FOUNDATION INVESTIGATION AND DESIGN REPORT
NORTH TROUT CREEK BRIDGE WBL
HIGHWAY 11/17 RED ROCK TO NIPIGON
FROM 4.8 KM WEST OF HWY 628 TO 1.5KM WEST OF HWY 585
TOWNSHIP OF NIPIGON

G.W.P. 647-89-00, SITE NO. 48C-11A

Geocres Number: 52A-176

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 proposed location of a bridge planned to carry the new Highway 11/17 westbound lanes (WBL) over the North Trout Creek near the boundary of the Townships of Red Rock and Nipigon, Ontario. The proposed bridge is part of the Highway 11/17 four-laning project, involving construction of a divided highway from 4.8 km west of Highway 628 to 1.5 km west of Highway 585 in the District of Thunder Bay.

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 profiles, 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-0006.

A previous foundation investigation report was available for the existing bridge on the current Highway 11/17 alignment (Soil Conditions, Proposed North Trout Creek Bridge, Highway No. 17, Nipigon, Ontario; November 26, 1956, by Geocon Ltd.; Geocres 56-F-216C). However, this bridge is located approximately 200 m to the east of the new location, and the data is not considered relevant to the new bridge site.

2 SITE DESCRIPTION

The site is located approximately 10 km (by highway) southwest of Nipigon, Ontario and about 500 m north of the intersection of Highway 11/17 and Highway 528. At the bridge location, the new westbound lanes of Highway 11/17 will be approximately 245 m west of the existing highway.

North Trout Creek at the proposed crossing generally flows southerly and then easterly towards Lake Superior at Red Rock. The creek is situated at the base of an approximate 80 m wide by 8 m deep valley. The surrounding lands are typically heavily treed with occasional vacant areas of grass and shrubs.

An MTO inspection station is located on the west side of existing Highway 11/17 approximately 200 m north of the site. A hydro corridor runs parallel to the west side of the highway.

Photographs in Appendix C show the general nature of the site and the surrounding lands.

The site lies within the physiographic region known as the Quetico Subprovince of the Superior Province of the Canadian Shield. The region is characterized by early Precambrian felsic igneous (granite) and metamorphic (granitic gneiss) bedrock. The bedrock is mantled by a thin discontinuous layer of drift or deeper deposits of glaciolacustrine clay.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project was carried out during the period of July 4 to 13, 2012 and consisted of drilling and sampling ten boreholes (numbered NTW-01 to NTW-10) in the area of the proposed foundation units. The borehole locations were selected on the basis of a three span structure originally proposed at this location.

The design was subsequently revised to two-spans, and two additional boreholes (numbered NTW-11 and NTW-12) were drilled at the revised location of the east abutment on February 23, 2014.

A summary of the borehole locations, designations, termination depths and termination elevations is provided in Table 3.1. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix G.

Table 3.1 – Borehole Designations

Location		Borehole	Borehole Termination Depth (m)	Borehole Termination Elevation (m)
original three-span structure	revised two-span structure			
West approach	West approach	NTW-01	13.2	204.7
West abutment	West abutment	NTW-02 and NTW-03	17.8 and 21.3	197.5 and 194.3
West pier	-	NTW-04 and NTW-05	18.5 and 16.4	192.8 and 196.0
East pier	Pier	NTW-06 and NTW-07	20.9 and 12.5	188.6 and 198.3
East abutment	-	NTW-08 and NTW-09	6.6 and 7.9	204.5 and 202.9
-	East abutment	NTW-11 and NTW-12	5.5 and 5.1	205.9 and 207.7
East approach	East approach	NTW-10	0.6	215.0

Boreholes NTW-03, NTW-04, NTW-06, NTW-09, NTW-11 and NTW-12 were advanced 3.0 m to 3.6 m into bedrock by NQ size diamond coring.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling.

Drilling was carried out using a track-mounted CME 45 drill rig and the boreholes were advanced with hollow-stem augers and NQ coring techniques. In general, samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the native soils. Rock cores were logged, and the Total Core Recovery (TCR), Fracture Index (FI) and Rock Quality Designation (RQD) were determined.

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 and rock samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. The boreholes were backfilled with bentonite holeplug in general accordance with O.Reg. 903 upon completion. Standpipe piezometers consisting of 19 mm PVC pipe with slotted screen enclosed in filter sand were installed in Boreholes NTW-02, NTW-05, NTW-07 and NTW-08 to permit longer term groundwater level monitoring. The piezometers were subsequently decommissioned in general accordance with MOE Regulation 903. The installation and completion details of the piezometer and boreholes are shown in Table 3.2.

Table 3.2 – Borehole Completion Details

Borehole	Piezometer Tip Depth/ Elevation (m)	Completion Details
NTW-01	None installed	Borehole backfilled with bentonite to 2.7 m, then auger cuttings to surface.
NTW-02	17.1/198.3	Borehole caved to 17.1 m, then backfilled with sand from 17.1 m to 14.2 m, bentonite from 14.2 m to 1.0 m, auger cuttings from 1.0 m to surface.
NTW-03	None installed	Borehole backfilled with bentonite and auger cuttings to surface.
NTW-04	None installed	Borehole backfilled with bentonite and auger cuttings to surface.
NTW-05	16.4/196.0	Sand from 16.4 m to 13.8 m, bentonite from 13.8 m to 1.2 m, auger cuttings from 1.2 m to surface.
NTW-06	None installed	Borehole backfilled with bentonite to surface.
NTW-07	11.7/199.1	Borehole caved to 11.7 m, then backfilled with sand from 11.7 m to 9.1 m, bentonite from 9.1 m to 1.9 m, auger cuttings from 1.9 m to surface.
NTW-08	5.9/205.2	Borehole caved to 5.9 m, then backfilled with sand from 5.9 m to 3.5 m, bentonite from 3.5 m to 1.1 m, auger cuttings from 1.1 m to surface.
NTW-09	None Installed	Borehole backfilled with bentonite from 7.9 m to 1.6m, then auger cuttings to surface.

Borehole	Piezometer Tip Depth/ Elevation (m)	Completion Details
NTW-10	None Installed	Borehole backfilled with auger cuttings to surface.
NTW-11	None Installed	Borehole backfilled with bentonite and auger cuttings to surface.
NTW-12	None Installed	Borehole backfilled with bentonite and auger cuttings to surface.

4 LABORATORY TESTING

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

Rock samples were subjected to geological logging. Point load tests were carried out on selected samples of intact bedrock upon arrival at the laboratory to assist in evaluation of the compressive strength of the bedrock. Results of point load tests on the rock core samples are included on the Record of Borehole sheets in Appendix A (as average unconfined compressive strength per run).

5 DESCRIPTION OF SUBSURFACE CONDITIONS

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

The subsurface stratigraphy at this site varies notably between the west and east sides of North Trout Creek. On the west side, the stratigraphy typically consists of a topsoil layer over a thick deposit of silty clay, underlain by a thin layer of sand overlying bedrock. On the east side, the stratigraphy consists of topsoil over a layer of sand, sandy silt and clayey silt, underlain by silty clay and sand strata, however the bedrock surface rises and the clay layer thins towards the east, and the thickness of the sand deposit varies substantially. More detailed descriptions of the individual strata are presented below.

5.1 Topsoil

Topsoil was identified at ground surface in all the boreholes. The topsoil thickness ranged from 200 mm to 460 mm. The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

5.2 Sand

A layer of native brown to dark brown sand containing trace to some silt and clay was encountered below the topsoil in Boreholes NTW-06, NTW-08 and NTW-10 drilled on the east side of the creek. The thickness of the sand layer varied from 0.4 m to 3.1 m.

In Boreholes NTW-06 and NTW-08, the lower boundary of the sand layer was encountered at depths of 1.4 m and 3.4 m (Elev. 208.1 and 207.7). Borehole NTW-10 was terminated below the sand layer upon refusal on probable bedrock at 0.6 m depth (Elev. 215.0).

SPT N-values recorded in the sand ranged from 1 to 5 blows per 0.3 m of penetration, indicating a very loose to loose relative density. Moisture contents ranged from 23% to 38%.

A grain size distribution curve for a sample of the sand is presented on the Record of Borehole sheet and on Figure B1 of Appendix B. The results are summarized as follows:

Gravel %	0
Sand %	69
Silt %	19
Clay %	12

5.3 Sandy to Clayey Silt

A brown to dark brown layer of sandy silt containing some clay to clayey silt containing some sand was encountered below the topsoil in Boreholes NTW-07 and NTW-09 drilled on the east side of the creek. The silt layer was 1.9 to 2.0 m thick. The lower boundary of the silt layer was encountered at 2.2 m depth (Elev. 208.6 and 208.7).

SPT N-values recorded in the silt ranged from 0 to 6 blows per 0.3 m of penetration, indicating a very loose to loose/firm condition. Moisture contents ranged from 34% to 42% with one value of 90% recorded, indicating a probable organic component.

5.4 Silty Clay

Native brown to grey silty clay containing silt seams (varved) was encountered below the topsoil, sand and silt in all boreholes except Borehole NTW-10 at the east approach.

On the west side of the creek, the thickness of the clay layer ranged from 14.3 m to 16.9 m. The lower boundary of the clay deposit was encountered at depths of 14.6 to 17.2 m (Elev. 198.4 to 196.7) in Boreholes NTW-02 to NTW-04, and Borehole NTW-05 was terminated at 16.4 m depth (Elev. 196.0) upon refusal at the base of the clay deposit. Borehole NTW-01 was terminated in the clay at 13.2 m depth (Elev. 204.7).

On the east side, the thickness of the clay deposit decreased towards the east, ranging from 7.3 m in Borehole NTW-06 to 0.8 m in Borehole NTW-09. The lower boundary of the clay deposit was encountered at depths of 1.2 m to 8.7 m (Elev. 211.6 to 200.9). Clay was not encountered in Borehole NTW-10.

Locally in Borehole NTW-02, the clay was interrupted by a 1.6 m thick layer of very loose sandy silt between 8.8 m and 10.4 m depth (Elev. 206.6 and 205.0).

Standard Penetration Test N-values obtained in the silty clay ranged from 0 to 9 blows per 0.3 m of penetration, indicating a very soft to stiff consistency. In general, the higher N-values of 4 to 9 blows per 0.3 m of penetration (firm to stiff) were obtained near the upper and lower boundaries of the deposit. Undrained shear strengths determined by in-situ vane shear testing ranged from 16 kPa to 96 kPa, indicating a soft to stiff consistency. The measured shear strengths may be affected by the silt seams in the clay.

The moisture content of samples of the silty clay ranged from 20% to 62%, typically in the order of 35% to 50%.

Samples of the silty clay underwent laboratory grain size analysis testing and Atterberg Limits tests. The grain size distribution curves for tested samples of silty clay are presented in Appendix B, Figures B2 to B5. The results of the Atterberg Limits tests are presented in Figures B8 to B10, Appendix B. The results are also summarized on the Record of Borehole sheets included in Appendix A and in the following tables:

Gravel %	0
Sand %	0 to 4
Silt %	27 to 71
Clay %	28 to 73

Liquid Limit	29 to 58
Plastic Limit	16 to 23

The above results and noted figures indicate that the silty clay is typically of medium plasticity with a group symbol of CI, and locally varies from low to high plasticity with group symbols of CL to CH.

5.5 Sand

A layer of grey sand was encountered below the clay layer and above the bedrock surface in Boreholes NTW-02 to NTW-04, NTW-06 to NTW-09, NTW-11 and NTW-12. The silt and gravel content in the sand varied, typically ranging from trace silt to silty, and from trace gravel to gravelly. Locally, this deposit graded to silt and sand and to sand and gravel. The sand layer also contains occasional cobbles.

The thickness of the sand layer varied. In Boreholes NTW-02 to NTW-04 on the west side of the creek, the sand layer was 0.6 m to 1.1 m thick, with a lower boundary at depths of 15.5 m to 18.3 m (Elev. 195.8 to 197.5). On the east side of the creek, the thickness of the sand layer varied from 0.6 m in Borehole NTW-12 to 8.6 m in Borehole NTW-06. The lower boundary of the sand deposit was encountered at depths of 1.8 m to 17.3 m (Elev. 211.0 to 192.3) on the east side of the creek.

In general, SPT N-values recorded in the sand layer ranged from 39 blows per 0.3 m to 100 blows per 0.1 m of penetration, indicating a dense to very dense relative density. However, SPT N-values of 6 to 16 blows per 0.3 m of penetration, indicating a loose to compact relative density, were recorded locally in Boreholes NTW-06, NTW-08 and NTW-09. The moisture content of the sand samples ranged from 8% to 19%.

Grain size distribution curves for samples of the sand layer are presented on the Record of Borehole sheets and on Figure B6 of Appendix B. The grain size curve for a sample of the sandy silt is presented on Figure B7. The results are summarized as follows:

	Sand to Silty Sand	Sandy Silt
Gravel %	6 to 26	0
Sand %	47 to 88	40
Silt & Clay %	6 to 27	60

5.6 Bedrock

Bedrock and auger refusal on probable bedrock were encountered below the native soils described above. Bedrock was proved by coring in six of the boreholes. The depths and elevations at which the top of bedrock or auger refusal on probable bedrock was encountered in the boreholes are summarized in Table 5.1.

Table 5.1 – Depths and Elevations of Top of Bedrock and Auger Refusal

Foundation Unit		Borehole	Top of Bedrock or Auger Refusal	
original three-span structure	revised two-span structure		Depth (m)	Elevation (m)
West Abutment	West Abutment	NTW-02	17.8	197.5
		NTW-03	18.3(1)	197.4
West Pier	-	NTW-04	15.5(1)	195.8
		NTW-05	16.4	196.0
East Pier	Pier	NTW-06	17.3(1)	192.3
		NTW-07	12.5	198.3
East Abutment	-	NTW-08	6.6	204.5
		NTW-09	4.4(1)	206.4
-	East Abutment	NTW-11	2.4(1)	208.9
		NTW-12	1.8(1)	211.0
East Approach	East Approach	NTW-10	0.6	215.0

(1) Bedrock proved by coring.

As indicated by the table, the depth to bedrock decreases significantly towards the east approach. In Boreholes NTW-02 to NTW-07, the bedrock was contacted at depths of 12.5 m to 18.3 m (Elev. 198.3 to 192.3). The bedrock surface then rises from 6.6 m depth (Elev. 204.5) in Borehole NTW-08 to 0.6 m depth (Elev. 215.0) in Borehole NTW-10 at the east approach.

The bedrock recovered in the cores typically consists of grey migmatitic gneiss with occasional white bands and intrusions of pink granite. In Borehole NTW-03, the bedrock consisted of pink granite.

The Total Core Recovery (TCR) in the bedrock ranged from 98% to 100%. The RQD values recorded on samples from Boreholes NTW-03 and NTW-04 ranged from 56 to 95%, indicating fair to excellent rock quality. In Boreholes NTW-06 and NTW-09, RQD values of 42 to 69% were typically recorded, indicating a poor to fair rock quality. RQD values of 0% (very poor quality) were noted in the upper 0.8 m of rock core from Borehole NTW-06. RQD values of 93 to 100% (excellent quality) were recorded in Boreholes NTW-11 and NTW-12.

The recorded Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to 12, typically 2 to 5. Zones of broken rock (rubble), 0.1 to 0.2 m thick, were encountered in Boreholes NTW-06, NTW-09, NTW-11 and NTW-12.

The unconfined compressive strength of the migmatitic gneiss, estimated from point load tests conducted on recovered rock cores, ranged from 107 MPa to 237 MPa, indicating a very strong rock. Approximate compressive strengths of 91 and 51 MPa were assessed on samples of granite core from Borehole NTW-03, indicating a strong rock. The results are presented on the Record of Borehole Sheets in Appendix A (as average per run).

5.7 Water Levels

Water levels were observed in the boreholes during and upon completion of drilling. However, water was added into the boreholes as part of the drilling and coring operations, and therefore natural groundwater levels were generally not measured during drilling.

Standpipe piezometers were installed in Boreholes NTW-02, NTW-05, NTW-07 and NTW-08 to monitor water levels after completion of drilling. The water levels measured in the piezometers, along with water levels measured upon completion of drilling, are summarized in Table 5.2.

Table 5.2 – Water Level Measurements

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
NTW-01	July 13, 2012	10.6	207.3	In open borehole
NTW-02	July 11, 2012 July 13, 2012 June 23, 2013	3.4 3.9 3.2	212.0 211.5 212.2	In piezometer In piezometer In piezometer
NTW-05	July 10, 2012 July 11, 2012 July 13, 2012 March 2, 2013 June 23, 2013	2.2 2.0 1.9 3.3 1.6	210.2 210.4 210.5 209.1 210.8	In piezometer In piezometer In piezometer In piezometer In piezometer
NTW-07	July 5, 2012	0.15	210.7	In piezometer
NTW-08	July 5, 2012 June 23, 2013	0.1 0.0	211.0 211.1	In piezometer In piezometer
NTW-11	February 23, 2014	0.6	210.8	In open borehole
NTW-12	February 23, 2014	0.2	212.6	In open borehole

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

The groundwater level is also expected to be influenced by the water level in North Trout Creek, which is shown on the preliminary GA drawing provided by Hatch Mott MacDonald to be at Elev. 208.9 in October 2010. The high water level is indicated to be at Elev. 209.6.

