FOUNDATION INVESTIGATION AND DESIGN REPORT
GULLIVER RIVER BRIDGE REPLACEMENT
HIGHWAY 17 IN THE NORTHWEST REGION

G.W.P. 6048-06-00, SITE No. 41S-72

Geocres Number: 52G-9

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

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation for a proposed replacement of the existing structure which carries Highway 17 over Gulliver River. The bridge site is located 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 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 Gulliver Bridge is located on Highway 17 approximately 10 km east of The Town of Ignace, Ontario (Kenora County).

At present, the highway crosses the Gulliver River on an eight-span structure supported on timber piles. The Gulliver River bridge spans approximately 49.0 m across the river channel. The width of the bridge is approximately 10.5 m. The 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 on March 18, 19, 21, 29, 30, and 31, 2011 and April 2, 4 and 6, 2011 and consisted of drilling and sampling six boreholes (numbered GRB11-01 to GRB11-06) in the area of the existing west and east approaches and abutments. Boreholes at the west and east approaches (Boreholes GRB11-01 and GRB11-06) were terminated at 9.8 m depth (elevations 440.1 and 439.8), respectively. Boreholes at the abutments (Boreholes GRB11-02 to GRB11-05) were terminated at depths ranging from 18.3 m to 29.0 m (elevations 420.5 to 431.3). Borehole GRB11-05 was supplemented by a dynamic cone penetration test (DCPT) conducted adjacent to the borehole. DCPTs were conducted from the base of Boreholes GRB11-03 and GRB11-06 extending to 20.1 m and 10.9 m depth, respectively (elevations 429.5 and 438.7).

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 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 the site consists of pavement structure (asphalt and concrete) over granular fill (a mix of sand and gravel, sand and gravelly sand). Peat was encountered below the fill at the west abutment and approach. Layers of native sand and gravel, sand, silty sand and silt were contacted below the fill and peat. Cobbles and boulders were encountered within the fill and native soils at various depths.

More detailed descriptions of the individual strata are presented below.

5.1 Pavement structure

All the boreholes were drilled through the existing Highway 17 lanes. With the exception of Borehole GRB-11-01, the pavement structure consists of approximately 75 mm to 150 mm of asphalt overlying concrete. The thickness of the concrete ranged from 100 mm to 600 mm in Boreholes GRB11-02 to GRB11-06. The concrete is underlain by granular fill.

In Borehole GRB-11-01, the asphalt was 150 mm thick and was underlain by granular fill.

5.2 Fill

Fill was contacted below the pavement structure in all the boreholes. The fill generally consists of light brown to brown gravelly sand, sand and gravel and sand containing trace to some silt and clay and some cobbles and boulders.

The thickness of the fill ranged from 3.8 m to 5.6 m.

The depth to the base of the fill varied from 4.0 m to 5.8 m (elevations 444.0 to 445.6).

SPT 'N' values recorded in the cohesionless fill ranged from 1 to 63 blows per 0.3 m penetration indicating a loose to very dense relative density. Higher SPT 'N' values of 100 blows per 0.125 m of penetration and 56 blows per 0.075 m of penetration were contacted in Boreholes GRB11-05 and GRB11-06 near elevation 448.8, indicating a very dense relative density. As noted on the borehole logs, for Boreholes GRB11-01 to GRB11-05, coring technique was required to get through the boulders where encountered in the fill.

Potential creosote contamination was noted around elevations 466 to 446.5 in the fill in Boreholes GRB11-01 and GRB11-03. The source of contamination is unknown.

The moisture content of the fill ranged from 4% to 42%.

Grain size distribution curves for samples of the fill tested are presented on the Record of Borehole sheets and on Figures B1 and B2 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	**(%)**
Gravel	0 to 36
Sand	54 to 74
Silt	18 to 35
Clay	1
Silt and Clay	6 to 24

5.3 Peat

Dark brown to black peat containing some sand and occasional rootlets was contacted below the fill at 5.8 m and 5.5 m depth (elevation 444.1) in Boreholes GRB11-01 and GRB11-03 drilled at the west approach and west abutment, respectively.

The thickness of the peat was 0.2 m and 1.1 m.

The depth to the base of the peat was 6.1 m and 6.6 m (elevations 443.8 and 443.0) in Boreholes 11-01 and 11-03, respectively.

An SPT 'N' value recorded in the peat was 12 blows per 0.3 m penetration indicating a compact relative density.

The moisture content of the peat was 79%.

5.4 Sand and Gravel with Cobbles and Boulders

Native brown to grey sand and gravel containing trace silt and trace clay was encountered below the fill in Boreholes GRB11-02, GRB11-04 and GRB11-06, below the peat in Borehole GRB11-03 and below the native silty sand in Borehole GRB11-05. Cobbles and boulders were encountered at various depths within the sand and gravel layer. At these locations coring through boulders was required to advance the boreholes.

The depths, elevations and thicknesses of the layer of sand and gravel with cobbles and boulders are indicated in Table 5.1.

Table 5.1 – Depths and Elevations of sand and gravel with cobles and boulders

Foundation Unit	Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
West Abutment	GRB11-02	5.5 to 18.3*	444.1 to 431.3	12.8
	GRB11-03	6.6 to 16.5	443.0 to 433.1	9.9
East Abutment	GRB11-04	5.0 to 12.2 22.9 to 29.0*	444.5 to 437.3 426.6 to 420.5	7.2 6.1
	GRB11-05	7.6 to 9.9	441.9 to 439.6	2.3
East Approach	GRB11-06	4.0 to 9.1	445.6 to 440.5	5.1

*Borehole termination depth

SPT 'N' values recorded in the sand and gravel ranged from 19 blows per 0.3 m of penetration to 160 blows per 0.05 m of penetration, indicating a compact to very dense relative density. An SPT 'N' value of 4 blows per 0.3 m of penetration, indicating a loose relative density, was measured in Borehole GRB11-02 near elevation 444.1.

The moisture content of the sand and gravel ranged from 5% to 19%.

Grain size distribution curves for samples of the sand and gravel tested are presented on the Record of Borehole sheet and on Figure B3 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	30 to 62
Sand	35 to 63
Silt and Clay	2 to 10

5.5 Sand

Native brown to grey sand containing trace to some gravel, some silt, trace clay and some cobbles and boulders was contacted at depths and elevations indicated in Table 5.2.

Table 5.2 – Depths and Elevations of Sand

Foundation Unit	Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
West Approach	GRB11-01	6.1 to 9.8*	443.8 to 440.1	3.6
East Abutment	GRB11-04	12.2 to 19.8	437.3 to 429.7	7.6
East Approach	GRB11-06	9.1 to 9.8*	440.5 to 439.8	0.7

*Borehole termination depth

Standard Penetration tests in the sand layer gave SPT 'N' values generally in the range of 13 to 53 blows per 0.3 m of penetration, indicating a compact to very dense relative density.

The moisture contents of samples from the sand layer generally vary between 8% and 24%.

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

Soil Particles	(%)
Gravel	0 to 14
Sand	71 to 85
Silt & Clay	14 to 18

5.6 Silty sand

Native brown to grey silty sand containing some gravel and trace to some clay was contacted depths and elevations indicated in Table 5.3.

Table 5.3 – Depths and Elevations of Silty Sand

Foundation Unit	Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
West Abutment	GRB11-03	16.5 to 18.8*	433.1 to 430.8	2.3
East Abutment	GRB11-04	19.8 to 22.9	429.7 to 426.6	3.1
	GRB11-05	5.5 to 7.6 9.9 to 17.4	444.0 to 441.9 439.6 to 432.1	2.1 7.5

*Borehole termination depth

Cobbles and boulders were encountered within the silty sand layer in Borehole GRB11-04.

Standard Penetration tests in the silty sand layer gave SPT N-values ranging from 32 blows per 0.3 m of penetration to 100 blows per 0.1 m of penetration, indicating a compact to very dense relative density.

The moisture contents of samples from the sand layer generally vary between 10% and 28%.

Grain size distribution curves for the sand samples tested are presented in Appendix B, Figure B5. The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	0 to 22
Sand	45 to 64
Silt	34
Clay	2
Silt & Clay	26 to 33

5.7 Silt

Native grey silt containing trace sand and trace clay was contacted at 17.4 m depth (elevation 432.1) in Borehole GRB11-05. Coring through boulders encountered within the silt layer was required to advance the borehole.

Boreholes GRB11-05 was terminated within the silt layer at 18.8 m depth (elevation 430.7), upon refusal on probable boulder.

SPT N-value in the silt was 51 blows per 0.3 m of penetration, indicating a very dense relative density. Moisture content was 21%

Grain size distribution curve for a silt sample is presented in Appendix B, Figure B6. The results are also summarized on the Record of Borehole sheets included in Appendix A. The results of the laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	0
Sand	7
Silt	85
Clay	8

5.8 Water Levels

Water levels were observed in the boreholes during and upon completion of drilling.

In Borehole GRB11-02 water level was observed at 5.4 m (elevation 444.2).

In the remaining boreholes, it was not possible to obtain water levels at the completion of drilling, as the boreholes caved in to depths shown in Table 5.4.

Table 5.4 – Depths of boreholes cave-in

Foundation Unit	Borehole	Depth below existing ground surface (m)
West approach	GRB11-01	1.2
West Abutment	GRB11-02	7.0
	GRB11-03	3.2
East Abutment	GRB11-05	3.4
East Approach	GRB11-06	1.2

Preliminary GA drawing indicates that water level in the Gulliver River was at elevation 444.7 on April 12, 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 CME75 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.

Thurber Engineering Ltd.

LICENSED PROFESSIONAL ENGINEER
R. Palomeque Reyna
100083209
March 5/2012
PROVINCE OF ONTARIO

Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
March 5/12
PROVINCE OF ONTARIO

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

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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 Gulliver River bridge located approximately 10 km east of the Town of Ignace, Ontario.

