

**FOUNDATION INVESTIGATION AND DESIGN REPORT
ENGLISH RIVER BRIDGE REPLACEMENT
EAST OF IGNACE, ONTARIO
HIGHWAY 17 IN THE NORTHWEST REGION**

W.P. 468-00-00, SITE No. 41S-73

Geocres Number: 52G-8

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of a proposed replacement of the existing bridge structure which carries Highway 17 over English River, east of The Town of Ignace, 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, stratigraphic profile and cross-sections, laboratory test results and a written description 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 English River Bridge is located on Highway 17 approximately 50 km east of The Town of Ignace, Ontario (Kenora County).

At present, the highway crosses the English River on a six-span structure supported on timber piles. The English River bridge spans approximately 36.0 m across the river channel. The width of the bridge is approximately 10.0 m. The English River flows to the north.

The surrounding area near the site is relatively flat. The areas to the east and west of the site are heavily treed.

Photographs in Appendix F show the general nature of the site.

The site lies within the physiographic region known as the Wabigoon Terrane subprovince of the Superior Province of the Canadian Shield. The region is characterized by Precambrian meta-volcanic and meta-sedimentary rocks intruded by later stage diabase dykes. In some areas the Precambrian rocks are covered by sedimentary rocks of the Huronian Supergroup. The bedrock is mantled by glaciolacustrine varved clays and sand and gravel deposits.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project was carried out from March 9 to 17, 2011 and consisted of drilling and sampling six boreholes (numbered ERB11-01 to ERB11-06) in the area of the existing west and east approaches and abutments. Boreholes ERB11-01 and ERB11-06 drilled at the west and east approaches were terminated at 9.8 m and 7.6 m depth (elevations 452.8 and 454.8), respectively. Boreholes ERB11-02 to ERB11-04 drilled at the abutments were terminated at depths ranging from 26.8 m to 31.6 m (elevations 431.0 to 435.7). Boreholes ERB11-02 to ERB11-05 were supplemented by dynamic cone penetration testing (DCPT) conducted adjacent to each borehole. The depths to the DCPT ranged from 12.8 m to 20.1 m (elevations 442.4 to 449.7). DCPT was conducted from the base of Boreholes ERB11-01 and ERB11-06 to 16.8 m and 15.8 m depth, respectively (elevations 445.8 and 446.6).

The approximate locations of the boreholes 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. Road occupancy permits were obtained for boreholes drilled on the existing Highway 17 platform.

The drilling was carried out from the highway grade using a CME75 truck-mounted drill rig. A combination of hollow-stem auger drilling techniques and coring methods were used to advance the boreholes. The coring methods were used at various depths in the boreholes where boulders were encountered. Overburden 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. Upon completion of drilling, boreholes caved in and they were subsequently backfilled with sand and/or auger cuttings to 0.3 m or 0.6 m, concrete to 0.1 m and then asphalt to surface.

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and moisture content determinations. 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 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 in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing 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.

In general terms, the stratigraphy encountered at this site consist of pavement structure overlying granular fill and peat. Extensive deposits of sand containing cobbles and boulders were contacted below the peat. Layers of sandy silt and clayey silt were also encountered in the boreholes at various depths. Bedrock was not encountered within the depth explored.

More detailed descriptions of the individual strata are presented below.

5.1 Pavement structure

Pavement structure was encountered in all the boreholes drilled at this site. The boreholes were drilled through the existing Highway 17 lanes. The pavement structure consists of approximately 90 mm to 150 mm of asphalt overlying granular fill.

5.2 Fill

Fill was contacted below the pavement structure in all the boreholes. The fill generally consists of brown to grey gravelly sand, sand and gravel and sand containing trace to some silt and clay and occasional cobbles and boulders. The lower part of the fill in Borehole ERB11-01 contained organics and wood fibres.

The thickness of the fill ranged from 3.6 m to 5.1 m.

The depth to the base of the fill varied from 3.7 m to 5.2 m (elevations 457.3 to 458.9).

SPT ‘N’ values recorded in the cohesionless fill ranged from 14 blows per 0.3 m of penetration to 166 blows per 0.1 m of penetration, indicating a compact to very dense relative density. Lower SPT ‘N’ values ranging from 3 to 7 blows per 0.3 m of penetration, indicating a very loose to loose relative density, were measured below 2.3 m depth in Boreholes ERB11-01 and ERB11-06 drilled at the approaches.

The moisture content of the fill ranged from 3% to 20%.

Grain size distribution curves for samples of the fill tested are presented on the Record of Borehole sheet and on Figure B1 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	13 to 80
Sand	18 to 74
Silt	13
Clay	1
Silt and Clay	2 to 19

5.3 Peat

Dark brown to black silty peat containing some sand was contacted below the fill in all the boreholes at depths ranging from 3.7 m to 5.2 m (elevations 457.3 to 458.9).

The thickness of the peat ranged from 0.1 m to 1.5 m.

The depth to the base of the peat ranged from 4.1 m to 6.1 m (elevations 456.3 to 458.5).

SPT 'N' values recorded in the peat were 3 and 4 blows per 0.3 m penetration indicating a soft consistency.

The moisture contents of the peat ranged from 32 % to 68%.

5.4 Sand

Native brown to grey sand containing trace gravel, trace to some silt, trace clay and some cobbles and boulders was contacted at depths and elevations indicated in Table 5.1. The Table 5.1 also indicates the depths and elevations to the base of the sand.

Table 5.1 – Depths and Elevations of Top and Base of Sand Stratum

Foundation Unit	Borehole	Top and Base Depths below existing ground surface (m)	Elevation of top and base of sand stratum (m)	Thickness (m)
West Approach	ERB11-01	4.6 to 9.8 ⁽¹⁾	458.0 to 452.8	5.2
West Abutment	ERB11-02	4.7 to 20.4 24.4 to 30.5 ^(1,2)	457.8 to 442.1 438.1 to 432.0	15.7 6.1
	ERB11-03	6.1 to 13.3 14.8 to 20.9	456.4 to 449.2 447.7 to 441.6	7.2 6.1
		24.4 to 26.8 ^(1,2)	438.1 to 435.7	2.4
East Abutment	ERB11-04	4.6 to 17.8 19.3 to 23.8 25.9 to 27.9	458.0 to 444.8 443.3 to 438.8 436.7 to 434.7	13.2 4.5 2.0
		4.9 to 18.3 20 to 27.4 ^(1,2)	457.6 to 444.2 442.5 to 435.1	13.4 7.4
East Approach	ERB11-06	6.1 to 7.6 ⁽¹⁾	456.3 to 454.8	1.5

⁽¹⁾Borehole termination depth

⁽²⁾Coring through boulders

The cobbles and boulders were generally encountered in the sand deposit below elevations 434 to 438.

At some locations coring through boulders was required to advance the boreholes.

A layer of gravel was contacted at 23.8 m depth (elevation 438.8) in Borehole ERB11-04 drilled at the east abutment. The thickness of the gravel layer was 2.1 m.

In Borehole ERB11-04, cobbles and boulders were encountered below the sand at 27.9 m depth (elevation 434.7). Borehole ERB11-04 was terminated within the cobbles and boulders at 31.6 m depth (elevation 431.0).

Standard Penetration tests in the sand layer gave SPT 'N' values generally in the range of 4 to 44 blows per 0.3 m of penetration, indicating a loose to dense relative density. An SPT 'N' value of 65 blows per 0.3 m of penetration was measured near elevation 436.5 in Borehole ERB11-05 drilled at the east abutment. The sand layer is generally in a compact state.

The moisture contents of samples from the sand generally vary between 8% and 28%.

Grain size distribution curves for the sand samples tested are presented in Figures B2 to B4 in Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	0 to 22
Sand	37 to 98
Silt	16 to 60
Clay	1 to 3
Silt and Clay	2 to 27

5.5 Sandy Silt

Brown to grey sandy silt containing trace gravel and trace to some clay was contacted at depths and elevations indicated in Table 5.2.

Table 5.2 – Depths and Elevations of Top and Base of Sandy Silt Layer

Foundati on Unit	Borehole	Top and Base Depths below existing ground surface (m)	Elevation of top and base of silt layer (m)	Thickness (m)
West Approach	ERB11-01	4.1 to 4.6	458.5 to 458.0	0.5
West Abutment	ERB11-03	13.3 to 14.8	449.2 to 447.7	1.5
East Abutment	ERB11-04	17.8 to 19.3	444.8 to 443.3	1.5
	ERB11-05	18.3 to 19.3	444.2 to 443.2	1.0

Standard Penetration tests in the sandy silt layer gave SPT 'N' values generally in the range of 11 to 23 blows per 0.3 m of penetration, indicating a compact relative density.

The moisture contents of samples from the sandy silt layer generally vary between 20% and 41%.

Grain size distribution curves for the sandy silt samples tested are presented in Figure B4 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	0
Sand	19 to 31
Silt	68 to 74
Clay	1 to 11

5.6 Clayey Silt

Brown to grey clayey silt containing trace sand was contacted below the sand and silty sand at 20.4, 20.9 and 19.3 m depth (elevations 442.1, 441.6 and 443.2) in Boreholes ERB11-02, ERB11-03 and ERB11-05, respectively.

The thickness of the clayey silt was 4.0 m, 3.5 m and 0.7 m at the three boreholes.

The depth to the base of the clayey silt was at 24.4 m (elevation 438.1) in Boreholes ERB11-02 and ERB11-03 and 20.0 m depth (elevation 442.5) in Borehole ERB11-05.

Standard Penetration tests in the clayey silt layer gave SPT 'N' values of 15 and 18 blows per 0.3 m of penetration, indicating a very stiff consistency.

The moisture contents of samples from the clayey silt layer were 32% and 58%.

A grain size distribution curve for one clayey silt sample tested is presented in Appendix B, Figure B5. The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	0
Sand	2
Silt	86
Clay	12

5.7 Water Levels

Water levels were observed in the boreholes during and upon completion of drilling. In Boreholes ERB11-01, ERB11-05 and ERB11-06, water levels were observed at 2.7 m, 2.5 m and 2.6 m depth (elevations 459.9, 460.0 and 459.8).

In the remaining boreholes, it was not possible to obtain water levels at the completion of drilling, as the boreholes caved in. The boreholes cave in to depths shown in Table 5.3.

Table 5.3 – Depths of boreholes cave-in

Foundation Unit	Borehole	Depth below existing ground surface (m)
West Abutment	ERB11-02	2.7
	ERB11-02	2.7
	ERB11-03	2.4
East Abutment	ERB11-04	1.5
	ERB11-05	4.3

Preliminary GA drawing indicates that water level in the English River was at Elevation 460.0 on April 13, 2011.

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. Surveyors from Engineering Northwest Ltd. provided data and drawings to obtain the co-ordinates and the ground surface elevations.

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

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied a truck mounted CME 75 drill rig and conducted the drilling, sampling and in-situ testing operations.

The field program was supervised by Mr. Ryan Kromer of Thurber.

Routine laboratory testing was carried out by Thurber Engineering Ltd.

Overall planning and supervision of the field program was conducted by Mr. Tony Harte, M.Sc. Interpretation of the data and preparation of the report were carried out by Ms. R. Palomeque Reyna, P.Eng.

