FOUNDATION INVESTIGATION AND DESIGN REPORT
NIPIGON RIVER BRIDGE TWINNING
HIGHWAY 11/17, TOWNSHIP OF NIPIGON
G.W.P.6047-89-02, STRUCTURE No. 48C-07-2
W.P. No. 124-90-01

Geocres Number: 52H-21

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 location of the bridge carrying Highway 11/17 over the Nipigon River in the Thunder Bay District, Ontario. As part of the Highway 11/17 Twinning Project, a new bridge will be constructed to accommodate the eastbound and westbound lanes of Highway 11/17.

The purpose of the investigation was to explore the subsurface conditions at the bridge location and, based on the data obtained, provide a borehole location plan, records of boreholes, stratigraphic profile, 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.

Information on subsurface conditions contained in two previous foundation reports for this site was also assessed during preparation of this report. The reference reports are listed as follows:

- Soils Investigation, Nipigon River Bridge, Nipigon, Ontario, W.P. No. 918-65-01, dated June 1972, by Dominion Soil Investigation Limited.
- Foundation Investigation Report for Nipigon River WBL Bridge, W.P. 647-89-02; Site 48C-7, Highway 11/17, District 19, Thunder Bay, dated May 13, 1994 by The Ministry of Transportation Ontario (MTO).

Records of boreholes from the previous MTO report are included in Appendix C for reference.

Thurber Engineering Ltd. (Thurber) carried out the investigation as a sub-consultant to McCormick Rankin under the Ministry of Transportation Ontario (MTO) Agreement Number 6009-E-00013.

2 SITE DESCRIPTION

The bridge site is located at the crossing of Highway 11/17 over the Nipigon River in the Township of Nipigon, Ontario. The Nipigon River Bridge is located approximately 500 m west of where

Highway 11/17 splits into Highway 11 and Highway 17 (east of the river). The existing Highway 11/17 is a two-lane paved highway and the existing Nipigon River Bridge is a two-lane, four-span structure with a total length of approximately 244 m. The abutments and piers of the existing highway bridge are variously supported on shallow and deep foundations.

An old highway bridge, constructed in 1936, was located immediately north of the existing highway bridge. This old bridge was removed following the completion of the existing highway bridge. The east and west piers of the old highway bridge were left in place to help stabilize erosion of the river banks during the construction of the existing highway bridge.

A multi-span bridge carrying the CPR mainline over the Nipigon River lies approximately 27 m south of the highway bridge. The CPR bridge was originally constructed between 1883 and 1885 and was supported on a combination of masonry piers and steel bents. A recent rehabilitation of the bridge reinforced some of the pier foundations and the placed concrete jackets around the masonry piers. An abandoned CN track passes under the bridges on the west flood plain.

At the proposed crossing, the west floodplain of the Nipigon River valley is relatively flat, however the east bank is steep and approximately 30 m in height. The river flows from north to south and the river channel is approximately 70 m wide. The bridge spans the river and its flood plain to the west. The surrounding valley lands are primarily tree covered and undeveloped, though to the southeast of the bridge, the trees have been cleared. The village of Nipigon occupies the higher ground beyond the valley.

Photographs of the site are presented in Appendix D.

The site lies within the physiographic region known as the Quetico Subprovince of the Superior Province of the Canadian Shield, which is underlain by Archean rocks. According to bedrock geology maps produced by The Ontario Geological Survey (OGS) the region is characterized by metasedimentary rocks consisting of wacke, siltstone, arkose, argillite, slate, mudstone, marble, chert, and iron formation, and minor metavolcanic rocks consisting of conglomerate, arenite, paragneiss and migmatites. Locally, the bedrock is mantled by deep deposits of sand and gravel and silt to clayey silt at depth.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out during the period of August 29 to November 29, 2011 and consisted of drilling and sampling eight boreholes (identified as NIP-01 to NIP- 08). Boreholes NIP-01 and NIP-06 were drilled at the west and east approaches, respectively and were both drilled to a depth of 9.8 m (Elevation 199.0 and 195.9, respectively). Boreholes NIP-02 and NIP-05 were drilled at the west and east abutments and were drilled to depths of 41.5 m (Elevation 167.4) and 40.1 m (Elevation 167.5), respectively. Borehole NIP-07 was also drilled at the east abutment, however this borehole was terminated at a depth of 9.8 m (Elevation 195.6) due to the proximity of a borehole (93-5) drilled during the 1994 MTO investigation. Boreholes NIP-03, NIP-04, and NIP-08 were drilled at the location of the proposed pier to depths of 63.4 m, 59.7 m and 59.4 m, respectively (Elevations 124.4, 128.0 and 125.5).

Bedrock was proven in the three boreholes located at the pier by obtaining 3.0 to 10.3 m of bedrock core.

A Dynamic Cone Penetration Test (DCPT) was conducted adjacent to Borehole NIP-04, drilled at the proposed pier location. Given the cobbles and boulders at surface at the location of Borehole NIP-04, the DCPT was conducted starting from a depth of 4.6 m (Elevation 183.1) and continued to a depth of 7.2 m (Elevation 180.5), where refusal was encountered. NW casing and coring was used to advance the borehole to a depth of 8.2 m where a second DCPT was performed. This DCPT ended at a depth of 9.0 m (Elevation 178.7) upon refusal.

A supplementary investigation, including two boreholes (RW-01 and RW-02), was carried out specifically for the proposed Reinforced Soil Systems (RSS) retaining walls at the west approach from July 15 to 17, 2012. RW-01 was advanced from the paved shoulder of the existing embankment and RW-02 was located at the north toe of the west approach embankment.

A previous investigation was completed at this site in 1994 by MTO for a new bridge to the north of the existing bridge to carry the westbound lanes of Highway 11/17 over the Nipigon River. This investigation consisted of drilling and sampling 6 boreholes (identified as 93-1 to 93-6) and performing 4 DCPTs. Boreholes 93-2 and 93-5 were drilled near the west and east abutments, respectively and Borehole 93-4 was drilled near the pier location. The stratigraphy encountered in these boreholes has been considered in ths report and the borehole logs are included in Appendix C.

The approximate locations of the boreholes drilled for this investigation (NIP-01 to NIP-08) are shown on the Borehole Locations and Soil Strata Drawings in Appendix F. The coordinates and elevations of the boreholes are listed on these drawings and on the individual Record of Borehole sheets included in Appendix A. The approximate locations of MTO Boreholes 93-1 to 93-6 are also shown on the Borehole Locations and Soil Strata Drawings in Appendix F. These locations are approximate only as borehole coordinates were not included in the 1994 report.

Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

A combination of hollow stem augers, casing, and coring techniques were used to advance the boreholes. Coring techniques were employed to advance the boreholes through cobbles and boulders encountered in the sand and gravel deposits. Samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). Where SPT yielded limited recovery, samples were obtained from the core barrel.

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, visually examined the recovered samples, and arranged for transportation of samples to Thurber's laboratory for further examination and testing.

Four standpipe piezometers, consisting of 19 mm diameter PVC pipe with slotted screen and enclosed in filter sand, were installed at this site to permit longer term groundwater level monitoring. The location and completion details of the piezometer and boreholes are summarized in Table 3.1. The boreholes were backfilled in general accordance with O. Reg. 903.

Table 3.1 – Borehole Completion Details

Location	Borehole	Piezometer Tip Depth/ Elevation (m)	Completion Details
West Approach	NIP-01	None installed	Borehole backfilled with cuttings to 0.15 m, then asphalt to surface.
West Abutment	NIP-02	41.1 / 167.8	Sand from 41.1 m to 35.1 m, bentonite holeplug from 35.1 m to 0.15 m, then asphalt cold patch to surface.
Pier	NIP-03	61.7 / 126.1	Sand from 61.7 m to 55.2 m, slough from 61.7 m to 21.3 m, bentonite from 21.3 m to 12.2 m, then cuttings to surface. PVC pipe stick-up of 0.6 m.
	NIP-04	None installed	Borehole backfilled with bentonite holeplug to surface.
	NIP-08	59.4 / 125.5	Sand from 59.4 m to 54.3 m, bentonite from 54.3 m to 51.2 m, slough from 51.2 m to 15.8 m, bentonite from 15.8 m to 2.4 m, then cuttings to surface. PVC pipe stick-up of 0.5 m.
East Abutment	NIP-05	39.6 / 168.0	Sand from 39.6 m to 35.7 m, bentonite holeplug from 35.7 m to 0.15 m, then asphalt cold patch to surface.
	NIP-07	None installed	Borehole backfilled with cuttings to surface.
East Approach	NIP-06	None installed	Borehole backfilled with cuttings to surface.
West Approach (EBL Shoulder)	RW-01	None installed	Borehole backfilled with bentonite holeplug and cuttings to surface.
West Approach (Toe of Slope)	RW-02	None installed	Borehole backfilled with bentonite holeplug and cuttings to surface.

The piezometers were decommissioned in accordance with O. Reg. 903.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to 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 in Appendix A and are presented on the figures contained in Appendix B.

Point load tests were carried out on selected samples of intact bedrock core to assist in evaluation of the compressive strength of the bedrock. Results of the point load tests are included on the Record of Borehole sheets in Appendix A (as average per core run).

In addition to the point load testing conducted by Thurber, five samples of the intact bedrock core were subjected to Unconfined Compression Testing (ASTM D 7012-07).

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A (current investigation) and Appendix C (previous investigation) for details of the encountered soil stratigraphy. A stratigraphic profile is presented on the Borehole Locations and Soil Strata Drawings included in Appendix F. Overall descriptions of the stratigraphy are given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

In general terms, the soil stratigraphy encountered at this site consists of interbedded layers of sand and gravelly sand overlying sandy silt to silt, underlain by clayey silt, overlying a layer of sand at depth. Sand fill was encountered at the west and east abutments overlying the native sand and gravelly sand layers. At the proposed pier location, the native soils are underlain at 49 to 60 m depth by slightly weathered to fresh metasedimentary bedrock.

More detailed descriptions of the individual strata are presented below.

5.1 Asphalt

Asphalt was encountered at surface in Boreholes NIP-01, NIP-02, NIP-05 and RW-01 as these boreholes were drilled on the shoulders of Highway 11/17. The asphalt was 50 to 200 mm thick.

5.2 Sand to Gravelly Sand Fill

Fill was encountered below the asphalt in Boreholes NIP-01, NIP-02, NIP-05 and RW-01, which were drilled through the existing highway embankments, and immediately at the ground surface in Borehole RW-02. The fill is brown and consists of sand to gravelly sand and contains trace to some silt and clay.

The thickness of the sand to gravelly sand fill ranged from 2.1 m at the east abutment to 8.0 m at the west abutment. The lower boundary of the fill was noted at depths of 8.2 m and 2.3 m at the west and east abutments, respectively (elevations 205.3 to 200.5). Surficial sand fill encountered in Borehole RW-02 was 0.6 m in thickness with base of layer at elevation 187.4.

SPT ‘N’ values recorded in the sand to gravelly sand fill generally ranged from 10 to 48 blows for 0.3 m penetration, indicating a compact to dense relative density. Higher SPT ‘N’ values of 66 blows for 0.3 m penetration and 50 blows for 0.125 m penetration were recorded in the fill in Borehole NIP-02 at a depth of 6 to 8 m. These SPT ‘N’ values indicate a very dense condition at this location and may be indicative of the presence of cobbles.

