile and Driven H-pile installation

The existing embankment fill and native soils contain cobbles and possibly boulders.

These cobbles and boulders may impede the driving of sheet piles as well as H-piles and at some locations the sheet piles or H-piles may not be able to penetrate the cobbles and boulders and reach the design depth of installation.

The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the piles to the design depth.

The sheet piles should be provided with pile tip protectors to minimize tip damage.

If the piles meet refusal at a depth less than the anticipated depth, the QVE must terminate driving before the pile is damaged due to over-driving. The QVE must immediately bring it to the attention of the CA. If the CA cannot resolve the issue, it must be referred to the design team for resolution.

3. Suggested text for a NSSP on Monitoring Requirements of the Existing Bridge

Monitoring of the existing bridge abutments and piers is required during pile driving of the new bridge foundations. As a minimum, the contractor must establish a reference point over each abutment and each pile bent of the existing structure and to monitor vertical and lateral movements of these points relative to known, fixed reference points on a regular basis.

The suggested monitoring frequency is:

- Three readings on separate days prior to construction to establish a baseline
- Twice daily while any foundation construction or other subsurface construction is in progress

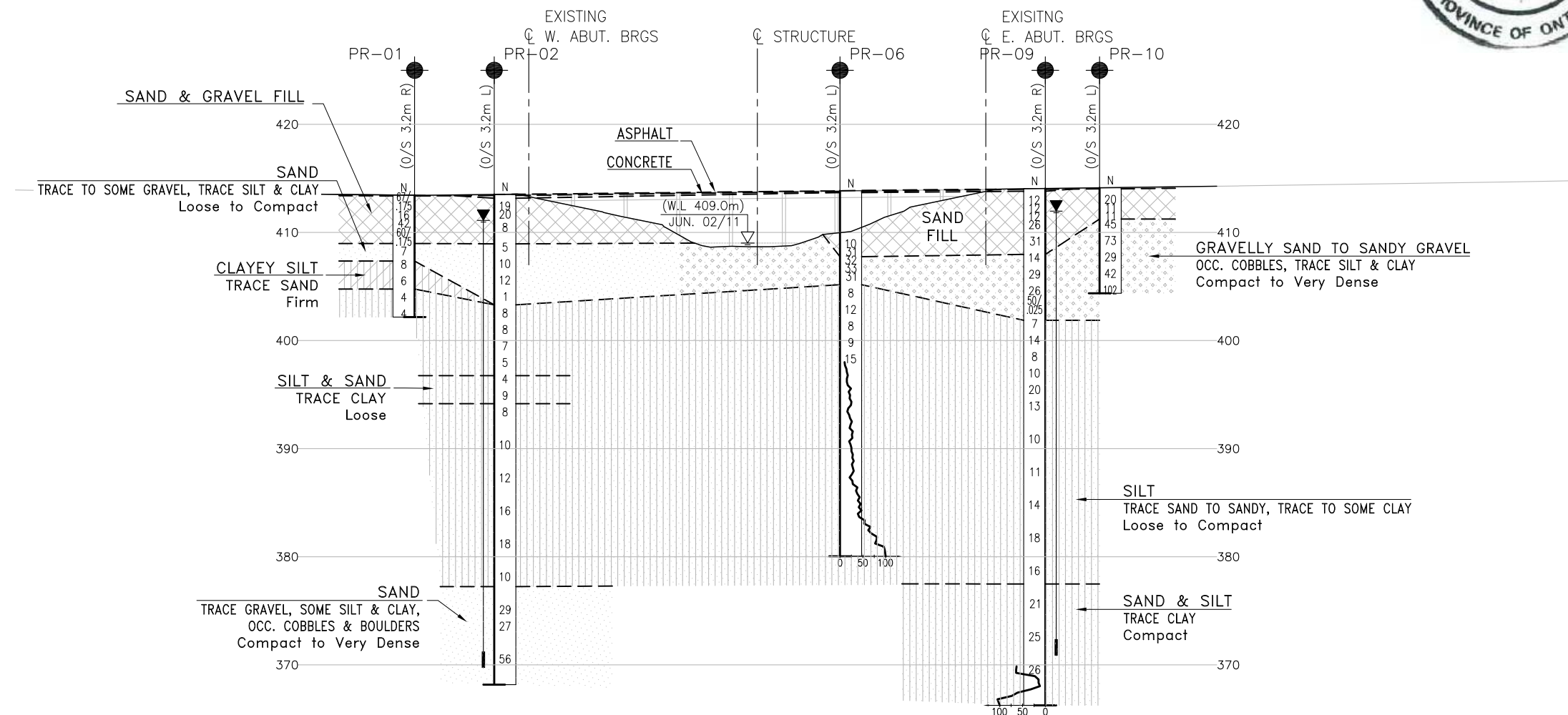
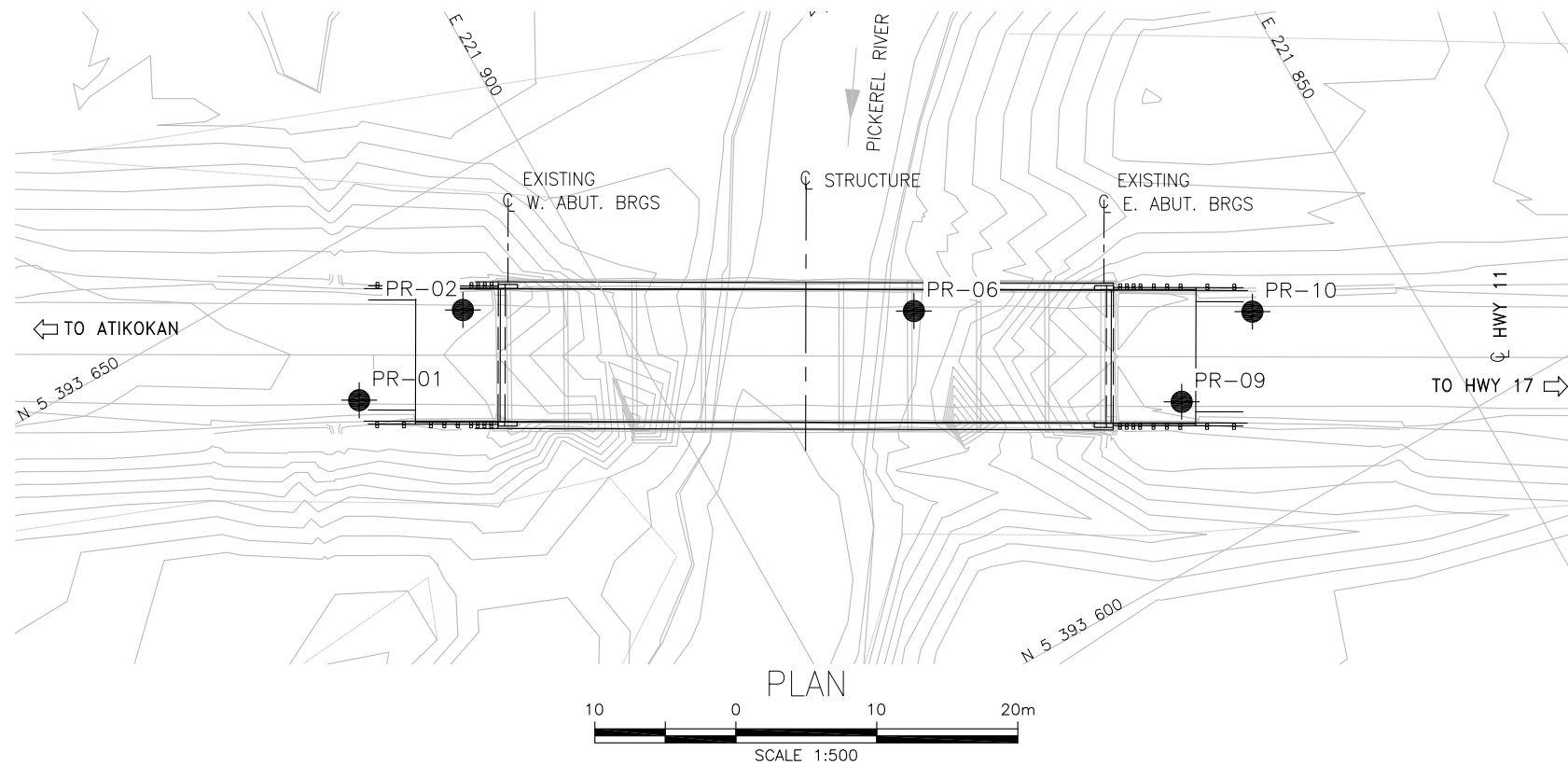
- Daily for one week after completion of foundation construction
- Reading should be taken at the same time each day.