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

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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 to assist the design team to select and design a suitable foundation system and approach embankments for the replacement of the existing English River bridge located approximately 50 km east of the Town of Ignace, Ontario.

At present, Highway 17 crosses English River on a six-span structure supported on timber piles. The length of the bridge is approximately 36.0 m. The highway grade is near elevations 462.4 to 462.6.

The English River bridge was constructed in 1950 and has undergone rehabilitation in 1985. The existing structure will be replaced maintaining the same alignment for the new structure. However, the highway grade will be raised approximately 1.0 m.

Based on the preliminary General Arrangement (GA) drawing dated January 2012 provided by Hatch Mott MacDonald, a single-span structure supported on two abutments is proposed. The total length of the structure will be 28.5 m. The proposed structure will be approximately 12.9 m wide.

GA drawings show that the abutments are proposed to be founded on driven steel H-piles with a sheet pile wall driven just behind the H-piles. Precast pre-stressed box girders will then be placed spanning the abutment pile caps to support the deck finishing.

A detour bridge is not being planned for this site anymore. Staged construction will be used with half of the bridge being constructed under one lane of running traffic.

The discussion and recommendations presented in this report are based on the information provided by Hatch Mott MacDonald and on the factual data obtained in the course of the investigations.

8 STRUCTURE FOUNDATIONS

It must be noted that the boreholes were drilled at locations selected according to the proposed bridge design shown in a Preliminary General Arrangement drawing (GA drawing) dated January 2011. However, a GA drawing dated January, 2012, shows a revised design structure with a shorter bridge length.

In general terms, the stratigraphy encountered at the site generally consists of pavement structure (asphalt) over very loose to very dense granular fill (a mix of gravelly sand, sand and gravel and sand) overlying peat. The thickness of the peat ranged from 0.1 m to 1.5 m. An extensive deposit of native compact to dense sand containing cobbles and boulders in the lower part of the deposit was encountered below the peat. Layers of compact sandy silt and very stiff clayey silt were also encountered in the boreholes at various depths. Cobbles and boulders were encountered in the highway fill and in the lower part of the native sand.

Preliminary GA drawing indicates that water level in the English River was at Elevation 460.0 on April 13, 2011. In Boreholes ERB11-01, ERB11-05 and ERB11-06, water levels were observed at 2.5 m to 2.7 m depth.

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 C.

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:

1. Founding the spread footings on suitably compact to dense, uniform native subgrade soils will require excavation of the fill and into native permeable, cohesionless sand below the water table and the river level. Such an excavation would require extensive dewatering and yet would remain at risk of becoming destabilized due to the inflow of unbalanced groundwater heads.
2. Spread footings could be subject to erosion or undermining/scour during high river flows.

3. The geotechnical resistance available in the near surface native soils is relatively low and there is potential for settlement.

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

8.2 Augered Caissons (drilled shafts)

Augered caisson foundations were also considered for supporting the structure at this site.

However, caissons will have to be extended to 25 m to 30 m depth to reach the dense to very dense soils suitable for caisson bearing. The caisson installation will largely be in cohesionless sands below the water table.

The permeable nature of the overburden soil would make it difficult to seal the bottom of the caisson liner into the founding stratum to exclude groundwater and prevent base boiling. Unwatering of the caissons would be impractical and attempts to do so might result in continued flow of fines into the caisson excavation.

Installation of deep caissons is also expected to be a more expensive option than driven piles.

Due to the above issues, the use of augered caissons is not recommended at this site and the option has not been developed further.

8.3 Driven Piles

The subsurface conditions at this site are considered suitable for the design of foundations supported on driven steel H-piles.

However, a distinct layer of refusal that would permit the piles to be designed as end-bearing elements was not encountered within the investigation depth at the west and east abutments.

Accordingly, the piles have been assumed to develop most of their resistance from shaft friction and some end bearing resistance. For initial design purposes, a pile length of 28 m below the pile cap has been assumed. Based on GA drawing, the underside of pile cap is near elevation 461.5. The approximate elevation at which the piles are expected to develop the required resistance is 433.5. This elevation should be used for estimating purposes only.

However, at both abutments, the native soils contain cobbles and boulders generally at or below 24.0 m depth. The presence of boulders and cobbles makes it difficult to predict the depth at which piles will achieve the required resistance.

The actual pile tip Elevations will be controlled as described in Section 8.4.4 Pile Driving.

8.3.1 Axial Resistance

The vertical, factored geotechnical resistances at Ultimate Limit States (ULS) and geotechnical resistances at Serviceability Limit States (SLS) for HP 310 x 110 piles when driven into the dense soils are presented in Table 8.1.

Table 8.1 – Axial Resistance of a Pile Section Founded on Dense Soils

Foundation Unit	Pile Section	
	HP 310 x 110	
	ULS (Factored) (kN)	SLS (kN)
Abutments	1,400	1,200

8.3.2 Pile Tips

Due to the presence of cobbles and boulders in the expected founding layer, the tips of all piles should be fitted with pile tip protection such as Titus Steel (Standard H-point) or approved equivalent.

The use of pile tip protection is recommended for the following reasons:

- Some piles will be driven into soil containing cobbles and boulders, generally at the east abutment, which requires a higher level of protection than driving into soils containing only smaller particle sizes

8.3.3 Pile Installation

Driven piles must be installed in accordance with OPSS 903.

The Contract Documents should contain a NSSP alerting the Bidders to:

- The presence of cobbles and boulders in the expected bearing stratum.
- The possibility of piles within a group achieving the specified resistance at different elevations.

Suggested texts for NSSP's are included in Appendix E.

8.3.4 Pile Driving

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 approaching 2.0 m above the design bearing stratum. 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 the minimum values of twice the design load at ULS.

8.3.5 Downdrag

The foundation soil at this site are largely compact granular soils and settlements induced in the foundation soils by 1.0 m raise in highway grade will be substantially complete as construction of the embankment is finished. In light of these factors, downdrag on the piles is not considered to be an issue at this site.

It is considered, that the layers of consolidated peat encountered below the fill at the abutments will not develop negative skin friction.

8.4 Lateral Resistance

The lateral resistance of the pile 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 in metres

n_h = value from Table 8.2

γ = unit weight (Table 8.2)

K_p = passive earth pressure coefficient (Table 8.2)

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 (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 in one pile be limited to no more than 150 kN at ULS and 50 kN at SLS. Parameters for lateral pile resistance are shown in Table 8.2.

Table 8.2 – Parameters for Lateral Pile Resistance

Location	Elevation	n_h (kN/m ³)	S_u (kPa)	K_p	Unit Weight (kN/m ³)	Soil Conditions
West Abutment	OGI to 456.0	8,000	-	3.3	21	Gravelly sand, sand and gravel, compact to very dense (FILL)
	456.0 to 441.0	4,400	-	3.3	11*	Sand, compact to dense
	441.0 to 438.0	-	100	3.0	10*	Clayey silt, very stiff
	Below 438.0	8,000	-	3.5	11*	Sand, cobbles and boulders, compact to dense
East Abutment	OGI to 457.0	6,000	-	3.3	21	Gravelly sand, sand and gravel, compact to very dense (FILL)
	457.0 to 439.0	4,400	-	3.3	11*	Sand, compact to dense
	Below 439.0	8,000	-	3.5	11*	Sand and gravel, cobbles, compact to dense

*Buoyant unit weight below the water table.

Pile interaction should be considered with reference to CHBDC Clause 6.8.9.2.

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

For conventional abutments, the lateral resistance may be provided by battered piles.

8.5 Abutment Design Considerations

The ground conditions at this site are considered suitable for conventional, semi-integral and integral abutment design.

8.6 Sheet Pile Walls

The lateral resistance of sheet piles may be computed using the lateral earth pressure distribution and parameters presented in Section 14. There is a potential of encountering cobbles and boulders in the highway embankment fill and the sheet pile installation techniques must be able to get through such obstructions.

8.7 Recommended Foundation

From a geotechnical point of view, it is recommended that the bridge abutments be supported on steel H-piles driven into the dense sand at or below elevation 433.5.

8.8 Frost Cover

The design depth of frost penetration at this site is 2.5 m.

Frost protection should be provided for pile caps, if used, and should consist of a minimum of 2.5 m of soil cover.

9 EXCAVATION

If 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, November 2010.

Bidders must be alerted to the fact that excavation might be carried out through cohesionless soils (fill and native), which include cobbles and boulders.

Excavation below the groundwater level without prior dewatering is not recommended since the inflow of groundwater will cause boiling and sloughing of the soil below the water table making it difficult to maintain a dry, sound base on which to work.

10 UNWATERING

Preliminary GA drawing indicates that water level in the English River was at Elevation 460.0 on April 13, 2011. In Boreholes ERB11-01, ERB11-05 and ERB11-06, water levels were observed at 2.5 m to 2.7 m depth (elevations 459.8 to 460.0).

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 groundwater level.

If dewatering is required during excavation, the design of any dewatering system should be the responsibility of the Contractor and the Contract Documents should alert him to this responsibility and the need to engage a dewatering specialist. The Contractor should be prepared to pump from sumps to remove any seepage water or surface water collecting in an excavation.

Unwatering for a structure excavation must be carried out in accordance with OPSS 902 and OPSS 518.

11 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 construction and support the existing Highway 17.

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

Conventional steel soldier pile is an option to provide temporary support to the roadway.

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	=	0.30	(Active pressure coefficient for road embankment fill and native sand)
K_p	=	3.3	(Passive pressure coefficient for road embankment fill and native sand)
h_w	=	460.0	(elevation for hydrostatic pressure build-up behind roadway protection)

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 will 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, who will determine an appropriate support system.

12 APPROACH EMBANKMENTS

Based on a contour drawing provided by Hatch Mott MacDonald, the existing approach embankment is up to 5.5 m high with forward slopes of 2.8H:1V. Communication with Hatch Mott MacDonald indicates that if the existing highway grade needs to be raised/modified, it would be approximately 1.0 m.

The foundation soils governing stability of the approach embankments consist generally of existing native compact to dense sand and sandy silt.

Evaluation of the slope stability of the approach embankments was conducted. Global stability analyses were conducted for granular fill embankments under possible new embankment height and slopes (6.5 m high, 2H:1V and 2.8H:1V slopes).

The stability of the embankments was not checked under seismic loading as the zonal acceleration at this site is 0.0g. The computed factors of safety are as shown in Table 12.1. Slope stability computation outputs are included in Appendix E.

Table 12.1 Estimated Factors of Safety

Location / Material	Height (m)	Slope	Factor of Safety	Figure (Appendix E)
West and East Approaches				
Earth Fill	6.5	2.8H:1V	1.8	2
Earth Fill	6.5	2H:1V	1.5	3

The factors of safety against global failure were 1.5 or greater. These factors of safety are considered to be acceptable for the proposed embankment bearing on non-cohesive soil. The existing embankment bearing on the foundation soils present at this site has performed well under the existing conditions. After the bridge rehabilitation is completed, it is expected that the embankment will perform satisfactorily if it is constructed with similar materials.

If placement of new fill is required, the existing slope surfaces should be appropriately benched, as per OPSD 208.010, after stripping of vegetation, topsoil, organics, soft soils or otherwise unsuitable overburden materials.