Moisture contents of samples of the sand to gravelly sand fill ranged from 2% to 8% in Borehole NIP-01 and NIP-05 and 10% to 22% in Borehole NIP-02, and 5% to 15% in Borehole RW-01.

Selected samples of the fill underwent laboratory grain size distribution analysis, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figures B1a and B1b, in Appendix B.

Soil Particle	Sand Fill (Fig. B1a)	Gravelly Sand Fill (Fig. B1b)
Gravel %	4 to 8	22 to 32
Sand %	76 to 84	60 to 71
Silt and Clay %	9 to 19	7 to 12

5.3 Cobbles and Boulders (Fill)

Cobbles and boulders with some sand and gravel were encountered at surface at the location of the proposed pier. The thickness of the cobbles and boulders was determined in Boreholes NIP-03 and NIP-08 only and was found to be 4.0 m and 2.3 m, respectively. The lower boundary of the cobbles and boulders was encountered at a depth of 2.3 to 4.0 m (Elevations 183.7 to 182.6).

5.4 Upper Sand

Native sand was encountered below the fill in Boreholes NIP-01 to NIP-05, RW-01 and RW-02, and at surface in Boreholes NIP-06 and NIP-07. Additional layers of sand were encountered at depth, interbedded with layers of gravelly sand to sandy gravel. The depths at which the various sand layers were encountered are summarized in Table 5.1 along with the corresponding elevations and thicknesses. The sand is generally brown and contains trace to some gravel, trace to some silt and clay, and occasional cobbles. In Borehole NIP-05 a silty sand zone was encountered at a depth of 18 m.

The data obtained from selected boreholes drilled during the 1994 investigation is also summarized in Table 5.1 for reference.

Table 5.1 – Depths, Elevations and Thickness of Sand Layers

Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
NIP-01	8.2 to 9.8 (borehole termination depth)	200.5 to 199.0	1.6
NIP-02	8.2 to 13.7 16.8 to 23.0 30.5 to 35.1	200.7 to 195.2 192.1 to 185.9 178.4 to 173.8	5.5 6.2 4.6
NIP-03	4.0 to 8.8	183.7 to 178.9	4.8

Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
NIP-04	7.6 to 8.4 12.2 to 15.2 18.9 to 20.6	180.1 to 179.3 175.5 to 172.5 168.8 to 167.1	0.8 3.0 1.7
NIP-05	2.3 to 16.0 18.3 to 24.4	205.3 to 191.6 189.3 to 183.2	13.7 6.1
NIP-06	0.0 to 9.8 (borehole termination depth)	205.7 to 195.9	> 9.8
NIP -07	0.0 to 9.8 (borehole termination depth)	205.3 to 195.6	> 9.8
NIP-08	6.1 to 7.9	178.8 to 177.0	1.8
93-2	0.0 to 20.6	197.1 to 176.5	20.6
93-4	0.0 to 8.4 14.4 to 16.5	186 to 177.6 171.6 to 169.5	8.4 2.1
93-5	0.0 to 9.2 17.2 to 20.7	205.0 to 195.8 187.8 to 184.3	9.2 3.5
RW-01	7.5 to 9.8 (borehole termination depth)	201.3	> 2.3
RW-02	0.6 to 9.8 (borehole termination depth)	187.4	> 9.2

SPT ‘N’ values recorded in the sand layers ranged from 11 blows for 0.3 m penetration to 50 blows for 0.025 m penetration, indicating a compact to very dense relative density. In general, the upper sand layer is in a dense to very dense condition.

Samples of the sand had moisture contents ranging from 2% to 24%.

Several samples of the sand were selected for laboratory gradation analysis, the results of which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and the grain size distribution curves for these samples are plotted on Figures B2 to B4, Appendix B.

Soil Particle	Sand (Fig. B2 to B4)	Silty Sand (Fig. B4)
Gravel %	0 to 18	0 to 13
Sand %	76 to 97	40 to 81
Silt and Clay %	2 to 8	-
Silt %	-	17 to 40
Clay %	-	2 to 7

5.5 Gravelly Sand to Sandy Gravel Containing Cobbles and Boulders

Layers of native gravelly sand to sandy gravel were encountered in Boreholes NIP-02 to NIP-05 and NIP-08, interbedded with layers of sand. The depths at which the various gravelly sand to sandy gravel layers were encountered are summarized in Table 5.2 along with the corresponding elevations and thicknesses. The gravelly sand to sandy gravel is brown to grey and contains trace silt and clay and some zones containing cobbles and boulders. Coring methods were required to advance the boreholes through these zones. These zones containing cobbles and boulders are noted on the individual Record of Borehole sheets included in Appendix A.

The data obtained from selected boreholes drilled during the 1994 investigation is also summarized in Table 5.2 for reference.

Table 5.2 – Depths, Elevations and Thickness of Gravelly Sand to Sandy Gravel Containing Cobbles and Boulders

Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
NIP-02	13.7 to 16.8 23.0 to 30.5 35.1 to 39.6	195.2 to 192.1 185.9 to 178.4 173.8 to 169.3	3.1 7.5 4.5
NIP-03	8.8 to 21.6	178.9 to 166.1	12.8
NIP-04	8.4 to 12.2 15.2 to 18.3	179.3 to 175.5 172.5 to 169.4	3.8 3.1
NIP-05	16.0 to 18.3	191.6 to 189.0	2.3
NIP-08	2.3 to 6.1 7.9 to 13.3	182.6 to 178.8 177.0 to 171.7	3.8 5.4
93-2	20.6 to 26.3	176.5 to 170.8	5.7
93-4	8.4 to 14.4	177.6 to 171.6	6.0
93-5	9.2 to 17.2	195.8 to 187.8	8.0

SPT ‘N’ values recorded in the gravelly sand to sandy gravel ranged from 34 blows for 0.3 m penetration to 50 blows for 0.025 m penetration, indicating a dense to very dense condition. In general, sample recovery from the SPT split spoon sampler was quite low. Due to the presence of cobbles and boulders within the gravelly sand/sand and gravel, coring techniques were used to advance the boreholes through these deposits. Samples were collected from the core barrel.

Moisture contents of samples of the gravelly sand/sand and gravel ranged from 8% to 20%

Selected samples of the gravelly sand to sandy gravel underwent laboratory grain size analysis testing. The results of these tests are presented on the Record of Borehole sheets in Appendix A and the grain size distribution curves for these samples are plotted on Figures B6 and B7, Appendix B. The lab results are as follows:

Soil Particle	Gravelly Sand	Sandy Gravel
Gravel %	24 to 53	64
Sand %	41 to 71	30
Silt and Clay %	2 to 6	6

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5.6 Sandy Silt

Native sandy silt was encountered below the interbedded layers of sand and sand and gravel in Boreholes NIP-02, NIP-03, and NIP-05. The sandy silt is grey and contains trace clay.

The thickness of the sandy silt ranged from 7.0 m in Borehole NIP-05 to 12.5 m in Borehole NIP-03. The lower boundary of the sandy silt layer was encountered at depths of 32.9 m and 34.1 m in Boreholes NIP-05 and NIP-03, respectively (Elevations 174.7 and 153.6). 1.9 m of sandy silt was encountered in Borehole NIP-02 however the sandy silt was not fully penetrated and the borehole was terminated at a depth of 41.5 m (Elevation 167.4).

SPT 'N' values recorded in the sandy silt ranged from 34 blows for 0.3 m penetration to 105 blows for 0.225 m penetration, indicating a dense to very dense relative density.

Samples of the sandy silt had moisture contents ranging from 17% to 27%.

Selected samples of the sandy silt underwent laboratory gradation analysis, the results of which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and are plotted on Figure B8, Appendix B.

Soil Particle	Percentage (%)
Gravel	0
Sand	22 to 29
Silt	66 to 73
Clay	2 to 5

Sandy silt was also encountered below the sand and gravelly sand in Boreholes 93-2, 93-4, and 93-5 at depths of 16.5 m (elevation 169.5) to 26.3 m (elevation 170.8) with a lower boundary at a depth of 37.6 m in Borehole 93-5 (Elevation 167.4). The sandy silt was not fully penetrated in Borehole 93-2 and 93-4, which were terminated at depths of 30.8 m and 23.3 m, respectively (Elevations 166.3 and 162.7).

5.7 Silt

A silt layer was encountered below the sandy silt in Boreholes NIP-03 and NIP-05 and below the interbedded sand and gravel layers in Boreholes NIP-04 and NIP-08. The silt is grey and contains trace to some clay and trace to some sand with occasional clay pockets.

The thickness of the silt layer ranged from 7.0 m in Borehole NIP-03 to 29.1 m in Borehole NIP-08. The lower boundary of the silt layer was encountered at depths of 38.1 m to 42.4 m (Elevations 146.6 and 142.6). Borehole NIP-05 penetrated 7.2 m of silt but did not fully penetrate this layer since the borehole was terminated at a depth of 40.1 m (Elevation 167.5). A 2.4 and 3.4 m thick layer of clayey silt was encountered within the silt in Boreholes NIP-04 and NIP-08, respectively. This clayey silt layer is further described in the following section.

SPT 'N' values recorded in the silt ranged from 37 blows for 0.3 m penetration to 100 blows for 0.075 m penetration, indication a dense to very dense relative density.

Moisture contents of samples of the silt ranged from 16% to 28%.

Twelve samples of the silt were selected for laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and the grain size distribution curves for these samples are plotted on Figures B9 and B10 of Appendix B.

Soil Particle	Percentage (%)
Gravel	0
Sand	0 to 18
Silt	80 to 95
Clay	2 to 14

5.8 Clayey Silt

A layer of clayey silt was encountered below the silt in Boreholes NIP-03 and NIP-04. Clayey silt zones were also encountered within the silt in NIP-04 and NIP-08. A thin layer of clayey silt was also encountered in Borehole NIP-05, below the interbedded sand and sand and gravel layers.

The clayey silt layer was 13.7 m to 14.1 m thick in Boreholes NIP-04 and NIP-03, with the bottom of the clayey silt encountered at depths of 51.8 m and 55.2 m in Boreholes NIP-04 and NIP-03, respectively (Elevations 135.9 and 132.6). The clayey silt zones within the silt in Boreholes NIP-04 and NIP-08 were 2.4 m and 3.4 m thick, respectively. These zones were encountered at elevations 156.6 and 157.8. A 1.5 m thick layer of clayey silt was encountered at elevation 183.2 in Borehole NIP-05.

SPT 'N' values recorded in the clayey silt generally ranged from 20 to 48 blows for 0.3 m penetration, indicating a very stiff to hard consistency. At some locations and depths, higher SPT 'N' values were recorded for less than 0.3 m penetration due to the presence of occasional cobbles and/or boulders.

Samples of the clayey silt had moisture contents ranging from 17% to 35%.

Selected samples of the clayey silt underwent laboratory grain size analysis testing and Atterberg Limits testing, the results of which are summarized below. The laboratory test results are also presented on the Record of Borehole sheets in Appendix A and plotted on Figures B11 and B12, Appendix B.

Soil Particle	Percentage (%)
Gravel %	0
Sand %	0
Silt %	67 to 77
Clay %	23 to 33

Index Property	Percentage (%)
Liquid Limit	24 to 25
Plastic Limit	16 to 17
Plasticity Index	7 to 8

The results of the Atterberg Limits tests indicate that the clayey silt is of low plasticity with a group symbol of CL-ML.