6 MISCELLANEOUS

Borehole locations were selected by Thurber Engineering Ltd. The borehole locations were staked in the field by TBT Engineering Limited surveyors. The co-ordinates and ground surface elevations at the boreholes were provided by the surveyors.

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied a track mounted CME 45 drill rig and conducted the drilling, sampling and in-situ testing operations.

Full time supervision of the field activities was carried out by Mr. Stephane Loranger and Mr. George Azzopardi of Thurber. Overall supervision of the field program was conducted by Mr. Mark Farrant, P. Eng.

Interpretation of the data and preparation of the report were carried out by Ms. R. Palomeque Reyna, P.Eng. and Mr. Murray Anderson, 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 recommendations for selection and design of a suitable foundation system for the new bridge planned to carry the Highway 11/17 westbound lanes (WBL) over North Trout Creek in the District of Thunder Bay, Ontario.

The new bridge will be located approximately 245 m west of the existing Highway 11/17 alignment. Based on the preliminary General Arrangement (GA) drawing provided by Hatch Mott MacDonald, the current design concept calls for a two span structure consisting of a hollow precast concrete girder deck carried on precast concrete header beams, supported on steel H-piles at the abutments and concrete caissons at the pier. The bridge will have a west span of 30 m, an east span of 22 m, and a total width of 14.4 m. The uneven span lengths were chosen with specific consideration of the subsurface conditions at the site.

The proposed finished road grade will be at about Elevation 216.2 m at the west abutment and Elevation 216.8 at the east abutment. The east abutment will be constructed as an RSS wall with a maximum exposed height of about 5.0 m. An approximate 1.0 m high RSS will be installed at the west abutment.

The discussions and recommendations presented in this report are based on the factual data obtained during the course of the investigation. The plans and profiles used for preparation of this report were provided by Hatch Mott MacDonald.

8 STRUCTURE FOUNDATIONS

The subsurface stratigraphy at this site varies notably between the west and east sides of North Trout Creek. On the west side, the stratigraphy typically consists of a topsoil layer over a 14.3 m to 16.9 m thick deposit of silty clay, underlain by a thin layer of sand overlying bedrock or probable bedrock at depths of 15.5 m to 18.3 m (Elev. 195.8 to 197.5). On the east side, the stratigraphy consists of topsoil over a layer of sand, sandy silt or clayey silt, underlain by silty clay and sand strata overlying bedrock; however the bedrock surface rises towards the east from depths of 17.3 m to 0.6 m (Elev. 192.3 to 215.0), the thickness of the clay layer decreases accordingly from 7.3 to 0.8 m, and the thickness of the sand deposit varies substantially.

The initial foundation investigation was carried out on the basis of a three span structure originally proposed at this site. The bridge design was recently revised to a two span structure.

Groundwater levels measured in four piezometers ranged from 0.0 m to 3.9 m below the ground surface, at Elev. 212.2 to 209.1. The preliminary GA drawing indicates a water level in North Trout Creek at Elev. 208.9 in October 2010 and a high water level at Elev. 209.6.

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

- Spread footings on native soils or bedrock
- Steel H-piles on bedrock
- Steel pipe piles to bedrock
- Augered caissons (drilled shafts) socketed into bedrock

A comparison of the technical advantages and disadvantages of alternate foundation schemes is presented in Appendix D. These foundation alternatives are discussed in the following sections. A foundation scheme preferred from a foundations perspective is also recommended.

8.1 Spread Footings on Native Soils or Bedrock

The very soft to stiff silty clay deposit underlying the pier and west abutment locations is considered unsuitable for support of spread footings due to the very low bearing resistance available and the potential for excessive consolidation settlements under foundation loads. Extending footings to the underlying bedrock at depths of up to 18.3 m is not practical.

The bedrock surface at the east abutment ranges from Elev. 208.9 to 211.0 in Boreholes NTW-11 and NTW-12. Consideration may be given to supporting the east abutment on footings founded on bedrock.

Spread footings bearing on undisturbed bedrock at Elev. 208.9 to 211.0 may be designed using a factored geotechnical resistance of 2,000 kPa at the Ultimate Limit State (ULS). The ULS resistance takes into account zones of fractured bedrock identified in the bedrock cores and a potentially sloping bedrock surface.

The SLS condition will not govern design of footings founded on bedrock.

This resistance value is for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design must be reduced in accordance with the CHBDC Clause 6.7.3 and Clause 6.7.4.

Excavation and backfilling for the footings must be in accordance with OPSS 902.

The footing should be placed on a level bedrock surface. If sloping bedrock is encountered under the footprint of the footing, the bedrock surface should be levelled by excavation of bedrock and/or placing mass concrete to the design base of the footings. If rock excavation is required, excavation must be carried out using pneumatic breakers or other methods that will avoid shattering and disturbing the bedrock on which foundations will be constructed.

The bearing surface should be prepared by removing all loose/disturbed material and shattered/loosened rock fragments. If during construction it is found that the prepared bedrock surface lies below the specified founding elevation, then the area must be brought up to founding elevation using concrete of the same class as used in the footing.

The horizontal resistance of footings on bedrock may be computed using an unfactored friction factor of 0.7 for concrete poured on clean sound bedrock.

If the frictional component is insufficient, the horizontal resistance may be increased by dowelling the footing into the rock mass. Using lower bound values for the strength of the rock, an ultimate horizontal resistance of 2.5 MN may be assumed for a 50 mm steel dowel embedded at least 1.0 m into the rock. The shearing resistance of the selected dowel must be checked structurally.

8.2 Steel H-Piles

The subsurface conditions at the west abutment and pier are considered suitable for the use of steel H-piles driven to refusal on bedrock. Due to the presence of shallow bedrock at the east abutment, H-piles will need to be socketed into the bedrock at this foundation element.

Pile installation at the east abutment should involve advancing a socket at least 1.5 m below the bedrock surface, inserting the pile to the base of the socket, and then backfilling around the pile with concrete. For a HP 310 x110 steel H-pile, a rock socket diameter of 610mm is required. The socket depth may need to be greater than 1.5 m to satisfy structural requirements such as lateral loads and maximum shear and moment demand on each pile.

The elevations of the bedrock surface at the foundation elements, based on the borehole data, and the anticipated pile lengths (based on an assumed pile cut-off elevation of 214.5) are given in Table 8.1. Since the bedrock surface is variable, the actual pile tip elevation and length of pile required may vary from those indicated in the table.

Table 8.1 – Estimated Depths and Elevations of Bedrock at Foundation Units

Foundation Unit		Boreholes	Bedrock/Pile Tip Elevation	Anticipated Pile Length (m below assumed pile cut-off Elev. 214.5)
West Abutment	North End	NTW-02	197.5	17.0
	South End	NTW-03[1]	197.4	17.1
Pier	North End	NTW-06[1]	192.3	22.2
	South End	NTW-07	198.3	16.2
East Abutment	North End	NTW-11[1]	208.9	5.6[2]
	South End	NTW-12[1]	211.0	3.5[2]

(1) Bedrock proved by coring.
(2) Will require socketing into bedrock.

The recommended axial, factored geotechnical resistance at Ultimate Limit States (ULS) for a steel HP 310x110 pile driven to refusal on bedrock or socketed into bedrock (east abutment) is 2,000 kN. The SLS condition will not govern for piles founded on bedrock.

The factored structural resistance of the piles at ULS must be checked by the structural designer as per Section 6.8.8 of the CHBDC.

Oversize materials (e.g. greater than 75 mm nominal diameter) must not be used in any fills through which the piles will be driven.

Since the elevation of the bedrock surface is variable across the site and there is evidence of cobbles and boulders immediately above the bedrock, it is critical to determine in the field during inspection of rock socket installation that the entire depth of socket is formed in sound bedrock and not partly in cobbles and boulders and partly in bedrock. This issue is addressed in an NSSP included in Appendix E.

8.2.1 Pile Tips

To prevent pile damage when setting the piles on bedrock, the tips of all driven piles must be fitted with pile tip protection from an approved manufacturer. At the pier where sloping bedrock may be encountered, use of H-section rock points such as the Titus Steel Rock Injector or approved equivalent is recommended to reduce the potential for slipping of the pile tip along the bedrock surface. At the west abutment, the Titus Steel Standard H-point or approved equivalent is considered adequate.

8.2.2 Pile Installation

Pile installation should be in accordance with OPSS 903.

For piles at the west abutment installed to the tolerances shown in Clause 903.07.05.01 of the Specification, the foundation drawing should include the note "Piles to be driven to bedrock".

If the proposed bridge design requires that the deviation at the top of the pile be limited to tight tolerances, a driving template or other means may be required to achieve the specified maximum deviation.

At the pier where sloping bedrock may be encountered, the driving energy should be reduced to seat the pile in bedrock and avoid sliding of the pile tip. For the pier, it is recommended that the pile driving note on the foundation drawing be modified as follows:

"Piles to be driven to bedrock". Upon initial contact with the bedrock:

1. Apply 10 blows at 10% of the hammer energy. Record the penetration.
2. Apply 10 blows at 50% of the hammer energy. If the penetration under 10 blows is less than 12.5 mm, the pile is set.
3. If the penetration under 10 blows is greater than 12.5 mm, refer the issue to the design team for resolution."

The wording for an NSSP addressing this issue is included in Appendix E. This NSSP must be included in the tender documents.

For rock socketed piles at the east abutment, the method of installation of the piles is the responsibility of the Contractor. The Contractor's drilling method must be capable of dislodging, removing or penetrating obstructions such as cobbles and boulders in the overburden soils. Care must be exercised while drilling the socket within the bedrock; the drilling methodology must be capable of excavating the bedrock to the specified socket dimensions without disturbing or fracturing the bedrock forming the sidewalls and base of the socket. Blasting to facilitate rock removal is not permitted.

The drilling method must also maintain sidewall stability of the drilled hole and allow cleaning of the socket without cohesionless soils running into the socket. During and subsequent to installation, the drilled hole and socket will be partially filled with water and it may not be practical to dewater the socket prior to concreting. Tremie concreting will be required for concreting these piles.

A NSSP addressing these issues is included in Appendix E. This NSSP must be included in the tender documents.

8.2.3 Pile Lateral Resistance

The geotechnical lateral resistance acting on an H-pile in cohesionless soils may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

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

$$p_{ult} = 3 \, \gamma \, z \, K_p \qquad (\text{kPa})$$

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)

For cohesive soils, the lateral resistance of the piles may be calculated using the following:

$$k_s = 67 \, S_u / D \qquad (\text{kN/m}^3)$$

p_{ult} = $9 \, S_u$ (kPa) at and below a depth of 3D reduced to zero at the ground surface

where	S_u	=	undrained shear strength (Table 8.2)
	D	=	pile width in metres

The parameters recommended for use with the above equations are provided in Table 8.2.

The ultimate passive force that can be mobilized by the embedded portion of a socket within rock is constant with depth and is given by:

$$P_p = 6 \, c \, D \, L$$

Where	c	=	2,000 kPa (equivalent Mohr-Coulomb cohesion based on Hoek and Brown rock mass classification)
	L	=	Depth of socket in rock, m
	D	=	Socket diameter, m

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	214.0 to 198.3	-	40	2.7	10	Very soft to firm silty clay
	198.3 to 197.5	6,000	-	3.3	11	Dense sand
Pier – North End	209.0 to 208.1	2,500	-	3.0	11	Very loose sand
	208.1 to 200.9	-	40	2.7	10	Very soft to soft silty clay
	200.9 to 192.3	5,000	-	3.3	11	Loose to very dense sand
Pier – South End	210.5 to 208.6	-	50	3.0	11	Firm clayey silt
	208.6 to 202.4	-	40	2.7	10	Very soft silty clay
	202.4 to 198.3	5,000	-	3.3	11	Compact to very dense sand
East Abutment	Below 208.9 to 211.0	-	-	-	-	Shallow bedrock

*Buoyant unit weight below the water table.

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 assumed in one pile be limited to no more than 120 kN at ULS and 35 kN at SLS.

The modulus of subgrade reaction 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.

8.3 Pipe Piles to Bedrock

An alternative foundation option is to support the west abutment and pier on steel pipe piles extended to bedrock and filled with concrete. At the west abutment, the piles may be driven to refusal on bedrock or alternatively drilled-in 1.0 m below the bedrock surface. At the pier, the potential exists for slipping and damaging the pile tip on a sloping bedrock surface while driving to refusal, and therefore it is recommended that pipe piles, if selected, be drilled-in to the bedrock to fix the pile tip in place.

The anticipated depths (below existing grade) and elevations of the bedrock surface at the abutments, interpreted from the available borehole data, were given previously in Table 8.1.

The pipe pile tip will be in direct contact with the bedrock. The factored geotechnical resistance at ULS recommended for selected pipe pile sections end-bearing on bedrock are presented in Table 8.3.

Table 8.3 – Factored Geotechnical Resistance of Pipe Piles

Pipe Pile Section		Factored Geotechnical Resistance at ULS (kN)
Diameter (mm)	Wall Thickness (mm)	
324	12.7	2,000
406	12.7	2,800
508	12.7	4,000
610	12.7	5,500

The resistance values presented above assume a steel yield strength of 245 MPa and a concrete compressive strength of 35 MPa. The resistances have been reduced to account for the possibility that residual crushed rock may remain at the base of the drilled-in pile. The depth of embedment into bedrock may need to be greater than 1.0 m to address the lateral resistance requirement, base fixity requirement and shear and moment demand for each pile.

8.3.1 Pipe Pile Installation

Installation of pipe piles must follow OPSS 903 specifications.

For piles driven to bedrock at the west abutment, the foundation drawing should include the note “Piles to be driven to bedrock”. Pile tip protection must be provided for pipe piles driven to bedrock.

If the proposed bridge design requires that the deviation at the top of the pile be limited to tight tolerances, a driving template or other means may be required to achieve the specified maximum deviation.

The method of installation of drilled-in pipe piles is the responsibility of the Contractor. One option for installing pipe piles is to drill them in using a concentric drilling method such as the Symmetrix system. The Contractor’s drilling method must be capable of dislodging, removing or penetrating obstructions such as cobbles, boulders or rock fill in the granular fill and overburden soils. Care must be exercised while drilling into the bedrock; the drilling methodology must be capable of advancing the pile without disturbing or fracturing the bedrock at the base of the pile. Blasting to facilitate rock removal is not permitted.

Since the rock cutting shoe at the tip of a pipe pile will be slightly larger in diameter than the outside diameter of a pipe pile, there will be a small gap between the rock wall and the pipe pile. It is recommended that the annular space between the pipe pile and rock wall be grouted to the bedrock surface to achieve fixity.

During and subsequent to installation, the pipe pile may be partially filled with water and it may not be practical to dewater the pipe prior to concreting. Tremie concreting will be required for concreting these pipe piles.

A NSSP addressing the above issues is included in Appendix E.

8.3.2 Lateral Resistance for Pipe Piles

Lateral resistance of pipe piles may be computed using the parameters presented in Section 8.2.3.

8.4 Caissons (Drilled Shafts) Socketed into Rock

Caissons socketed into bedrock are considered a feasible foundation option to support the bridge structure. The anticipated depths (below existing grade) and elevations of the bedrock surface at the foundation elements, based on the borehole data, were given previously in Table 8.1.

It is recommended that a minimum socket depth of 1.5 m be employed on this site in view of the fractured nature of portions of the bedrock. The factored vertical geotechnical resistance computed for 0.9 m, 1.2 m and 1.5 m diameter sockets with lengths of 1.5 and 3.0 m below the bedrock surface are presented in Table 8.4. The SLS condition will not govern for caissons socketed into the rock.

Table 8.4 – Recommended Resistance Values for Caisson Design

Caisson Diameter (m)	Socket Length below Bedrock Surface (m)	Factored Geotechnical Resistance at ULS (kN)
0.9	1.5	3,000
	3.0	6,000
1.2	1.5	3,500
	3.0	7,500
1.5	1.5	4,500
	3.0	9,500

The vertical geotechnical resistances were computed using the method outlined in the Canadian Foundation Engineering Manual, 4th Edition, Section 18.6.4. The resistance values are based on an average unit shaft resistance of 750 kPa in the bedrock socket, with an allowance for the presence of some weathered and broken up rock just below the bedrock surface. End-bearing resistance has been ignored in anticipation of difficulties cleaning and inspecting the caisson base below the water level.

The selection of a suitable socket depth will be governed by axial loads, lateral load and maximum shear and moment demand on each caisson. The depth of rock socket should not be less than 1.5 m and the axial load, shear and moment demands may require a deeper depth of rock socket.