If additional fill is needed to be placed on the existing slopes, the settlement induced by the placement of new fill is considered negligible.

13 SCOUR AND EROSION PROTECTION

A specialist in river hydrology should be consulted regarding the potential for erosion and, if necessary, erosion protection must be provided for the approach embankment slopes and along the river banks.

In general, earth fill embankment slopes must be provided with erosion protection in accordance with OPSS 804, November 2010.

Erosion and scour protection measures should be designed by a qualified and experienced professional.

14 BACKFILL TO ABUTMENTS

Backfill to the abutments should consist of Granular A or Granular B Type II material meeting the requirements of Special Provision 110S13 "Amendment to OPSS 1010, April 2004". The backfill must be in accordance with OPSS 902, and placed to the extents shown in OPSD 3101.150.

15 EARTH PRESSURE

Earth pressures acting on the structure may be assumed to be triangular and to be governed by the characteristics of the abutment backfill. 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 15.1)

γ = unit weight of retained soil (see Table 15.1)

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

q = value of any surcharge (kPa)

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.

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 15.1.

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) might be preferred as it results in lower earth pressures acting on the wall.

The factors in Table 15.1 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.

Table 15.1 – Earth Pressure Coefficient (K)

Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		Existing Sand and Gravel Fill or OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$		Native Sand $\phi = 32^\circ$ $\gamma = 21 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (Unrestrained Wall)	0.27	0.40*	0.31	0.48*	0.31	0.48*
At rest (Restrained Wall)	0.43	-	0.47	-	0.47	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-	3.3	-

* For wing walls.

16 SEISMIC CONSIDERATIONS

16.1 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 0.02

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

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 16.1 may be used:

Table 16.1 – 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 Sand $\phi = 32^\circ$ $\gamma = 21 \text{ kN/m}^3$
Active (K_{AE})*	0.28	0.32	0.32
Passive (K_{PE})	3.7	3.2	3.2
At Rest (K_{OE})**	0.45	0.50	0.49

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

** After Woods

The foundation soils at the abutments are not in danger of liquefaction under earthquake loading.

17 CONSTRUCTION CONCERNS

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

1. The potential variability of pile lengths at refusal.
2. The possibility of H-piles and sheet piles reaching refusal on large boulders.
3. Destabilization of excavations

If excavation is required, proper groundwater and surface water control measures must be in place prior to commencing excavation. Perched water may be encountered within the sand and gravel fill. The impact of this perched groundwater could destabilize the sides and or base of the excavation. The Contractor's unwatering plan must be available for rapid implementation should the need arise.

18 CLOSURE

Engineering analysis and preparation of the report were carried out by Ms. R. Palomeque Reyna, P.Eng.

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

Thurber Engineering Ltd.

Rocío Palomeque Reyna, P.Eng., M.Eng.
Geotechnical Engineer



Report reviewed by:
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




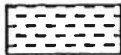



Shear Strength Determination by Pocket Penetrometer

- (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			

EXPLANATION OF ROCK LOGGING TERMS

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

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
TERMS					
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No ERB11-01

1 OF 2

METRIC

W.P. 468-00-00 LOCATION N 5 455 520.0 E 234 084.1 English River Bridge ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2011.03.14 - 2011.03.14 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				
462.6							20 40 60 80 100					
0.0	ASPHALT: (150mm)						20 40 60 80 100					
0.2	Gravelly SAND, occasional cobbles and boulders Dense to Very Dense Brown Moist (FILL)		1	AS								
			1	SS	45/ 0.275							
			2	SS	30							
460.3												
2.3	SAND, medium grained, some gravel, some silt, trace clay, occasional organics and wood fibres Loose to Very Loose Brown to Dark Brown Moist (FILL)		3	SS	7							13 73 13 1
			4	SS	3							
458.9												
3.7	PEAT, silty Soft											
458.5	Dark Brown to Black		5	SS	11							
4.1	Wet											
458.0	Sandy SILT Compact											
4.6	Greyish Brown Moist		6	SS	4							3 89 8 (SI+CL)
	SAND, medium to coarse grained, trace gravel, trace silt and clay Very Loose to Compact Grey Wet											
			7	SS	20							
	Silty		8	SS	7							0 73 26 1
			9	SS	17							
452.8												
9.8	DCPT start at 9.8m.											


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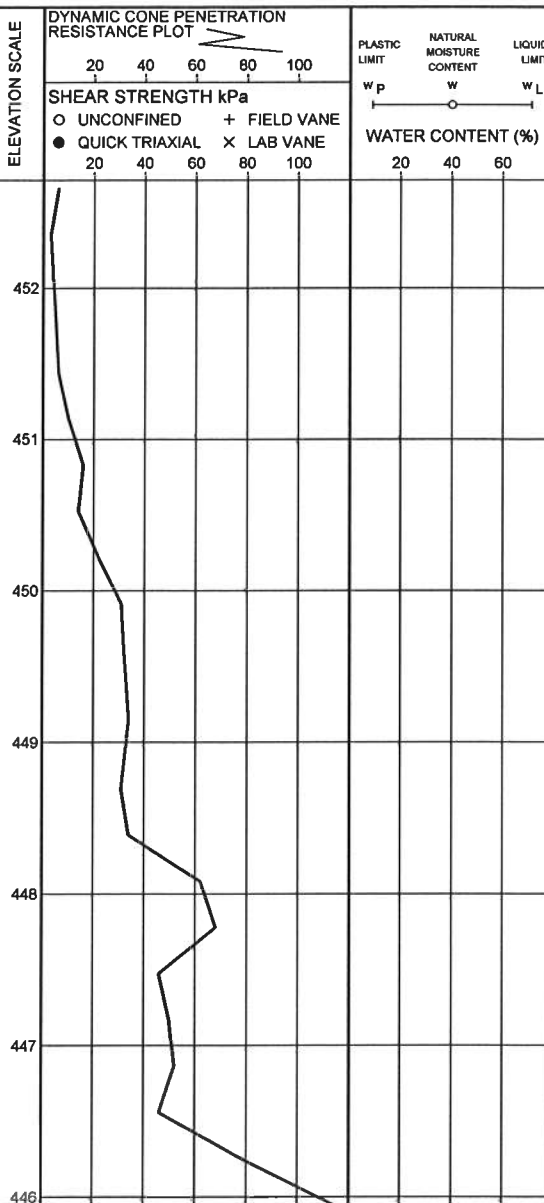
+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES		w _p	w		
	Continued From Previous Page						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				kN/m³	GR SA SI CL
							20 40 60 80 100 20 40 60 80 100				20 40 60	



END OF BOREHOLE AT 16.8m.
DCPT TERMINATED UPON
REFUSAL AT 16.8m.
WATER LEVEL AT 2.7m.
BOREHOLE CAVED TO 2.7m.
BOREHOLE BACKFILLED WITH
AUGER CUTTINGS TO 0.6m,
CONCRETE TO 0.1m, THEN
ASPHALT TO SURFACE.

RECORD OF BOREHOLE No ERB11-02

1 OF 4

METRIC

W.P. 468-00-00 LOCATION N 5 455 521.9 E 234 094.2 English River Bridge ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.03.11 - 2011.03.11 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			20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
462.5	ASPHALT: (100mm)											
0.0 0.1	SAND and GRAVEL, occasional cobbles Very Dense to Compact Brown to Grey Wet (FILL)		1	SS	57		462					
			2	SS	166/ 0.100		461					
			3	SS	35		460					62 31 7 (SI+CL)
	Cobbles		4	SS	30		459					
457.9							458					
457.6	PEAT, silty, some sand Brown Wet (100mm)		5	SS	14		457					
4.7	SAND, medium to coarse, trace gravel, trace silt and clay Compact to Dense Grey Wet		6	SS	31		456					1 97 2 (SI+CL)
			7	SS	22		455					
			8	SS	14		454					
							453					

Continued Next Page

+ ³ , × ³ : Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

W.P.	468-00-00	LOCATION	N 5 455 521.9 E 234 094.2 English River Bridge	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	Casing	COMPILED BY	AN
DATUM	Geodetic	DATE	2011.03.11 - 2011.03.11	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 (%)	
								○ UNCONFINED	+ FIELD VANE							
								● QUICK TRIAXIAL	× LAB VANE							
	Continued From Previous Page															
	SAND, fine, some silt to silty, trace clay Loose to Compact Greyish Brown Wet		9	SS	6									0 70 28 2		
			10	SS	11											
			11	SS	18											
			12	SS	16									0 83 16 1		
			13	SS	16											
			14	SS	21											

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No ERB11-02

3 OF 4

METRIC

W.P. 468-00-00 LOCATION N 5 455 521.9 E 234 094.2 English River Bridge ORIGINATED BY RK
HWY 11 BOREHOLE TYPE Casing COMPILED BY AN
DATUM Geodetic DATE 2011.03.11 - 2011.03.11 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			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
	Continued From Previous Page											
442.1 20.4	SAND, some silt, trace clay Dense Greyish Brown Wet		15	SS	35		442					0 83 16 1
	Clayey SILT, sand layers Very Stiff Grey		16	SS	18		441					
							440					
							439					
438.1 24.4	SAND, some gravel, some silt and clay, occasional cobbles and boulders Dense Grey Wet		17	SS	37		438					22 51 27 (SI+CL)
							437					
							436					
			18	SS	41		435					
							434					
							433					
	Boulders from 29.2m to 29.9m											

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 (%) 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page													
432.0	SAND , some silt and clay, boulders Dense Grey Wet													
30.5	END OF BOREHOLE AT 30.5m. BOREHOLE CAVED TO 2.7m. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO 0.6m, CONCRETE TO 0.07m, THEN ASPHALT TO SURFACE.					432								

RECORD OF BOREHOLE No ERB11-03

1 OF 3

METRIC

W.P. 468-00-00 LOCATION N 5 455 517.5 E 234 093.1 English River Bridge ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE Casing COMPILED BY MFA
 DATUM Geodetic DATE 2011.03.14 - 2011.03.15 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			20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
462.5	ASPHALT: (100mm)											
0.0												
0.1	SAND and GRAVEL, trace silt and clay, occasional cobbles and boulders Brown Moist (FILL)		1	SS	-		462					
	Very Dense to Compact Greyish Brown Wet		2	SS	27		461					
			3	SS	62		460					80 18 2 (SI+CL)
			4	SS	42		459					
			5	SS	21		458					
			6	SS	14		457					
457.3	PEAT, silty Dark Brown						456					
5.2							455					
456.4	SAND, fine grained, some silt to silty Dense to Compact Greyish Brown Wet		7	SS	44		454					
6.1			8	SS	15		453					
	Loose		9	SS	9							0 79 20 1

Continued Next Page

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

RECORD OF BOREHOLE No ERB11-03

2 OF 3

METRIC

W.P. 468-00-00 LOCATION N 5 455 517.5 E 234 093.1 English River Bridge ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE Casing COMPILED BY MFA
 DATUM Geodetic DATE 2011.03.14 - 2011.03.15 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			20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%) 20 40 60			
449.2	SAND, some silt to silty Loose Brown to Grey Wet		10	SS	7		452					
							451					
			11	SS	5		450					
13.3	Sandy SILT, trace clay Compact Brown to Grey Wet		12	SS	15		449					0 31 68 1
447.7							448					
14.8	SAND, some silt to silty Compact to Dense Brown to Grey Wet		13	SS	12		447					
							446					0 81 18 1
			14	SS	17		445					
							444					
			15	SS	31		443					

Continued Next Page

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

RECORD OF BOREHOLE No ERB11-03

3 OF 3

METRIC

W.P. 468-00-00 LOCATION N 5 455 517.5 E 234 093.1 English River Bridge ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE Casing COMPILED BY MFA
 DATUM Geodetic DATE 2011.03.14 - 2011.03.15 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE								
								● QUICK TRIAXIAL × LAB VANE								
	Continued From Previous Page															
441.6	SAND, some silt to silty Compact Brown to Grey Wet		16	SS	24											
20.9	Clayey SILT, trace sand Very Stiff Grey		17	SS	15										0 2 86 12	
438.1																
24.4	SAND, fine grained, gravelly layers, occasional cobbles and boulders Dense Grey Wet Coring through boulders from 25.3m to 26.8m		18	SS	31											
435.7																
26.8	END OF BOREHOLE AT 26.8m. BOREHOLE CAVED TO 2.4m. BOREHOLE BACKFILLED WITH SAND AND AUGER CUTTINGS TO 0.3m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.															