Clayey silt was also encountered in Borehole 93-5 at a depth of 37.6 m (Elevation 167.4). The clayey silt was not fully penetrated in this borehole, which was terminated at a depth of 40.1 m (Elevation 164.9).

5.9 Lower Sand

A layer of sand to gravelly sand was encountered below the clayey silt in Boreholes NIP-03 and NIP-04 and below the silt in Borehole NIP-08. The sand is grey and contains some gravel to gravelly, trace silt, and occasional to some cobbles and boulders. Coring methods were required to advance through the cobbles and boulders encountered in this sand layer.

The thickness of the sand layer ranged from 4.5 m in Borehole NIP-03 to 6.7 m in Borehole NIP-08. The lower boundary of the sand layer was encountered at depths of 49.1 m to 59.7 m (Elevations 135.8 to 128.1).

SPT 'N' values recorded in the sand layer ranged from 141 blows for 0.3 m penetration to 100 blows for 0.025 m penetration, indicating a very dense condition. High 'N' values are indicative of the presence of cobbles and boulders within the very dense sand.

Moisture contents of samples of the lower sand layer ranged from 10% to 23%.

Two samples of the sand underwent laboratory gradation analysis, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A and the grain size distribution curves for these samples are plotted on Figure B5, Appendix B.

Soil Particle	Percentage (%)
Gravel %	16 to 30
Sand %	59 to 73
Silt and Clay %	11

A layer of cobbles and boulders, approximately 100 mm thick, was encountered at the bottom of the sand layer, overlying bedrock, in Borehole NIP-03.

5.10 Bedrock

Bedrock was proven by coring in the three boreholes drilled at the location of the proposed pier. The depths and elevations at which bedrock was encountered are summarized in Table 5.3. The bedrock surface slopes down from Borehole NIP-08 to Borehole NIP-03.

Table 5.3 – Depths and Elevations of Bedrock Surface

Borehole	Bedrock Surface	
	Depth (m)	Elevation (m)
NIP-03	59.8	128.0
NIP-04	56.7	131.0
NIP-08	49.1	135.8

The bedrock was described as a blackish grey metasedimentary rock (possibly arkose). Total Core Recovery (TCR) was 100% in all runs. The RQD values ranged from 80 to 100%, indicating good to excellent rock quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was generally less than 3, except within approximately 0.6 m of the bedrock surface where values of 5 to greater than 25 were recorded.

Point Load Tests were conducted on selected rock cores recovered from the boreholes in order to estimate the unconfined compressive strength (UCS) of the rock. UCS values determined from point load testing ranged from 62 MPa to 198 to MPa, indicating a strong to very strong rock.

Selected rock cores also underwent Unconfined Compression Testing. The results of these tests indicate that the UCS values ranged from 48.8 MPa to 101.2 MPa, indicating a medium strong to very strong rock, and are summarized below.

Borehole	Sample Depth (m)	UCS (MPa)
NIP-03	60.3 – 60.5	48.8
NIP-03	61.9 – 62.2	65.2
NIP-08	51.7 – 51.9	78.8
NIP-08	53.9 – 54.1	101.2
NIP-08	57.3 – 57.5	59.6

5.11 Water Levels

Drilling and coring operations require water to be added into the boreholes and therefore groundwater levels were generally not measured in the open borehole during drilling.

A standpipe piezometer was installed in four boreholes at this site upon completion of drilling. The groundwater depths and elevations measured in the piezometers are shown in Table 5.4.

Table 5.4 – Groundwater Depths and Elevations in Piezometers

Borehole	Date	Water Level (m)	
		Depth	Elevation
NIP-02	27-Oct-2011	6.9	202.0
	30-Nov-2011	13.0	195.9
NIP-03	3-Oct-2011	3.6	184.2
	28-Oct-2011	3.4	184.4
	15-Nov-2011	3.5	184.3
	25-Nov-2011	3.5	184.3
NIP-05	28-Oct-2011	7.2	200.4
	30-Nov-2011	15.5	192.1
NIP-08	28-Oct-2011	0.5	184.4
	15-Nov-2011	0.5	184.4
	22-Nov-2011	0.7	184.2

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 water level in the Nipigon River was at Elevation 183.3 m in December 2011, as surveyed by Engineering Northwest Ltd.

5.12 Old Buried Foundations

During the advance piling program, four old pier foundations from the 1936 structures were encountered within the footprint of the new pier. These old foundations were exposed and surveyed.

6 MISCELLANEOUS

The borehole locations were selected by Thurber Engineering and were marked out in the field by Engineering Northwest Ltd. The coordinates and ground surface elevations at the drilled borehole locations were surveyed by Engineering Northwest upon completion of drilling.

Thurber obtained utility clearances for the borehole locations prior to drilling as well as a permit from CN for access to boreholes located at the proposed pier location.

Eastern Ontario Diamond Drilling Ltd. supplied the drill rigs and drilling equipment and conducted the drilling, sampling and in-situ testing operations for the boreholes.

The field program was supervised by Ms. Eckie Siu, Mr. Ryan Kromer, E.I.T, Mr. Stephane Loranger, C.E.T., and Mr. George Azzopardi of Thurber Engineering Ltd. Overall supervision of the field program was provided by Ms. Lindsey Blaine, E.I.T. and Mr. Alastair E. Gorman, P.Eng..

Interpretation of the data and preparation of the report was carried out by Ms. Lindsey Blaine, E.I.T., Mr. Jason Lee, P.Eng. and Mr. Alastair E. Gorman, 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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THURBER

FOUNDATION INVESTIGATION AND DESIGN REPORT
NIPIGON RIVER BRIDGE TWINNING
HIGHWAY 11/17, TOWNSHIP OF NIPIGON
G.W.P. 6047-89-02, STRUCTURE NO. 48C-07-2
W.P. 124-90-01
Geocres Number: 52H-21

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

As part of the Highway 11/17 Twinning Project, a new bridge will be constructed over the Nipigon River to accommodate the eastbound (EB) and westbound (WB) lanes of Highway 11/17.

This report presents interpretation of the geotechnical data in the factual report and the information obtained from an advance piling contract awarded by the Ministry in 2012. The report provides foundation design recommendations for the proposed replacement of the bridge carrying Highway 11/17 over the Nipigon River in the Thunder Bay District, Ontario.

The existing Highway 11/17 is a two-lane paved roadway with one lane each for the EB and WB directions. The existing Nipigon River Bridge is a four-span structure with a total length of approximately 244 m. The abutments and piers are variously supported on shallow and deep foundations. Table 7.1 summarizes the foundation types constructed for the abutments and piers of the existing highway bridge.

Table 7.1 – Foundation Types of the Existing Highway Bridge

Location	Foundation Type
West Abutment	Driven Steel Piles (HP 12 x 53)
Pier #1	Spread Footing
Pier #2	36” diameter Pipe Piles
Pier #3	Driven Steel Piles (HP 12 x 74)
East Abutment	Spread Footing

An old highway bridge, constructed in 1936, was located immediately north of the existing highway bridge. This old bridge was removed following the completion of the existing highway bridge. The piers of the old highway bridge near the west and east banks were left in place. In addition remnants of foundation remain.

A multi-span bridge carrying the CPR mainline over the Nipigon River lies approximately 27 m south of the highway bridge. The CPR Bridge was originally constructed between 1883 and 1885 and was supported on a combination of masonry piers and steel bents. It has been reported that a recent rehabilitation of the bridge reinforced some of the pier foundations and placed concrete jackets around the masonry piers[1]. An abandoned CN track passes under the bridges on the west flood plain.

The Highway 11/17 Twinning Project will create two new lanes to the north of the existing highway to carry the proposed new WB lanes. The proposed new bridge will be a two-span cable-stayed bridge approximately 252 m long and 36 m wide with a maximum span length of 139 m. The new pier and tower will be located on the west side of the Nipigon River near Pier 2 of the existing highway bridge.

Approach embankments to the existing Nipigon River Bridge will be widened to the north side and raised to accommodate the new bridge. The maximum height of the existing west and east approach embankments are approximately 8.2 m and 2.3 m, respectively. The maximum grade raise at the highway centreline of new approach embankments are 4 m and 3.3 m at west abutment and east abutment, respectively. Up to 13 m of new fill will be added to the existing north embankment slope at the west approach. Multi-levelled retaining walls consisting of reinforced soil systems (RSS) will be required due to the Right-of-Way (ROW) constraint and construction of a 3 m wide walkway on the west approach embankment slope. The total length of RSS to be constructed is approximately 420 m.

Structural loads used for the foundation design of the Abutments and Pier were provided by McCormick Rankin. These loads are summarized in Appendix G.

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 McCormick Rankin.

8 ASSESSMENT OF FOUNDATION ALTERNATIVES

Subsurface stratigraphy encountered at this bridge site consists of interbedded layers of compact to very dense sand and gravelly sand overlying very dense sandy silt to silt, which is in turn underlain by hard clayey silt and a lower layer of very dense gravelly sand overlying bedrock. Sand fill was encountered at the west and east abutments overlying the native compact to very dense sand and gravelly sand layers. At the proposed pier location, the native soils are underlain by slightly weathered to fresh meta-sedimentary bedrock encountered at a depth of 49 to 60 m (Elevation 128 m to 136 m).

The groundwater level at the pier is above Elevation 184.2 and the water level in the Nipigon River was noted to be at Elevation 183.3 m on December 7, 2011. At the abutments, water level ranges from Elevation 192.1 m at the east abutment to Elevation 195.1 m at the west abutment.

[1] *Rehabilitation of Masonry Piers at Nipigon, Ontario, Daniel E. J. Adamson, P.Eng., Canadian Pacific Railway*

The following sections provide a comparison of the available foundation alternatives in the context of soil and groundwater conditions encountered at the project site. Table 8.1, appended at the end of the text, provides the respective advantages and disadvantages of each foundation alternative.

8.1 Spread Footings

Spread footing is not considered a suitable foundation option for the pier given the high scour potential resulting from the adjacent Nipigon River flow and high loads.

At the bridge abutments, spread footings are also not considered suitable due to scour potential of the east river bank during high river level seasons which precludes the use of spread footings as the abutment foundation may become unstable near the slope.

For these reasons, the option of spread footings has not been developed further.

8.2 Caissons or Drilled Shafts socketed into bedrock

In light of the significant load that will be carried by the foundations of the pier and tower (see Appendix G), large diameter (in the order of 2 m or more) and deep caissons (50 to 60 m deep) socketed into bedrock will likely be required to carry the bridge load. The presence of deep granular deposits and high groundwater table at the bridge site will pose challenges for maintaining the wall and basal stability of the caissons during its excavation and concrete pouring. Specialized installation equipment and a specialized contractor will be required to install these large diameter caissons and socket them into bedrock. Furthermore, the borehole data indicates sloping bedrock at the pier location and it may be difficult to obtain an effective seal between the caisson liner and the bedrock to exclude sands and gravel flowing into the rock socket. Installation of these large diameter caissons socketed into bedrock is anticipated to be expensive and not cost-effective.

For the above reasons, the option of caisson or socketed drilled shaft was not developed further.