At present, Highway 17 crosses Gulliver River on an eight-span structure supported on timber piles. The highway grade is near elevation 449.5. The approach slopes are approximately 6.0 m high.

The Gulliver River bridge was constructed in 1942 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 0.7 m.

Based on the preliminary General Arrangement (GA) drawing provided by Hatch Mott MacDonald, a single-span structure supported on two abutments is proposed. The total length of the structure will be 35.0 m. The proposed structure will be approximately 12.9 m wide.

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

In general terms, the stratigraphy encountered at the site generally consists of pavement structure (asphalt and concrete) over loose to very dense granular fill (a mix of gravelly sand, sand and gravel and sand) overlying native layers of compact to very dense sand and gravel containing cobbles and boulders, sand, silty sand and silt. Peat was encountered below the fill in the southern part of the west abutment and under the west approach.

In Borehole GRB11-02 water level was observed at 5.4 m (elevation 444.2).

Preliminary GA drawing indicates that water level in the Gulliver River was at elevation 444.7 on April 12, 2011.

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 for the following reasons:

1. Founding the spread footings on suitably dense to very dense, uniform subgrade soils will require relatively deep excavation in sand and gravel fills and into permeable, cohesionless native soils below the water table. 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 flow and would have to be founded below the maximum depth of scour necessitating an even deeper excavation below the water table.

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 the very dense granular soils contacted at depths ranging from 10.0 m to 20.0 m. This suitable bearing material is generally below the groundwater level. The caissons would have to be extended through sand and gravel deposits, containing frequent obstructions in the form of cobbles and boulders and caisson drilling will be laboured and difficult through these soils.

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. Unwatering of the caissons would be impractical and attempts to do so might result in boiling of the caisson bases and 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.

8.3 Driven Piles

Consideration was given to supporting the abutments on driven piles.

The subsurface conditions at the site are considered suitable for the design of foundations supported on steel H-piles driven to achieve resistance in the very dense soils.

At both abutments, the native soils contain cobbles and boulders which makes it difficult to predict the depth at which piles will achieve the required resistance. Consequently, it is recommended that the foundations be designed on the basis of the geotechnical resistance achieved through shaft resistance and end bearing by piles driven in the very dense soil.

The elevations at which the piles are expected to develop the required resistance are given in Table 8.1.

Table 8.1 – Estimated Pile Tip Elevation

Foundation Unit	Borehole	Anticipated Pile Tip Elevation To Develop Required Resistance	Anticipated Pile Length below underside of pile cap (m)	Anticipated Founding Material
West abutment	GRB11-02	431.0	17.5	Very dense sand and gravel with cobbles and boulders, silty sand
	GRB11-03			
East abutment	GRB11-04	429.0	19.5	Very dense sand/silt with cobbles and boulders
	GRB11-05			

The actual pile tip elevations will be controlled as described in Section 8.3.4 Pile Driving.

8.3.1 Axial Resistance

The axial geotechnical resistances at factored Ultimate Limit States (ULS_f) and Serviceability Limit States (SLS) for 17.5 m to 19.5 m long HP 310x110 pile section driven to elevation 431.0 and 429.0 in the very dense sand and gravel, silty sand, sand and silt are presented in Table 8.2.

Table 8.2 – Axial Resistance of a Pile Section Founded on Very Dense Soils

Foundation Unit	Pile Section HP 310 x 110	
	ULS (Factored) (kN)	SLS (kN)
Abutments	1,600	1,400

* Geotechnical resistances calculated for 17.5 m to 19.5 m long piles

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 protected with pile tip protection such as Titus Steel 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, which requires a higher level of protection than driving into soils containing only smaller particle sizes
- Some piles may achieve refusal on large boulders, which will require the same pile tip protection and reinforcement as founding on bedrock.

8.3.3 Pile Installation

Pile installation should be in accordance with OPSS 903, November 2009.

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.
- The possibility of some piles meeting refusal on a large boulder. When boulders are encountered within a shallow depth, pre-drilling through the boulders may be required to advance and install the piles to the required pile tip elevation. Rock coring and rock breaking equipment may be required in addition to augering equipment.

Suggested text for NSSP's is included in Appendix D.

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 a minimum value of twice the design load at ULS.

8.3.5 Downdrag

The foundation soils at this site are largely dense granular soils and downdrag on the piles is not considered to be an issue at this site.

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:

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

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

where
- z = depth of embedment of pile in metres
- D = pile width in metres
- n_h = value from Table 8.5
- γ = unit weight (Table 8.5)
- K_p = passive earth pressure coefficient (Table 8.5)

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, $K = k_s*L*D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m^3), 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, $P_{ult} = p_{ult}*L*D$. 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 8.5.

Table 8.5 – Parameters for Lateral Pile Resistance

Location	Elevation	n_h (kN/m³)	K_p	Unit Weight (kN/m³)	Soil Conditions
West Abutment	445.0 to 444.0	3,500	3.3	21	Gravelly sand, loose to very dense (FILL)
	444.0 to 433.0	8,000	3.7	11*	Sand and gravel, cobbles and boulders, loose to very dense
	Below 433.0	10,000	3.5	11*	Silty sand, very dense to dense
East Abutment	445.0to 444.0	3,500	3.3	21	Gravelly sand, loose to very dense (FILL)
	444.0 to 439.0	6,000	3.6	11*	Sand and gravel, cobbles and boulders, compact to very dense
	439.0 to 426.0	6,000	3.5	11*	Silty sand, sand, very dense to dense
	Below 426.0	10,000	3.7	11*	Sand and gravel, cobbles, very 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 13.

The presence of cobbles and boulders will potentially have an impact on the installation of sheet pile walls at the site. The cobbles/boulders may impede the driving of the sheet piles resulting in more arduous driving and refusal at varying depths.

8.7 Recommended Foundation

From a geotechnical point of view, it is recommended that all foundations for the bridge structure (abutments) be supported on steel H-piles driven into the very dense soil at or below elevations recommended in Table 8.1.

8.8 Frost Cover

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

Frost protection should be provided for the undersides of all foundation elements 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, 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

In Borehole GRB11-02 water level was observed at 5.4 m (elevation 444.2)

Preliminary GA drawing indicates that water level in the Gulliver River was at elevation 444.7 on April 12, 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 groundwater level.

If dewatering is required, the design of the dewatering system is the responsibility of the Contractor and the Contract Documents must alert him to this responsibility and the need to engage a dewatering specialist.

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

11 APPROACH EMBANKMENTS

Based on the GA, the existing approach embankment is approximately 6.0 m high. Communication with Hatch Mott MacDonald indicates that if the existing highway grade needs to be raised/modified, it would be less than 1.0 m. Additionally, the GA drawing shows placement of approximately 4.0 m of fill behind the sheet piles.

The foundation soils governing stability of the approach embankments consist generally of existing native compact to very dense sand and gravel, sand and silty sand.

11.1 Slope stability

The existing embankments bearing on the foundation soils at this site appear to be performing satisfactorily under the existing conditions. Placement of an additional 1.0 m of new fill to raise the road grade is not expected to have impact on the stability of the embankments.

The additional approach fill to be placed behind the new abutment will be supported within a sheet pile enclosure. A global slope stability analysis was conducted to assess the embedment requirements for a sheet pile supporting the new approach fill including the 1.0 m grade raise. 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 for the long term conditions of 1.5 is achieved if the sheet pile is driven to elevation 442.0. This factor of safety is considered to be acceptable for the proposed embankment bearing on non-cohesive soil.

The slope stability computation output is included in Appendix E.

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

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.

11.2 Settlement

The settlement due to the placement of 4.0 m of fill behind the sheet pile is estimated to range from 25 mm to 30 mm. Some pavement maintenance may be required at the abutments to re-establish grades as necessary.

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

12 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 dated November 2010, and placed to the extents shown in OPSD 3101.150.

13 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 13.1)

γ = unit weight of retained soil (see Table 13.1)

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 13.1.

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 13.1 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 13.1 – Earth Pressure Coefficient (K)

Condition	**Earth Pressure Coefficient (K)**			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°, \gamma = 22.8\ kN/m^3$		**OPSS Granular B Type I $\phi = 32°, \gamma = 21.2\ kN/m^3$**	
	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*
At rest (Restrained Wall)	0.43	-	0.47	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-

* For wing walls.

14 SEISMIC CONSIDERATIONS

14.1 Seismic Design Parameters

The site is treated as lying in Seismic Zone 2. 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 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 $\phi = 35°$ $\gamma = 22.8$ kN/m^3	OPSS Granular B Type I $\phi = 32°$ $\gamma = 21.2$ kN/m^3
Active (K_{AE})*	0.28	0.32
Passive (K_{PE})	3.7	3.2
At Rest (K_{OE})**	0.45	0.50

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

14.2 Liquefaction Potential

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

15 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 piles reaching refusal on large boulders at shallow depth, requiring predrilling.
3. The embankment side slopes should be inspected after construction for surficial disturbance. Where necessary, erosion control measures must be implemented.

16 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

C_{pen} 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

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

SYMBOLS

CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

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

TERMS

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

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	(psi)	Field Estimation of Hardness*
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

THURBER

Ministry of Transportation Ontario

RECORD OF BOREHOLE No GRB11-01

METRIC

W.P.	6048-06-00	LOCATION	N 5 469 376.3 E 412 044.9 Gulliver River Bridge	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.03.30 - 2011.03.30	CHECKED BY	RPR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
449.9					
0.0	**ASPHALT:** (150mm)				
0.2	Gravelly **SAND**, occasional boulder, some staining, Light Brown, Moist (FILL)	1	AS		
	Cored through boulder from 1.5m to 1.8m	1	RUN		
447.6 / 2.3	**SAND**, some silt to silty, trace clay, Very Loose to Loose, Light Brown, Moist to Wet (FILL)	1	SS	1	
		2	SS	3	0 64 35 1
	Black creosote from 3.7m to 5.5m	3	SS	5	
		4	SS	5	
	Cored through boulders from 5.6m to 5.9m	2	RUN		
444.0 / 5.9	**PEAT**, Black, Wet				
443.8 / 6.1	**SAND**, some gravel, some cobbles and boulders, Compact to Very Dense, Grey to Brown, Wet	5	SS	24	11 71 18 (SI+CL)
	Cored through boulders from 7.2m to 7.6m	3	RUN		
		6	SS	53	
		7	SS	51	
440.1 / 9.8	END OF BOREHOLE AT 9.8m.				