+ ³, x ³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

W.P.	488-00-00	LOCATION	N 5 455 510.1 E 234 132.4 English River Bridge	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.03.09 - 2011.03.10	CHECKED BY	RPR

[illegible]

Continued Next Page

+³, ×³; Numbers refer to Sensitivity

RECORD OF BOREHOLE No ERB11-04

2 of 4

METRIC

W.P. 468-00-00 LOCATION N 5 455 510.1 E 234 132.4 English River Bridge ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2011.03.09 - 2011.03.10 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			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%) 20 40 60			GR SA SI CL
	SAND, some silt to silty, trace clay Compact Brown to Grey Wet		9	SS	20		452					
							451					
	Layer of sandy silt		10	SS	15		450					0 37 60 3
							449					
			11	SS	28		448					0 63 36 1
							447					
			12	SS	17		446					
							445					
			13	SS	16		444					0 70 29 1
444.8							443					
17.8	Sandy SILT, some clay Compact Grey Wet		14	SS	23							0 19 70 11
443.3												
19.3	SAND, some silt to silty, trace clay Compact Brown to Grey Wet											

Continued Next Page

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

RECORD OF BOREHOLE No ERB11-04

3 OF 4

METRIC

W.P. 468-00-00 LOCATION N 5 455 510.1 E 234 132.4 English River Bridge ORIGINATED BY RK
HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA
DATUM Geodetic DATE 2011.03.09 - 2011.03.10 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						
	Continued From Previous Page		15	SS	39									
	SAND, some silt to silty, trace clay Compact to Dense Grey Wet						442							
							441							
							440							
			16	SS	27									
438.8							439							
23.8	GRAVEL, some sand Grey Wet						438							
	occasional cobbles and boulders						437							
436.7							436							
25.9	SAND, some gravel to gravelly, some silt and clay Compact Grey Wet		17	SS	17		435							
							434							
434.7							433							
27.9	Coring through cobbles and boulders: (GRANITE, pink and grey)		1	RUN										
			2A	RUN										
			2B	RUN										

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S 5121.GPJ 9/13/11

RECORD OF BOREHOLE No ERB11-04

4 OF 4

METRIC

W.P. 468-00-00 LOCATION N 5 455 510.1 E 234 132.4 English River Bridge ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2011.03.09 - 2011.03.10 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									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
						20	40	60	80	100	20	40	60				
	Continued From Previous Page																
	Coring through boulders: (GRANITE, pink and grey)		3	RUN													
431.0																	
31.6	END OF BOREHOLE AT 31.6m. BOREHOLE CAVED TO 1.5m, BACKFILLED WITH SAND TO 0.6m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.																

RECORD OF BOREHOLE No ERB11-05

1 OF 3

METRIC

W.P. 468-00-00 LOCATION N 5 455 505.9 E 234 129.7 English River Bridge ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE Casing COMPILED BY MFA
 DATUM Geodetic DATE 2011.03.16 - 2011.03.16 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			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
462.5	ASPHALT: (100mm)											
0.0												
0.1	SAND and GRAVEL Very Dense to Compact Brown Wet (FILL)		1	SS	44							
	Cobbles		2	SS	19							
			3	SS	50							
	becoming Grey		4	SS	22							
458.8												
3.7	PEAT, silty Soft Black Wet		5	SS	4							
457.6			6	SS	15							
4.9	SAND, medium grained, trace silt and clay Dense to Compact Brown Wet											
			7	SS	32							
			8	SS	15							
			9	SS	15							

Continued Next Page

+ 3, X 3: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ERB11-05

2 OF 3

METRIC

W.P. 468-00-00 LOCATION N 5 455 505.9 E 234 129.7 English River Bridge ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE Casing COMPILED BY MFA
 DATUM Geodetic DATE 2011.03.16 - 2011.03.16 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 (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
	Continued From Previous Page							20 40 60 80 100	20 40 60						
	SAND, trace silt to silty, trace clay Loose to Compact Brown to Grey Wet						452								
			10	SS	7		451								
			11	SS	11		450								
			12	SS	10		449								
							448								
			13	SS	13		447								
							446								
			14	SS	12		445								
444.2 18.3	Sandy SILT Compact Brown to Grey Wet		15	SS	19		444								
443.2 19.3	Clayey SILT Reddish Brown to Grey Wet														
442.5							443								

Continued Next Page

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

RECORD OF BOREHOLE No ERB11-05

3 OF 3

METRIC

W.P. 468-00-00 LOCATION N 5 455 505.9 E 234 129.7 English River Bridge ORIGINATED BY RK
HWY 11 BOREHOLE TYPE Casing COMPILED BY MFA
DATUM Geodetic DATE 2011.03.16 - 2011.03.16 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				
								WATER CONTENT (%)				
			</									

ONTMT4S 5121.GPJ 9/13/11

RECORD OF BOREHOLE No ERB11-06

1 OF 2

METRIC

W.P. 468-00-00 LOCATION N 5 455 507.6 E 234 140.2 English River Bridge ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2011.03.09 - 2011.03.09 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					
462.4								20 40 60 80 100					
0.0	ASPHALT: (90mm)												
0.1	SAND, some gravel to gravelly, trace to some silt, trace clay Very Dense to Loose Brown Moist (FILL)		1	AS			462						
			1	SS	81								18 63 19 (SI+CL)
			2	SS	26		461						
	Moist to Wet		3	SS	6		460						21 70 9 (SI+CL)
	Brown to Grey		4	SS	5		459						28 58 14 (SI+CL)
457.8							458						
4.6	PEAT, silty, some sand Soft Dark Brown Wet		5	SS	3		457						
456.3													
6.1	SAND, medium grained, trace clay Compact Grey Wet		6	SS	10		456						0 98 2 (SI+CL)
454.8							455						
7.6	END OF BOREHOLE AT 7.6m. WATER LEVEL AT 2.6m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO 0.6m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE. Start DCPT at 7.6m.						454						
							453						

Continued Next Page

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

RECORD OF BOREHOLE No ERB11-06

2 OF 2

METRIC

W.P. 468-00-00 LOCATION N 5 455 507.6 E 234 140.2 English River Bridge ORIGINATED BY RK
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2011.03.09 - 2011.03.09 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								
	Continued From Previous Page											
446.6												
15.8	END OF DCPT AT 15.8m.											

Appendix B

Laboratory Test Results

U.S.S. Sieve size, meshes/inch

Size of openings, inches

200 100 60 50 40 30 16 10 8 4 3 3/8" 1/2" 3/4" 1" 1 1/2" 3" 4 1 1/4" 6"

100
90
80
70
60
50
40
30
20
10
0

PERCENT FINER THAN

0.0001 0.001 0.01 0.1 1 10 100

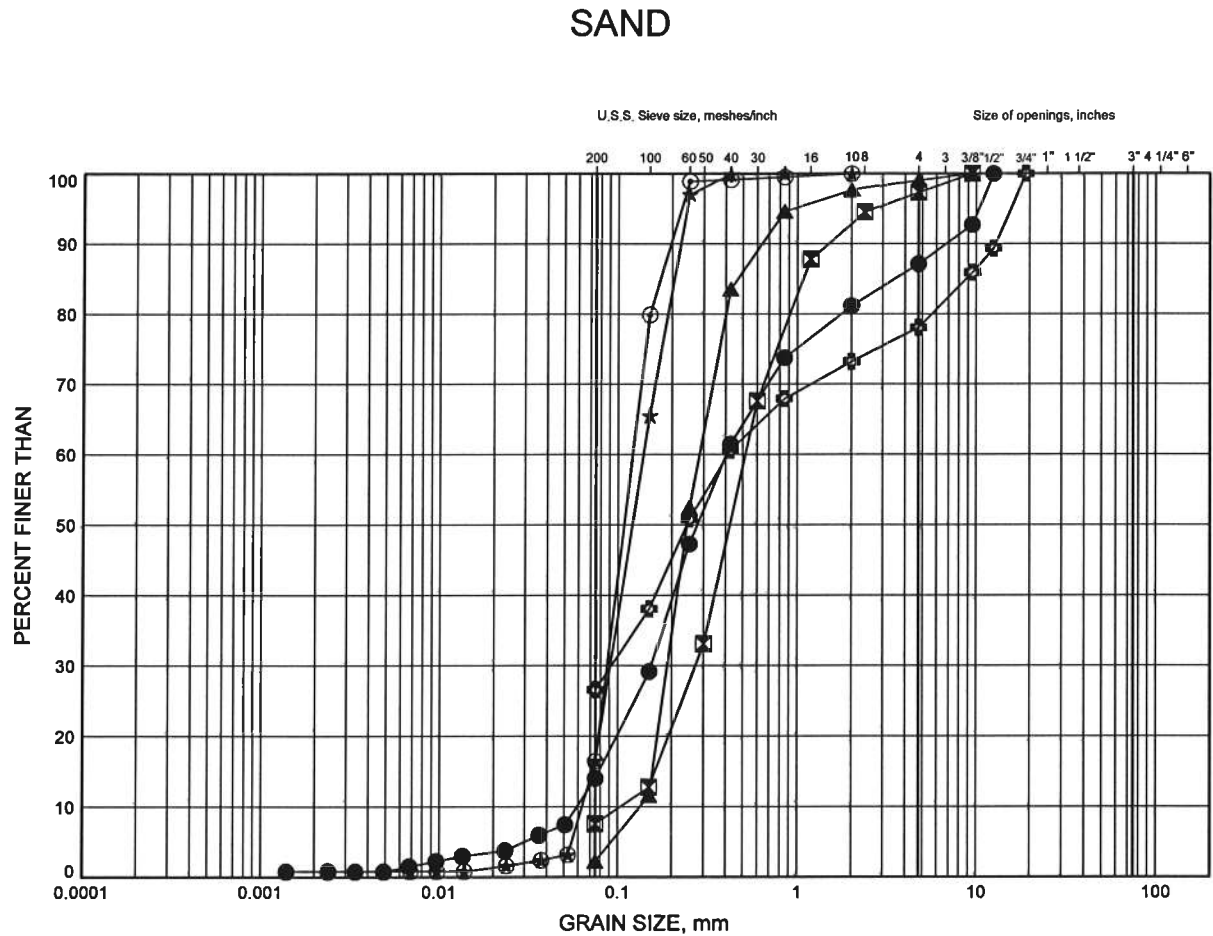
GRAIN SIZE, mm

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

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	ERB11-02	2.59	459.91
☒	ERB11-03	2.59	459.91
▲	ERB11-04	0.30	462.30
★	ERB11-06	1.07	461.33
⊙	ERB11-06	2.59	459.81
⊕	ERB11-06	3.35	459.05