8.3 Steel Pipe Piles

Pier 2 of the existing bridge is supported on 0.9 m diameter pipe piles. Once again for the high pier loads, larger diameter (1.8 m or more) pipe piles driven to bedrock may be required to support these pier loads. Steel pipe piles driven into these dense ground conditions may sustain significant tip damage if they encounter obstructions. Furthermore the vibration generated due to driving these deep pipe piles may be higher than that from other pile types.

For these reasons, the option of pipe piles was not developed further.

8.4 Steel H-Piles

The subsurface stratigraphy at this site is considered suitable for steel H-piles driven to bedrock and is the preferred foundation option at this bridge site. Piles driven to bedrock will provide high carrying capacity and relatively low susceptibility to installation damages in ground conditions typical of this site. This option has the added advantage that the pile driving experience is readily available in the Province of Ontario. HP 310x110 and HP 360x132 are selected for abutments and pier foundations, respectively, to meet both the load capacities and serviceability requirements.

9 ADVANCE PILING CONTRACT

Due to the critical importance of the pier foundation of a cable-stayed bridge, an advance piling contract was carried out at the pier foundation between July 6 and September 12, 2012. This program was carried out after the assessment of all feasible foundation types had concluded that driven piles were the preferred solution at this site. Based on the site stratigraphy and using static analysis, it was anticipated that friction piles in the order of 30 m long would develop a factored ultimate resistance of 2,000kN.

A total of 26 piles (HP 360x132) were driven to depths ranging from 32 m to 82.6 m. Titus rock injector points were attached to all pile tips to provide protection during driving. A Delmag D46-32 hammer with rated energy of 70 to 145 KJ was used to drive the piles. No pre-augering was required to drive the piles.

The first 6 piles were driven to Elevation 153 m. The subsurface condition at a tip elevation of 153 m consisted of a dense to very dense silt layer. Dynamic pile testing involving the application of Hiley Formula on these first 6 piles yielded a range of ultimate axial pile capacities from 1762 to 3017 kN for piles driven to depths ranging from 29.8 to 35.0 m. The test results suggest that the geotechnical resistance of the friction piles would range between 881 and 1509 kN, which is well below the anticipated geotechnical resistance of 2,000 kN per pile.

The results obtained from these initial six piles were discussed in a series of meetings and teleconferences involving:

- MTO Region staff
- MTO Foundations Group
- McCormick Rankin
- Thurber

It was agreed in these meetings that piles with a maximum factored resistance of 1,500 kN would not permit a viable foundation design for the pier. Accordingly, it was decided to advance all remaining 20 piles to bedrock, which had been identified to lie at Elevation 128 to 135.8 m based on the available borehole data. The lengths of piles driven to bedrock or to refusal in a dense gravelly sand layer just above the bedrock ranged from 51.5 to 64.5 m below a cut-off elevation of 189.5 m. All of these piles were driven to a final refusal set between 0.7 and 1.8 mm/blow. For detailed information of the advance piling contract, reference should be made to Thurber’s Report No.3 (Final Report)[2], dated January 30, 2013.

Field monitoring, including ground vibration, tilt and settlement of existing CPR piers and bents and MTO Bridge Pier No. 2, was carried out during the course of the advance piling contract. The program was designed not only to monitor the performance of the CPR and MTO bridges during pile driving but also to monitor vibration along the east bank of the Nipigon River where there is a fish spawning area as requested by Ministry of Natural Resources (MNR). In general, the

[2] *Pile Driving Summary Report, Nipigon River Bridge Pier Advance Piling Contract, Hwy 11/17, Nipigon, Ontario, January 30, 2013*

measured structure vibration due to piling was below the review level of 8 mm/s PPV (peak particle velocity) albeit with occasional spikes. Tilting of the piers and bents measured by tiltmeters was essentially below the detection limit. Settlements monitored by level survey were consistently below the review level of 5 mm. For detailed description and interpretation of the monitoring data, reference should be made to Thurber's Report No.2 (Final Report)[3], dated November 2, 2012.

10 AXIAL PILE CAPACITY

Axial bearing capacities of HP 310x110 (Min. Grade 350W) at the abutments and HP 360x132 (Min. Grade 350W) at the pier were assessed based on the soil and groundwater conditions at the proposed foundation locations in conjunction with the results of the advance piling contract. It is recommended that piles be driven to bedrock at the pier and to a minimum of 20 m depth below the underside of the pile caps at the abutments. Table 10.1 summarizes the axial geotechnical resistances for both abutment piles and pier piles that may be used for design.

Table 10.1 – Recommended Axial Geotechnical Resistances

Location	Pile Type	Proposed Elevation at U/S of Pile Cap	Estimated Pile Length	Estimated Pile Tip Elevation	Factored ULS / pile (kN)	SLS / pile (kN)
West Abutment	HP 310x110	204.5	20 m	184.5	850	650
East Abutment	HP 310x110	203.0	20 m	183.0	850	650
Pier	HP 360x132	184.0	46 to 59m (Driven to bedrock)	125 to 138	3000 (*)	Does not govern for piles driven to bedrock.

Note (*): The piles should be designed on the basis of acceptable structural resistance as per CHBDC and MTO Bridge office design bulletin on capacity of Steel H-piles dated April 29, 2013. The value of 3000 kN has been chosen in discussion with the MTO Northwest Region and MTO Foundations Office and subject to confirmation of the structural resistance of the piles by the structural designer.

It is understood that the HP 310x110 steel piles supporting the north half of the west abutment and stairway will be installed through granular fill that will be placed with the rock fill embankment. Rock fill is proposed to be placed to approximate Elevation 197 to 198 m. Above Elevation 197 to 198 m, granular soil is proposed to be placed where piles will be driven through the embankment with rock fill being placed elsewhere simultaneously. A layer of filter fabric is recommended to separate the granular soil and rock fill in order to prevent loss of granular soil into the rock fill at the interface.

[3] *Summary of Vibration, Settlement and Tilt Monitoring of The MTO and CPR Structures During Driving of Test Piles, Nipigon River Bridge Pier Advance Piling Contract, Hwy 11/17, Nipigon, Ontario, November 2, 2012*

11 LATERAL PILE CAPACITY

Assessment of lateral geotechnical resistances of steel H-piles were carried out using the commercially available software LPILE 6.0 (developed by Ensoft Inc.) and assuming that the pile head is rigidly connected to the pile cap. Table 11.1 summarizes the recommended lateral pile resistances for both abutment piles and pier piles.

Table 11.1 – Recommended Lateral Pile Resistances

Location	Pile Type	Estimated Pile Length	Factored ULS (kN)		SLS (kN)	
			Load perpendicular to flanges	Load perpendicular to web	Load perpendicular to flanges	Load perpendicular to web
Abutments	HP 310x110	20 m	180	120	120	80
Pier	HP 360x132	46 to 59 m (Driven to bedrock)	250	150	180	110

The above lateral pile capacities are for a single pile with no consideration given to group effect due to pile spacing. For piles closely spaced in a pile group, following reduction factors should be applied:

For loading direction perpendicular to the pile alignment:

Centre-to-Centre Pile Spacing (D – Pile Width or Diameter)	Subgrade Reaction Reduction Factor
1D	0.50
2D	0.67
3D	0.83
≥ 4D	1.00

For loading direction parallel to the pile alignment:

Centre-to-Centre Pile Spacing (D – Pile Width or Diameter)	Subgrade Reaction Reduction Factor
3D	0.25
4D	0.40
6D	0.70
≥ 8D	1.00

For intermediate pile spacing not listed in the above tables, reduction factors can be obtained by linear interpolation.

12 SETTLEMENT OF ABUTMENTS AND PIER PILES

Settlement of the abutment footings (pile caps) was estimated based on the structural loads provided by McCormick Rankin using the commercially available software GROUP 8.0 developed by Ensoft Inc. A summary of the estimated immediate settlement per construction stage is given in Table 12.1.

Table 12.1 – Estimated Settlements of Abutments

Location	Stage 1		Final Stage	
	North Half	South Half	North Half	South Half
West Abutment	4 mm	N/A	1 mm	5 mm
East Abutment	3 mm	N/A	1 mm	4 mm

The bridge pier will be supported on H-piles driven to bedrock. Settlement of the bedrock is not expected however it is anticipated that there will be deformation associated with elastic compression of the steel H-piles subject to the high structural loads.

13 PILE INSTALLATION

Pile installation must be carried out in accordance with OPSS 903. The contract must specify that HP 360x132 steel piles (Min. Grade 350W) shall be driven to bedrock at the pier and that HP 310x110 steel piles (Min. Grade 350W) shall be driven to a minimum of 20 m below the underside of pile caps at the abutments and controlled by the dynamic pile driving test as per Standard SS103-11.

13.1 Piles at Bridge Pier

Given the possible presence of cobbles and boulders in the gravelly sands just above the bedrock, some piles may encounter refusal above the anticipated bedrock elevations at the pier location. The borehole information also indicates sloping bedrock condition at the pier. Pile tips should be equipped with rock injector point, such as Titus Rock Injector points, to reduce the potential for the pile tip sliding on the sloping bedrock surface and to minimize tip damage during driving through the soil layer containing cobbles and boulders.

Old buried concrete foundations believed to belong to the 1936 structure and an old mud slab were encountered within 2 m of the ground surface in the advance piling contract area and it was not possible to drive the piles through these obstructions. These obstructions were exposed and were surveyed. The obstructions must be plotted on the contract drawings and the contract documents must specify how the contractor will be expected to deal with the obstructions.

In the north half of the pier foundation footprint, some dense to very dense layers of cobbles and boulders encountered at about 5 m depth forced piles to move out of location and alignment. The cobbles and boulders were removed by excavation and the resulting excavation backfilled with crusher run gravel prior to continuing driving of the piles in the advance piling contract. This solution was adopted by the contractor and proved to be effective.

Based on the experience gained from the Advance Piling Contract, the following recommendations are made for the pier piles:

- Full time inspection of pile driving and confirmation of pile set by experienced geotechnical personnel is recommended for the remaining pile installation.
- For the final pile driving contract, the contract must specify removal of the obstructions identified during the advance piling program including though not necessarily limited to the buried foundations and mud slab.
- The contract documents must identify that cobbles and boulders may be encountered within the footprint of the pier and alert bidders to the need to allow for excavation and replacement or other methods such as pre-augering in order to overcome the obstructions.
- The Pile driving note on the foundation drawing should say: “Piles to be driven to bedrock.”
- The tips of the HP 360x132 piles must be protected with Titus Steel rock injector points, or other equivalent, to reduce tip damage and to reduce the potential of piles slipping on the sloping bedrock surface.
- The piles must be driven using a hammer capable of delivering a rated energy of 70 kJ to 120 kJ.
- Each pile should be set using the following steps:
  - Continuous pile driving record (Number of blows per 200 mm of pile penetration) must be kept for each pile.
  - In general the dynamic pile driving test as per Standard SS103-11 should be started when the piles are within 3 m of the design tip elevation.
  - A Hiley plot must be generated when more than 10 blows for 20 mm of penetration has been encountered.
  - The final set of the pile and associated dynamic pile driving test as per SS103-11 should be achieved using the lowest energy setting of the hammer (approximately 70 kJ).
  - A minimum of 20 blows should be used for the Hiley plot.
  - An average set from the 20 blows recorded on the Hiley plot should be calculated.
  - The Pile is set if the average is less than 1.5 mm per blow.