Continued Next Page

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

Elevation scale: 450, 449, 448, 447, 446, 445, 444, 443, 442, 441

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

ONTMT4S 5121.GPJ 9/13/11

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No GRB11-01

METRIC

W.P. 6048-06-00 | LOCATION N 5 469 376.3 E 412 044.9 Gulliver River Bridge | ORIGINATED BY RK

HWY 11 | BOREHOLE TYPE Casing | COMPILED BY MFA

DATUM Geodetic | DATE 2011.03.30 - 2011.03.30 | CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	BOREHOLE CAVED TO 1.2m, BOREHOLE BACKFILLED WITH SAND TO 0.3m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.										

ONTMT4S 5121.GPJ 9/13/11

+ ³, × ³ : Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No GRB11-02

METRIC

W.P.	6048-06-00	LOCATION	N 5 469 371.2 E 412 051.4 Gulliver River Bridge	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.03.21 - 2011.03.29	CHECKED BY	RPR

Soil Profile

ELEV / DEPTH	DESCRIPTION
449.6	
0.0	**ASPHALT:** (100mm)
0.1 / 449.2	**CONCRETE:** (250mm)
0.4	**SAND**, some gravel, some silt, trace clay, occasional cobbles Very Dense to Loose Brown Moist (FILL) Cored through cobbles from 0.0m to 0.8m
444.1 / 5.5	**SAND and GRAVEL**, trace silt, trace clay, occasional cobbles and boulders Loose to Very Dense Brown to Grey Wet Some silt Cored through boulders from 9.1m to 10.1m

Samples

NUMBER	TYPE	"N" VALUES	Water content (%)	Remarks & Grain Size Distribution (%) GR SA SI CL
1	RUN			
1	SS	48		
2	SS	55		7 74 18 1
3	SS	7		
4	SS	8		(No recovery)
5	SS	15		
6	SS	4		(No recovery)
7	SS	38		
8	SS	64		

Ground water level indicated at approx. elevation 444.1.

Elevation scale: 449, 448, 447, 446, 445, 444, 443, 442, 441, 440

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No GRB11-02

METRIC

W.P.	6048-06-00	LOCATION	N 5 469 371.2 E 412 051.4 Gulliver River Bridge	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.03.21 - 2011.03.29	CHECKED BY	RPR

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND and GRAVEL, trace silt and clay, occasional cobbles and boulders Dense to Very Dense Grey Wet	9	SS	62		o	62 36 2 (SI+CL)
					439		
					438		
					437		
		10	SS	88		o	58 35 7 (SI+CL)
					436		
					435		
		11	SS	35			
					434		
	Blowback of sand at 16.2m. Cored out inside casing twice, no SPT 'N' possible.						
					433		
					432		
	Cored through boulder from 17.7m to 18.3m	3	RUN				
431.3 18.3	END OF BOREHOLE AT 18.3m. WATER LEVEL AT 5.4m UPON COMPLETION OF DRILLING. BOREHOLE CAVED TO 7.0m, BOREHOLE BACKFILLED WITH SAND TO 0.6m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.	~~12~~	~~SS~~	~~100/~~ .025			

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; GROUND WATER CONDITIONS; STRAT PLOT.

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

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

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Ontario

THURBER

RECORD OF BOREHOLE No GRB11-03

METRIC

W.P. 6936-10-00
LOCATION N 5 469 367.4 E 412 048.5 Gulliver River Bridge
ORIGINATED BY RK

HWY 61
BOREHOLE TYPE Casing/DCPT
COMPILED BY MFA

DATUM Geodetic
DATE 2011.03.31 - 2011.04.02
CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
449.6						
0.0	**ASPHALT:** (110mm)					
449.3 / 0.1	**CONCRETE:** (200mm)					
0.3	Gravelly **SAND**, some silt, some clay, occasional cobbles Very Dense to Loose Brown Moist to Wet Cored from 0.0m to 0.8m	1	RUN			
		1	SS	63	o	
		2	SS	57	o	22 54 24 (SI+CL)
		3	SS	11	o	
	Creosote contamination from 3.0m to 4.6m	4	SS	9		
	Cored through boulder from 4.0m to 4.6m	2	RUN			
		5	SS	21	o	
444.1 / 5.5	**PEAT**, some sand, occasional rootlets Dark Brown Compact Wet	6	SS	12	o	
443.0 / 6.6	**SAND** and **GRAVEL**, some cobbles and boulders Very Dense to Compact Brown to Grey Wet	7	SS	100/.075	o	
	Cored through boulders from 7.6m to 9.1m	3	RUN			
		8	SS	0		(No recovery)

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (449, 448, 447, 446, 445, 444, 443, 442, 441, 440); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20, 40, 60; UNIT WEIGHT γ kN/m³.

Continued Next Page

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

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RECORD OF BOREHOLE No GRB11-03

METRIC

W.P.	6048-06-00	LOCATION	N 5 469 367.4 E 412 048.5 Gulliver River Bridge	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	Casing/DCPT	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.03.31 - 2011.04.02	CHECKED BY	RPR

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100) | SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100) | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L – WATER CONTENT (%) (20, 40, 60) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS (GR SA SI CL)
	SAND and **GRAVEL**, some cobbles and boulders Compact to Very Dense Brown to Grey Wet				439	
		9	SS	100/ .075		
					438	
		10	SS	103	437	
	Cored through boulders from 12.2m to 14.3m	4	RUN		436	
		11	SS	23		
		5	RUN		435	
	Cored through cobbles and boulders from 15.2m to 16.5m	12	SS	160/ .050	434	
433.1 / 16.5	Silty **SAND**, some gravel, some clay Very Dense to Dense Grey Wet				433	
		13	SS	51/ .125	432	
		14	SS	43	431	18 56 26 (SI+CL)
430.8 / 18.8	Start DCPT at 18.8m				430	

Continued Next Page

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

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

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Ontario

RECORD OF BOREHOLE No GRB11-03

METRIC

W.P.	6048-06-00	LOCATION	N 5 469 367.4 E 412 048.5 Gulliver River Bridge	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	Casing/DCPT	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.03.31 - 2011.04.02	CHECKED BY	RPR

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
429.5 20.1	END OF BOREHOLE AT 18.8m. END OF DCPT AT 20.1m UPON REFUSAL. BOREHOLE CAVED TO 3.2m, BOREHOLE BACKFILLED WITH SAND TO 0.6m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.						429				

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No GRB11-04

METRIC

W.P.	6046-06-00	LOCATION	N 5 469 338.8 E 412 095.2 Gulliver River Bridge	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.03.18 - 2011.03.19	CHECKED BY	RPR

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
449.5										
0.0	**ASPHALT:** (150mm)									
0.2	**CONCRETE SLAB** (600mm)									
448.7 / 0.8	**SAND and GRAVEL**, trace silt, trace clay; Loose to Compact; Light Brown; Moist				449					
		1	SS	37		o				
		2	SS	26	448	o	36	58	6 (SI+CL)	
		3	SS	12	447					
		4	SS	6	446	o				
	Cored through boulder from 4.3m to 4.6m	1	RUN		445					
444.5		5	SS	11		o	48	45	7 (SI+CL)	
5.0	**SAND and GRAVEL**, with cobbles and boulders				444					
	Cored through cobbles and boulders from 5.6m to 6.6m	2	RUN		443					
		3	RUN		442, 441					
	Cored through cobbles, boulders and gravel from 6.6m to 12.2m.				440					

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

Continued Next Page

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No GRB11-04

METRIC

W.P. 6048-06-00 LOCATION N 5 469 338.8 E 412 095.2 Gulliver River Bridge ORIGINATED BY RK

HWY 11 BOREHOLE TYPE Casing COMPILED BY MFA

DATUM Geodetic DATE 2011.03.18 - 2011.03.19 CHECKED BY RPR

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND and GRAVEL, with cobbles and boulders. Cored through boulders from 6.6m to 12.2m	3	RUN		439, 438		
437.3 / 12.2	SAND, some gravel, some silt, trace clay. Dense to Very Dense. Brown to Grey. Wet	6	SS	52	437	o	14 72 14 (SI+CL)
		7	SS	35	436	o	
		8	SS	37	435	o	
		9	SS	47	434, 433	o	0 85 15 (SI+CL)
	Occasional silt layer				432		
	Cored through cobbles, boulders and gravel from 17.7m to 19.8m	4	RUN		431, 430		
429.7 / 19.8	Silty SAND, some gravel						

Continued Next Page

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

+ 3, X 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No GRB11-04

METRIC

W.P.	6048-06-00	LOCATION	N 5 469 338.8 E 412 095.2 Gulliver River Bridge	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.03.18 - 2011.03.19	CHECKED BY	RPR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Continued From Previous Page									
	Silty SAND, some gravel Very Dense Grey Wet	10	SS	100/ .100		o (~10)				
					429					
	Cored through cobbles and boulders from 20.4m to 22.9m	5	RUN		428					
					427					
426.6 22.9	**SAND and GRAVEL**, with cobbles and boulders Very Dense Greyish Brown Wet	11	SS	100/ .150		o (~18)	30	63	7 (SI+CL)	
					426					
		6	RUN		425					
					424					
		12	SS	100/ .150						
	Boulders				423					
	Cored through boulders from 26.3m to 29.0m.	7	RUN		422					
					421					
420.5 29.0	END OF BOREHOLE AT 29.0m UPON REFUSAL ON BOULDER. BOREHOLE BACKFILLED WITH SAND TO 0.3m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.									