6010-E-0010 Bridge and Culvert Rehabs NWR
GRAIN SIZE DISTRIBUTION

FIGURE B2



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

LEGEND

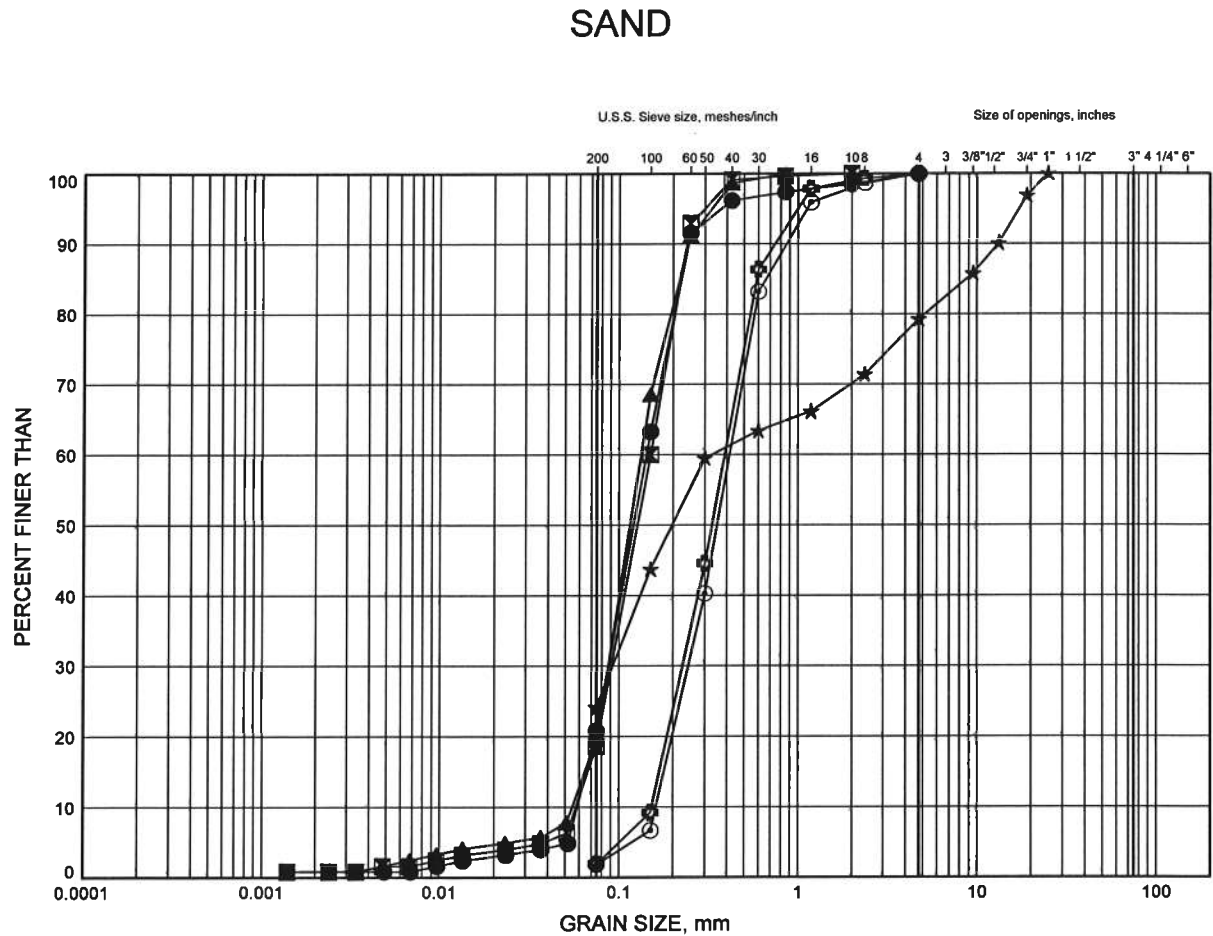
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	ERB11-01	2.59	460.01
⊠	ERB11-01	4.88	457.72
▲	ERB11-02	6.40	456.10
★	ERB11-02	15.54	446.96
⊙	ERB11-02	20.12	442.38
⊕	ERB11-02	24.69	437.81



W.P.# .468-00-00.....
Prepared By .AN.....
Checked By .RPR.....

6010-E-0010 Bridge and Culvert Rehabs NWR
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)
●	ERB11-03	9.45	453.05
■	ERB11-03	17.07	445.43
▲	ERB11-04	23.16	439.44
★	ERB11-04	26.21	436.39
⊙	ERB11-05	7.92	454.58
⊕	ERB11-06	6.40	456.00

GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 9/13/11

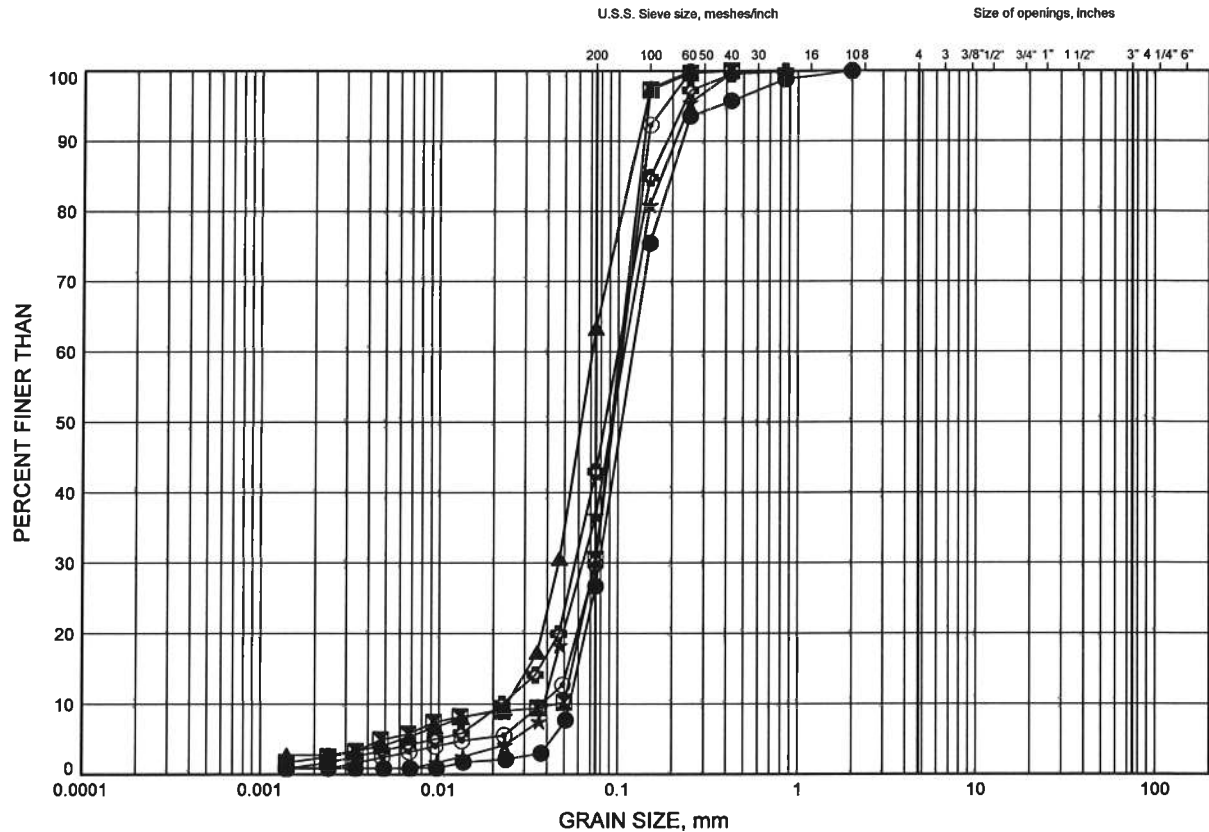
W.P.# .468-00-00.....
Prepared By .AN.....
Checked By .RPR.....



6010-E-0010 Bridge and Culvert Rehabs NWR
GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND (SILTY)



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

LEGEND

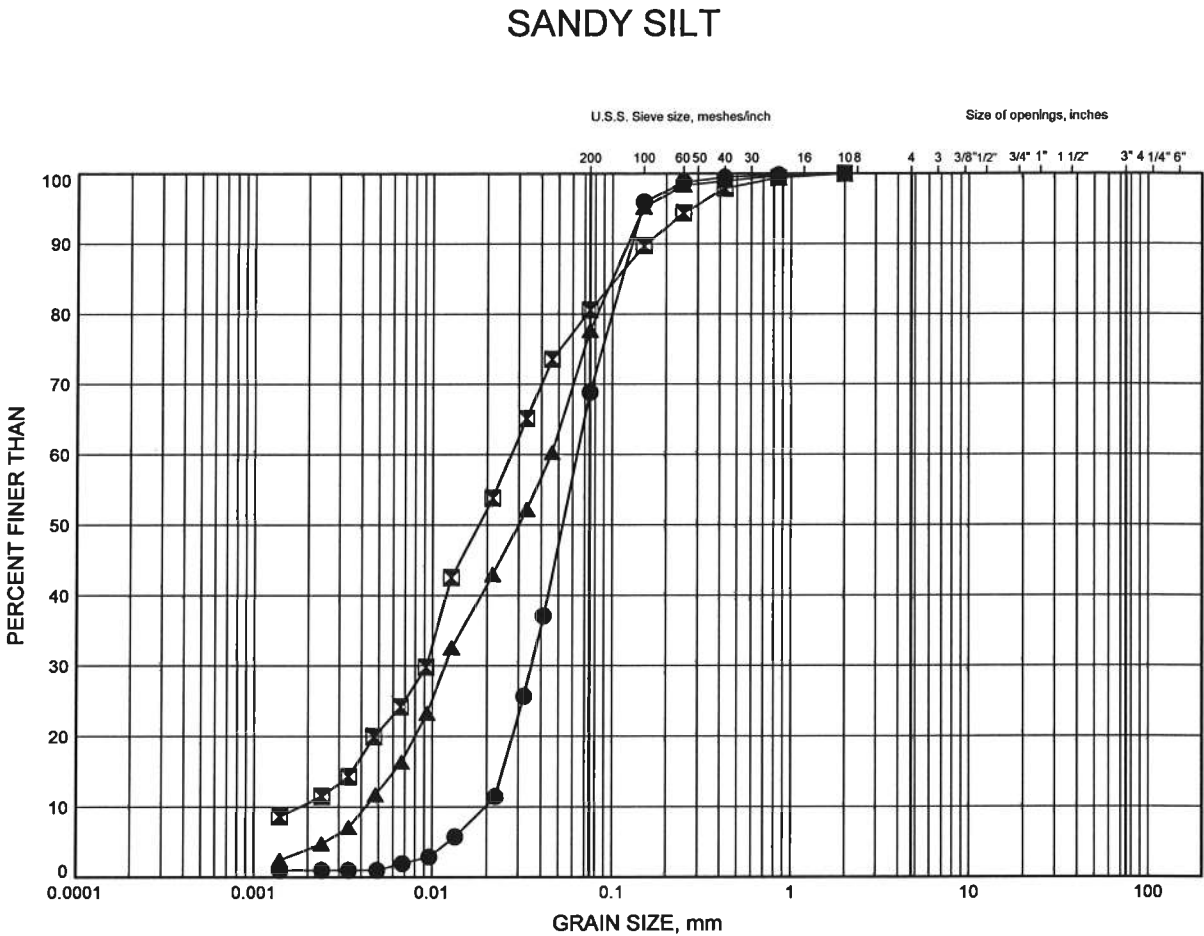
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	ERB11-01	7.92	454.68
■	ERB11-02	10.97	451.53
▲	ERB11-04	12.50	450.10
★	ERB11-04	14.02	448.58
⊙	ERB11-04	17.07	445.53
⊕	ERB11-05	14.02	448.48