It is understood that sheet piles will be installed adjacent to the east and north sides of the pier for erosion protection purpose. In order to facilitate the sheet pile installation, it is recommended that:

- Prior to driving sheet piles near the river, all soils at the sheet pile locations should be excavated to an elevation of 182.5 m or to the ground water table to remove any cobbles or boulders that may exist near the surface. The excavation shall be filled with non-cohesive material passing 150 mm sieve. Final excavation depths for removal of cobbles and boulders prior to sheet piling shall be determined by an experienced geotechnical engineer on site.

- Sheet piles should be provided with sheet pile tip protector to minimize tip damage during installation.

13.2 Piles at Bridge Abutments

Pile driving at the abutments must be controlled by the dynamic pile driving test as per Standard SS103-11. The Hiley Formula need not be used until the piles are within 3.0 m of the design tip elevations (elevation 184.5 for west abutment and elevation 183.0 for east abutment). The appropriate pile driving note is "Piles to be driven in accordance with Standard SS103-11 using an ultimate geotechnical resistance of "R" kN per pile". "R" must have a minimum value of twice the design load at ULS but must not exceed 1700 kN for HP 310x110 piles.

If a pile has not developed the specified resistance after being driven 2 m beyond the design pile tip elevation, the contractor shall stop pile driving and check the Hiley calculation and all input values. If calculation still shows that the pile has not reached the specified resistance, the following procedure should be implemented:

1) Stop driving in that pile group for 48 hours (minimum);
2) After 48 hours, warm up the hammer on another pile then re-tap the subject pile and measure the resistance;
3) If the pile still does not reach the specified resistance, the Quality Verification Engineer (QVE) must immediately advise the Contract Administrator (CA) who, in turn, should refer the issue to the design team.

Since the abutment piles are designed as friction piles, driving shoes should not be used. The abutment piles should be driven using a hammer capable of delivering a rated energy of 50 to 100 kJ.

14 MONITORING OF THE EXISTING CPR BRIDGE DURING PILE DRIVING

Although the vibration, tilt and settlement monitoring of the CPR structure during the advance piling contract indicated that the structure vibration levels, settlements and tilting of the piers and bents were below the review and detection levels, consideration should be given to continuing a reduced level of monitoring of the fish spawning area and the CPR bridge during the installation of the remaining piles.

15 APPROACH EMBANKMENTS / REINFORCED SOIL SYSTEMS (RSS)

15.1 Embankment Widening

Grade raise and platform widening of the existing approach embankments will be required to accommodate the new bridge abutments. The maximum grade raise at the new highway centreline of the approach embankments are 4 m and 3.3 m at west abutment and east abutment, respectively. The existing approach embankments will be widened to the north side. Up to 13 metres of new fill will be added to the existing north embankment slope at the west approach. Rock fill must be used as the primary fill material for the embankment construction. All embankment construction including rock fill embankment must be carried out in accordance with OPSS 206.

15.2 RSS System

Multi-leveled retaining walls consisting of reinforced soil systems (RSS) will be required due to the Right-of-Way (ROW) constraint and construction of a 3 m wide walkway on the west approach embankment slope. The total length of RSS to be constructed is approximately 407 m. RSS retaining walls will be installed at three locations of the new west approach embankment, i.e. north toe of slope, north shoulder and south mid-slope between approximate Sta. 26+150 and 26+315.

15.2.1 Global Stability

The borehole information indicates that the foundation soils governing stability of the approach embankments and RSS retaining walls consist of existing sand fill and native compact to dense sand. These foundation soils are considered suitable for support of the RSS walls. Topsoil, loose fill and any excessively soft/loose native materials must be stripped from the footprint of the RSS walls.

Based on the embankment section drawings provided by McCormick Rankin, the rock fill embankment slopes at the west approach are proposed to be built to 1.25H: 1V. The global stability of RSS walls (RSS Wall #2) up to 4 m high founded either on the existing compact to dense sand fill or the new rock fill at the north shoulder was found to be satisfactory. Table 15.1 summarizes the minimum RSS wall widths and highest founding elevations required to achieve a minimum factor of safety of 1.3 for global stability.

The minimum RSS wall widths shown in Table 15.1 indicate the minimum tie strip lengths of RSS mass required to maintain the global stability of the RSS systems. The minimum RSS wall width does not include the width of precast concrete facing panel or wire basket.

Table 15.1 – Minimum RSS Wall Widths and Highest Founding Elevations (West Approach)

Stations			**RSS Wall #1 (North Toe of Slope)**		**RSS Wall #3 (South Mid-Slope)**	
Hwy 11/17 Mainline	RSS Wall #1	RSS Wall #3	Minimum RSS Wall Width (m)	Highest Founding Elevation (m)	Minimum RSS Wall Width (m)	Highest Founding Elevation (m)
26+315	1+295	-	1.0	187.25	-	-
26+310	1+290	-	3.75	187.25	-	-
26+305	1+285	-	5.0	187.25	-	-
26+300	1+280	3+536	6.5	188.0	2.75	202.25
26+295	1+275	3+531	7.5	187.0	3.5	202.5
26+290	1+270	3+526	7.0	187.5	2.0	203.5
26+280	1+260	3+516	6.0	190.5	2.25	203.5
26+270	1+250	3+506	3.75	194.5	2.5	203.5

Stations			RSS Wall #1 (North Toe of Slope)		RSS Wall #3 (South Mid-Slope)	
Hwy 11/17 Mainline	RSS Wall #1	RSS Wall #3	Minimum RSS Wall Width (m)	Highest Founding Elevation (m)	Minimum RSS Wall Width (m)	Highest Founding Elevation (m)
26+260	1+240	3+496	3.0	196.5	3.0	203.5
26+250	1+230	3+486	2.0	199.0	3.5	203.5
26+240	1+220	3+476	2.5	199.0	4.0	203.0
26+230	1+210	3+466	3.0	199.0	4.5	203.0
26+220	1+200	3+456	3.0	199.5	5.0	203.0
26+210	1+190	3+446	2.0	199.5	5.0	203.0
26+200	1+180	3+436	2.0	199.5	5.25	203.5
26+190	1+170	3+426	2.0	199.5	4.5	205.5
26+180	1+160	3+416	2.25	199.5	4.5	205.5
26+170	1+150	3+406	3.0	200.0	4.5	205.5
26+160	1+140	-	3.25	200.5	-	-
26+150	1+130	-	3.5	200.5	-	-

RSS wall stations shown in Table 15.1 are approximate due to the curvature of wall alignments. Reference shall be made to the Highway 11/17 mainline station for minimum RSS wall width and highest founding elevation required when designing the RSS walls.

The RSS walls should be constructed to the dimensions shown in Table 15.1. Dimensions of RSS walls between stations can be obtained by linear interpolation. The above minimum RSS wall widths and highest founding elevations must be provided in a Non-Standard Special Provision (NSSP).

15.2.2 Bearing Capacity

The performance of a RSS wall is dependent on, among other factors, the characteristics of its foundation. Failure to provide an adequate foundation may lead to excessive settlement and distortion of the RSS wall and, in severe cases, possible failure of the system. It is critical that the RSS walls are not subject to excessive settlement due to compression of the foundation soils and embankment fill. The foundation of the entire RSS mass must be considered from the face of the wall to the furthest extent of the reinforcement strips.

For RSS walls founded on the native compact sand typical at the toe of north slope, the following geotechnical resistances may be used:

- Factored Geotechnical Resistance at ULS = 450 kPa
- Geotechnical Resistance at SLS = 300 kPa.

The geotechnical resistances provided above are for concentric, vertical loading. The effects of load inclination and eccentricity need to be taken into account according to the Canadian Highway Bridge Design Code (CHBDC) Clause 6.7.3 and Clause 6.7.4.Any engineered fill placed under the

RSS mass to achieve the design founding level must consist of OPSS Granular A or Granular B Type II compacted to 100% of its Standard Proctor Maximum Dry Density (SPMDD) at a moisture content within 2% of optimum. The engineered fill pad must extend at least 500 mm beyond the limits of the RSS mass and levelling strip. For all RSS walls, a minimum 150 mm thick engineered fill pad should be placed for support of RSS mass.

15.2.3 Settlement

Settlements of the RSS walls located at the south mid-slope and north shoulder of the west approach will occur primarily during the RSS wall construction. Settlements following the RSS wall construction were estimated to be minimal and will not affect the serviceability of the RSS walls.

Following the completion of the RSS wall construction at the north toe of slope, settlements of the RSS walls will take place primarily due to the fill placement above the top of RSS walls. The maximum settlements at the base of RSS walls were estimated to vary from 20 to 60 mm from the outer face of the RSS walls to the furthest extent of the reinforcement strip. For every 10 m long section, the maximum differential settlements at the base of RSS walls along the embankment alignment were estimated to vary from 5 to 20 mm at the outer face and from 15 to 60 mm at the furthest extent of reinforcement strip, respectively.

The design of RSS walls must take into account the differential settlements of the RSS walls. Considerations may be given to postponing the installation of facing panels until the completion of settlement due to fill placement.

The entire RSS wall block must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall on compact sand or engineered fill may be estimated using ultimate friction coefficients of 0.5 and 0.6, respectively. These are "ultimate" values and require a degree of sliding movement (typically less than 5 mm) to occur to fully mobilize the resistance. The internal stability of the RSS wall must be analyzed by the supplier/designer of the proprietary product selected for this site.

The Contract Drawings must 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 walls.

16 ABUTMENT BACKFILL AND LATERAL EARTH PRESSURES

The backfill to the abutment walls must be Granular A or Granular B Type II and should be in accordance with OPSS 902. Granular backfill should be placed to the extents shown in OPSD 3101.150. The design of the abutment must include a subdrain as shown in OPSD 3102.100.

All granular material must meet the specifications of Special Provision 110S13 (June 2011). Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS 501.

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 16.1)

γ = unit weight of retained soil (see Table 16.1)

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 given in Table 16.1.

The coefficients in Table 16.1 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 under Clause C6.9.1 in the Commentary to the CHBDC.

Table 16.1 – Earth Pressure Coefficients (K)

Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32°, \gamma = 21.2$ kN/m^3		Rock Fill (Max. Size = 150 mm) $\phi = 42°, \gamma = 19$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active, K_A (Unrestrained Wall)	0.27	0.39*	0.31	0.47*	0.20	0.26*
At-rest, K_0 (Restrained Wall)	0.43	-	0.47	-	0.33	-
Passive, K_P	3.7	-	3.3	-	5.0	-

* For wing walls.

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge must be added. The magnitude must 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 at a depth of 1.7 m for Granular A or Granular B Type II.

17 FROST PROTECTION

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

18 EROSION CONTROL AND SCOUR PROTECTION

Erosion protection must be provided for all foundation units and embankment slopes. Typically, rock protection should be provided over all surfaces with which river flow is likely to be in contact.

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

Due to high scour potential at the pier location, scour protection must be provided for the pier foundation. It is recommended that sheet piles be installed at the pier foundation. The installation depth of sheet piles must be determined based on, among other factors, scour depth, rate of scour and stability of the sheet piles. A detailed scour protection design must be done by a qualified engineer specialized in the field.

19 EXCAVATION, ROADWAY PROTECTION AND GROUNDWATER CONTROL

Excavations for construction of pile caps at the abutments and pier are expected to be limited to the existing gravelly sand fill above the water level in the Nipigon River.