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

$+^3, \times^3$: Numbers refer to Sensitivity   20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

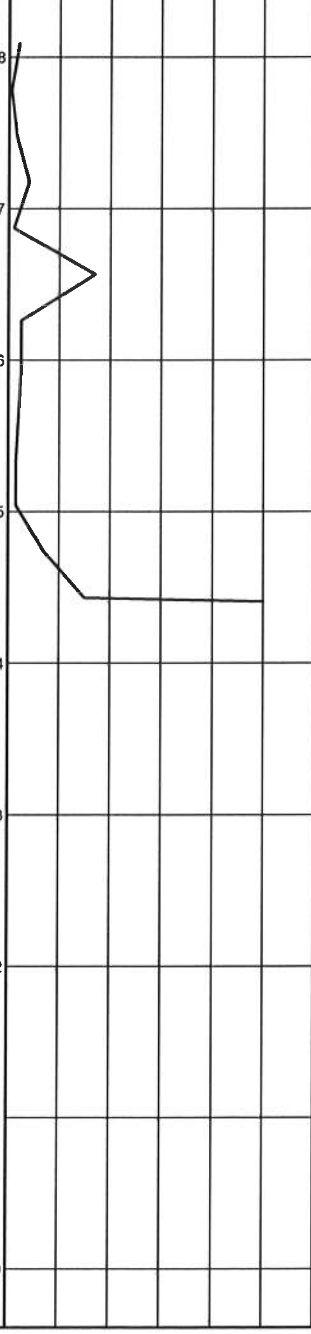
RECORD OF BOREHOLE No GRB11-05

METRIC

W.P.	6048-06-00	LOCATION	N 5 469 334.9 E 412 093.0 Gulliver River Bridge	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	Casing/DCPT	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.04.04 - 2011.04.06	CHECKED BY	RPR

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) | SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE (20 40 60 80 100) | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	GR	SA	SI	CL
449.5										
0.0	**ASPHALT:** (115mm)									
0.1 / 449.1	**CONCRETE:** (250mm)									
0.4	Gravelly **SAND**, some silt and clay, occasional boulders Loose to Very Dense Brown Moist (FILL)				449					
		1	SS	100/ .125						
		2	SS	19	448	o				
		3	SS	4	447	o	25	63	12 (SI+CL)	
		4	SS	32	446					
	Moist to Wet				445					
		5	SS	22		o				
444.4 / 5.1	Silty **SAND**, some gravel, some clay Very Dense Brown Wet Cored through boulders from 5.3m to 6.1m				444					
		6	SS	51						
		1	RUN							
					443	o	22	45	33 (SI+CL)	
441.9 / 7.6	**SAND** and **GRAVEL**, trace silt and clay, some cobbles and boulders Compact to Very Dense Brown to Grey Wet				442					
		7	SS	40						
	Cored through cobbles and boulders from 7.6m to 9.1m	2	RUN		441					
		8	SS	19	440	o	40	50	10 (SI+CL)	
439.6										



Continued Next Page

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

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

ONTMT4S 5121.GPJ 9/13/11

RECORD OF BOREHOLE No GRB11-05

METRIC

W.P. 6048-06-00 LOCATION N 5 469 334.9 E 412 093.0 Gulliver River Bridge ORIGINATED BY RK

HWY 11 BOREHOLE TYPE Casing/DCPT COMPILED BY MFA

DATUM Geodetic DATE 2011.04.04 - 2011.04.06 CHECKED BY RPR

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
9.9	Silty **SAND**, trace clay Dense to Very Dense Brown to Grey Wet				439	
		9	SS	35	438	
		10	SS	60	437	
		11	SS	32	436 / 435	
		12	SS	35	434	0 64 34 2
432.1		13	SS	37	433	
17.4	**SILT**, trace sand, trace clay Very Dense Grey Wet Cored through boulders from 17.4m to 18.3m	3	RUN		432	
430.7		14	SS	51	431	0 7 85 8
18.8	END OF BOREHOLE AT 18.8m UPON REFUSAL ON POSSIBLE BOULDER. BOREHOLE CAVED TO 3.4m, BOREHOLE BACKFILLED WITH SAND TO 0.3m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.					

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No GRB11-06

METRIC

W.P.	6048-06-00	LOCATION	N 5 469 330.7 E 412 098.5 Gulliver River Bridge	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	Casing/DCPT	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.04.06 - 2011.04.06	CHECKED BY	RPR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
449.6 / 0.0							
0.1	**ASPHALT:** (75mm)						
0.2	**CONCRETE:** (100mm)						
	Gravelly **SAND**, some silt and clay, occasional cobbles and boulders Loose to Very Dense Brown Moist (FILL)				449		
		1	SS	56/ .075			
		2	SS	41	448	o	32 55 13 (SI+CL)
		3	SS	8	447		(No recovery)
		4	SS	16	446		
445.6 / 4.0	**SAND** and **GRAVEL**, with cobbles and boulders Cored through boulders from 4.0m to 9.1m	1	RUN		445		
		2	RUN		444		
					443		
		3	RUN		442		
					441		
440.5 / 9.1	**SAND**, medium to coarse grained, trace gravel Compact Brown Wet	7	SS	13		o	
439.8 / 9.8					440		

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa — O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No GRB11-06

METRIC

W.P.	6048-06-00	LOCATION	N 5 469 330.7 E 412 098.5 Gulliver River Bridge	ORIGINATED BY	RK
HWY	11	BOREHOLE TYPE	Casing/DCPT	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.04.06 - 2011.04.06	CHECKED BY	RPR

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	SAMPLES – TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L – WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Start DCPT at 9.8m.						439				
438.7 10.9	END OF BOREHOLE AT 9.8m. END OF DCPT AT 10.9m UPON REFUSAL. BOREHOLE CAVED TO 1.2m. BOREHOLE BACKFILLED WITH SAND TO 0.3m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.										

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

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Appendix B

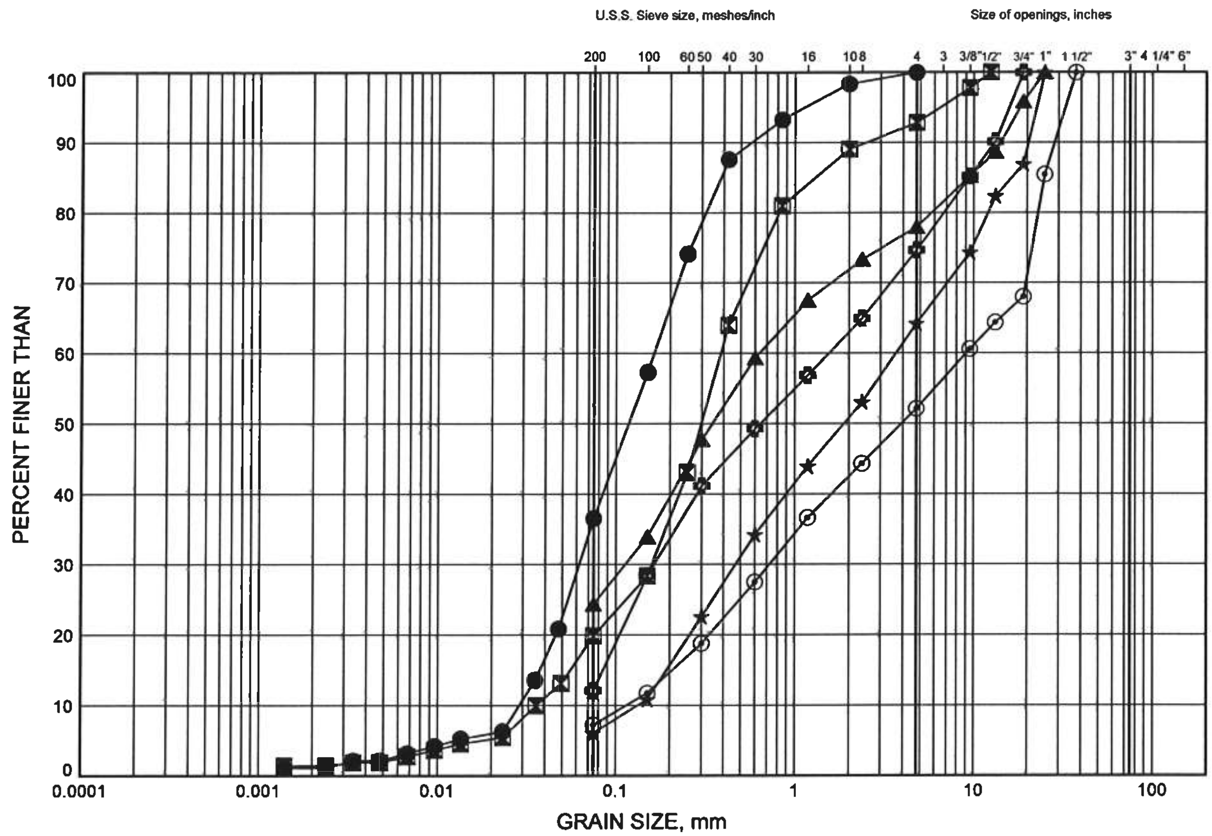
Laboratory Test Results

6010-E-0010 Bridge and Culvert Rehabs NWR

GRAIN SIZE DISTRIBUTION

FIGURE B1

FILL (SAND, GRAVELLY SAND, SAND & GRAVEL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GRB11-01	3.35	446.55
⊠	GRB11-02	1.83	447.77
▲	GRB11-03	1.83	447.77
★	GRB11-04	1.83	447.67
⊙	GRB11-04	4.88	444.62
✪	GRB11-05	2.59	446.91