W.P.# .468-00-00.....
Prepared By .AN.....
Checked By .RPR.....

6010-E-0010 Bridge and Culvert Rehabs NWR
GRAIN SIZE DISTRIBUTION

FIGURE B5



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	ERB11-03	14.02	448.48
☒	ERB11-04	18.59	444.01
▲	ERB11-05	18.59	443.91

GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 9/13/11

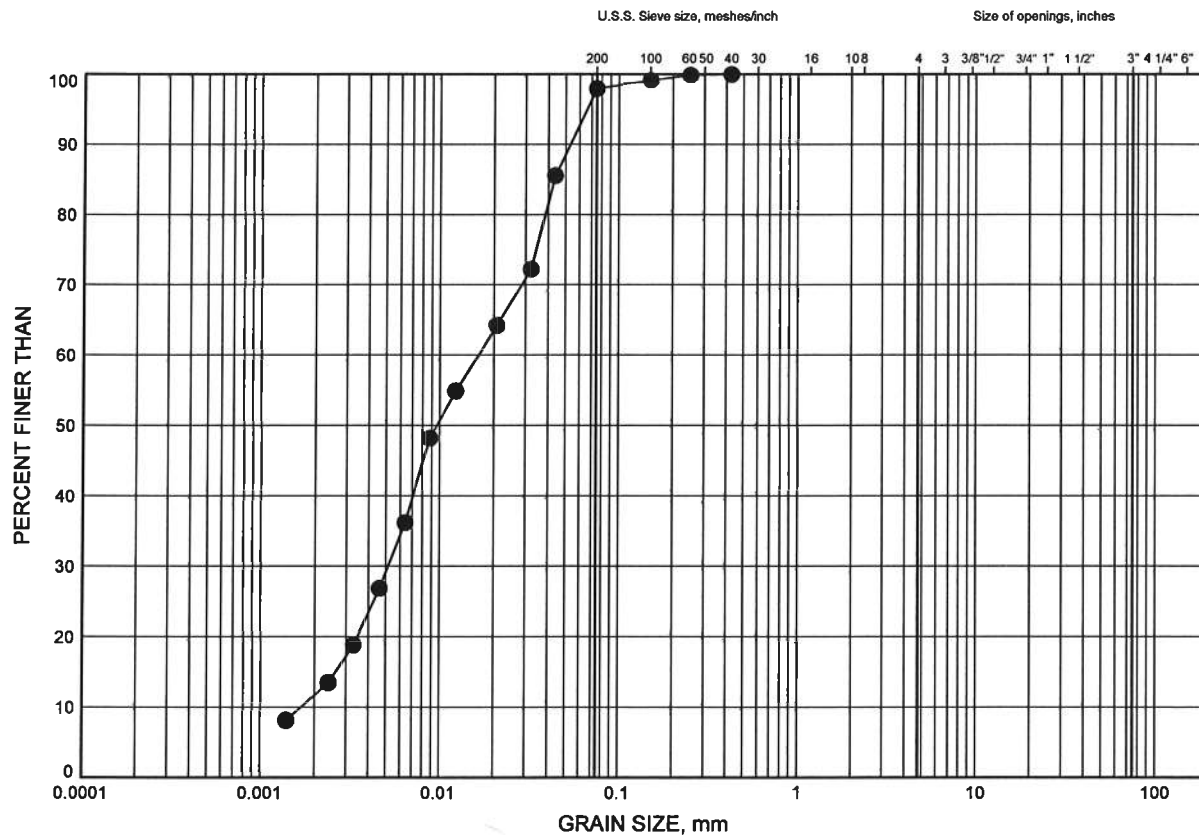
W.P.# 468-00-00
Prepared By AN
Checked By RPR



6010-E-0010 Bridge and Culvert Rehabs NWR
GRAIN SIZE DISTRIBUTION

FIGURE B6

CLAYEY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	ERB11-03	21.64	440.86



W.P.# 468-00-00
Prepared By AN
Checked By RPR

Appendix C

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Footings on Native Soil	Augered Caissons (drilled shafts)	Driven Piles
<p>Advantages:</p> <ul style="list-style-type: none"> i. Economical to install. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. High groundwater levels. ii. Deep excavation extending below the groundwater level is required. iii. Require relatively expensive s and extensive unwatering procedures. iv. Foundations close to water would be at risk due to scour and erosion v. Potential for settlement vi. Low geotechnical resistance in native soils. <p>NOT RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Deeper foundation system is less susceptible to slope erosion processes. ii. Construction of caissons could continue in freezing weather. iii. Subexcavation of fill and variable material not required. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Difficulty in unwatering, cleaning and inspecting bases. Requires placement of concrete by tremie methods. ii. Higher unit cost compared to other foundation options such as footings or driven piles <p>NOT RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistance available by driving piles to achieve resistance in the dense soils. ii. Permits integral abutment design. iii. Readily installed. iv. Installation less influenced by weather and groundwater than spread footings. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Presence of boulders within the fill and native soils. ii. Higher unit cost compared to footings <p>RECOMMENDED</p>

Appendix D

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

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

- OPSS 903, November 2009.
- OPSS 902, November 2010.
- OPSS 804, November 2010.
- OPSD 208.010
- OPSD 3101.150
- Special Provision 110S13 “Amendment to OPSS 1010, April 2004”.

2. Suggested text for a NSSP on Pile Installation

Cobbles and boulders were encountered in the expected founding layer for the H-piles, particularly at the east abutment. Some possible impacts that must be taken into consideration include, but are not necessarily limited to:

- The need to provide protection to the pile tips.
- As a result of the presence of boulders, piles may meet refusal at varying depths.
- If a pile meets refusal at a depth less than the anticipated depth, the QVE must terminate driving before the pile is damaged due to over-driving and refer the issue to the CA.

Appendix E

Slope Stability Output

Thurber Engineering Ltd. - Toronto
 19-1605-121,
 English River Bridge, Hwy 17
 Site 41S-73
 6.5 m high, 2H:1V
 August 12, 2011

	Gamma C	Phi	Min	Piezo
	kN/m ³	deg	c/p	Surf.
Water	9.81	0	0	1
Earth Fill	21	0	32	1
Sand	21	0	32	1

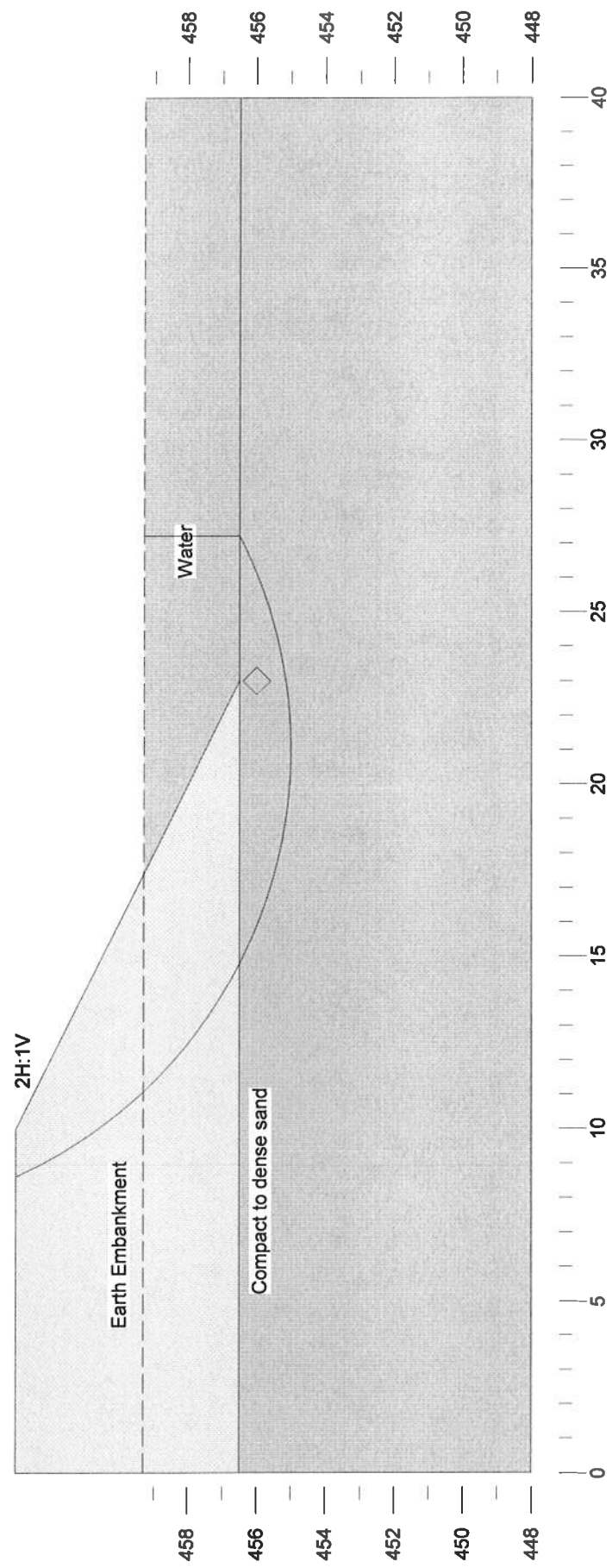
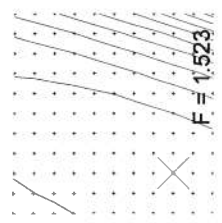


FIGURE 1

Thurber Engineering Ltd. - Toronto
 19-1605-121,
 English River Bridge, Hwy 17
 Site 41S-73
 6.5 m high, 2.8H:1V
 August 12, 2011