Since the elevation of the bedrock surface is variable across the site and there is evidence of sloping bedrock at the pier, it is critical to confirm in the field during inspection of caisson installation that the depth of socket is taken from the lowest point on the bedrock surface encountered in the caisson excavation. This issue is addressed in an NSSP included in Appendix E.

8.4.1 Caisson Socket Lateral Resistance

The ultimate passive force that can be mobilized by the caisson socket within rock is constant with depth and is given in Section 8.2.3 of this report.

8.4.2 Caisson Socket Installation

Caisson installation must be in accordance with OPSS 903.

Caisson installation at this site will require excavation through very soft to firm silty clay as well as loose to very dense sand above the bedrock. The caisson installation will involve excavation below the ground water table, and construction of sockets in the underlying bedrock. The installation of caissons at this site must consider the following issues:

- The installation method must prevent squeezing of the silty clay, sloughing of saturated silt seams, collapse of caisson sidewalls, and washing of cohesionless soils into the rock socket. In this regard, it is recommended that steel liners be installed to support the sidewalls and left in place permanently.
- Sealing the liner into the bedrock may be difficult with the sloping rock surface, and may result in washing of cohesionless soils into the rock socket.
- Placing concrete by tremie methods may be required where dewatering of the caisson is not practical.
- The strength and hardness of the bedrock at this site must be considered when selecting equipment to excavate the rock socket. Blasting to facilitate rock removal is not permitted.
- The caisson excavating equipment must be capable of coring into a potentially sloping/variable bedrock surface and penetrating through zones of highly fractured rock.

Selection of the methods and equipment employed to address the above issues is the responsibility of the Contractor. The contract documents must contain a statement to alert bidders of the above conditions. The wording for an NSSP addressing this issue is included in Appendix E.

8.5 Downdrag

As the bridge span lengths and abutment locations have been specifically selected to avoid placement of embankment fill over the compressible clay soils on site, consolidation settlement and resulting downdrag loads on the piles are not expected to be a concern.

8.6 Recommended Foundation

From a geotechnical perspective and based on the subsurface conditions, steel H-piles driven to refusal on bedrock are the recommended foundation option for supporting the pier and west abutment of the proposed bridge structure. Spread footings founded on bedrock are the preferred option for supporting the east abutment, however H-piles socketed into bedrock may also be employed if integral abutments are planned.

Use of driven/drilled-in pipe piles or augered caissons socketed into bedrock is also considered feasible. The preliminary design indicating the use of driven H-piles at the west abutment, socketed caissons at the pier, and socketed H-piles at the east abutment is therefore considered suitable.

8.7 Depth of Frost Penetration

The design depth of frost penetration at this site is 2.3 m. The base of all buried pile caps, if employed, must be provided with a minimum of 2.3 m of earth cover as protection against frost action.

9 BACKFILL TO ABUTMENTS

The current design concept calls for construction of an RSS abutment to contain the approach fill at the east abutment. The west abutment will comprise a header beam placed in a cut with a low RSS wall. Recommendations regarding RSS wall design are provided in a subsequent section of this report. Recommendations regarding conventional abutments are provided in this section in the event that the design concept changes.

Backfill to the abutments should consist of Granular A, Granular B Type II or Granular B Type III material meeting the requirements of OPSS.PROV 1010. The backfill must be in accordance with OPSS 902, and placed to the extents shown in OPSD 3101.150.

All new embankment earth fill should be placed in uniform lifts and be compacted in accordance with OPSS 501. Also, compaction equipment to be used adjacent to retaining structures must be restricted in accordance OPSS 501 and SP 105S21.

The design of the abutment must incorporate a subdrain as shown in OPSD 3101.150 or OPSD 3101.200, as applicable.

10 LATERAL EARTH PRESSURES

Lateral 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 10.1)

γ = unit weight of retained soil (see Table 10.1)

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

q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 10.1.

Table 10.1 – 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 or Granular B Type III $\phi = 32°$, $\gamma = 21.2$ kN/m^3	
	Horizontal Surface	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface	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	-

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

The factors in Table 10.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.16 in the Commentary to the Canadian Highway Bridge Design Code.

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

11 SEISMIC CONSIDERATIONS

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.0
- Acceleration Related Seismic Zone 0
- Zonal Acceleration Ratio 0.0
- Peak Horizontal Acceleration 0.011g

The soil profile type at this site has been classified as Type III. Therefore, according to Clause 4.4.6 of the CHBDC, Site Coefficients “S” (ground motion amplification factor) of 1.5 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 11.1 may be used:

Table 11.1 – 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 or Granular B Type III $\phi = 32°$ $\gamma = 21.2$ 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

The west side of the site is underlain by very soft to firm silty clay, and the east side is underlain by relatively thin sand and clay deposits over bedrock. The silty clay and sand deposits have a low susceptibility to liquefaction. In view of these conditions and the velocity related seismic zone of zero, liquefaction is not considered to be a concern at this site.

12 RETAINED SOIL SYSTEMS

In general, RSS walls used in conjunction with the new abutment must be "High Performance" and "High Appearance". The contract drawings should include information on the longitudinal alignment of the wall in plan, the top and base elevations of the wall in profile, cross-sectional space constraints and an NSSP for the RSS wall.

12.1 East Abutment

The current design concept calls for the east abutment to be constructed as a Retained Soil System (RSS). Based on the preliminary GA drawing for the two span structure, the maximum exposed wall height will be about 5.0 m. The RSS wing walls will extend back parallel to the roadway, with a length of approximately 8.0 m.

Based on the borehole data, it is recommended that the RSS be founded on dense to very dense sand/sand and gravel with a base level no higher than Elev. 210.2 to 211.6 at the north and south ends of the abutment, respectively. A wall founded on the dense to very dense sand/gravel should be designed for a factored geotechnical resistance at ULS of 450 kPa and a geotechnical reaction at SLS of 300 kPa. Erosion protection must be provided to prevent undermining of the RSS.

The RSS may also be founded on bedrock. A factored geotechnical resistance at ULS of 2,000 kPa is available for design of the RSS system founded on bedrock. The SLS condition does not apply.

Global stability and settlement are not issues for an RSS system constructed on dense to very dense sand/gravel or bedrock.

If sloping bedrock is encountered at the RSS base level, the bedrock surface should be levelled by excavation of bedrock and placing concrete fill to the design base of the RSS wall. If rock excavation is required, excavation must be carried out using pneumatic breakers or other methods that will avoid shattering and disturbing the bedrock on which foundations will be constructed.

12.2 West Abutment

An approximate 1.0 m high RSS wall will be installed at the west abutment. As the west approach is within a cut section and the top of the RSS will be essentially at the same level as existing grade, no net increase in loading will be applied to the subgrade below the wall. Settlement and bearing resistance will not be an issue for this configuration.

Analysis of the global stability of the west valley slope was conducted to assess the stability of the existing slope geometry. The existing inclination of approximately 3H:1V will remain essentially unchanged by construction of the low RSS near the top of the slope. The stability analyses were carried out using the commercially available slope stability program GEO-SLOPE, applying the Morgenstern-Price method and geotechnical parameters evaluated from the borehole and laboratory data. Drained strength parameters for the silty clay were determined through correlation with the results of direct shear tests carried out in other sections of the Highway 11/17 four-laning project. The geotechnical model and results of the analysis are shown on Figure 1 in Appendix F.

The long term (effective) factor of safety was computed to be 1.4, which is marginally less than the minimum value of 1.5 normally accepted for this type of analysis. Since the current slope appears to be performing satisfactorily and the proposed roadway cut will lessen the forces potentially driving movement, the global stability of the west valley slope is considered to be acceptable. Erosion protection must be provided to maintain this stability.

13 SCOUR AND EROSION PROTECTION

Erosion protection should be provided along any soil surfaces that may be in contact with the creek flow. In particular, erosion protection must be provided to prevent instability of the west valley slope and undermining of the RSS walls.

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

14 EXCAVATION AND GROUNDWATER CONTROL

Earth excavation for foundation or RSS construction must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the native soils are classed as Type 4 soils in view of the soft to very soft consistency of the silty clay, the loose to very loose condition of the cohesionless deposits, and the high water table on site.

The excavation and backfilling for foundations must be carried out in accordance with OPSS 902.

Excavation below the groundwater level/creek level without prior dewatering is not recommended since the inflow of groundwater will it make difficult to maintain a dry, sound base on which to work.

The Contract Documents should contain a NSSP alerting the Contractor to the conditions associated with excavation of the soils below the groundwater level. The design of any excavation and dewatering system is the responsibility of the Contractor.

15 CONSTRUCTION CONCERNS

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

- The surface of the bedrock is variable at this site. Since the elevation of the bedrock surface was only established at discrete points, it is possible that higher or lower bedrock elevations will be encountered during construction. This may impact the length of caisson or pile required.
- Sloping bedrock may be present at the pier. Driven piles must be equipped with rock injector points and be driven with caution to minimize the potential for damage to the pile tip and slipping of the tip down the bedrock surface.
- The bedrock contains fractured zones that may hinder advance of rock sockets. The drilling methodology must be capable of excavating the bedrock to the specified socket dimensions without disturbing or further fracturing the bedrock. The rock sockets must be completed in sound bedrock.
- Use of a permanent liner is recommended for installation of caissons through the soft to very soft silty clay and cohesionless deposits below the groundwater level. Placing concrete by tremie methods may be required where dewatering of the caisson is not practical.
- Soft silty clay underlies much of the site. The Contractor’s selection of construction equipment and methodology must include assessment of the capability of the soft subgrade to support the proposed construction equipment and any temporary structures or fill (i.e, as a pad for crane support). Site conditions may limit the type of equipment suitable for use. The design and safety of any temporary works is the responsibility of the Contractor.

16 CLOSURE

Engineering analysis and preparation of the report were carried out by Mr. Murray Anderson, P.Eng.

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

Thurber Engineering Ltd.

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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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NTW-01

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 853.4 E 206 869.7	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.12 - 2012.07.13	CHECKED BY	RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
217.9											
0.0	**TOPSOIL:** (250mm)										
217.6 / 0.3	Silty **CLAY** varved Stiff to Very Soft Brown										
			1	SS	9		217				
	With silt seams		2	SS	7		216				
			3	SS	0		215				0 0 42 58
	Grey		4	SS	0		214	3.0 +			
			5	SS	0		213				
			6	SS	0		212 / 211	6.0 +			
			7	SS	1		210 / 209				
			8	SS	0		208				0 0 32 68

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NTW-01

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 853.4 E 206 869.7	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.12 - 2012.07.13	CHECKED BY	RPR

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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
	Continued From Previous Page						
	Silty **CLAY**, varved, silt seams Very Soft Grey					∇	
			9	SS	0		207
							206
			10	SS	0		205
204.7 13.2	END OF BOREHOLE AT 13.2m. BOREHOLE OPEN TO 11.0m AND WATER LEVEL AT 10.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE TO 2.7m, THEN AUGER CUTTINGS TO SURFACE.						

Field vane readings: 3.0 (near top of page), 4.0 (near elev. 205).

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NTW-02

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 874.4 E 206 869.8	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	NW Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.10 - 2012.07.10	CHECKED BY	RPR

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

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH	GR	SA	SI	CL
215.4									
0.0	**TOPSOIL:** (275mm)								
215.1 / 0.3	Silty **CLAY**, trace rootlets, with silt seams Soft to Very Soft Brown								
		1	SS	3					
		2	SS	0		0	0	40	60
	Grey	3	SS	0					
		4	SS	0					
		5	SS	0					
					5.0 (field vane, sensitivity)				
		6	SS	1		0	0	44	56
		1	TW						
					5.0 (field vane, sensitivity)				
206.5 / 8.8	Sandy **SILT**, trace to some clay Very Loose Grey Wet								
		7	SS	3					

Elevation scale: 215, 214, 213, 212, 211, 210, 209, 208, 207, 206

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NTW-02

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 874.4 E 206 869.8	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	NW Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.10 - 2012.07.10	CHECKED BY	RPR

SOIL PROFILE: ELEV / DEPTH, DESCRIPTION, STRAT PLOT. SAMPLES: NUMBER, TYPE, "N" VALUES. GROUND WATER CONDITIONS. ELEVATION SCALE. DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100). SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100). PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60). UNIT WEIGHT γ kN/m³. REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL.

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH (FIELD VANE, kPa)	GR	SA	SI	CL
	Sandy **SILT**, trace to some clay Very Loose Grey Wet									
205.0 / 10.4	Silty **CLAY** Soft to Very Soft Grey				205					
		8	SS	2						
					204	7.0				
		9	SS	0	203		0	0	27	73
					202					
		10	SS	0						
					201	4.0				
	Trace sand Firm									
		11	SS	6	200					
					199					
	Silty sand seams	12	SS	39			0	4	54	42
198.2 / 17.2	Silty, gravelly **SAND** Dense Grey Wet				198		26	47	27 (SI+CL)	
197.5 / 17.8	END OF BOREHOLE AT 17.8m UPON REFUSAL ON PROBABLE BEDROCK OR BOULDER. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.									

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Jul. 11/12	3.4	212.0
Jul. 13/12	3.9	211.5
Mar. 02/13	Frozen at Ground Surface	
Jun. 23/13	3.2	212.2

+3, ×3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NTW-03

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 871.4 E 206 880.9	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	NW Casing/NQ Coring	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.09 - 2012.07.09	CHECKED BY	RPR

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

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH (field vane)	WATER CONTENT	GR	SA	SI	CL
215.7											
0.0	**TOPSOIL:** (250mm)										
215.4 / 0.3	Silty **CLAY** Firm to Very Soft Brown				215						
		1	SS	5			○				
		2	SS	0	214		○				
	Grey	3	SS	0	213		w_P ⊢○⊣ w_L	0	0	37	63
		4	SS	0	212		○				
						+ 2.0					
	With silt seams	5	SS	0	211		○				
					210						
		1	TW		209		○				
						+ 4.0					
		6	SS	0	208		⊢⊣ ○	0	0	58	42
					207						
		7	SS	0	206		○				

Continued Next Page

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NTW-03

METRIC

WP# 647-89-00 | LOCATION North Trout Creek - WBL N 5 425 871.4 E 206 880.9 | ORIGINATED BY SLL

HWY 11/17 | BOREHOLE TYPE NW Casing/NQ Coring | COMPILED BY MFA

DATUM Geodetic | DATE 2012.07.09 - 2012.07.09 | CHECKED BY RPR

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	FI	REMARKS / GRAIN SIZE (GR SA SI CL)
	Silty **CLAY**, with silt seams Very Soft Grey				205		
		8	SS	1			
					204		
		9	SS	1			
					203		
					202		
	Soft	10	SS	3			0 0 34 66
					201		
	Stiff	11	SS	9			
					200		
					199		
198.4		12	SS	47			0 0 39 61
17.2	Silty **SAND**, some gravel Dense Grey Wet				198		
197.4	Cobbles					FI	
18.3	**BEDROCK**, granite, pink with white bands, vertical and horizontal breaks					3	RUN #1 TCR=98% SCR=98% RQD=56% UCS=91MPa (Average)
					197	2	
		1	RUN			5	
						3	
					196	4	RUN #2 TCR=98%

Continued Next Page

+ 3, × 3 : Numbers refer to Sensitivity

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NTW-03

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 871.4 E 206 880.9	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	NW Casing/NQ Coring	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.09 - 2012.07.09	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 (○ 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										
194.3	**BEDROCK**, granite, pink with white bands, vertical and horizontal breaks		2	RUN			195			1 4 1 0 0	SCR=98% RQD=95% UCS=51MPa (Average)
21.3	END OF BOREHOLE AT 21.3m. BOREHOLE BACKFILLED WITH BENTONITE AND AUGER CUTTINGS TO SURFACE.										

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NTW-04

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 886.0 E 206 872.9	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers/NW Casing/NQ Coring	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.08 - 2012.07.08	CHECKED BY	RPR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
211.3								
0.0	**TOPSOIL:** (275mm)							
211.0 / 0.3	Silty **CLAY**, with silt seams Firm to Very Soft Brown				211			
		1	SS	4				
					210			
	Grey	2	SS	3				
					209			
		3	SS	0				0 0 36 64
					208			
		4	SS	0				
						4.0 (field vane)		
					207			
		5	SS	1				
					206			
		1	TW		205			No recovery
						4.0 (field vane)		
					204			
		6	SS	0				
					203			
					202			
		2	TW					

Continued Next Page

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

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No NTW-04

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 886.0 E 206 872.9	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers/NW Casing/NQ Coring	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.08 - 2012.07.08	CHECKED BY	RPR

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

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH	UNIT WEIGHT	REMARKS / GR SA SI CL
	Silty **CLAY**, with silt seams Soft to Very Soft Grey					201	+ 6.0		
			7	SS	3				0 0 63 37
						200			
			8	SS	1	199			
						198	+ 2.0		
	Firm		9	SS	5				0 1 66 33
196.7	With sand seams					197			
14.6	**SAND**, some silt and gravel, occasional cobbles Dense Grey Wet								
195.8			10	SS	100/ .150	196		FI	
15.5	**BEDROCK**, migmatitic gneiss, grey with white bands and pink granite intrusions, occasional vertical and horizontal fractures		1	RUN		195		2 1 1 2 2	RUN #1 TCR=100% SCR=100% RQD=93% UCS=220MPa (Average)
			2	RUN		194 193		3 2 3 3 4	RUN #2 TCR=100% SCR=100% RQD=75% UCS=237MPa (Average)
192.8									
18.5	END OF BOREHOLE AT 18.5m. BOREHOLE BACKFILLED WITH BENTONITE AND AUGER CUTTINGS TO SURFACE.								