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

W.P.# 6048-06-00

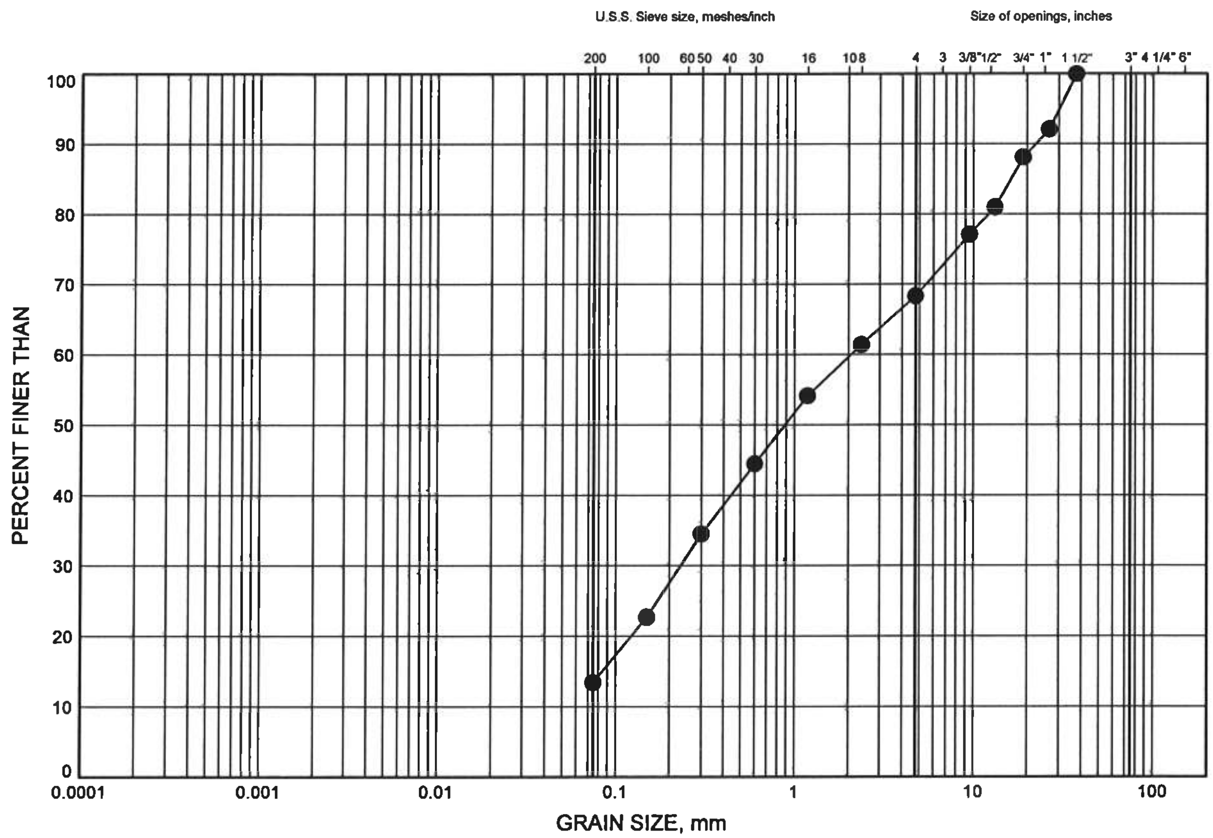
Prepared By AN

Checked By RPR

THURBER

6010-E-0010 Bridge and Culvert Rehabs NWR GRAIN SIZE DISTRIBUTION	FIGURE B2

FILL (GRAVELLY SAND)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GRB11-06	1.83	447.77

W.P.# 6048-06-00
Prepared By AN
Checked By RPR

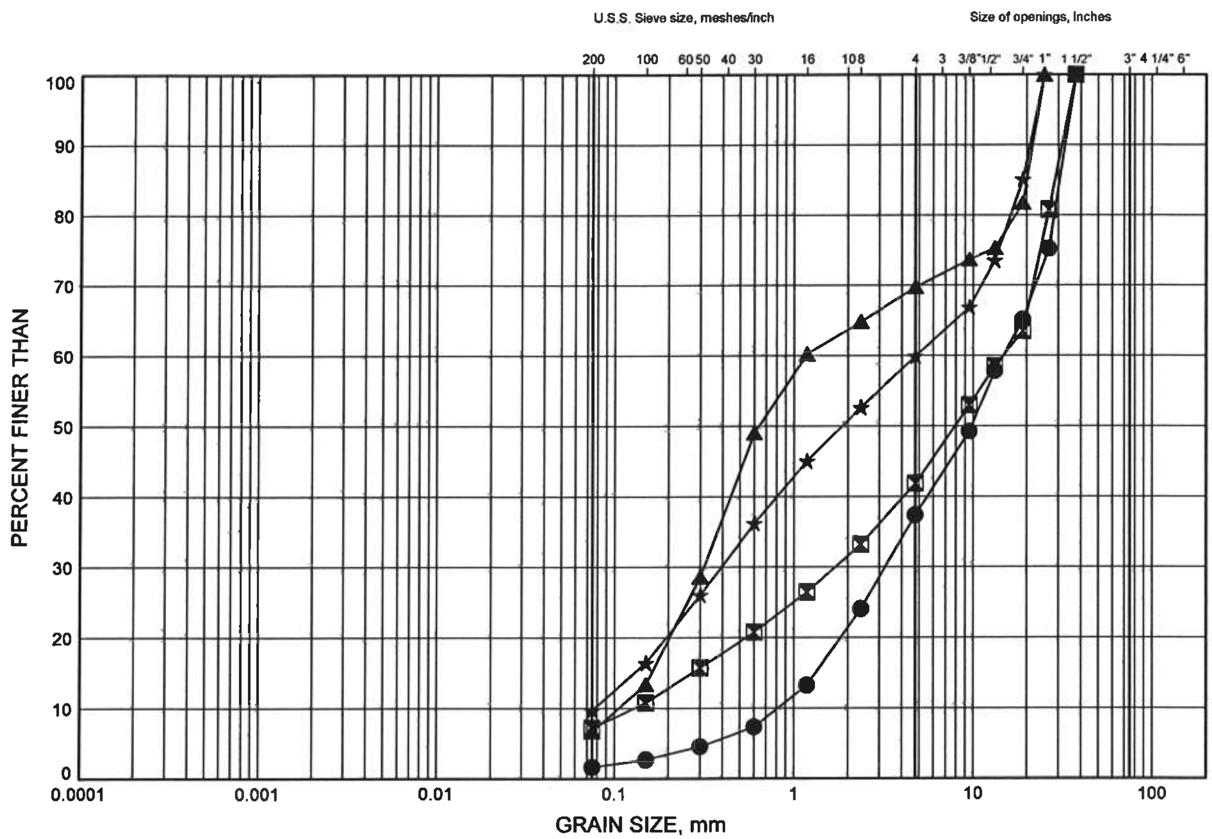
THURBER

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

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

FIGURE B3

SAND & GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GRB11-02	10.36	439.24
⊠	GRB11-02	13.41	436.19
▲	GRB11-04	23.16	426.34
★	GRB11-05	9.45	440.05

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

W.P.# 6048-06-00
Prepared By AN
Checked By RPR

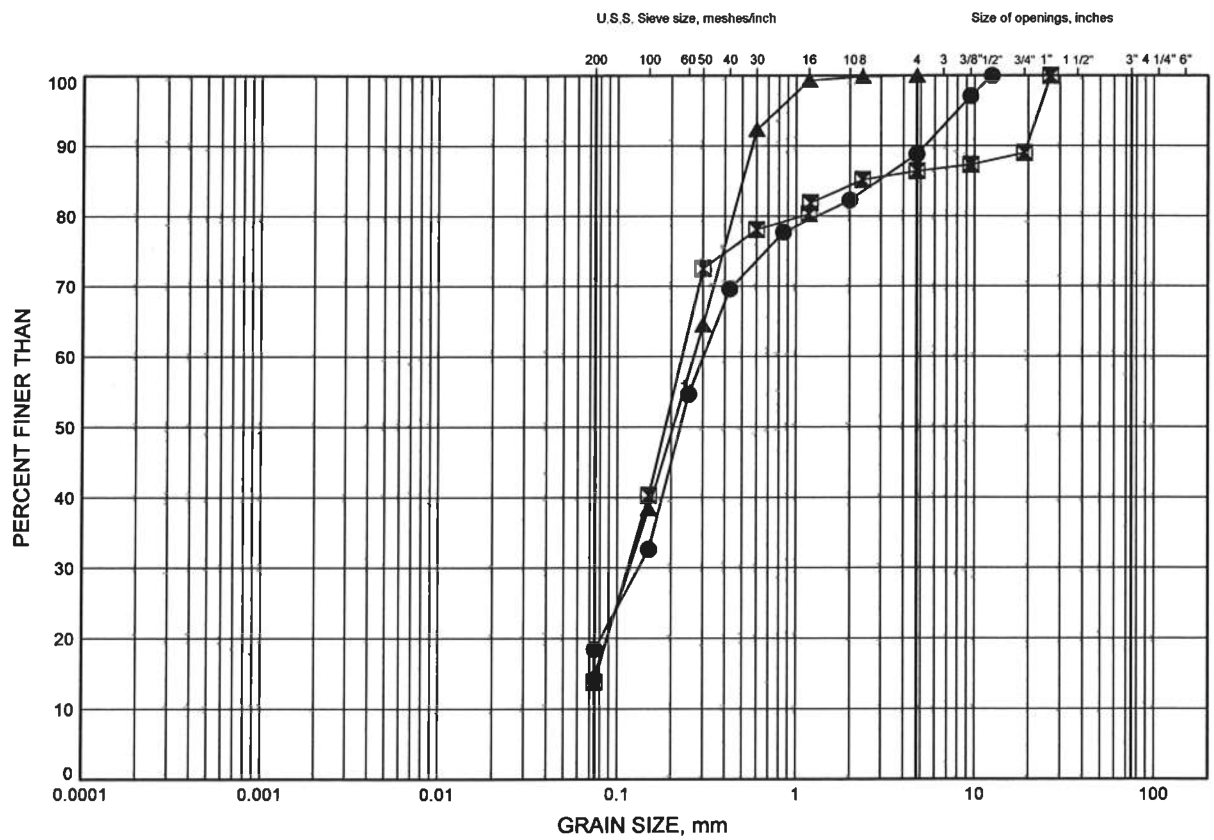
THURBER

6010-E-0010 Bridge and Culvert Rehabs NWR

GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GRB11-01	6.40	443.50
⊠	GRB11-04	12.50	437.00
▲	GRB11-04	16.46	433.04