	Gamma C	Phi	Min	Piezo
	kN/m ³	deg	c/p	Surf.
Water	9.81	0	0	1
Earth Fill	21	0	0	1
Sand	21	0	0	1

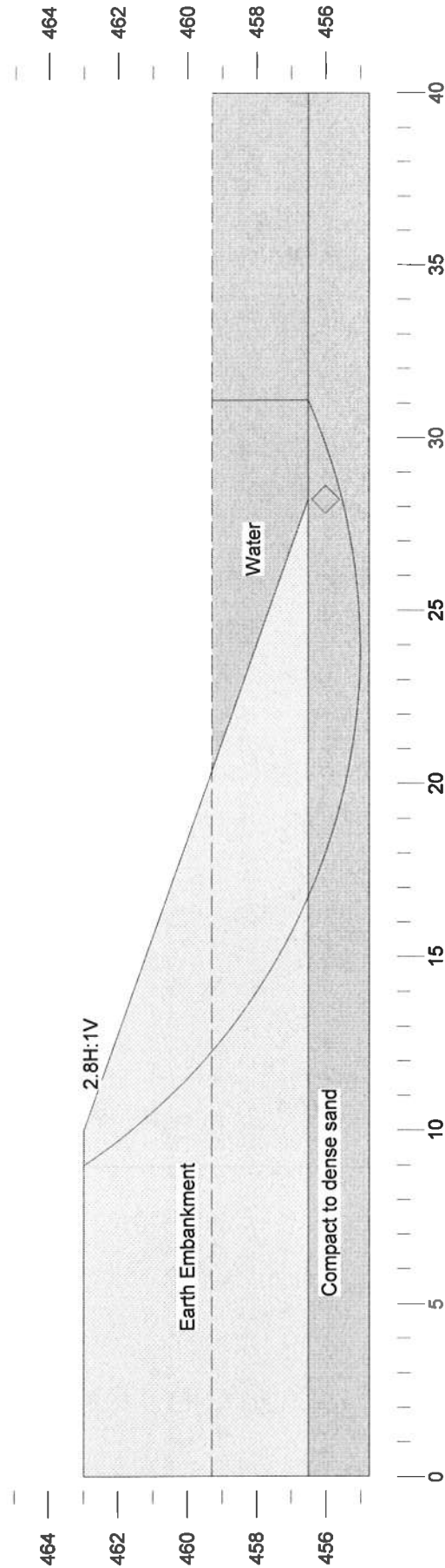
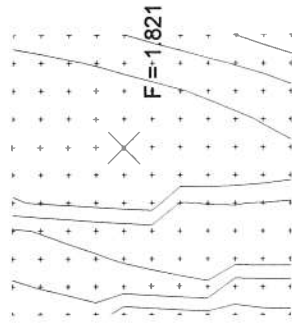
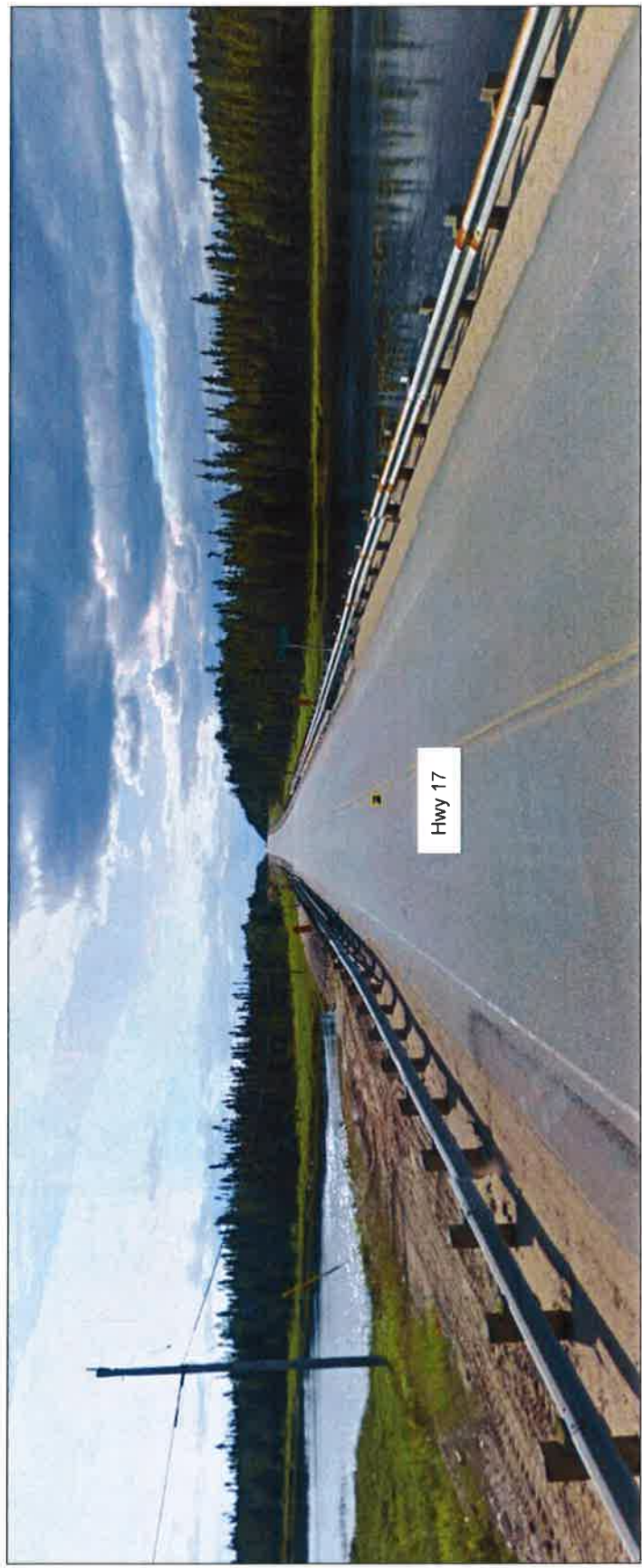


FIGURE 2

Appendix F

Site Photographs

English River Bridge Replacement
Highway 17, Site 41S-73



Photograph 1 – Existing English River Bridge & Highway 17



Photograph 2– English River Bridge



Photograph 3 – North side of the English River Bridge

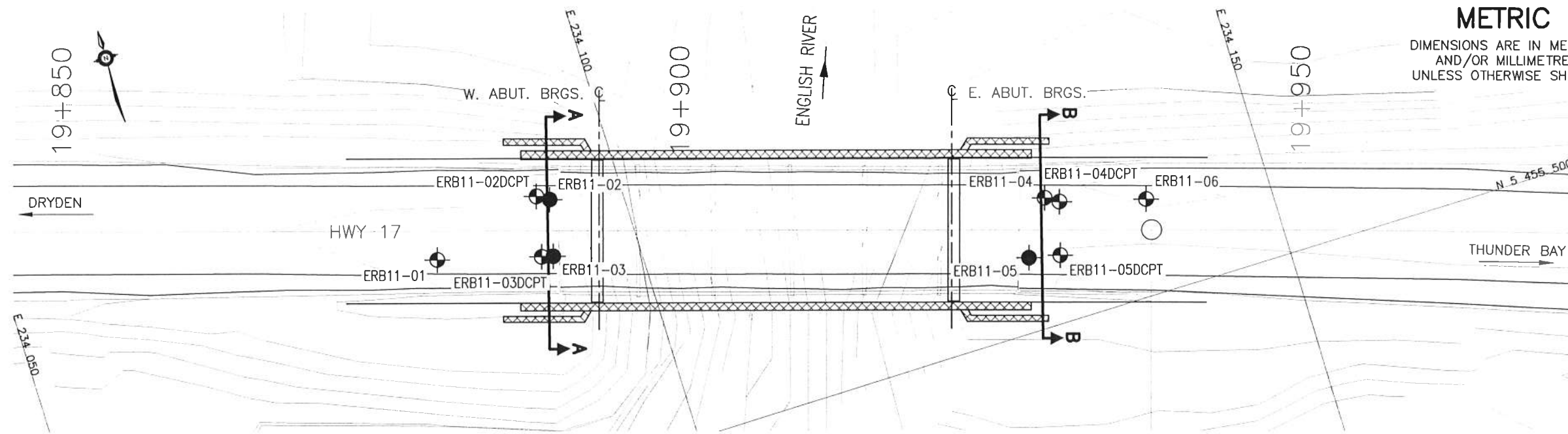


Photograph 4 – South side of the English River Bridge

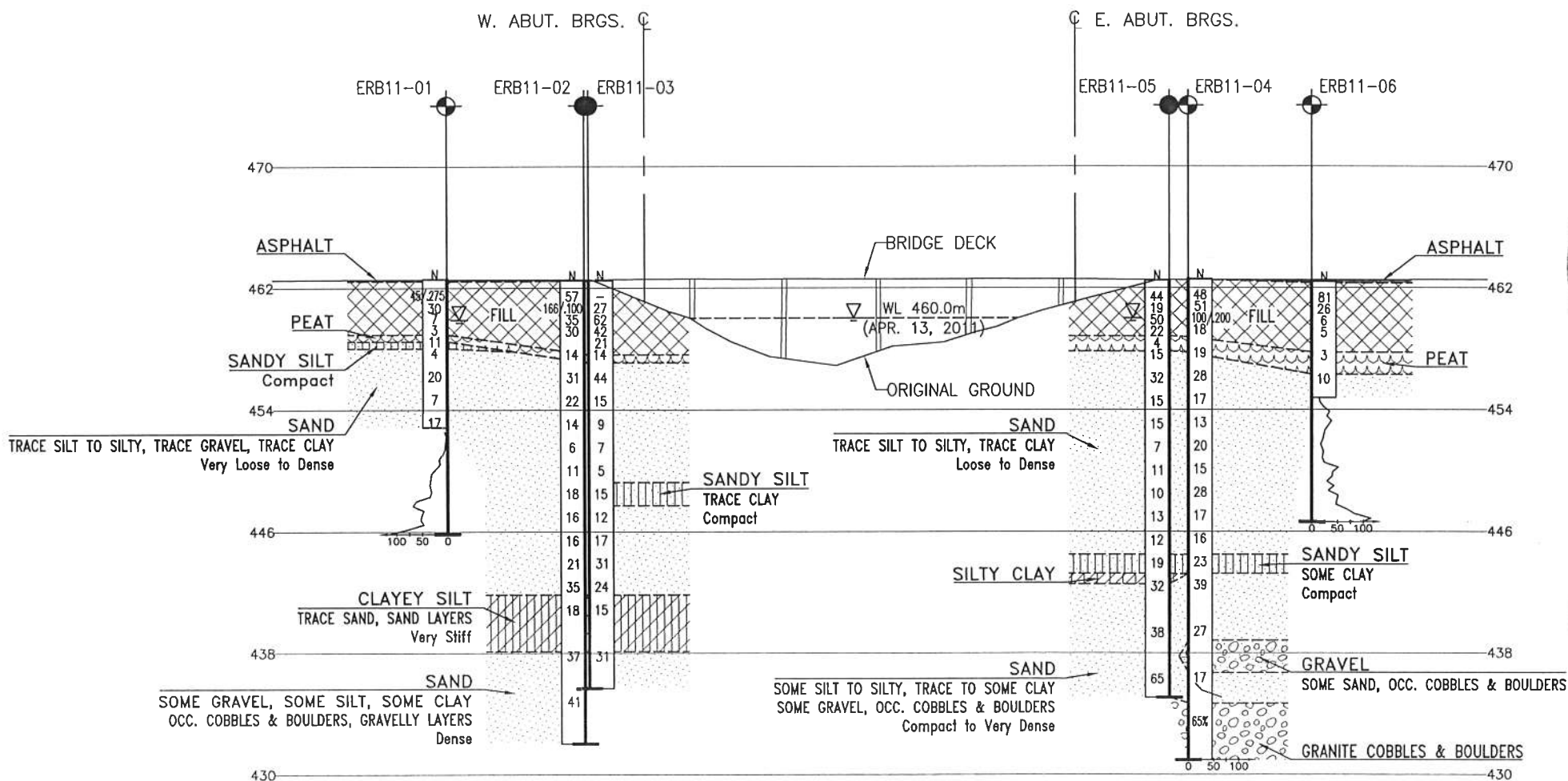
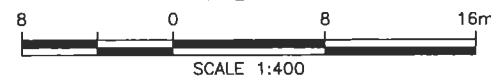
Appendix G