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NTW-05

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 883.0 E 206 884.0	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers/NW Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.09 - 2012.07.09	CHECKED BY	RPR

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
212.4								
0.0	**TOPSOIL:** (250mm)							
212.2 / 0.3	Silty **CLAY** Soft to Very Soft Brown				212			
		1	SS	4				
	With thin silt seams				211			
		2	SS	0				0 0 35 65
	Grey				210			
		3	SS	0				
		4	SS	0	209			
					208			
		5	SS	0				
					207	3.0 (field vane)		
		6	SS	1	206			0 0 37 63
					205			
		1	TW					
					204	2.0 (field vane)		
		7	SS	0	203			

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NTW-05

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 883.0 E 206 884.0	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers/NW Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.09 - 2012.07.09	CHECKED BY	RPR

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

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	Continued From Previous Page									
	Silty **CLAY** Very Soft to Soft Grey					202				
			8	SS	0		0	0	29	71
						201				
			9	SS	2	200				
						199				
			10	SS	4					
						198				
	Firm Trace sand		11	SS	5	197	0	1	71	28
196.0 16.4	END OF BOREHOLE AT 16.4m UPON REFUSAL ON PROBABLE BEDROCK OR BOULDER.									

Field vane shear strength plotted between elevations 201 and 200, labelled 2.0.

END OF BOREHOLE AT 16.4m
UPON REFUSAL ON PROBABLE
BEDROCK OR BOULDER.
Piezometer installation consists of
19mm diameter Schedule 40 PVC pipe
with a 1.52m slotted screen.

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Jul. 10/12	2.2	210.2
Jul. 11/12	2.0	210.4
Jul. 13/12	1.9	210.5
Mar. 02/13	3.3	209.1
Jun. 23/13	1.6	210.8

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+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NTW-06

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 905.3 E 206 878.1	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers/NW Casing/NQ Coring	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.04 - 2012.07.05	CHECKED BY	RPR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	GR	SA	SI	CL
209.6 / 0.0	**TOPSOIL:** (460mm)										
209.1 / 0.5	**SAND**, some silt, trace organics Very Loose Dark Brown Moist	1	SS	2	209						
208.1 / 1.4	Silty **CLAY** Soft to Very Soft Grey	2	SS	0	208						
	With silt seams	3	SS	2	207			0	0	62	38
		4	SS	1	206	Field vane 3.0					
		5	SS	0	205						
		1	TW		204 / 203	Field vane 3.0					
		6	SS	1	202			0	0	49	51
200.9 / 8.7	**SAND**, trace to some silt, trace gravel Loose to Very Dense Grey Wet	7	SS	7	201 / 200						

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

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

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Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NTW-06

METRIC

WP# 647-89-00 | LOCATION North Trout Creek - WBL N 5 425 905.3 E 206 878.1 | ORIGINATED BY SLL

HWY 11/17 | BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring | COMPILED BY MFA

DATUM Geodetic | DATE 2012.07.04 - 2012.07.05 | CHECKED BY RPR

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND, trace gravel, trace to some silt Loose to Very Dense Grey Wet				199			
		8	SS	100/ .250		○		
					198			
		9	SS	8	197	○		6 89 5 (SI+CL)
					196			
	Very Dense	10	SS	100/ .150		○		
					195			
		11	SS	100/ .125	194	○		
					193			
192.3		12	SS	100/ .100				
17.3	**BEDROCK**, migmatitic gneiss, grey with white bands and pink granite intrusions, vertical and horizontal breaks Rubble zones from 17.5 to 17.6, and 17.8 to 17.9m.	1	RUN				FI 12	RUN #1 TCR=100% SCR=100% RQD=0%
		2	RUN		192		7 7	RUN #2 TCR=100% SCR=74% RQD=0% UCS=160MPa (Average)
		3	RUN		191		9 8 4 2	RUN #3 TCR=100% SCR=100% RQD=42% UCS=234MPa
					190		1	RUN #4 TCR=100% SCR=100%

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

+3, ×3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NTW-06

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 905.3 E 206 878.1	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers/NW Casing/NQ Coring	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.04 - 2012.07.05	CHECKED BY	RPR

Continued From Previous Page

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 (○ 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
	BEDROCK, migmatitic gneiss, grey with white bands and pink granite intrusions, vertical and horizontal breaks		4	RUN			189			3 6 4 5	RQD=50% UCS=138MPa (Average)
188.6 / 20.9	END OF BOREHOLE AT 20.9m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.										

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NTW-07

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 902.4 E 206 889.1	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.04 - 2012.07.04	CHECKED BY	RPR

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

Ground surface elevation: 210.8

ELEV / DEPTH	DESCRIPTION
0.0	**TOPSOIL:** (200mm)
0.2	Clayey **SILT**, some sand Firm Brown
208.6 / 2.2	Silty **CLAY**, with thin silt seams Very Soft Grey ... Firm Some sand
202.4 / 8.4	**SILT** and **SAND**, trace clay Very Dense Grey Moist

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	6				
2	SS	6				
3	SS	2				
4	SS	0	0	2	36	62
5	SS	0				
6	SS	0	0	0	27	73
7	SS	6				
8	SS	69	0	40	56	4

Field vane sensitivity values: 2.0 (at approx. elev. 207.0), 2.0 (at approx. elev. 203.8)

Elevation scale: 210, 209, 208, 207, 206, 205, 204, 203, 202, 201

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Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No NTW-07

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 902.4 E 206 889.1	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.04 - 2012.07.04	CHECKED BY	RPR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Continued From Previous Page									
200.6 / 10.2	**SAND**, some silt to silty, some gravel, occasional cobbles Very Dense Grey Wet	9	SS	73	200	○				
					199					
		10	SS	100/.150		○	11	66	23 (SI+CL)	
198.3 / 12.5	END OF BOREHOLE AT 12.5m UPON AUGER REFUSAL ON PROBABLE BEDROCK. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.									

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 (%)

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Jul. 05/12	0.15	210.7
Mar. 02/13	Frozen at Ground Surface	

+3, ×3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NTW-08

METRIC

WP# 647-89-00	LOCATION North Trout Creek - WBL N 5 425 916.9 E 206 881.2		ORIGINATED BY SLL
HWY 11/17	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY MFA
DATUM Geodetic	DATE 2012.07.04 - 2012.07.04		CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
211.1								
0.0 / 210.8	**TOPSOIL:** (250mm)							
0.3	**SAND**, some silt, some clay Loose to Very Loose Brown Moist	1	SS	5				
	Wet	2	SS	4	0	69	19	12
		3	SS	1				
207.7	Grey	4	SS	1				
3.4	Silty **CLAY**, some sand Very Soft Grey							
206.8 / 4.3	**SAND**, some silt and gravel Loose Grey Wet	5	SS	6				
	Dense							
204.5	Occasional cobble	6	SS	100/ .275	18	63	19 (SI+CL)	
6.6	END OF BOREHOLE AT 6.6m UPON AUGER REFUSAL ON PROBABLE BEDROCK. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.							

Column headings also include: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (211, 210, 209, 208, 207, 206, 205); 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/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Jul. 05/12	0.1	211.0
Mar. 02/13	Frozen at Ground Surface	
Jun. 23/13	0.0	211.1

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+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NTW-09

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 913.9 E 206 892.3	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers/NW Casing/NQ Coring	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.04 - 2012.07.04	CHECKED BY	RPR

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

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	UNIT WEIGHT / FI	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
210.9							
0.0 / 210.6	**TOPSOIL:** (250mm)						
0.3	Sandy **SILT**, some clay, trace organics Loose to Very Loose Dark Brown Moist	1	SS	0	90		
		2	SS	4	○		
208.7 / 2.2	Silty **CLAY** Very Soft Grey	3	SS	0	○		0 0 63 37
207.9 / 3.0	**SAND**, some gravel, trace silt Compact Grey Wet	4	SS	16	○		13 80 7 (SI+CL)
206.4 / 4.4	**BEDROCK**, migmatitic gneiss, grey with white bands and pink granite intrusions, vertical and horizontal breaks	1	RUN			FI: 2, 3	RUN #1 TCR=100% SCR=100% RQD=69% UCS=180MPa
	Rubble zones from 6.0 to 6.2, and 6.3 to 6.4m.	2	RUN			4, 5, 5, 9, 7	RUN #2 TCR=100% SCR=92% RQD=55% UCS=111MPa (Average)
		3	RUN			5, 2, 3, 2	RUN #3 TCR=100% SCR=82% RQD=57% UCS=107MPa (Average)
202.9 / 7.9	END OF BOREHOLE AT 7.9m. BOREHOLE BACKFILLED WITH BENTONITE TO 1.6m, THEN AUGER CUTTINGS TO SURFACE.						

Elevation scale: 210, 209, 208, 207, 206, 205, 204, 203

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NTW-10

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 935.3 E 206 891.7	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MFA
DATUM	Geodetic	DATE	2012.07.07 - 2012.07.07	CHECKED BY	RPR

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
215.6											
0.0	**TOPSOIL:** (200mm)										
0.2	**SAND**, trace gravel, trace silt Brown Moist										
215.0 0.6	END OF BOREHOLE AT 0.6m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.										

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NTW-11

METRIC

WP# 647-89-00	LOCATION North Trout Creek - WBL N 5 425 925.8 E 206 882.7		ORIGINATED BY GA
HWY 11/17	BOREHOLE TYPE Hollow Stem Augers/NQ Coring		COMPILED BY AN
DATUM Geodetic	DATE 2014.02.23 - 2014.02.23		CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
211.4									
0.0	**TOPSOIL:** (200mm)								
0.2	Silty **CLAY**, trace rootlets, organics Firm Dark Brown to Brown Wet		1	SS	6	∇	211		
210.2 / 1.2	**SAND** and **GRAVEL**, trace silt Dense Dark Grey Wet		2	SS	44		210		
208.9 / 2.4	**BEDROCK**, migmatitic gneiss, grey with pink and white bands Occasional horizontal breaks Highly broken zone at 2.4m, 2.5m, 2.6m		1	RUN			209 208	FI 5 1 0 0 0	RUN #1 TCR=100% SCR=93% RQD=93%
			2	RUN			207	0 0 1 0 0	RUN #2 TCR=100% SCR=100% RQD=100%
205.9 / 5.5	END OF BOREHOLE AT 5.5m. BOREHOLE OPEN TO 5.5m AND WATER LEVEL AT 0.6m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.						206		

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

WATER CONTENT (%): 20 40 60

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NTW-12

METRIC

WP#	647-89-00	LOCATION	North Trout Creek - WBL N 5 425 920.3 E 206 894.0	ORIGINATED BY	GA
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers/NQ Coring	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.02.23 - 2014.02.23	CHECKED BY	MEF

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	SAMPLE TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
212.8 / 0.0	**TOPSOIL:** (200mm)									
0.2	Silty **CLAY**, trace rootlets Stiff Dark Brown to Brown Damp	1	SS	8		212				
211.6 / 1.2	**SAND**, trace silt Very Dense Grey Wet	2	SS	50/ 0.150					FI	
211.0 / 1.8	**BEDROCK**, migmatitic gneiss, grey with pink and white bands Occasional horizontal and near vertical breaks	1	RUN			211 210			1 0 0 0 1	RUN #1 TCR=100% SCR=93% RQD=93%
	Highly broken zone at 4.6m (200mm)	2	RUN			209 208			2 1 1 1 4	RUN #2 TCR=100% SCR=93% RQD=93%
207.7		3	RUN						0	RUN #3 TCR=100% SCR=100% RQD=100%
5.1	END OF BOREHOLE AT 5.1m. BOREHOLE OPEN TO 5.1m AND WATER LEVEL AT 0.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.									

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

+ 3, × 3: Numbers refer to Sensitivity

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

Appendix B

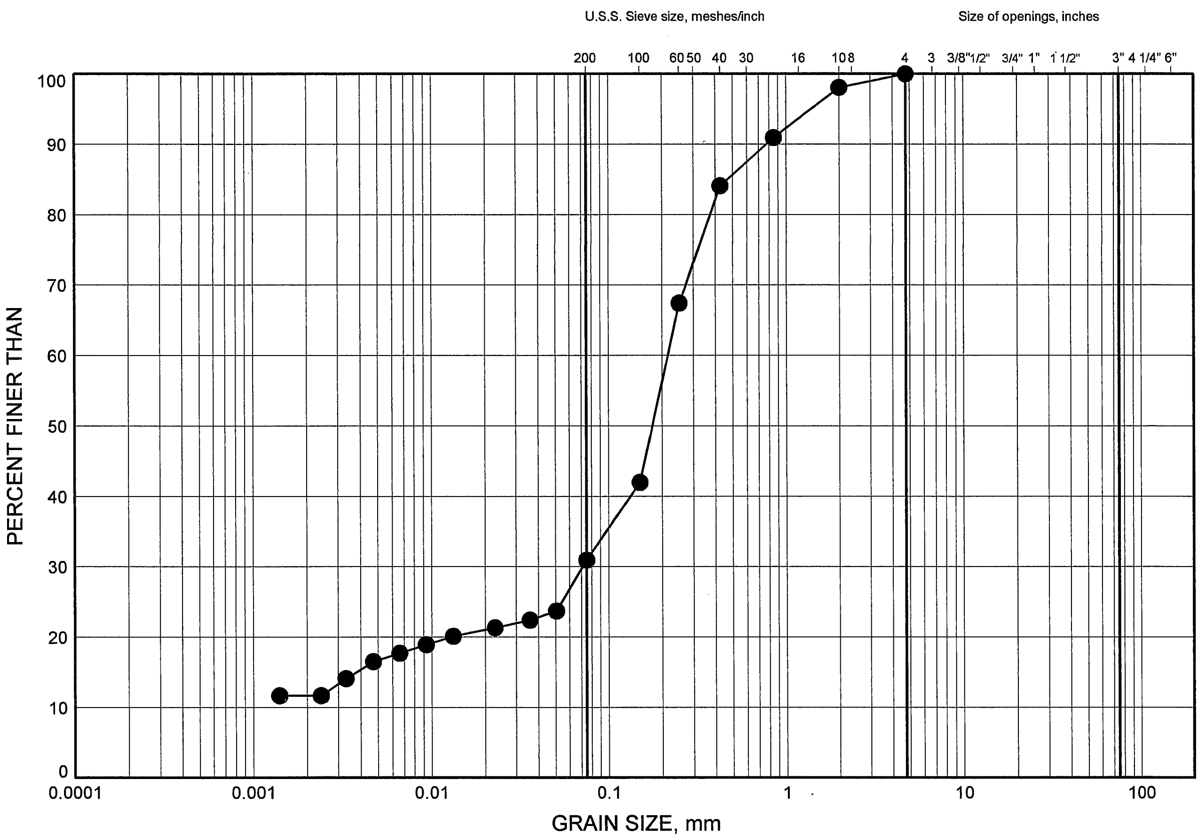
Laboratory Test Results

North Trout Creek - WBL

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NTW-08	1.83	209.25

GRAIN SIZE DISTRIBUTION - THURBER 05117.GPJ 9/18/13

Date September 2013

GWP# 647-89-00

THURBER

Prep'd AN

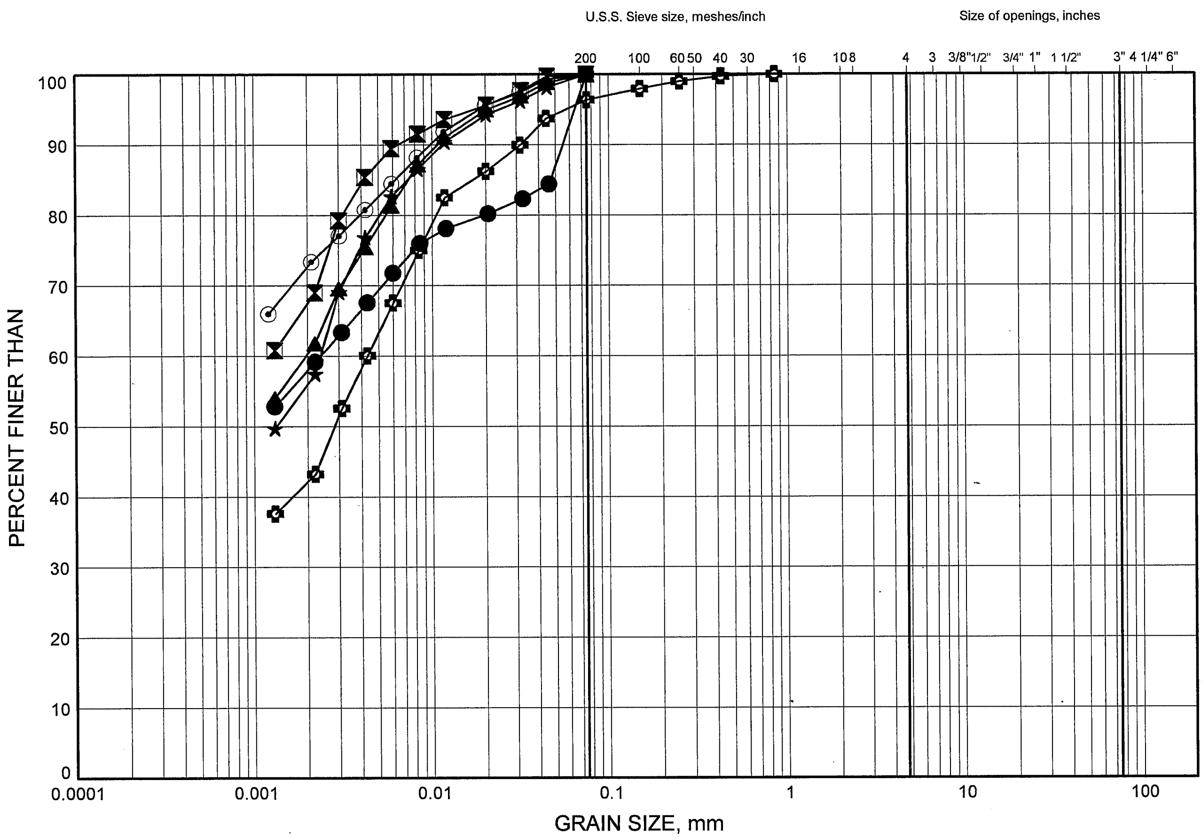
Chkd. RPR

North Trout Creek - WBL

GRAIN SIZE DISTRIBUTION

FIGURE B2

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NTW-01	2.59	215.31
⧗	NTW-01	9.45	208.45
▲	NTW-02	1.83	213.55
★	NTW-02	6.40	208.98
⊙	NTW-02	12.50	202.88
✿	NTW-02	16.99	198.39