W.P.# 6048-06-00

Prepared By AN

Checked By RPR

THURBER

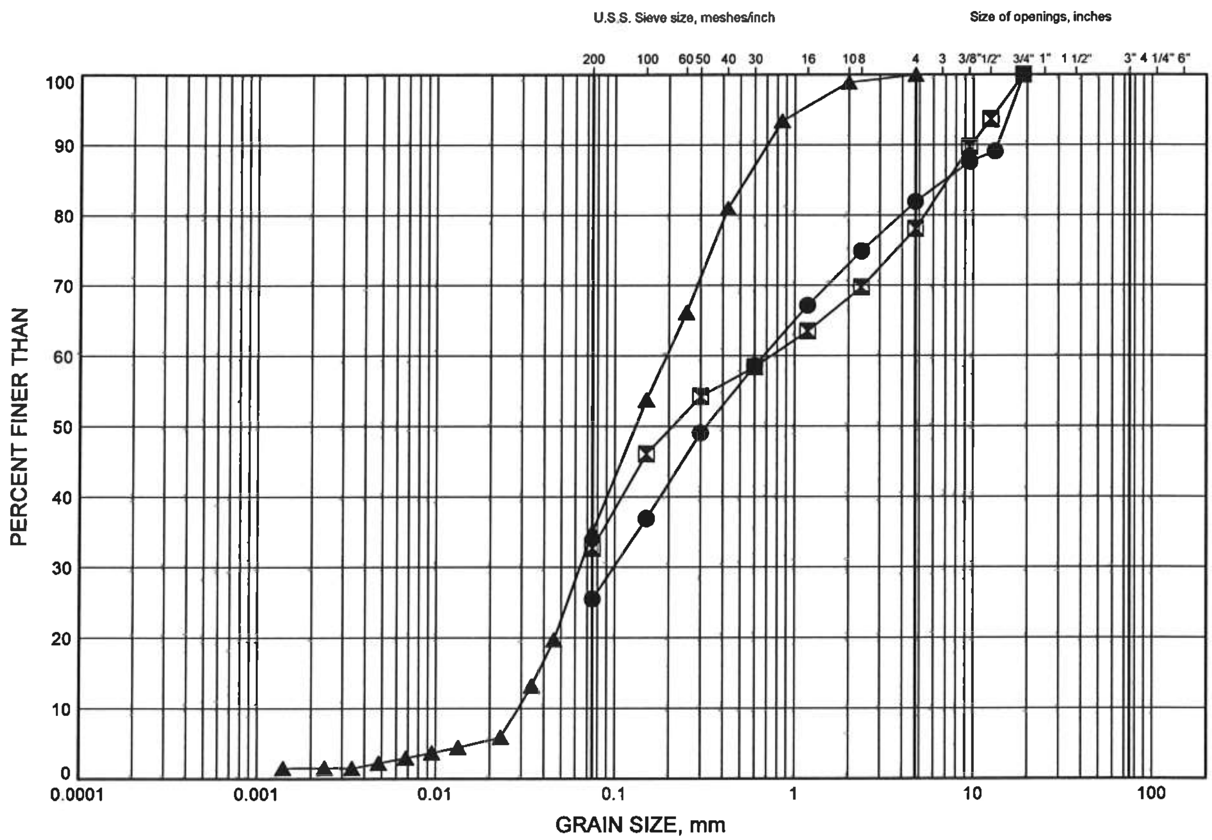
GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 9/13/11

6010-E-0010 Bridge and Culvert Rehabs NWR

GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GRB11-03	18.59	431.01
⊠	GRB11-05	6.40	443.10
▲	GRB11-05	15.54	433.96

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

W.P.# 6048-06-00

Prepared By AN

Checked By RPR

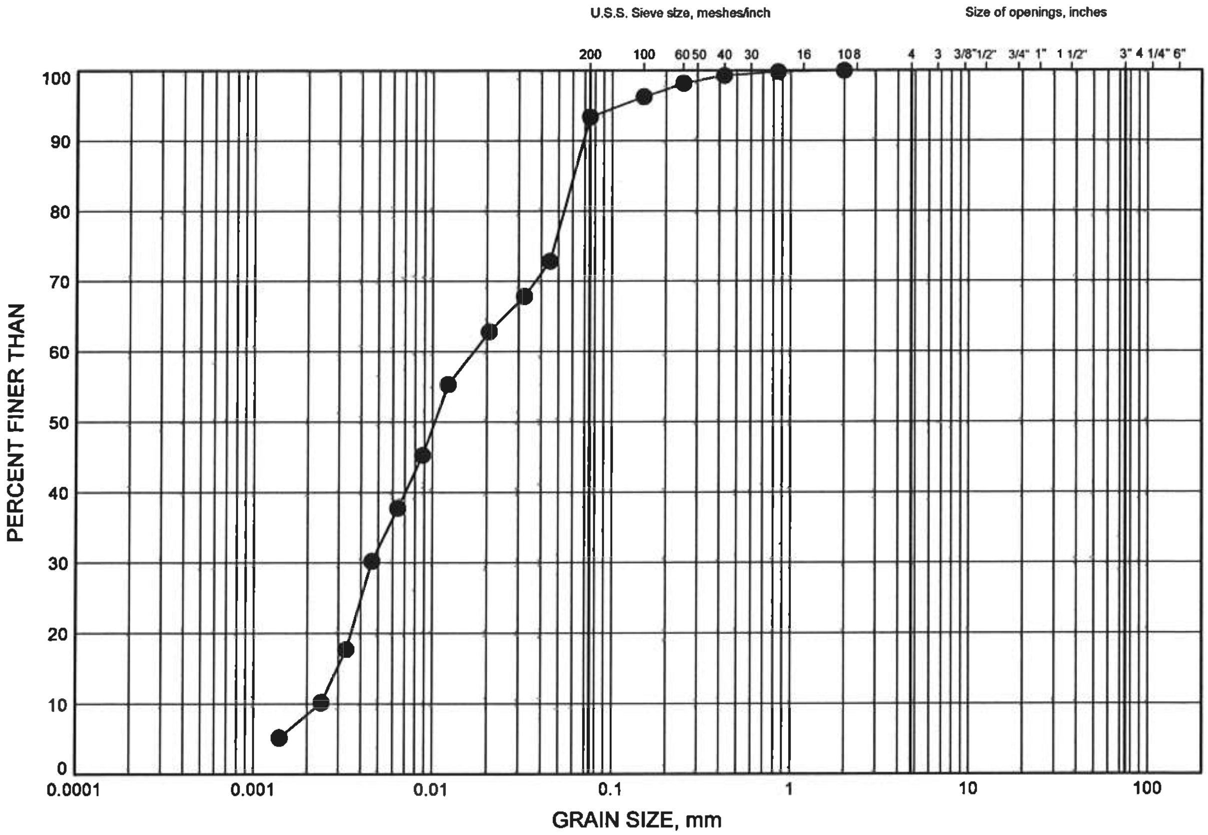
THURBER

6010-E-0010 Bridge and Culvert Rehabs NWR

GRAIN SIZE DISTRIBUTION

FIGURE B6

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GRB11-05	18.59	430.91

W.P.# 6048-06-00

Prepared By AN

Checked By RPR

THURBER

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

Appendix C

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Footing on Native Soil	Augered Caissons (drilled shafts)	Driven Piles
Advantages: i. Economical to construct.	***Advantages:*** i. . Higher geotechnical resistance. ii. Installation less influenced by weather than spread footings	***Advantages:*** i. High geotechnical resistance available by driving piles to achieve resistance in the very dense soils ii. Permits integral abutment design. iii. Readily installed. iv. Installation less influenced by weather and groundwater than spread footings.
Disadvantages: i. High groundwater levels. ii. Deep excavation extending below the groundwater level is required.	***Disadvantages:*** 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	***Disadvantages:*** i. Presence of boulders within the fill and native soils. Pre-drilling might be required for pile installation. ii. Higher unit cost compared to footings
NOT RECOMMENDED	**NOT RECOMMENDED**	**RECOMMENDED**

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
- OPSS 902, November 2010
- OPSD 208.010
- OPSS 804
- Special Provision 110S13 “Amendment to OPSS 1010, April 2004”.
- OPSD 3101.150.
- OPSD 3101.200

3. Suggested text for a NSSP on Pile Installation

The soils (fill and native) contains cobbles and boulders, which will potentially have an impact on the installation of piles at the site. 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.
- The cobbles and boulders may impede the driving of the piles resulting in more arduous driving to reach the design tip depth.
- 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.
- If piles need to be extended below boulder to achieve an adequate embedment length, pre-drilling may be required to install the piles. Rock coring/breaking equipment may be required for predrilling.

4. Suggested text for a NSSP on Dewatering

If excavation is required to be carried out below the groundwater level prevailing at the time of construction, appropriate means of dewatering must be implemented to depress the groundwater level sufficiently far below the base of the excavation to prevent any instability, sloughing, or boiling and so as to preserve the stability of the excavation and to allow the work to proceed in the dry.