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the sand fill and granular soils above the water level is classified as a Type 3 soil and cohesionless soil below the water level is classified as Type 4 soil.

Roadway protection will be required to facilitate staging of bridge construction at this site. Temporary roadway protection must be provided in accordance with OPSS 539 and designed for Performance Level 2. Performance level may be increased based on the displacement tolerance of the existing structure. The protection systems must be designed by a licensed Professional Engineer experienced in design of shoring with consideration of adjacent traffic loads and any sloping retained surfaces. Based on available subsurface information, a shoring system consisting of steel sheet piles or soldier piles with timber lagging may be considered.

The Contractor must be prepared to pump from sumps to remove any seepage water or surface water collecting in an excavation at the abutment locations. At the pier location, the proposed base of the pile cap is at Elevation 184 m. The groundwater conditions at this site indicate that groundwater may enter pile cap excavations in the form of seepage through the cohesionless fills and native soils

It is recommended that the Contract Documents identify a river level against which the cofferdam must provide protection and prevent flooding of the work area. The appropriate river level should be determined by a river hydrologist but should probably be at least the expected spring freshet level or the level reached during a storm of an appropriate return period. It may be useful also to give the peak flow velocity to allow the Contractor to design appropriate protection for the cofferdam.

Where a cofferdam is required, the design of the cofferdam must be carried out by the Contractor.

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

20 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 0.036

The soil profile type has been classified as Type II based on a primarily cohesionless soil deposit with thickness exceeding 60 m. Therefore, according to Table 4.4.6.1 of the CHBDC, a Site Coefficients "S" (ground motion amplification factor) of 1.2 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 20.1 may be used:

Table 20.1 – Earth Pressure Coefficients for Earthquake Loading (K_E)

Condition	Earth Pressure Coefficient (K_E)					
	OPSS Granular A or Granular B Type II $\phi = 35°, \delta = 17°$		Existing Sand Fill or OPSS Granular B Type I $\phi = 32°, \delta = 16°$		Rock Fill (Max. Size = 150 mm) $\phi = 42°, \delta = 21°$	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active (K_{AE})*	0.25	0.39	0.28	0.48	0.18	0.26
Passive (K_{PE})*	3.6	-	3.2	-	5.0	-
At-rest (K_{0E})**	0.47	-	0.52	-	0.38	-

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

In Table 20.1, the angle of friction between the wall and the backfill, δ, is taken as 50% of the angle of internal friction of the backfill, ϕ.

The potential for liquefaction of the foundation soils has been assessed using the Seed and Idriss (1971) method[4]. Using this method, it was determined that the foundation soils at the abutments and pier are not in danger of liquefaction under earthquake loading.

[4] Seed, H.B. and Idriss, I.M. 1971, "Simplified Procedure for Evaluating Soil Liquefaction Potential" *Journal of Soil Mechanics and Foundations Division,* ASCE, Vol. 101, No. SM9, pp. 1249 – 1273.

21 CONSTRUCTION CONCERNS

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

- Full-time pile inspection and a reduced level of monitoring of ground vibration and tilt and settlement of the nearby structures should be continued for the installation of the pier and abutment piles. Efficient communications among parties involved must be maintained during the course of pile installation to facilitate necessary adjustments and expedite the piling operation.
- The native sands and gravels at this site contain cobbles and boulders. The possibility exists that piles may encounter refusal in cobbles and boulders above the anticipated founding elevation, and that piles within a group may achieve refusal at different elevations. The bedrock surface elevation may vary from that encountered in the boreholes.

  It is important that the founding elevations of the piles be monitored closely and any significant deviation from the predicted elevation must be reported to the design team for assessment. "Significant" in this instance can be taken as 2 to 3 m.
- Excavation for pile cap construction is expected to encounter sands and gravels containing cobbles and boulders. Excavation may be laborious and require removal of large boulders. Buried foundations must be removed for the pier footprint area and replaced with compacted crusher run gravel.
- If sheet piling is used for scour protection or temporary roadway protection, installation into the native sands and gravels may be difficult due to the presence of cobbles and boulders. Fills may also contain other obstructions that may impact sheet pile installation. Under these circumstances, Contractors must allow for the possibility of excavating the obstructions or pre-drilling prior to sheet pile installation.

22 CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Mr. Keli Shi, P.Eng. and Mr. Jason Lee, P.Eng. The report was reviewed by Mr. Alastair Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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TABLE 8.1 COMPARISON OF FOUNDATION ALTERNATIVES

Footings on Native Soil or Engineered Fill	Caissons	Steel Pipe Piles	Steel H-Piles
Advantages: i. Generally less costly construction than deep foundations.	***Advantages:*** i. Construction of caissons could continue in freezing weather. ii. Higher geotechnical resistance than steel pipe piles and H-piles can be achieved with large diameter caisson socketed into bedrock.	***Advantages:*** i. Higher geotechnical resistances can be achieved if piles are driven to bedrock. ii. Installation of piles could continue in freezing weather. iii. Foundation construction may require less volume of excavation than footings.	***Advantages:*** i. Higher geotechnical resistances can be achieved if piles are driven to bedrock. ii. Installation of piles could continue in freezing weather iii. Foundation construction may require less volume of excavation than footings. iv. Suitable for integral abutment.
Disadvantages: i. Scour potential at the pier and east river bank. ii. Dewatering will be required at the pier, depending on depth of excavation. iii. Large foundation settlement likely when subjected to high structural loading. iv. Relatively low resistance to horizontal loads.	***Disadvantages:*** i. Specialized installation techniques and a specialized contractor will be required for large diameter caisson socketed into bedrock. ii. Potential difficulty in cleaning and inspecting bases. iii. Expensive compared with other alternatives.	***Disadvantages:*** i. Pile lengths required to achieve design resistance may vary due to varying depth to bedrock. ii. Pile ends are prone to sustain significant damage due to obstructions in the native soils. iii. Relatively more expensive than footings and H-piles.	***Disadvantages:*** i. Pile lengths required to achieve design resistance may vary due to varying depth to bedrock. ii. May require tip protection due to presence of obstructions in the native till deposit.
NOT RECOMMENDED	**NOT RECOMMENDED**	**NOT RECOMMENDED**	**RECOMMENDED FOR PIER AND ABUTMENTS**

Appendix A

Record of Borehole Sheets
(Current Investigation)

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

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

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

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value — Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT — Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

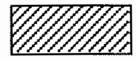
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels,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

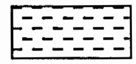
EXPLANATION OF ROCK LOGGING TERMS

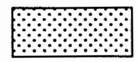
ROCK WEATHERING CLASSIFICATION

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

SYMBOLS


CLAYSTONE


SILTSTONE


SANDSTONE


COAL


Bedrock (general)

DISCONTINUITY SPACING

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

TERMS

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

STRENGTH CLASSIFICATION

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

THURBER

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NIP-01

METRIC

WP# 124-90-01	LOCATION N 5 431 984.9 E 213 165.5		ORIGINATED BY ES
HWY 11/17	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY MFA
DATUM Geodetic	DATE 2011.09.20 - 2011.09.20		CHECKED BY LRB

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

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS (GR SA SI CL)
208.7						
0.0	**ASPHALT:**(150mm)					
0.2	**SAND**, trace to some gravel, trace to some silt Dense to Compact Brown Damp to Moist (FILL)	1	GS			
					208	
		1	SS	41		
		2	SS	25	207	
		3	SS	38		4 77 19 (SI+CL)
					206	
		4	SS	27		
					205	
					204	
		5	SS	15		
					203	
		6	SS	17		
					202	
201.4 / 7.3	Gravelly **SAND**, trace silt Compact Brown Moist (FILL)					
					201	
		7	SS	10		32 60 8 (SI+CL)
200.5 / 8.2	**SAND**, some gravel, trace silt Compact Brown Moist					
					200	
	Occasional cobbles					
		8	SS	22		
199.0 / 9.8	END OF BOREHOLE AT 9.8m.					

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 NIP-01

METRIC

WP#	124-90-01	LOCATION	N 5 431 984.9 E 213 165.5	ORIGINATED BY	ES
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.09.20 - 2011.09.20	CHECKED BY	LRB

SOIL PROFILE			SAMPLES					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										
	BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.15m, THEN ASPHALT 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 NIP-02

METRIC

WP#	124-90-01	LOCATION	N 5 431 980.3 E 213 178.6	ORIGINATED BY	RK
HWY	11/17	BOREHOLE TYPE	HW Casing and Coring	COMPILED BY	AN
DATUM	Geodetic	DATE	2011.09.23 - 2011.09.28	CHECKED BY	LRB

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	WATER CONTENT (%)	GR	SA	SI	CL
208.9										
0.0	**ASPHALT:**(200mm)									
0.2	Gravelly **SAND**, trace to some silt Compact to Very Dense Brown Moist (FILL)									
					208					
		1	SS	13		~5				
		2	SS	29		~21				
					207					
		3	SS	17		~19				
					206					
		4	SS	35		~6	26	62	12 (SI+CL)	
					205					
		5	SS	41	204	~19				
					203					
	No recovery	6	SS	50/ .125						
					202					
		7	SS	66	201	~15	30	63	7 (SI+CL)	
200.7 / 8.2	**SAND**, trace to some gravel, trace silt Compact to Dense Brown Moist									
					200					
	No recovery	8	SS	18						
					199					

Continued Next Page

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

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

ONTMT4S 1180.GPJ 2012TEMPLATE(MTO).GDT 2/4/13

RECORD OF BOREHOLE No NIP-02

METRIC

WP# 124-90-01	LOCATION N 5 431 980.3 E 213 178.6	ORIGINATED BY RK
HWY 11/17	BOREHOLE TYPE HW Casing and Coring	COMPILED BY AN
DATUM Geodetic	DATE 2011.09.23 - 2011.09.28	CHECKED BY LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND, some gravel, trace silt Compact to Dense Brown Moist						
		9	SS	49	198	~21	
					197		
		10	SS	13		~17	
					196 (water level)		
195.2 / 13.7	**SAND** and **GRAVEL**, trace silt Very Dense Brown Moist Cored from 13.7m to 16.8m	11	SS	100/ .280	195	~17	39 57 4 (SI+CL)
					194		
	No recovery	12	SS	50/ .075			
					193		
192.1 / 16.8	**SAND**, fine grained, trace silt Dense Brown Moist	13	SS	42	192	~24	
					191		
		14	SS	50		~21	
					190		
					189		

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 NIP-02

METRIC

WP#	124-90-01	LOCATION	N 5 431 980.3 E 213 178.6	ORIGINATED BY	RK
HWY	11/17	BOREHOLE TYPE	HW Casing and Coring	COMPILED BY	AN
DATUM	Geodetic	DATE	2011.09.23 - 2011.09.28	CHECKED BY	LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SAND, fine grained, trace silt Dense Brown Moist		15	SS	42		~17	0	93	7 (SI+CL)	
			16	SS	50/ .025	186	~15				
185.9 23.0	**SAND** and **GRAVEL**, trace silt, occasional cobbles Very Dense Brown Wet Cored from 23.0m to 32.0m										
			17	SS	95		~12	53	41	6 (SI+CL)	
	No recovery		18	SS	100/ .125						