Date May 2013

GWP# 647-89-00

THURBER

Prep'd AN

Chkd. RPR

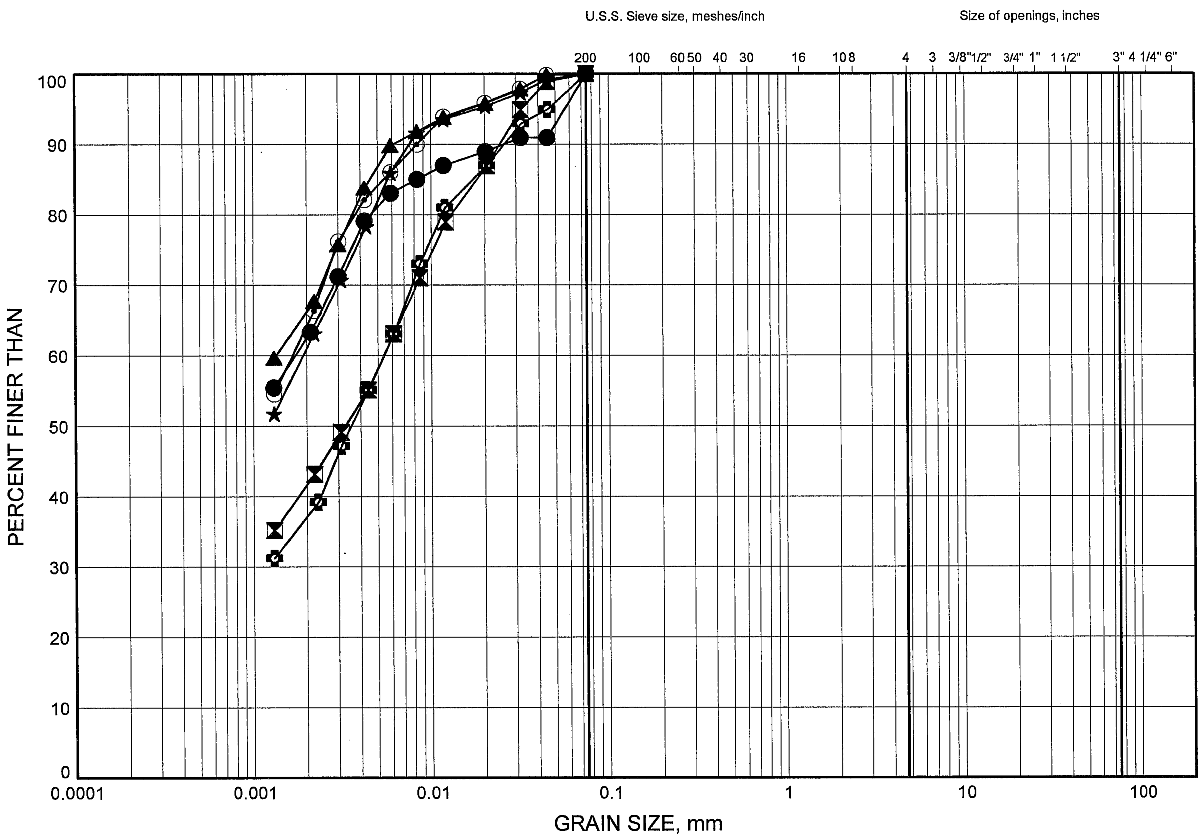
GRAIN SIZE DISTRIBUTION - THURBER 05117.GPJ 5/22/13

North Trout Creek - WBL

GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NTW-03	2.59	213.07
⧗	NTW-03	7.92	207.74
▲	NTW-03	14.02	201.64
★	NTW-03	16.99	198.67
⊙	NTW-04	2.59	208.71
✪	NTW-04	10.97	200.33

Date May 2013

GWP# 647-89-00

THURBER

Prep'd AN

Chkd. RPR

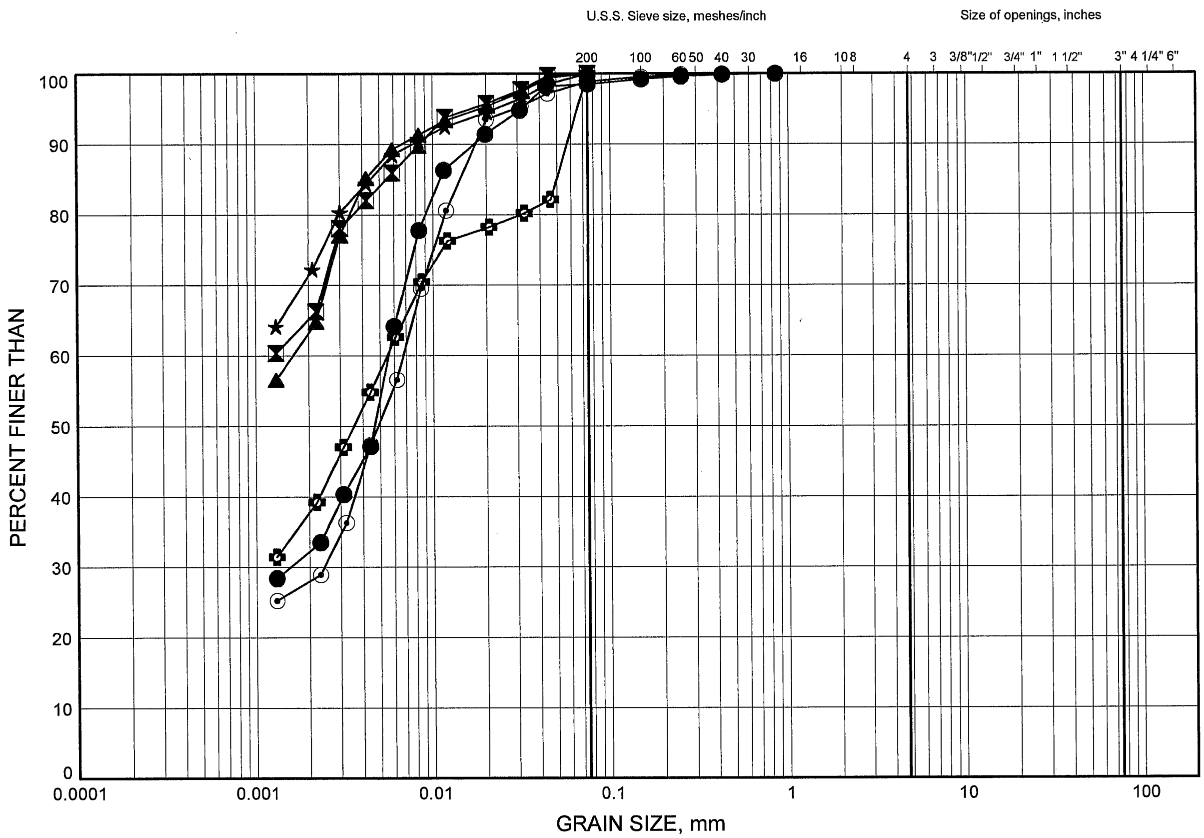
GRAIN SIZE DISTRIBUTION - THURBER 05117.GPJ 5/22/13

North Trout Creek - WBL

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NTW-04	14.02	197.28
⧗	NTW-05	1.83	210.60
▲	NTW-05	6.40	206.03
★	NTW-05	10.97	201.46
⊙	NTW-05	15.54	196.89
✿	NTW-06	2.59	206.96

Date May 2013

GWP# 647-89-00

THURBER

Prep'd AN

Chkd. RPR

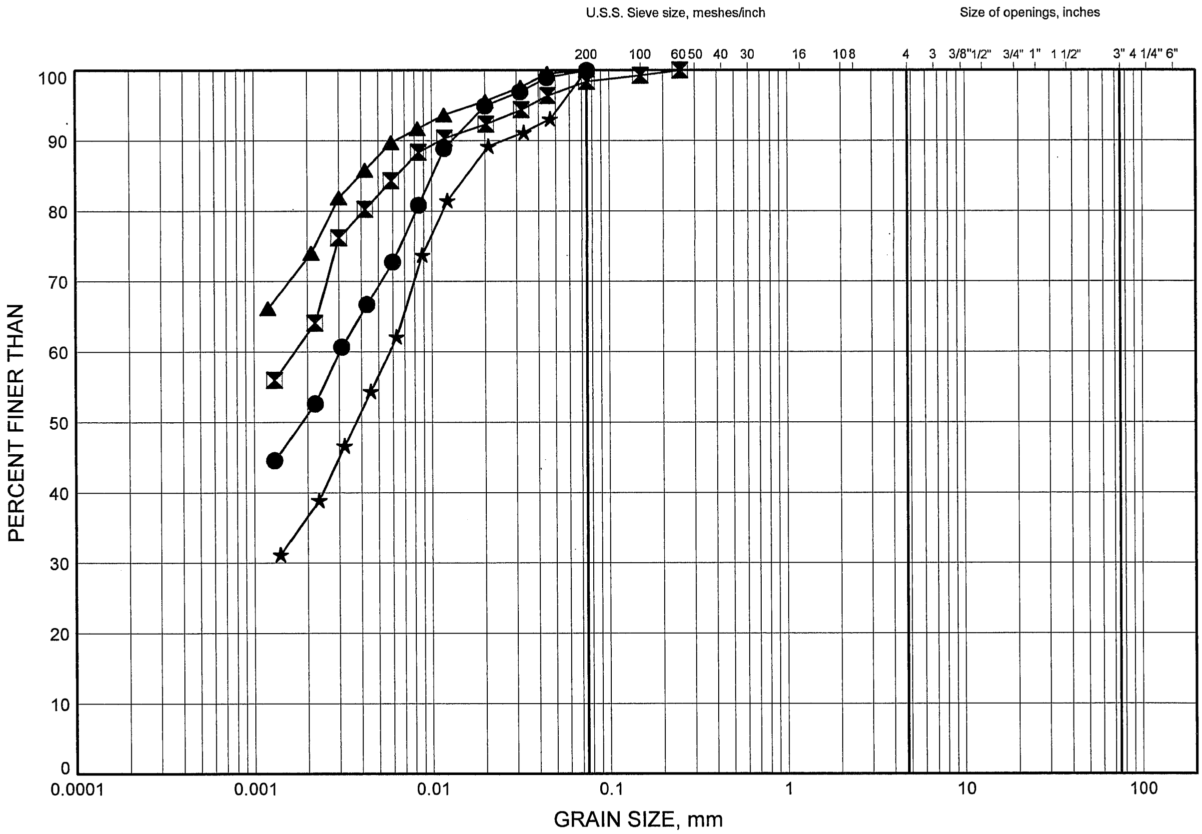
GRAIN SIZE DISTRIBUTION - THURBER 05117.GPJ 5/22/13

North Trout Creek - WBL

GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NTW-06	7.92	201.63
⧗	NTW-07	3.35	207.48
▲	NTW-07	6.40	204.43
★	NTW-09	2.59	208.30

GRAIN SIZE DISTRIBUTION - THURBER 05117.GPJ 5/22/13

Date May 2013

GWP# 647-89-00

THURBER

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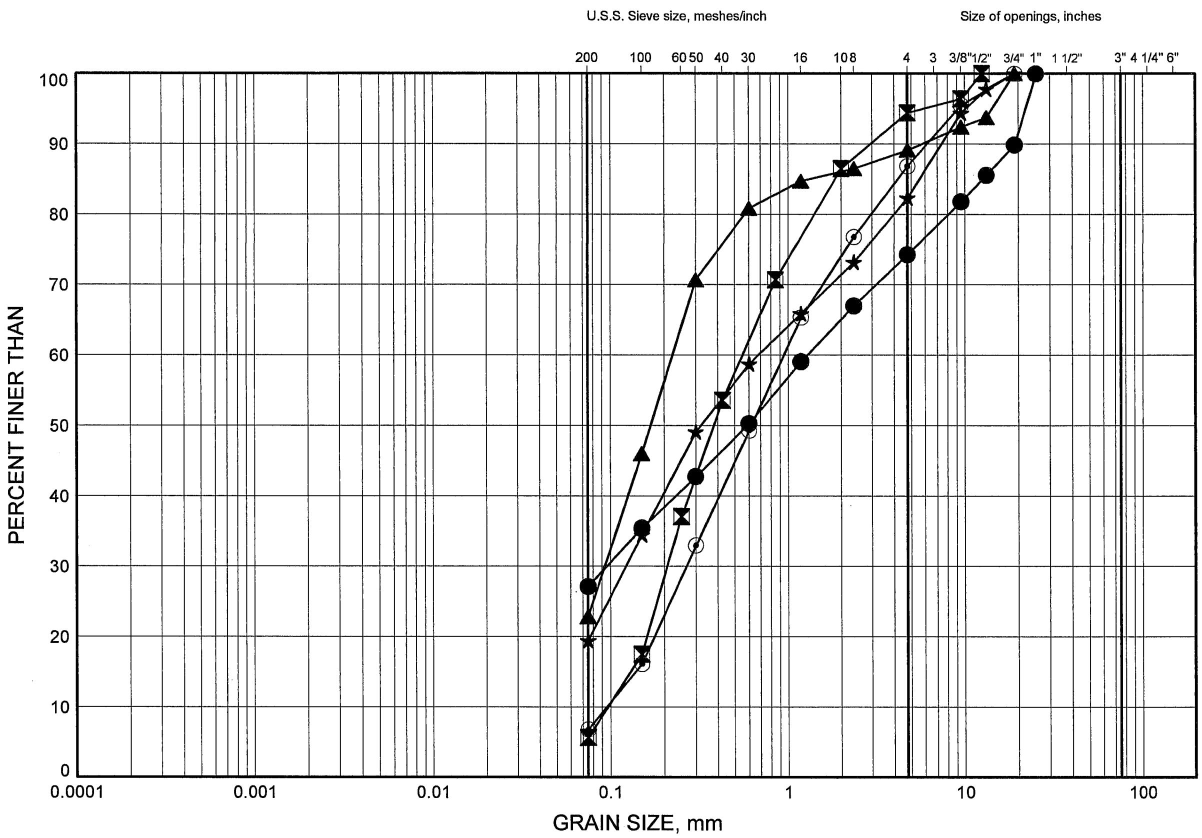
North Trout Creek - WBL

GRAIN SIZE DISTRIBUTION

FIGURE B6

SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NTW-02	17.30	198.08
⧗	NTW-06	12.50	197.05
▲	NTW-07	12.34	198.49
★	NTW-08	6.31	204.77
⊙	NTW-09	3.35	207.54