Drawing

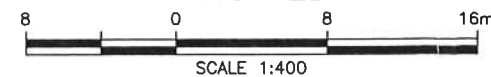
Borehole Locations and Soil Strata



PLAN



PROFILE



METRIC

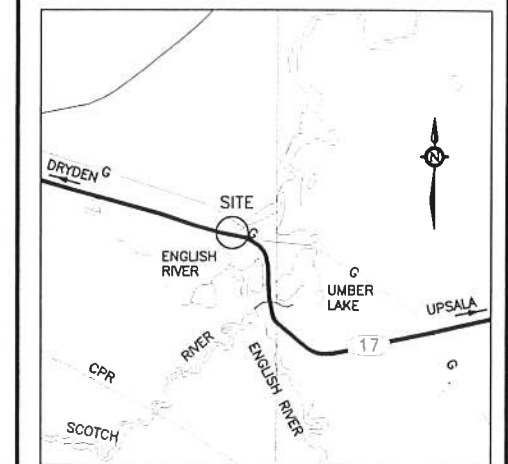
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 468-00-00

HIGHWAY 17
BRIDGE AND CULVERT REHABS NWR
ENGLISH RIVER BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

Hatch Mott
MacDonald

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



KEYPLAN

LEGEND

◆	Borehole
◆	Borehole and Cone / Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
W	Water Level
W	Head Artesian Water
W	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
ERB11-01	462.6	5 455 520.0	234 084.1
ERB11-02	462.5	5 455 521.9	234 094.2
ERB11-02DCPT	462.5	5 455 522.5	234 093.3
ERB11-03	462.5	5 455 517.5	234 093.1
ERB11-03DCPT	462.5	5 455 517.7	234 092.2
ERB11-04	462.6	5 455 510.1	234 132.4
ERB11-04DCPT	462.6	5 455 509.5	234 133.4
ERB11-05	462.5	5 455 505.9	234 129.7
ERB11-05DCPT	462.5	5 455 505.3	234 132.2
ERB11-06	462.4	5 455 507.6	234 140.2

NOTES

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

GEOCRES No. 52G-8



DATE	BY	DESCRIPTION
DESIGN	RPR	CHK PKC
DRAWN	MFA	CHK RPR
LOAD	DATE	JAN. 2012
STRUCT	DWG	1

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

CONT No
WP No 468-00-00

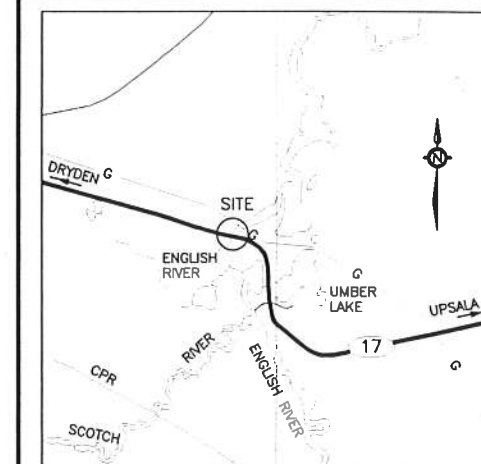


HIGHWAY 17
BRIDGE AND CULVERT REHABS NWR
ENGLISH RIVER BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

**Hatch Mott
MacDonald**

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



**KEYPLAN
LEGEND**

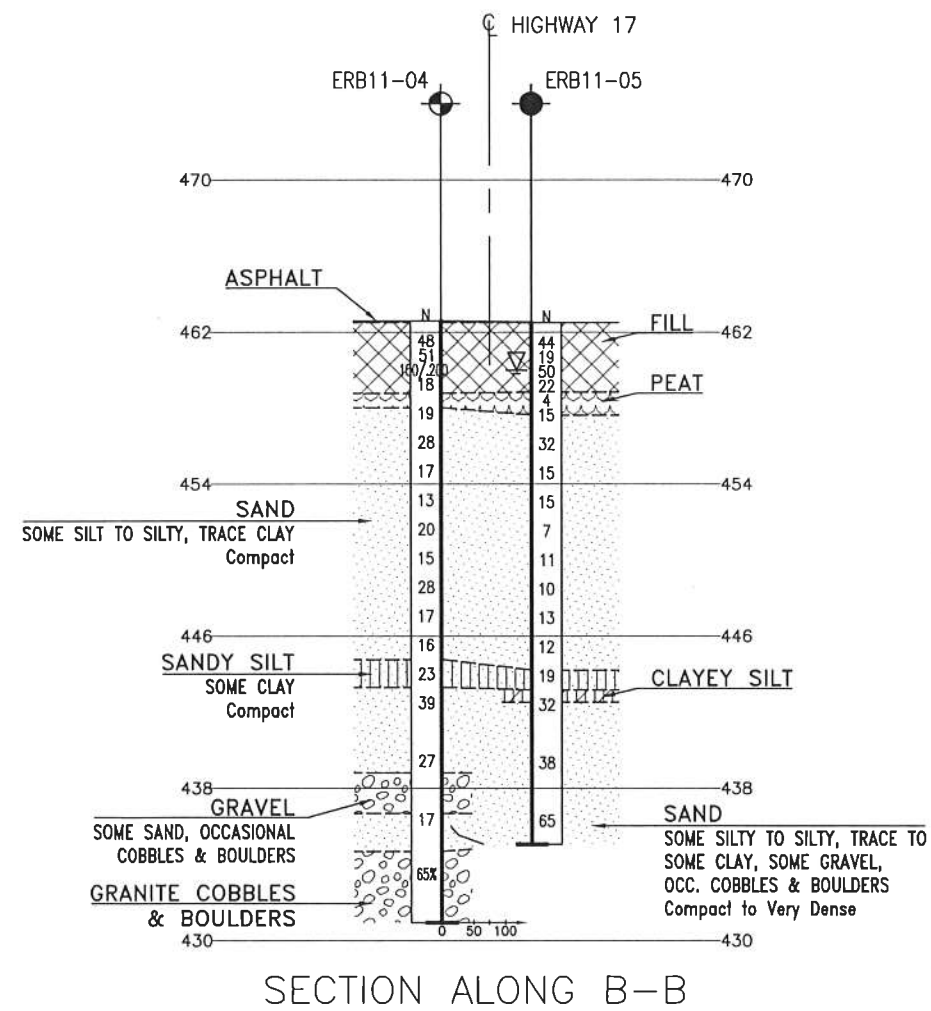
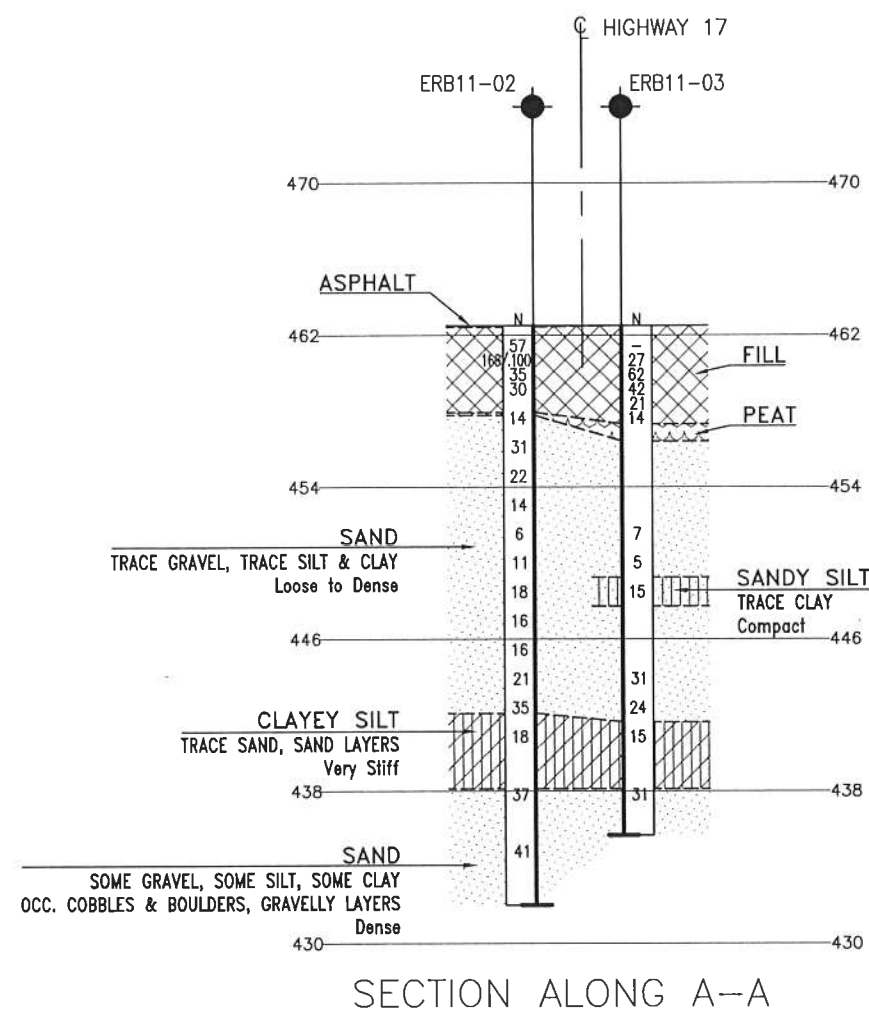
	Borehole
	Borehole and Cone / Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
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ERB11-03DCPT	462.5	5 455 517.7	234 092.2
ERB11-04	462.6	5 455 510.1	234 132.4
ERB11-04DCPT	462.6	5 455 509.5	234 133.4
ERB11-05	462.5	5 455 505.9	234 129.7
ERB11-05DCPT	462.5	5 455 505.3	234 132.2
ERB11-06	462.4	5 455 507.6	234 140.2

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GEOCRES No. 52G-8



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK PKC	CODE
DRAWN	MFA	CHK RPR	SITE
			LOAD
			STRUCT
			DWG 2
			DATE JAN. 2012