Elevation scale: 188, 187, 186, 185, 184, 183, 182, 181, 180, 179

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

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

RECORD OF BOREHOLE No NIP-02

METRIC

WP# 124-90-01 | LOCATION N 5 431 980.3 E 213 178.6 | ORIGINATED BY RK

HWY 11/17 | BOREHOLE TYPE HW Casing and Coring | COMPILED BY AN

DATUM Geodetic | DATE 2011.09.23 - 2011.09.28 | CHECKED BY LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
178.4 / 30.5	**SAND**, trace silt Very Dense Greyish Brown to Brown Wet	19	SS	73	~21	0	92	8 (SI+CL)	
173.8 / 35.1	Gravelly **SAND**, trace silt, occasional cobbles and boulders Very Dense Greyish Brown to Brown Wet Cored from 35.0m to 41.1m	20	SS	50/ .125	~15	25	70	5 (SI+CL)	
		~~21~~	~~SS~~	~~50/~~ .025					
169.3 / 39.6	Sandy **SILT**, trace clay Very Dense								

Elevation scale: 178, 177, 176, 175, 174, 173, 172, 171, 170, 169

Continued Next Page

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/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NIP-02

METRIC

WP# 124-90-01 LOCATION N 5 431 980.3 E 213 178.6 ORIGINATED BY RK

HWY 11/17 BOREHOLE TYPE HW Casing and Coring COMPILED BY AN

DATUM Geodetic DATE 2011.09.23 - 2011.09.28 CHECKED BY LRB

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)	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										
	Sandy **SILT**, trace clay Very Dense Grey Wet						168				
167.4 41.5			22	SS	105/ .225				○		0 25 73 2
	END OF BOREHOLE AT 41.5m. WATER LEVEL AT 25.8m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Oct.27/11	6.9	202.0
Nov.30/11	13.0	195.9

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NIP-03

METRIC

WP# 124-90-01 LOCATION N 5 431 995.4 E 213 289.2 ORIGINATED BY ES

HWY 11/17 BOREHOLE TYPE Casing COMPILED BY MFA

DATUM Geodetic DATE 2011.08.29 - 2011.09.12 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
187.8							
0.0	**COBBLES** and **BOULDERS**, some sand, trace to some gravel Brown Moist (FILL)	1	GS			o	
		1	CORE		187		
		2	CORE		186		
		3	CORE		185		
		4	CORE		184 (water level ▼)		
183.7 4.0	**SAND**, trace gravel, occasional cobbles Dense to Very Dense Brown to Grey Moist	5	CORE				
		1	SS	50/.150	183	o	
					182		
		2	SS	31	181	o	7 90 3 (SI+CL)
		3	SS	65	180	o	
178.9 8.8	Gravelly **SAND**, occasional cobbles and boulders Very Dense Grey to Brown Moist				179		
		4	SS	56	178	o	24 71 5 (SI+CL)

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

Continued Next Page

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

RECORD OF BOREHOLE No NIP-03

METRIC

WP#	124-90-01	LOCATION	N 5 431 995.4 E 213 289.2	ORIGINATED BY	ES
HWY	11/17	BOREHOLE TYPE	Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.08.29 - 2011.09.12	CHECKED BY	LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Gravelly **SAND**, occasional cobbles and boulders Very Dense Grey to Brown Moist						
		5	SS	84	177	o (~9)	
					176		
	No recovery	6	SS	100/ .100			
	Cored through cobbles and occasional boulders from 12.2m to 16.2m				175		
	No recovery	7	SS	100/ .130	174		
					173		
	No recovery	8	SS	100/ .080			
					172		
171.6 / 16.2	**SAND** and **GRAVEL**, occasional cobbles Very Dense Grey Wet				171		
		9	SS	71		o (~4)	
					170		
		10	SS	62		o (~5)	50 47 3 (SI+CL)
	Silt layer from 18.8 m to 19.4 m				169	o (~20)	
					168	o (~5)	

Continued Next Page

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: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NIP-03

METRIC

WP# 124-90-01 | LOCATION N 5 431 995.4 E 213 289.2 | ORIGINATED BY ES

HWY 11/17 | BOREHOLE TYPE Casing | COMPILED BY MFA

DATUM Geodetic | DATE 2011.08.29 - 2011.09.12 | CHECKED BY LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
	SAND and **GRAVEL**, occasional cobbles, Very Dense, Grey, Wet, Cobbles and boulders from 20.1 m to 21.2 m	11	SS	134/.200	~20				
166.1 / 21.6	Sandy **SILT**, trace clay, Dense to Very Dense, Grey, Moist to Wet	12	SS	70	~19	0	29	66	5
		13	SS	49	~21				
		14	SS	44	~19	0	22	73	5

Elevation scale: 167, 166, 165, 164, 163, 162, 161, 160, 159, 158

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 NIP-03

METRIC

WP#	124-90-01	LOCATION	N 5 431 995.4 E 213 289.2	ORIGINATED BY	ES
HWY	11/17	BOREHOLE TYPE	Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.08.29 - 2011.09.12	CHECKED BY	LRB

Legend: 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	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Sandy **SILT**, trace clay Dense to Very Dense Grey Wet				157, 156					
		15	SS	34	155.5	~27				
153.6 34.1	**SILT**, some clay, trace sand, occasional clay pockets Hard Grey				155, 154, 153					
		16	SS	100/ .075	152.7	~18				
		17	SS	64	152, 151, 150, 149.5	~24	0	3	86	11
					149, 148					

Continued Next Page

+ ³, × ³ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No NIP-03

METRIC

WP#	124-90-01	LOCATION	N 5 431 995.4 E 213 289.2	ORIGINATED BY	ES
HWY	11/17	BOREHOLE TYPE	Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.08.29 - 2011.09.12	CHECKED BY	LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SILT, some clay, trace sand, occasional clay pockets Hard Grey				147					
146.6 / 41.1	Clayey **SILT** Hard Grey	18	SS	31	146	wP ~20, w ~22	0	0	77	23
					145					
	No recovery Boulder (300mm) at 44.1m	19	SS	50/.075	144					
					143					
					142					
					141					
		20	SS	39	140	~21				
					139					
					138					

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

RECORD OF BOREHOLE No NIP-03

METRIC

WP#	124-90-01	LOCATION	N 5 431 995.4 E 213 289.2	ORIGINATED BY	ES
HWY	11/17	BOREHOLE TYPE	Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.08.29 - 2011.09.12	CHECKED BY	LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Clayey **SILT**, trace sand Hard Grey							
		21	SS	45	137	o		0 0 67 33
					136			
					135			
	Cobble at 53.5m Gravelly sand layer from 53.6m to 53.7m	22	SS	175/ .228	134	o		
					133			
132.6 / 55.2	**SAND**, some gravel , some cobbles Very Dense Grey Wet				132			
	No recovery Cored through cobbles and occasional boulders from 56.4m to 59.7m	~~23~~	~~SS~~	~~100/~~ .025	131	o		
					130			
					129			
128.1	No recovery	~~24~~	~~SS~~	~~100/~~ .050			FI	
127.9 / 59.7	**COBBLES** and **BOULDERS**				128			RUN #1 TCR=100%
59.8		1	RUN				>25	

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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

RECORD OF BOREHOLE No NIP-03

METRIC

WP# 124-90-01 LOCATION N 5 431 995.4 E 213 289.2 ORIGINATED BY ES
HWY 11/17 BOREHOLE TYPE Casing COMPILED BY MFA
DATUM Geodetic DATE 2011.08.29 - 2011.09.12 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						
	METASEDIMENTARY BEDROCK fresh, strong to very strong, blackish-grey					>5	SCR=80% RQD=80% UCS=93MPa (average)
		2	RUN		127	0, 0, 0	RUN #2 TCR=100% SCR=100% RQD=100% UCS=142MPa (average)
	Occasional sub-vertical fractures	3	RUN		126	0, 0, 0, 1, 1	RUN #3 TCR=100% SCR=100% RQD=100% UCS=135MPa (average)
124.4		4	RUN		125	1, 1	RUN #4 TCR=100% SCR=100% RQD=100% UCS=102MPa (average)
63.4	END OF BOREHOLE AT 63.4m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.						

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Oct.3/11	3.6	184.2
Oct.28/11	3.4	184.4
Nov.15/11	3.5	184.3
Nov.25/11	3.5	184.3

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
15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NIP-04

METRIC

WP# 124-90-01 LOCATION N 5 432 012.4 E 213 290.0 ORIGINATED BY SLL/GA

HWY 11/17 BOREHOLE TYPE Casing and Coring COMPILED BY LRB

DATUM Geodetic DATE 2011.11.15 - 2011.11.29 CHECKED BY AEG

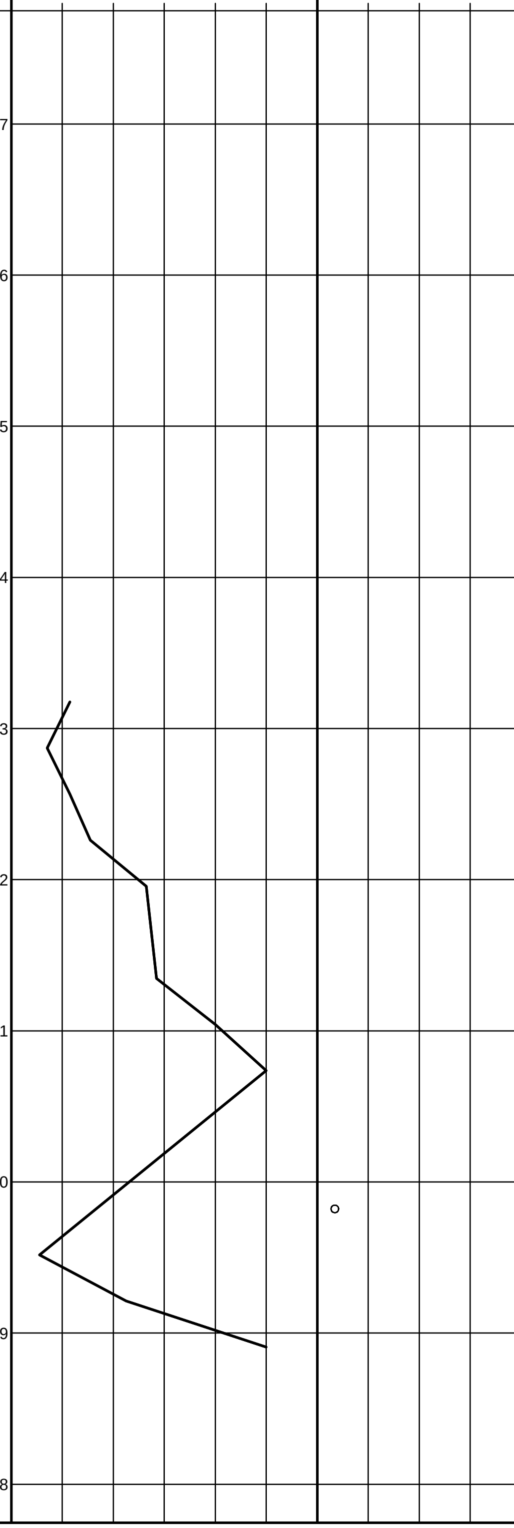
ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
187.7 0.0	Advanced NW casing to 4.6m.						187	
							186	
							185	
							184	
	Begin DCPT at 4.6m					∇	183	
							182	
							181	
	DCPT refusal at 7.2m. Advanced NW casing to 7.6m. Cored to 8.2m. Continued DCPT at 8.2m. DCPT refusal at 9.0m.							
180.1 7.6	**SAND**, some gravel Compact Brown Wet		1	SS	20		180	
179.3 8.4	Sandy **GRAVEL**, occasional cobbles and boulders Very Dense Grey Wet		2	SS	50/.100		179	
	No recovery		3	SS	50/.150		178	