The vertical and horizontal accuracy of readings should be 2 mm. All readings must be reported to the CA within 24 hours and immediately if any movement exceeds limits set by the structural designers.

The CA must be advised of the importance of monitoring and be required to advise the Ministry immediately if the vertical or horizontal movement exceeds the specified limits.

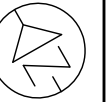
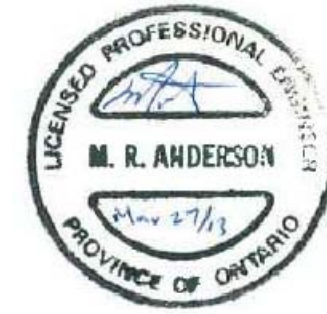
Appendix G

Drawing
Borehole Locations and Soil Strata



PROFILE ALONG C HIGHWAY 11

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



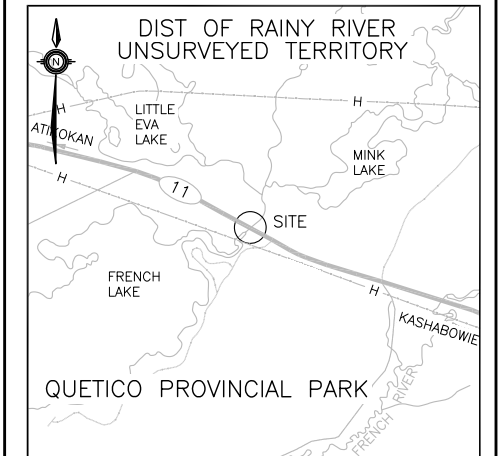
CONT No
GWP No 6042-08-00

PICKEREL RIVER BRIDGE STRUCTURAL REPLACEMENT BOREHOLE LOCATIONS AND SOIL STRATA

SHEET |







THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

[illegible]

-NOTES-

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

GEOCRES No. 52B-16

REVISIONS										
	DATE	BY				DESCRIPTION				
DESIGN	MC	CHK	PKC	CODE		LOAD			DATE	MAR. 2013
DRAWN	MFA	CHK	MC	SITE	45-96	STRUCT		DWG	1	