Date September 2013

GWP# 647-89-00

THURBER

Prep'd AN

Chkd. RPR

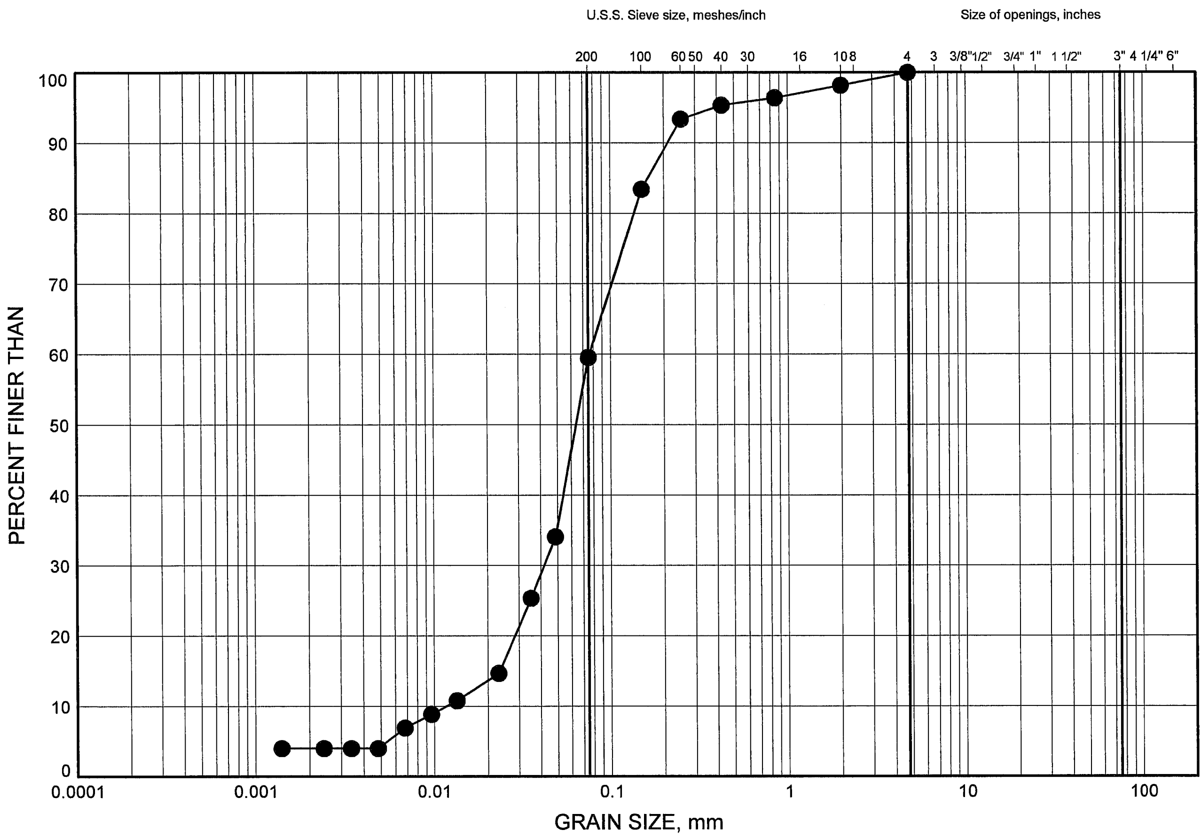
GRAIN SIZE DISTRIBUTION - THURBER 05117.GPJ 9/18/13

North Trout Creek - WBL

GRAIN SIZE DISTRIBUTION

FIGURE B7

SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NTW-07	9.45	201.38

Date September 2013

GWP# 647-89-00

THURBER

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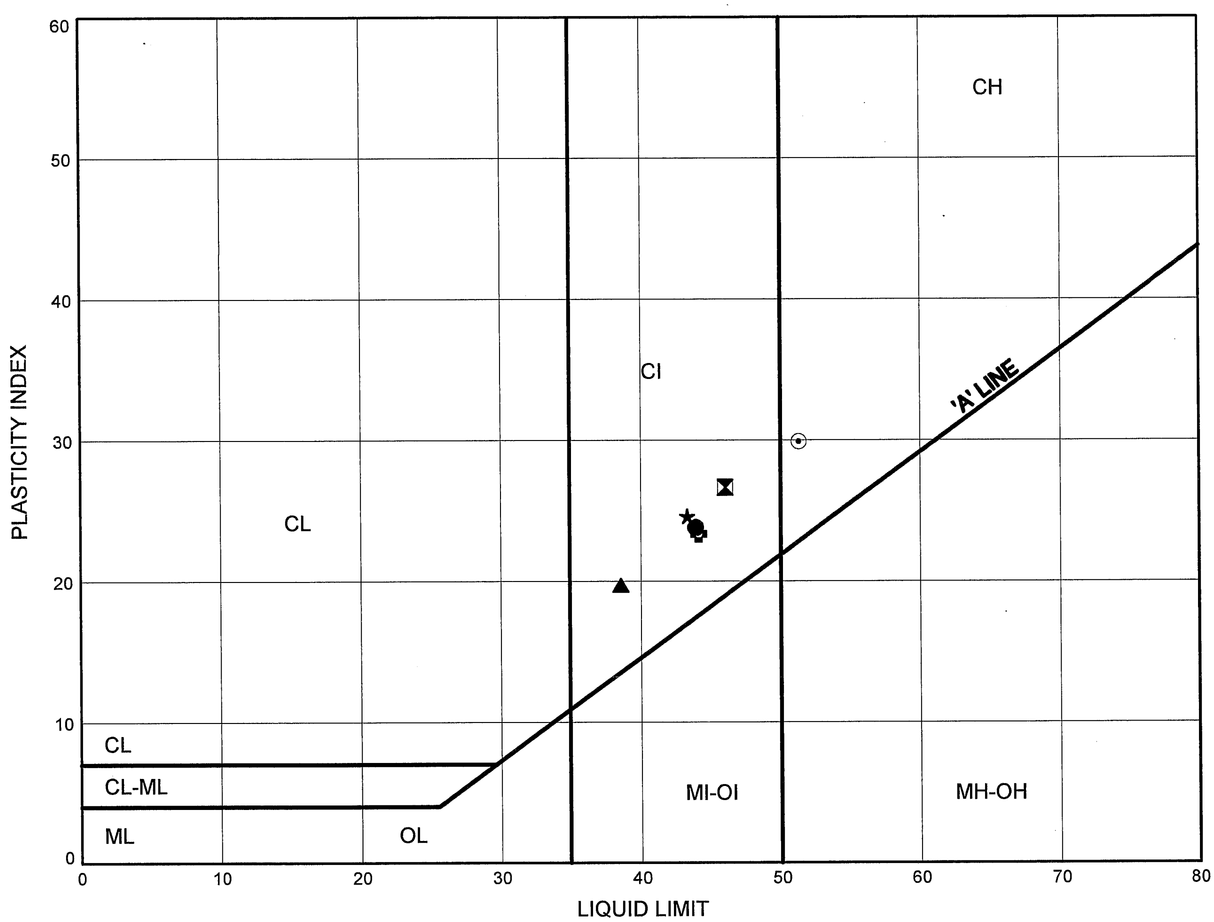
Chkd. RPR

North Trout Creek - WBL

ATTERBERG LIMITS TEST RESULTS

FIGURE B8

SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NTW-01	9.45	208.45
⧗	NTW-02	1.83	213.55
▲	NTW-02	6.40	208.98
★	NTW-02	12.50	202.88
⊙	NTW-03	2.59	213.07
✿	NTW-03	7.92	207.74

Date May 2013

GWP# 647-89-00

THURBER

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Chkd. RPR

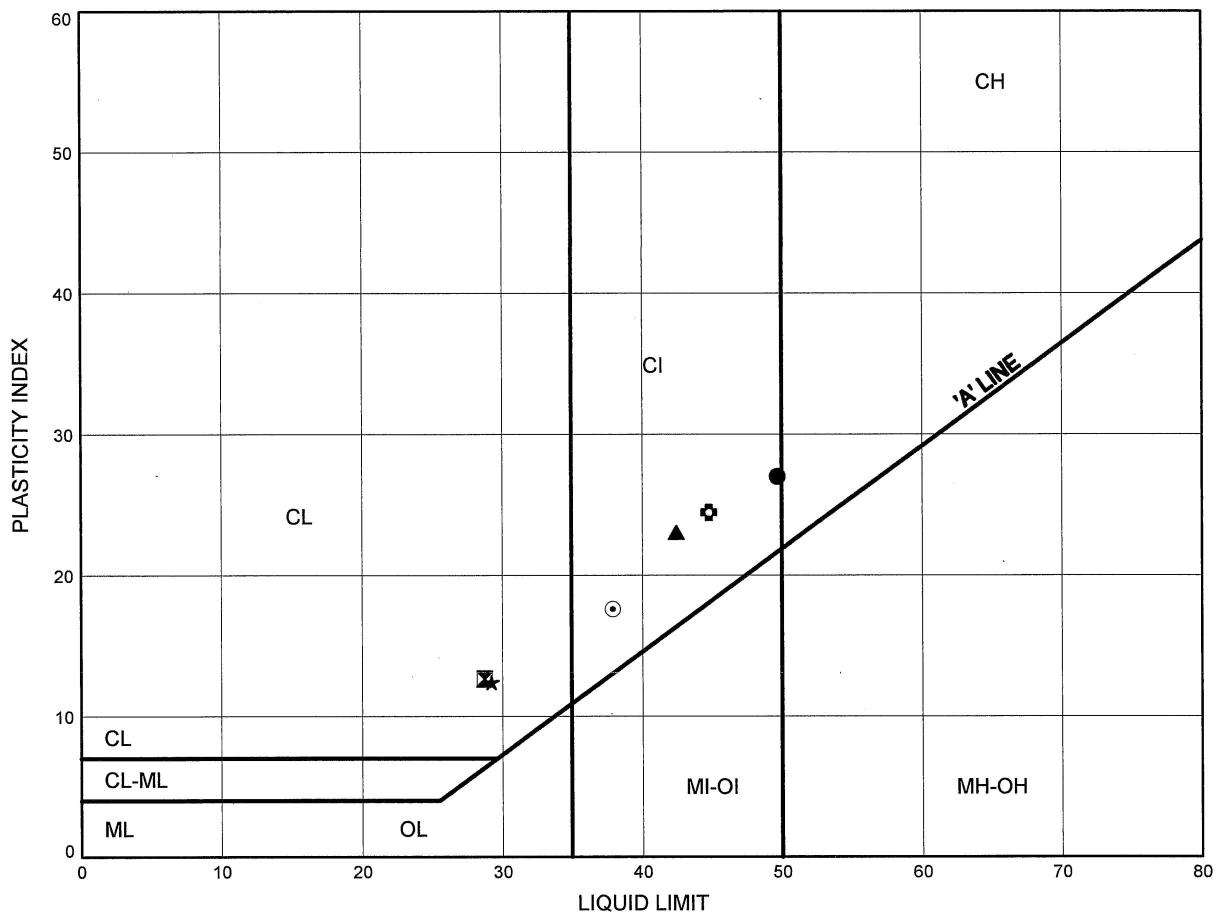
THURBALT 05117.GPJ 5/22/13

North Trout Creek - WBL

ATTERBERG LIMITS TEST RESULTS

FIGURE B9

SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NTW-03	14.02	201.64
⧗	NTW-03	16.99	198.67
▲	NTW-04	2.59	208.71
★	NTW-04	10.97	200.33
⊙	NTW-05	1.83	210.60
✿	NTW-05	6.40	206.03

Date May 2013

GWP# 647-89-00

THURBER

Prep'd AN

Chkd. RPR

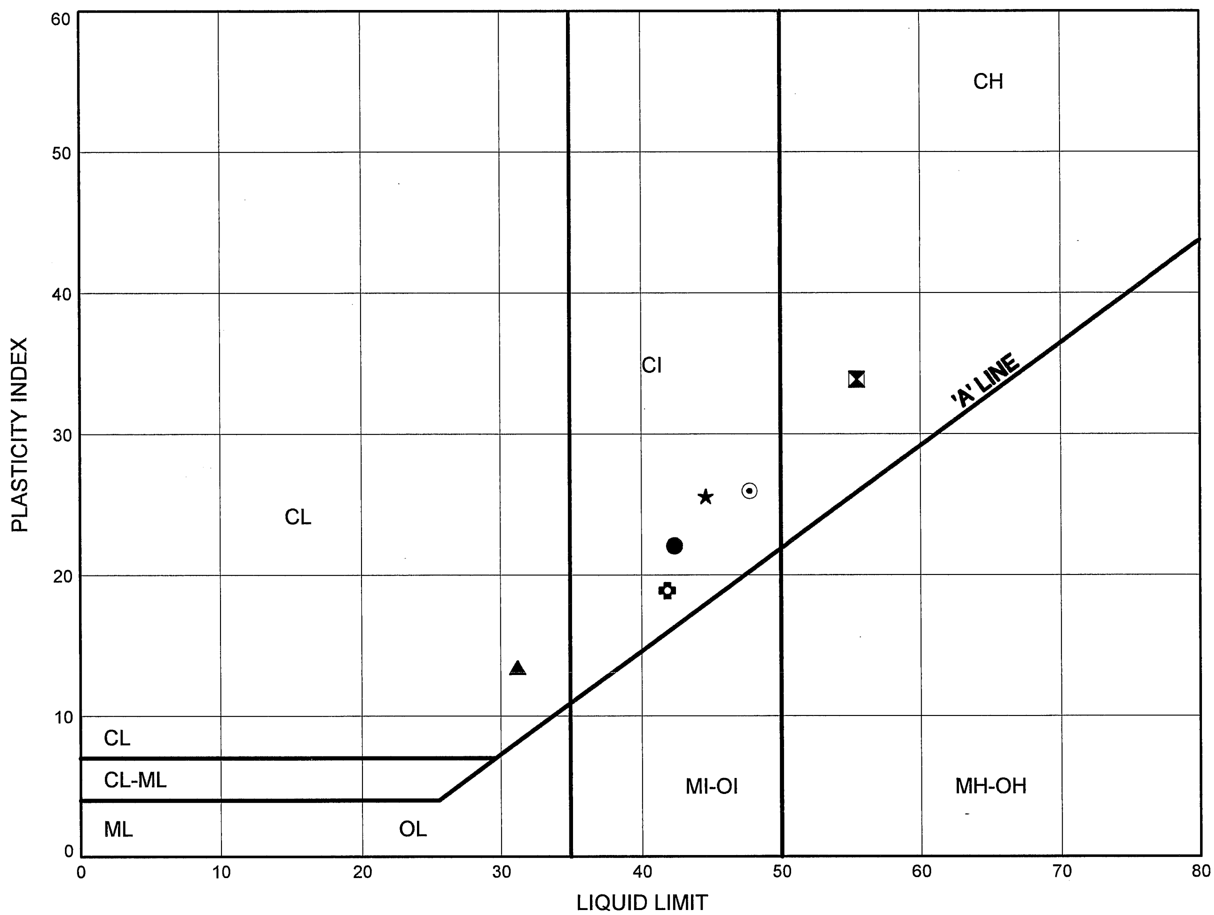
THURBALT 05117.GPJ 5/22/13

North Trout Creek - WBL

ATTERBERG LIMITS TEST RESULTS

FIGURE B10

SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NTW-05	7.92	204.51
⧗	NTW-05	10.97	201.46
▲	NTW-06	2.59	206.96
★	NTW-06	7.92	201.63
⊙	NTW-07	3.35	207.48
✿	NTW-07	6.40	204.43

THURBALT 05117.GPJ 5/22/13

Date May 2013

GWP# 647-89-00

THURBER

Prep'd AN

Chkd. RPR

Appendix C

Site Photographs

Photograph 1 – Existing conditions at North Trout Creek, looking west from east bank.

Photograph 2 – Existing conditions at North Trout Creek, looking north.