Appendix E

Slope Stability Output

19-1605-121
Gulliver River Bridge, Hwy 17, Site 41S-72
Earth approach
6.0 m high, Slope 2H:1V
February 9, 2011

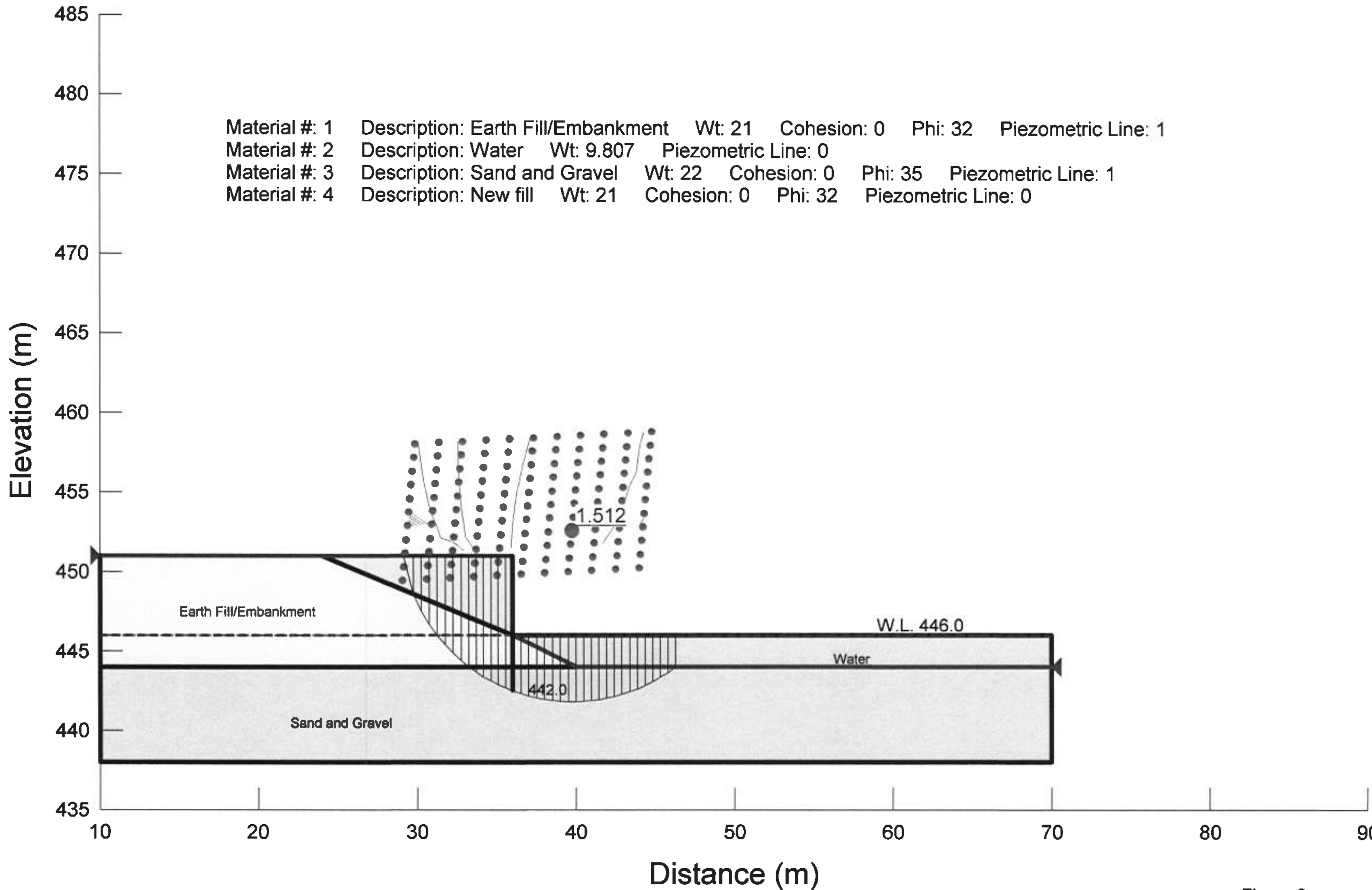


Figure 2

Name: gu6-sh.gsz

Appendix F

Site Photographs

Photograph 1 – Existing Gulliver River Bridge & Highway 17

THURBER

Photograph 2– Gulliver River Bridge, existing foundation elements

Photograph 3 – Gulliver River Bridge, existing foundation elements

Photograph 4 – North side of the Gulliver River Bridge

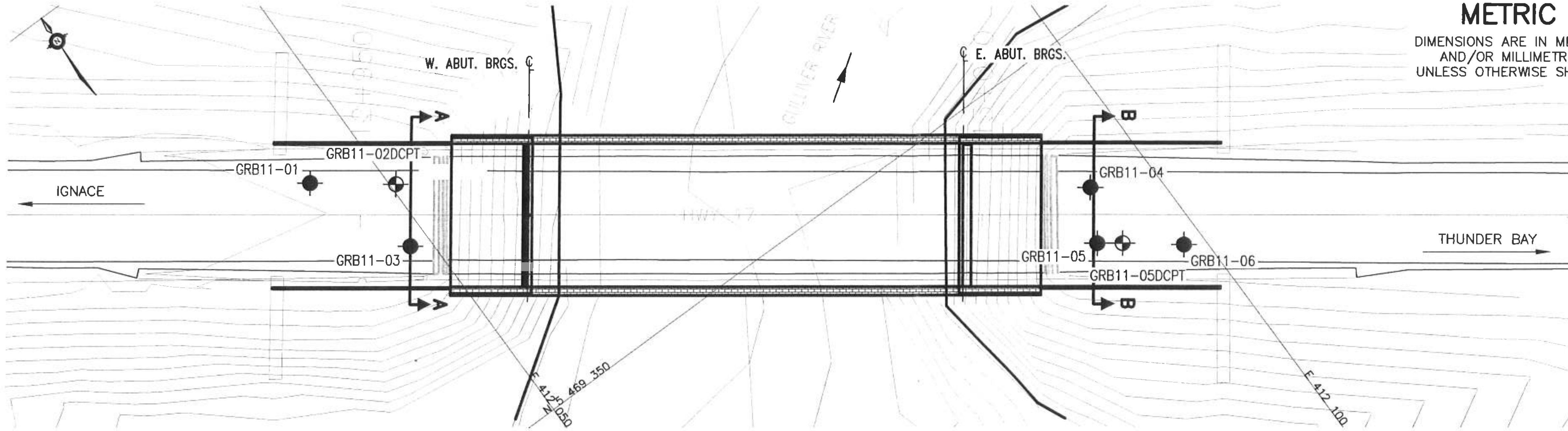
Photograph 5 – South side of the Gulliver River Bridge

Appendix G

Drawing
Borehole Locations and Soil Strata

METRIC

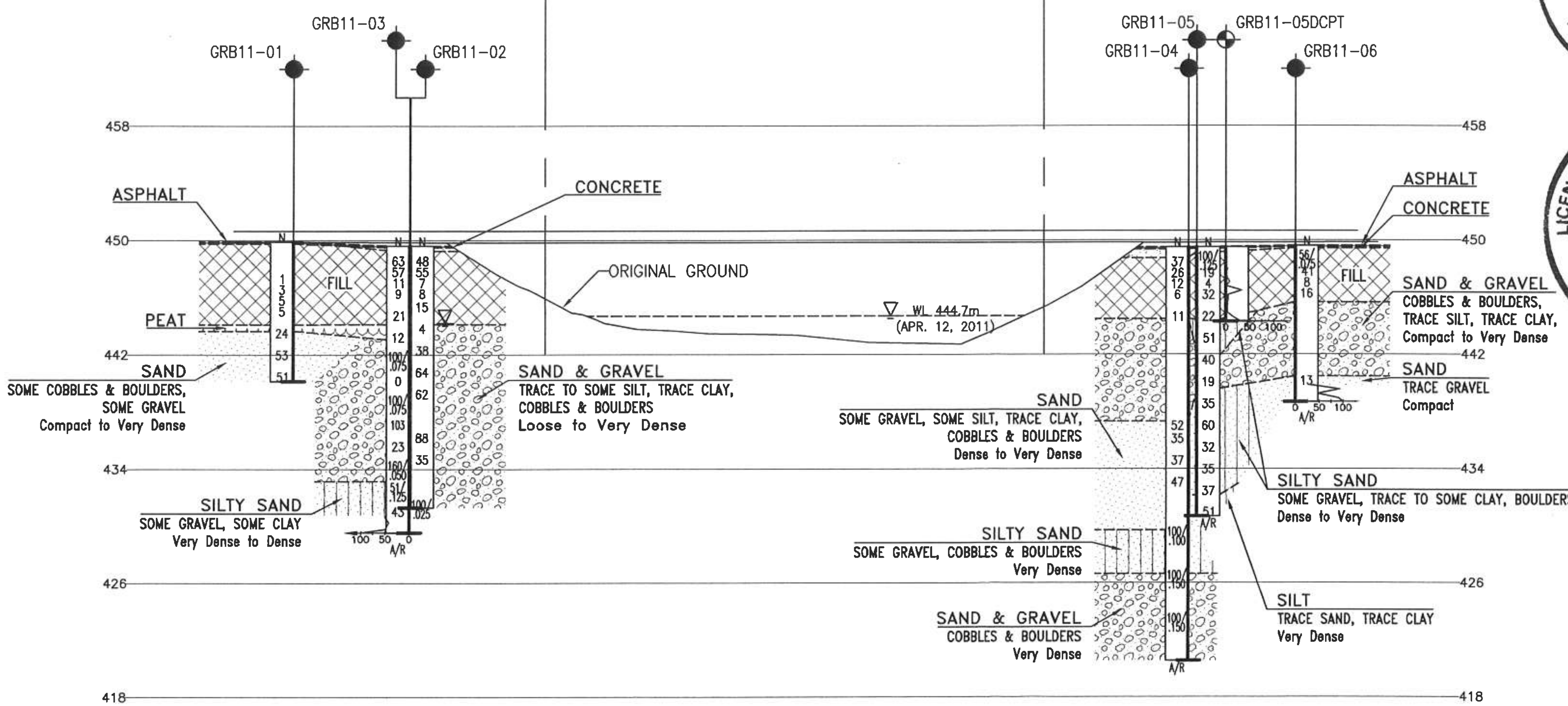
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PLAN