Photograph 3 – Existing conditions at North Trout Creek

Photograph 4 – Existing conditions at North Trout Creek

Appendix D

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES

Footings on Native Soil or Bedrock	Augered Caissons	Drilled in Pipe Piles	Steel H-Piles
Advantages: i. Generally less costly construction than deep foundation elements. ii. High values of geotechnical resistance are available on the bedrock on east bank.	***Advantages:*** i. High geotechnical resistance available for caissons socketed into bedrock. ii. Construction of caissons could continue in freezing weather. iii. Excavation and dewatering requirements are minimized.	***Advantages:*** i. High geotechnical resistance available for pipe piles driven to or drilled into bedrock. ii. Liner is not required to support excavation sidewalls. iii. Excavation and dewatering requirements are minimized. iv. Cleaning and inspection of the socket base is not required.	***Advantages:*** i. High geotechnical resistance available for H-piles driven to bedrock. ii. Installation of piles could continue in freezing weather. iii. Excavation and dewatering requirements are minimized.
Disadvantages: i. Low geotechnical resistance available in native soils on west bank. ii. Potential consolidation settlement. iii. Excavation depth to construct footings on bedrock is not practical. iv. Potential uneven/sloping bedrock surface on east bank. v. Temporary excavation for footing construction may have environmental impact on the creek.	***Disadvantages:*** i. Higher unit costs than footings on bedrock. ii. Caissons must be socketed into very strong bedrock with fractured zones and sloping surface. iii. Permanent liner will be required to maintain sidewall stability. iv. Difficulties in obtaining a seal below the liner. Tremie concrete may be required. v. Potential difficulty in cleaning and inspection of socket base.	***Disadvantages:*** i. Higher unit cost than footings on bedrock. ii. Piles at pier and east abutment must be socketed into very strong bedrock with fractured zones and sloping surface. iii. Variable depth to bedrock on east bank. iv. Concreting or grouting of the annular space within the pile socket is required.	***Disadvantages:*** i. Higher unit cost than footings on bedrock. ii. H-piles may encounter refusal at varying depths on sloping bedrock at the pier. iii. Potential for sliding of pile tips on sloping bedrock at pier. iv. Piles must be socketed into bedrock at east abutment.
NOT RECOMMENDED for West Abutment and Pier. RECOMMENDED for East Abutment	**FEASIBLE**	**FEASIBLE**	**RECOMMENDED for West Abutment and Pier. FEASIBLE for East Abutment**

THURBER

Appendix E

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

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

- OPSS 501
- OPSS 804
- OPSS 902
- OPSS 903
- OPSS.PROV 1010
- OPSD 3101.150
- OPSD 3101.200
- SP 105S21

2. Suggested Text for NSSP on "H-Piles Driven to Sloping Bedrock"

Piles driven to refusal at the pier may encounter a sloping bedrock surface. Care must be taken during driving of the piles to set the pile in bedrock and minimize the potential for sliding of the pile tip along the sloping bedrock surface. In this regard, Clause 903.07.02.07.03.03 of OPSS 903 is modified by the following procedure:

Upon initial contact with the bedrock:

1. Apply 10 blows at 10% of the hammer energy. Record the penetration.
2. Apply 10 blows at 50% of the hammer energy. If the penetration under 10 blows is less than 12.5 mm, the pile is set.
3. If the penetration under 10 blows is greater than 12.5 mm, refer the issue to the design team for resolution.

H-piles driven at the pier must be provided with the Titus H bearing pile point, rock injector model, or approved equivalent.

3. Suggested text for a NSSP on "Construction of H-Piles in Rock Sockets"

Installation of H-piles shall be in accordance with OPSS 903 and the following.

H-pile installation at the east abutment will require excavation through cohesionless soils below the groundwater table and construction of sockets in the underlying bedrock. Bedrock is present at shallow depths. The Contractor is advised of the following:

- The cohesionless soil above the bedrock is susceptible to disturbance under conditions of unbalanced hydrostatic head, and measures must be employed to maintain sidewall stability during installation of the piles and prevent collapse/washing of cohesionless soils into the rock socket. Selection of the methods and equipment employed to achieve this is the responsibility of the Contractor.
- The installation methods and equipment must be capable of dislodging, removing or otherwise penetrating cobbles and boulders in the soils overlying the bedrock.
- The bedrock consists of strong to very strong gneiss and granite. The strength and hardness of this rock must be taken into account when selecting equipment to advance the socket into rock. Equipment supplied to construct or drill the rock socket must be capable of excavating the bedrock to the specified socket dimensions without disturbing or fracturing the bedrock forming the sidewalls and base of the socket. Blasting to facilitate the removal of bedrock is not permitted.
- The rock socket must be formed entirely within the bedrock below the level of any cobbles and boulders. Any length of pile above the bedrock surface will not be considered part of the specified length of rock socket.
- H-piles shall be placed centred into the holes, bearing directly on the sound rock at the bottom of the hole. Piles shall be stabilized in place by temporary supports.
- The annular space between the rock socket wall and H-pile shall be filled with 30 MPa concrete to top of existing ground. The plumbness and alignment of the pile shall be maintained during concreting.

4. Suggested Text for a NSSP on "Construction of Drilled-in Pipe Piles"

Installation of drilled-in pipe piles shall be in accordance with OPSS 903 and the following. The Contractor is further advised of the following:

- The bedrock consists of strong to very strong gneiss and granite. The strength and hardness of this rock must be taken into account when selecting equipment to advance the pile into rock. Equipment supplied to advance the pile into rock must be capable of penetrating the bedrock without disturbing or fracturing the bedrock adjacent to the pile. Blasting to facilitate the removal of bedrock is not permitted.
- The rock embedment length must be formed entirely within the bedrock below the level of any rubble or highly fractured material. Any length of pile above the bedrock surface will not be considered part of the specified length of rock embedment.
- The length of socket shall be taken from the lowest point of the bedrock surface around the perimeter of the socket.
- During and subsequent to installation, the pipe pile may be partially filled with water and it may not be practical to dewater the pipe prior to concreting. Tremie concreting will be required for concreting these pipe piles.

5. Suggested Text for NSSP on "Construction of Caissons"

Caisson installation shall be in accordance with OPSS 903. The Contractor is further advised of the following:

- Caisson installation will extend through soft to very soft silty clay and cohesionless soils below the water table. Permanent steel liners are required to support and prevent squeezing of the caisson sidewalls and to prevent collapse/washing of cohesionless soils into the rock socket. Tremie concrete procedures may be required where dewatering of the caisson is not practical.

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

- The rock socket must be formed entirely within the bedrock below the level of any rubble or highly fractured material. Any length of caisson above the bedrock surface will not be considered part of the specified length of rock socket. The length of socket shall be taken from the lowest point of the bedrock surface around the perimeter of the socket.

Appendix F

Slope Stability Output

Title: North Trout Creek, WBL (Nipigon HWY 11/17)
Name: WA - 0E (2)
Comments: Slope Stability Analysis
Last Solved Date: 2014-03-26, 9:40:30 AM

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1 m
Horz Seismic Load: 0

CLAY (ESA)	18 kN/m³	7 kPa	23 °	1
SAND/GRAVEL	20 kN/m³	0 kPa	32 °	1
Bedrock				
Sandy SILT	19 kN/m³	0 kPa	30 °	1

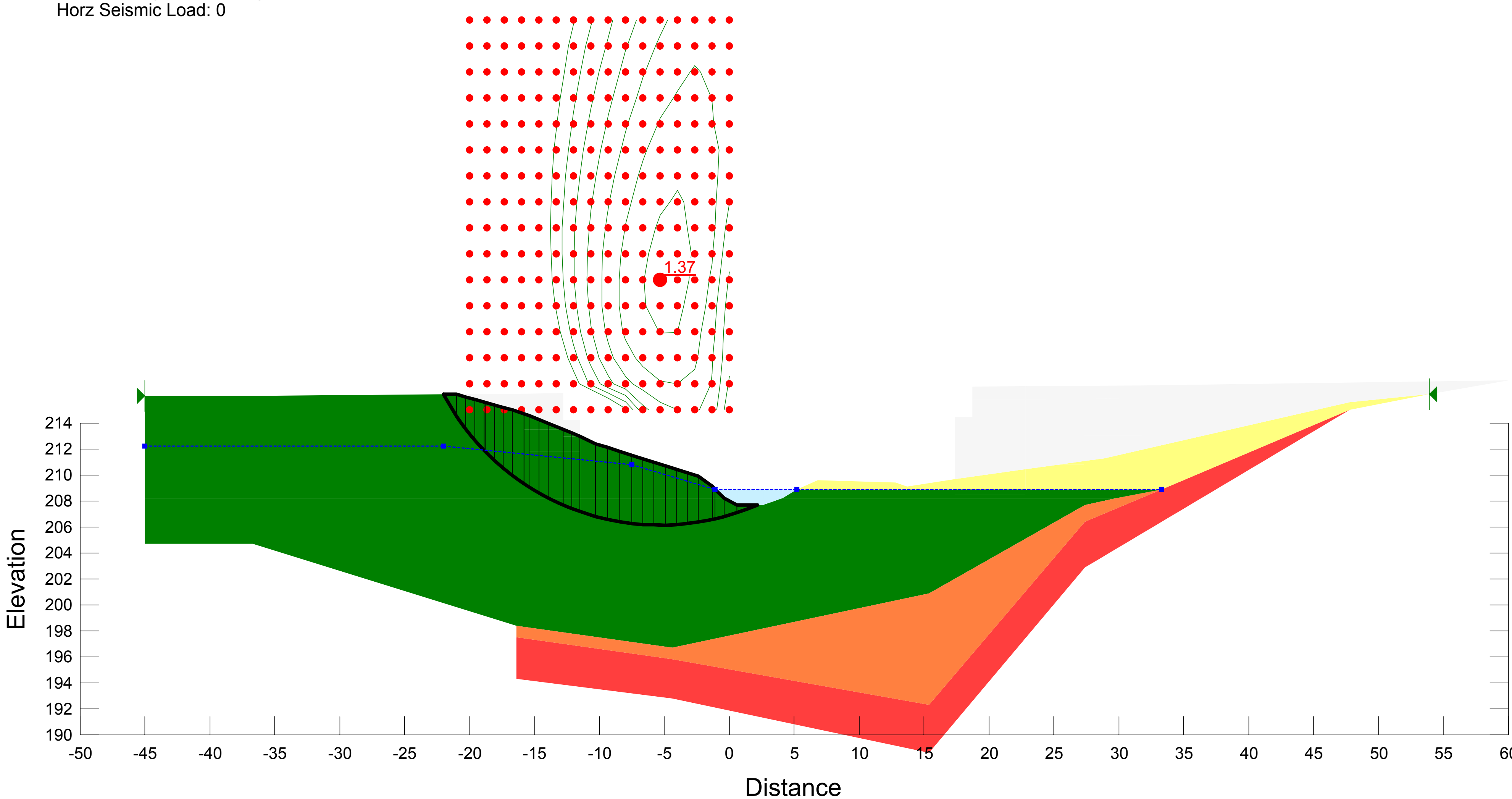


Figure 1

Directory: H:\19\1605\117 Hwy 11-17 Nipigon\Reports & Memos\NTW\02 Analysis\Stability -3\NTW_001.gsz

Appendix G

Borehole Locations and Soil Strata Drawings

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

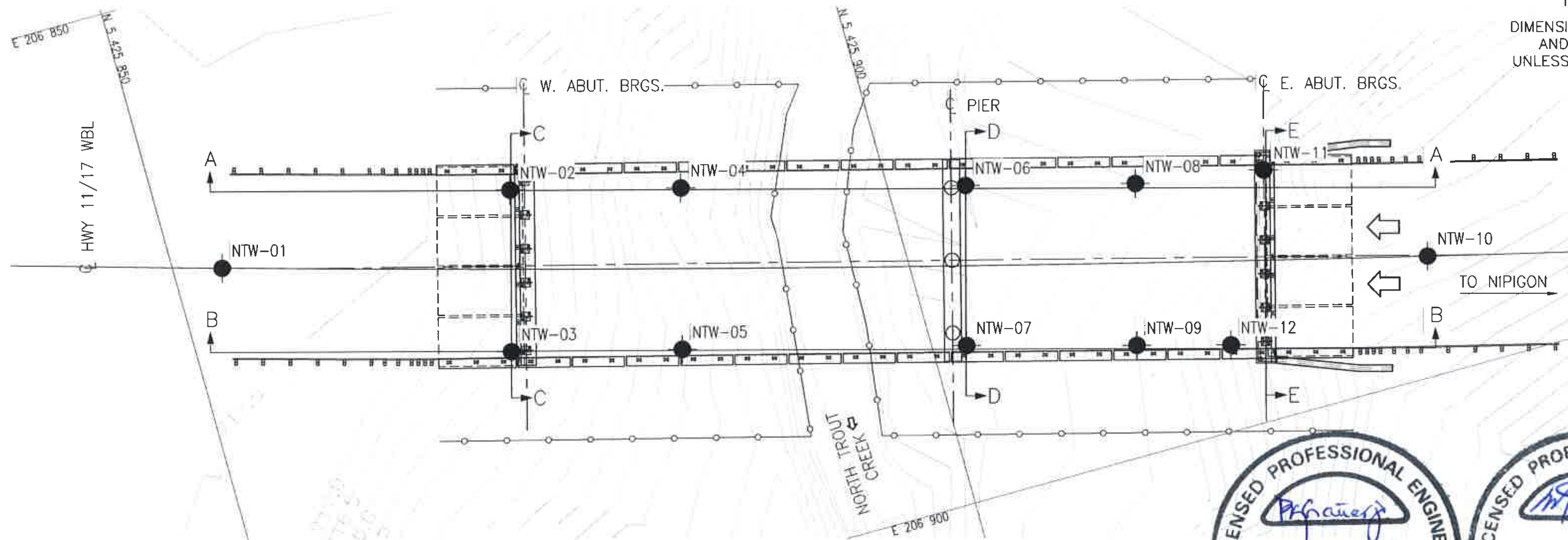
CONT No
WP No 647-89-00

HIGHWAY 11/17 FOUR LANING
NORTH TROUT CREEK
WESTBOUND LANE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Hatch Mott MacDonald

THURBER ENGINEERING LTD.



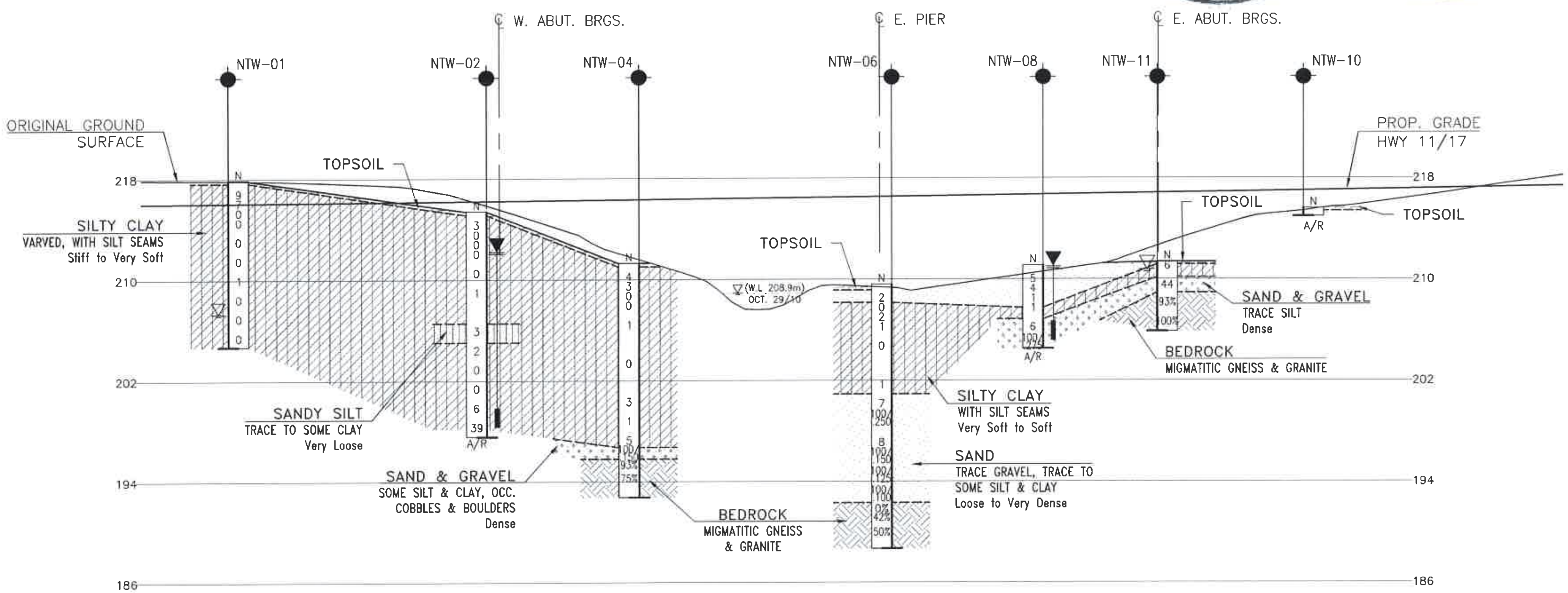
PLAN

8 0 8 16m

SCALE 1:400

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Mar 28, 2014
PROVINCE OF ONTARIO