8 0 8 16m

SCALE 1:400



PROFILE

8 0 8 16m

SCALE 1:400

LICENSED PROFESSIONAL ENGINEER
R. Palomeque Reyna
100083209
March 5, 2012
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
March 5/12
PROVINCE OF ONTARIO

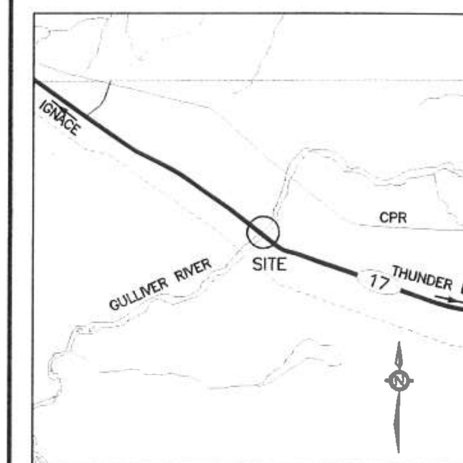
CONT No
WP No 6048-06-00

SHEET

HIGHWAY 17
BRIDGE AND CULVERT REHABS NWR
GULLIVER 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
▽	Water Level
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
GRB11-01	449.9000	5469376.3437	412044.9450
GRB11-02	449.6000	5469371.2396	412051.3683
GRB11-02DCPT	449.6000	5469372.1716	412050.4402
GRB11-03	449.6000	5469367.4170	412048.4643
GRB11-04	449.5000	5469338.8477	412095.1735
GRB11-05	449.5000	5469334.8926	412092.9554
GRB11-05DCPT	449.5000	5469333.7064	412094.5656
GRB11-06	449.6000	5469330.7198	412098.4515

-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. 52G-9

REVISIONS	DATE	BY	DESCRIPTION			
DESIGN RPR	CHK PKC	CODE		LOAD		DATE MAR. 2012
DRAWN MFA	CHK RPR	SITE		STRUCT		DWG 1

FILENAME: H:\Drafting\19\1605\121\ed5121-GulliverRiverBridge.dwg
PLOTDATE: 3/1/2012 1:56 PM

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

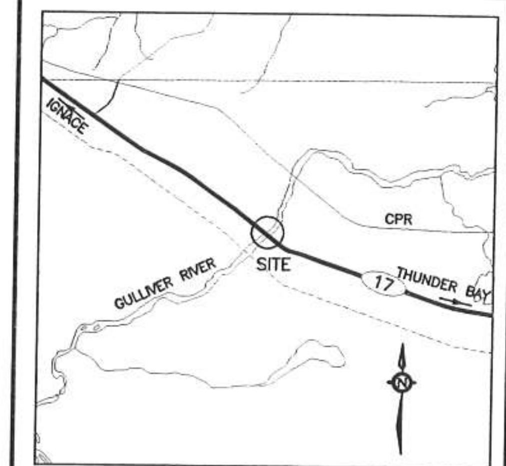
CONT No
WP No 6048-06-00

SHEET

HIGHWAY 17
BRIDGE AND CULVERT REHABS NWR
GULLIVER 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
▽	Water Level
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

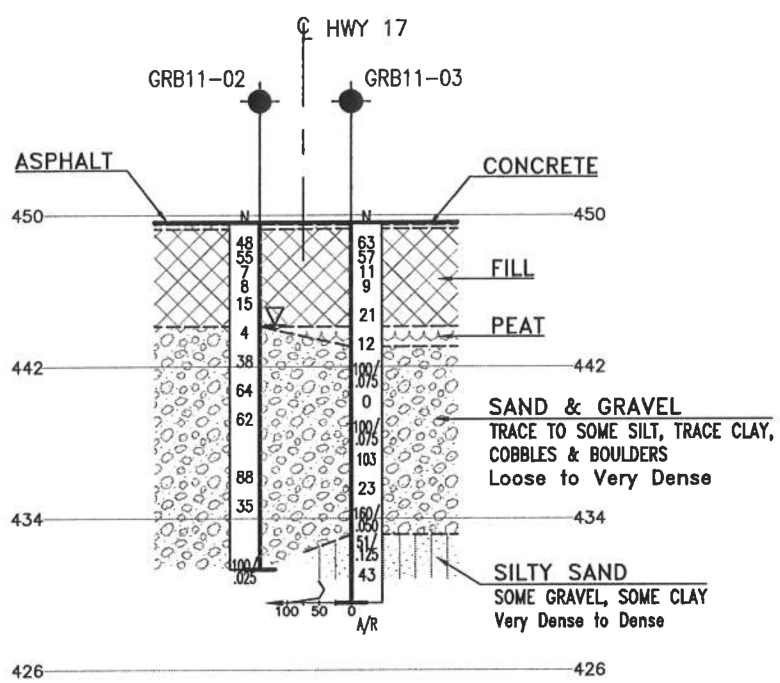
NO	ELEVATION	NORTHING	EASTING
GRB11-01	449.9000	5469376.3437	412044.9450
~~GRB11-02~~	~~449.6000~~	~~5469371.2396~~	~~412051.3683~~
~~GRB11-02DC PT~~	~~449.6000~~	~~5469372.1716~~	~~412050.4402~~
GRB11-03	449.6000	5469367.4170	412048.4643
GRB11-04	449.5000	5469338.8477	412095.1735
~~GRB11-05~~	~~449.5000~~	~~5469334.8926~~	~~412092.9554~~
~~GRB11-05DC PT~~	~~449.5000~~	~~5469333.7064~~	~~412094.5656~~
GRB11-06	449.6000	5469330.7198	412098.4515

-NOTES-

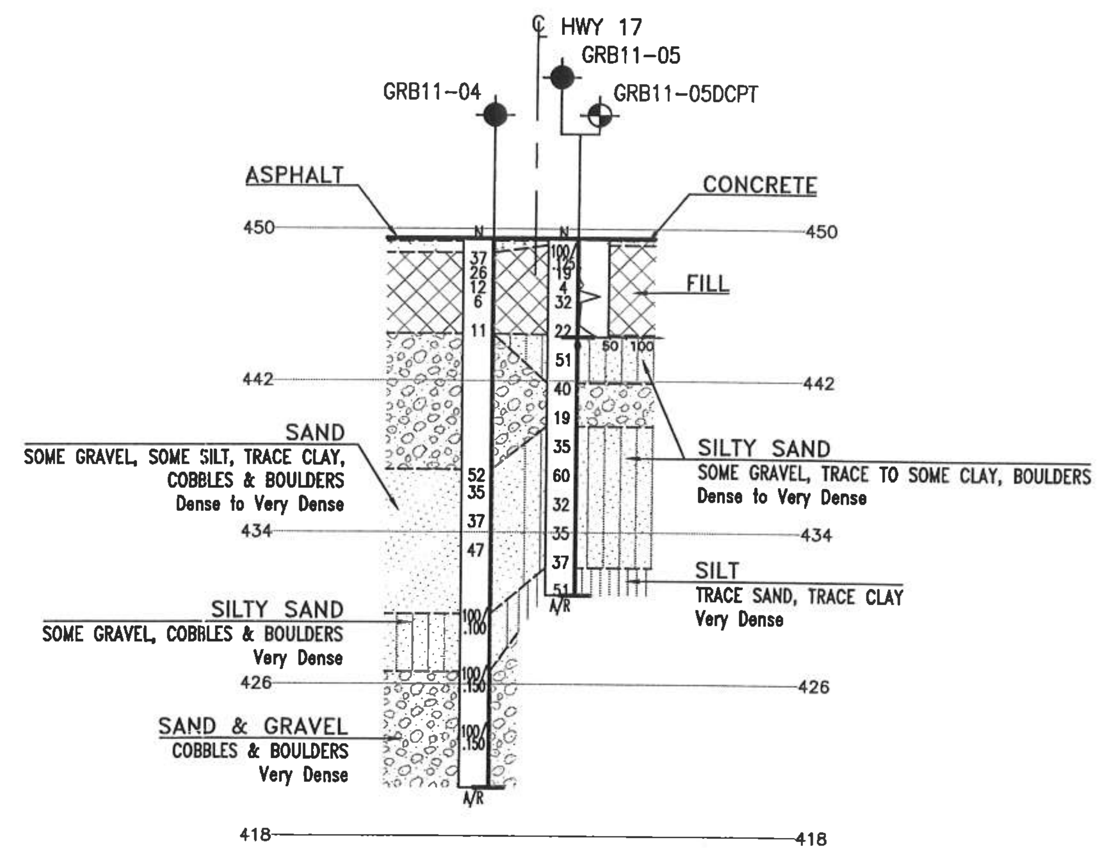
1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

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

GEOCRES No. 52G-9



SECTION A-A



SECTION B-B

8 0 8 16m
SCALE 1:400

LICENSED PROFESSIONAL ENGINEER
R. Palomeque Reyna
100063209
March 5, 2012
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
March 5/12
PROVINCE OF ONTARIO

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN RPR	CHK PKC	CODE	LOAD	DATE DEC. 2011	
DRAWN MFA	CHK RPR	SITE	STRUCT	DWG 2	