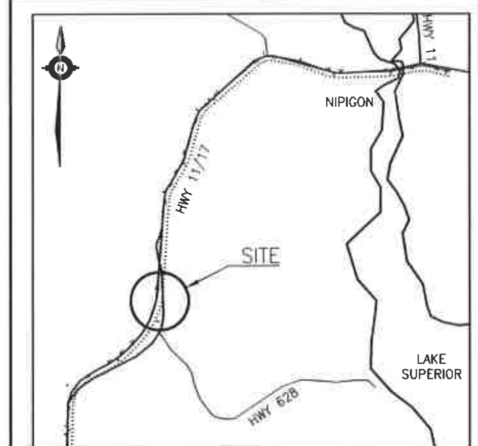
LICENSED PROFESSIONAL ENGINEER
M. R. ANDERSON
Mar 28/14
PROVINCE OF ONTARIO



PROFILE ALONG A-A

8 0 8 16m

SCALE 1:400



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
NTW-01	217.9	5 425 853.4	206 869.7
NTW-02	215.4	5 425 874.4	206 869.8
NTW-03	215.7	5 428 871.4	206 880.9
NTW-04	211.3	5 425 886.0	206 872.9
NTW-05	212.4	5 425 883.0	206 884.0
NTW-06	209.6	5 425 905.3	206 878.1
NTW-07	210.8	5 425 902.4	206 889.1
NTW-08	211.1	5 425 916.9	206 881.2
NTW-09	210.9	5 425 913.9	206 892.3
NTW-10	215.6	5 425 935.3	206 891.7
NTW-11	211.4	5 425 925.8	206 882.7
NTW-12	212.8	5 425 920.3	206 894.0

-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. 52A-176

REVISIONS	DATE	BY	DESCRIPTION

DESIGN RPR	CHK RPR	CODE	LOAD	DATE MAR 2014		
DRAWN AN	CHK	SITE 48C-11A	STRUCT	DWG 1		

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PLOTDATE: 3/28/2014 10:28 AM

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

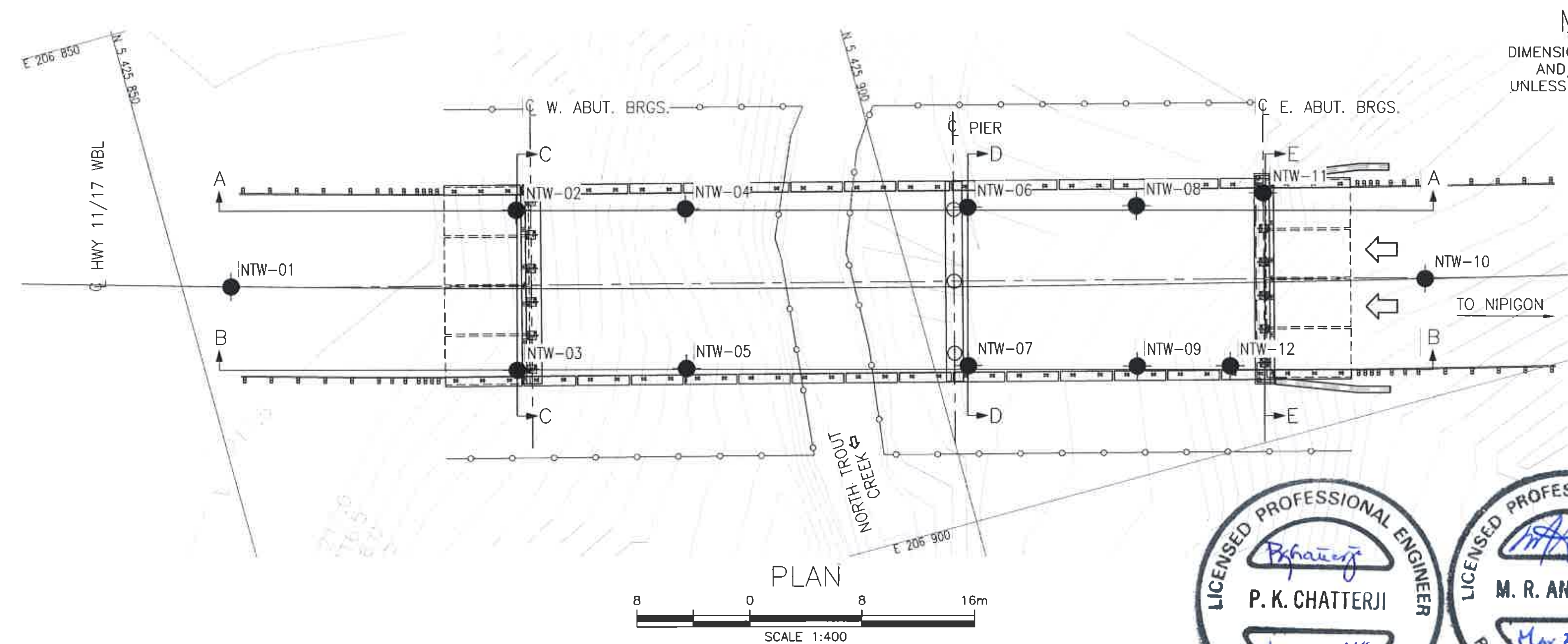
CONT No
WP No 647-89-00

HIGHWAY 11/17 FOUR LANING
NORTH TROUT CREEK
WESTBOUND LANE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

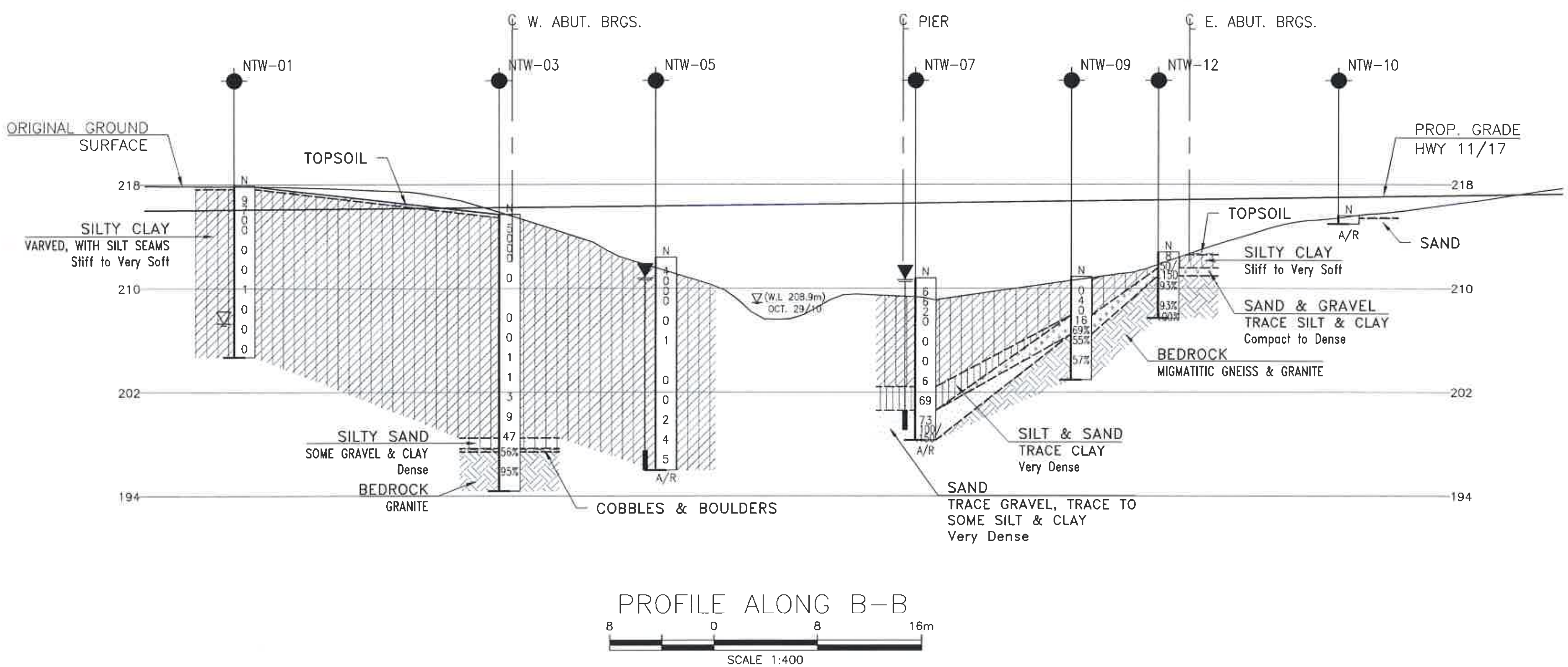
Hatch Mott MacDonald

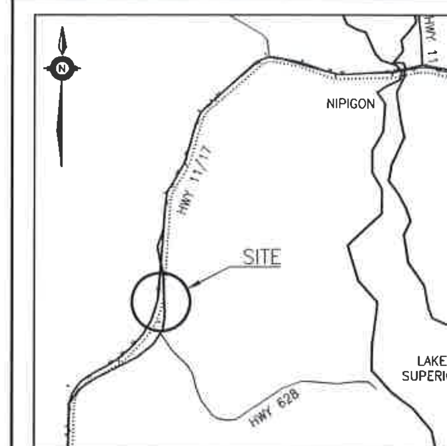
THURBER ENGINEERING LTD.



LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Mar 24, 2014
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
M. R. ANDERSON
Mar 28/14
PROVINCE OF ONTARIO





KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
NTW-01	217.9	5 425 853.4	206 869.7
NTW-02	215.4	5 425 874.4	206 869.8
NTW-03	215.7	5 428 871.4	206 880.9
NTW-04	211.3	5 425 886.0	206 872.9
NTW-05	212.4	5 425 883.0	206 884.0
NTW-06	209.6	5 425 905.3	206 878.1
NTW-07	210.8	5 425 902.4	206 889.1
NTW-08	211.1	5 425 916.9	206 881.2
NTW-09	210.9	5 425 913.9	206 892.3
NTW-10	215.6	5 425 935.3	206 891.7
NTW-11	211.4	5 425 925.8	206 882.7
NTW-12	212.8	5 425 920.3	206 894.0

-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. 52A-176

REVISIONS | DATE | BY | DESCRIPTION

DESIGN RPR | CHK RPR | CODE | LOAD | DATE MAR 2014
DRAWN AN | CHK | SITE 48C-11A | STRUCT | DWG 2

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

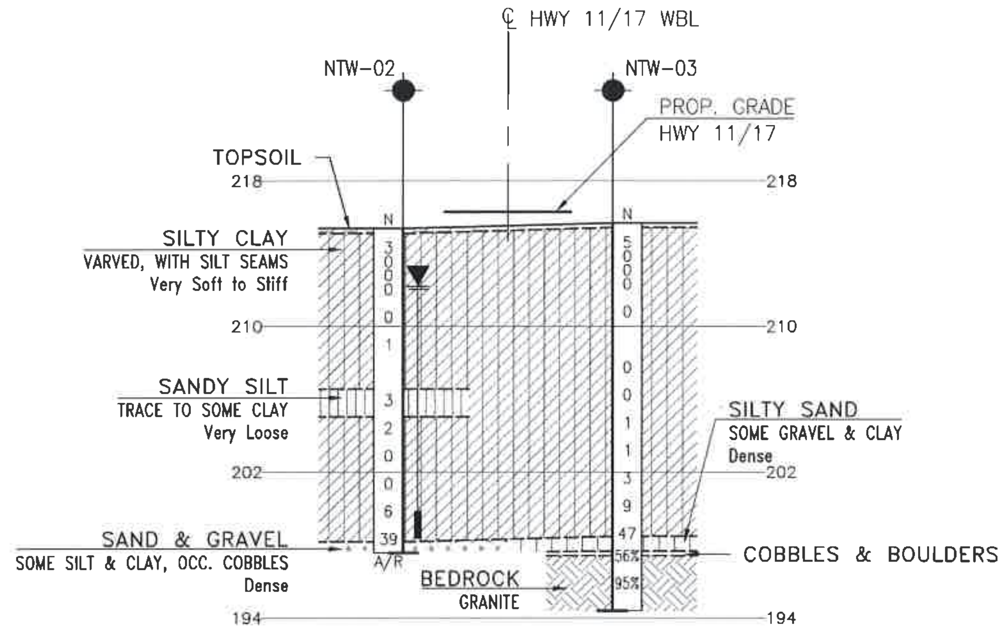
CONT No
WP No 647-89-00

HIGHWAY 11/17 FOUR LANING
NORTH TROUT CREEK
WESTBOUND LANE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Hatch Mott MacDonald

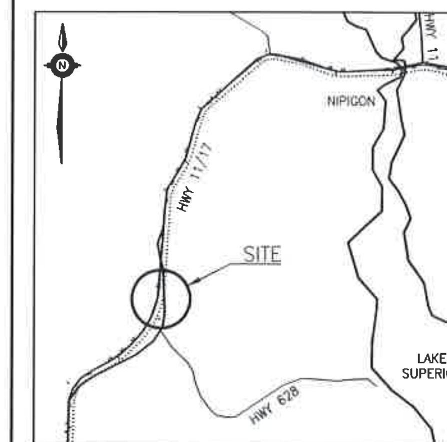
THURBER ENGINEERING LTD.



SECTION ALONG C–C

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Mar 28, 2014
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
M. R. ANDERSON
Mar 28/14
PROVINCE OF ONTARIO

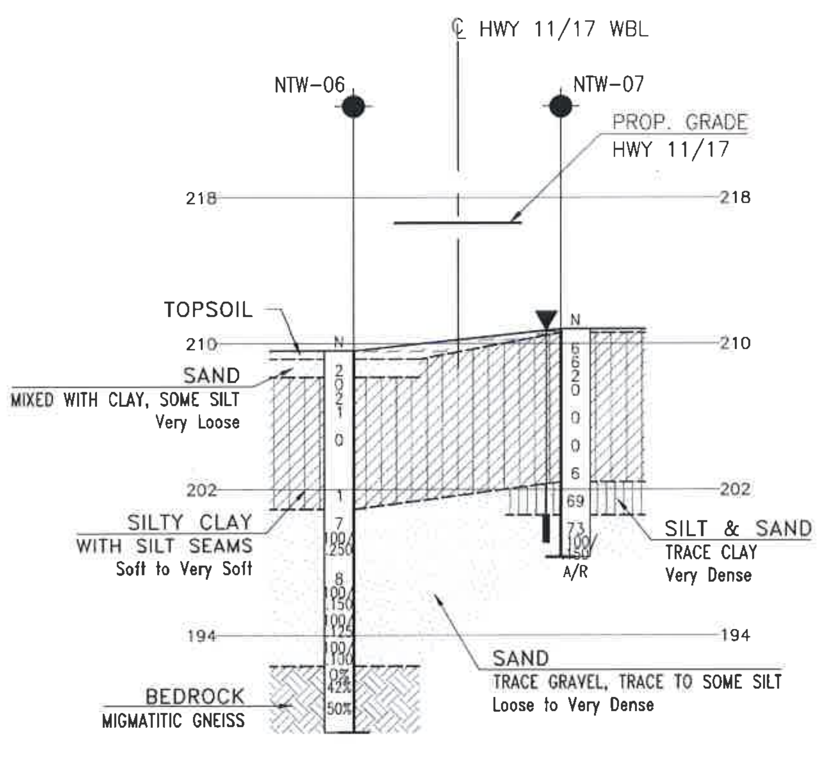


KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
NTW-01	217.9	5 425 853.4	206 869.7
NTW-02	215.4	5 425 874.4	206 869.8
NTW-03	215.7	5 428 871.4	206 880.9
NTW-04	211.3	5 425 886.0	206 872.9
NTW-05	212.4	5 425 883.0	206 884.0
NTW-06	209.6	5 425 905.3	206 878.1
NTW-07	210.8	5 425 902.4	206 889.1
NTW-08	211.1	5 425 916.9	206 881.2
NTW-09	210.9	5 425 913.9	206 892.3
NTW-10	215.6	5 425 935.3	206 891.7
NTW-11	211.4	5 425 925.8	206 882.7
NTW-12	212.8	5 425 920.3	206 894.0



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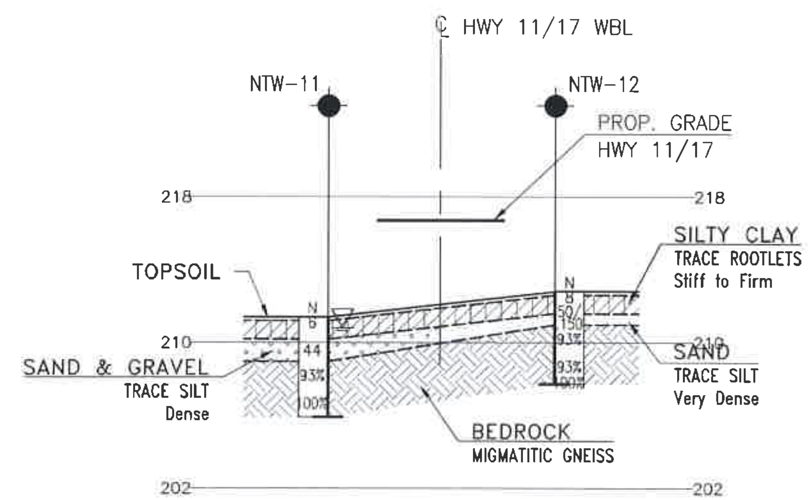

SECTION ALONG E–E

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SCALE 1:400

-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. 52A-176

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN RPR	CHK RPR	CODE	LOAD	DATE MAR 2014	
DRAWN AN	CHK	SITE 48C-11A	STRUCT	DWG 3	