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



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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 NIP-04

METRIC

WP# 124-90-01 | LOCATION N 5 432 012.4 E 213 290.0 | ORIGINATED BY SLL/GA

HWY 11/17 | BOREHOLE TYPE Casing and Coring | COMPILED BY LRB

DATUM Geodetic | DATE 2011.11.15 - 2011.11.29 | CHECKED BY AEG

SOIL PROFILE – Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Sandy **GRAVEL**, occasional cobbles and boulders Very Dense Grey Wet Poor recovery from 9.9m to 11.9m.	4	SS	50/.150	
		5	SS	85	
175.5		6	SS	50/.150	
12.2	**SAND**, some gravel Very Dense to Dense Grey Wet	7	SS	63	
		8	SS	36	
		9	SS	81	
172.5		10	SS	94	
15.2	Sandy **GRAVEL**, trace silt and clay Very Dense Grey Wet Boulder (230mm)	11	SS	63	64 30 6 (SI+CL)
		12	SS	89	
		13	SS	50/.150	
169.4	Boulder (300mm)	~~14~~	~~SS~~		
168.8 / 18.3	**SILT**, some sand, trace gravel Very Dense Grey Wet	~~15~~	~~SS~~	~~50/.150~~	
18.9	**SAND**, some gravel, trace silt Very Dense Grey Wet	~~16~~	~~SS~~	~~50/.150~~	
	No recovery. Probable cobbles.	~~17~~	~~SS~~	~~50/.000~~	

Elevation scale: 177, 176, 175, 174, 173, 172, 171, 170, 169, 168

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

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity; (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NIP-04

METRIC

WP#	124-90-01	LOCATION	N 5 432 012.4 E 213 290.0	ORIGINATED BY	SLL/GA
HWY	11/17	BOREHOLE TYPE	Casing and Coring	COMPILED BY	LRB
DATUM	Geodetic	DATE	2011.11.15 - 2011.11.29	CHECKED BY	AEG

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
167.1	Poor recovery from 20.4m to 22.0m											
20.6	**SILT**, trace to some clay, trace sand Very Dense Grey Wet		18	SS	50/.150		167					
			19	SS	72		166					
			20	22	50/.150				0	2	87	11
			21	SS	55		165					
			22	SS	53		164					
			23	SS	79		163					
			24	SS	54		162					
			25	SS	60				0	2	94	4
			26	SS	37		161					
			27	SS	43		160					
			28	SS	53		159					
			29	SS	65		158					
			30	SS	39				0	1	90	9

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

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+ 3, × 3: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

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Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NIP-04

METRIC

WP# 124-90-01 | LOCATION N 5 432 012.4 E 213 290.0 | ORIGINATED BY SLL/GA

HWY 11/17 | BOREHOLE TYPE Casing and Coring | COMPILED BY LRB

DATUM Geodetic | DATE 2011.11.15 - 2011.11.29 | CHECKED BY AEG

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILT, trace to some clay, trace sand Very Dense Grey Wet	31	SS	39	157	
156.6 31.1	Clayey **SILT**, trace sand Hard to Very Stiff Grey Wet	32	SS	33	156	
		33	SS	31	155	
		34	SS	20		
154.2 33.5	**SILT** , trace to some clay, trace sand Very Dense Grey Wet	35	SS	60	154	
		36	SS	50/.150	153	0 2 94 4
		37	SS	50/.150	152	
		38	SS	50/.150		
		39	SS	50	151	
					150	
149.6 38.1	Clayey **SILT**, trace sand, occasional silt and sand seams Hard Grey Wet	40	SS	40	149	
		41	SS	37	148	

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.

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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 NIP-04

METRIC

WP# 124-90-01 LOCATION N 5 432 012.4 E 213 290.0 ORIGINATED BY SLL/GA

HWY 11/17 BOREHOLE TYPE Casing and Coring COMPILED BY LRB

DATUM Geodetic DATE 2011.11.15 - 2011.11.29 CHECKED BY AEG

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Clayey **SILT**, trace sand, occasional silt and sand seams Hard Grey Wet				147					
		42	SS	37		~19				
					146					
					145					
		43	SS	42		~20				
					144					
					143					
					142					
		44	SS	32		~20 (wP ~19, wL ~25)	0	0	70	30
					141					
					140					
					139					
		45	SS	48		~30				
					138					

Column headings: SOIL PROFILE; 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/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

Ministry of Transportation
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THURBER

RECORD OF BOREHOLE No NIP-04

METRIC

WP#	124-90-01	LOCATION	N 5 432 012.4 E 213 290.0
HWY	11/17	BOREHOLE TYPE	Casing and Coring
DATUM	Geodetic	DATE	2011.11.15 - 2011.11.29

ORIGINATED BY SLL/GA
COMPILED BY LRB
CHECKED BY AEG

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	FI	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Clayey **SILT**, trace sand, occasional silt and sand seams Hard Grey Wet Boulder (610mm)				137		
135.9 / 51.8	Gravelly **SAND**, occasional cobbles Very Dense Grey Wet	46	SS	100/.125	136		30 59 11 (SI+CL)
	Boulder (300mm)				135 134		
		47	SS	100/.150	133 132		
131.0 / 56.7	**METASEDIMENTARY BEDROCK** fresh, very strong, blackish-grey, occasional quartz interbeds	1	RUN		131 130	0 0 1 1 0	RUN #1 TCR=100% SCR=100% RQD=100% UCS=118MPa (average)
		2	RUN		129	0 0 0 0 0	RUN #2 TCR=100% SCR=100% RQD=100% UCS=127MPa (average)
128.0 / 59.7	END OF BOREHOLE AT 59.7m.				128		

Continued Next Page

Legend: 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

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

RECORD OF BOREHOLE No NIP-04

METRIC

WP# 124-90-01 LOCATION N 5 432 012.4 E 213 290.0 ORIGINATED BY SLL/GA

HWY 11/17 BOREHOLE TYPE Casing and Coring COMPILED BY LRB

DATUM Geodetic DATE 2011.11.15 - 2011.11.29 CHECKED BY AEG

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										
	WATER LEVEL AT 4.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.										

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

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

RECORD OF BOREHOLE No NIP-05

METRIC

WP# 124-90-01 | LOCATION N 5 432 034.2 E 213 438.8 | ORIGINATED BY ES/RK
HWY 11/17 | BOREHOLE TYPE HSA/Casing | COMPILED BY MFA
DATUM Geodetic | DATE 2011.09.20 - 2011.10.02 | CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
207.6								
0.0	**ASPHALT:**(150mm)							
0.2	**SAND**, some gravel, trace silt Dense to Compact Brown Damp to Moist (FILL)		1	GS				
							207	
			1	SS	39			
							206	
			2	SS	25			8 83 9 (SI+CL)
205.3 2.3	**SAND**, coarse grained, trace silt, trace gravel Compact to Dense Brown Moist							
			3	SS	24		205	
			4	SS	15			
							204	
							203	
			5	SS	19			
							202	
			6	SS	33			1 92 7 (SI+CL)
							201	
							200	
			7	SS	30			
							199	
			8	SS	31			
							198	

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

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 NIP-05

METRIC

WP# 124-90-01 | LOCATION N 5 432 034.2 E 213 438.8 | ORIGINATED BY ES/RK

HWY 11/17 | BOREHOLE TYPE HSA/Casing | COMPILED BY MFA

DATUM Geodetic | DATE 2011.09.20 - 2011.10.02 | CHECKED BY LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND, coarse grained, trace silt, trace gravel Dense to Very Dense Brown Moist				197	
		9	SS	44		
					196	
		10	SS	41	195	1 93 6 (SI+CL)
					194	
		11	SS	48	193	
		12	SS	54	192	
191.6 16.0	**SAND** and **GRAVEL**, trace silt, occasional cobbles Dense Grey Wet Boulder (660mm) at 16m				191	
		13	SS	48	190	52 46 2 (SI+CL)
189.3 18.3	**SAND**, fine grained, some silt to silty, trace clay, trace to some gravel Very Dense Brown Moist	14	SS	79	189	
					188	

Groundwater level symbol shown at approx. elev. 192.2.

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; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Continued Next Page

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NIP-05

METRIC

WP# 124-90-01	LOCATION N 5 432 034.2 E 213 438.8		ORIGINATED BY ES/RK
HWY 11/17	BOREHOLE TYPE HSA/Casing		COMPILED BY MFA
DATUM Geodetic	DATE 2011.09.20 - 2011.10.02		CHECKED BY LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	NATURAL MOISTURE CONTENT	GR	SA	SI	CL
	SAND, fine grained, some silt to silty, trace clay, trace to some gravel Very Dense Brown Moist	15	SS	100		○	0	81	17	2
					187					
		16	SS	100	186	○	13	40	40	7
					185					
					184					
183.2 24.4	Clayey **SILT** Hard Grey Wet	17	SS	54/.125	183	○	0	0	76	24
					182					
181.7 25.9	Sandy **SILT** Very Dense Grey Wet				181					
		18	SS	100/.250	180	○				
					179					
					178					

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NIP-05

METRIC

WP#	124-90-01	LOCATION	N 5 432 034.2 E 213 438.8	ORIGINATED BY	ES/RK
HWY	11/17	BOREHOLE TYPE	HSA/Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.09.20 - 2011.10.02	CHECKED BY	LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Sandy **SILT**, Very Dense, Grey, Wet	19	SS	50/ .125	177	~22				
174.7 / 32.9	**SILT**, some clay, trace sand, occasional clay pockets, Very Dense, Grey, Wet	20	SS	80	174	~20	0	7	83	10
		21	SS	80	171	~22				
		22	SS	100/	168	~20				

Elevation scale: 177, 176, 175, 174, 173, 172, 171, 170, 169, 168

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 (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 (%)

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NIP-05

METRIC

WP# 124-90-01
LOCATION N 5 432 034.2 E 213 438.8
ORIGINATED BY ES/RK

HWY 11/17
BOREHOLE TYPE HSA/Casing
COMPILED BY MFA

DATUM Geodetic
DATE 2011.09.20 - 2011.10.02
CHECKED BY LRB

SOIL PROFILE: 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 (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
167.5 40.1	END OF BOREHOLE AT 40.1m. Piezometer installation consists of 30mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.				.275						

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Oct.28/11	7.2	200.4
Nov.30/11	15.5	192.1

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NIP-06

METRIC

WP#	124-90-01	LOCATION	N 5 432 054.4 E 213 447.6	ORIGINATED BY	ES
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.09.17 - 2011.09.18	CHECKED BY	LRB

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
205.7 / 0.0	**SAND**, trace gravel, trace silt, occasional cobbles at surface Compact to Dense Brown Moist	1	GS			o	
		1	SS	19	205	o	
		2	SS	11	204	o	1 95 4 (SI+CL)
		3	SS	16	203	o	
		4	SS	15	202	o	
		5	SS	23	201	o	
		6	SS	25	200 / 199	o	3 91 6 (SI+CL)
		7	SS	32	198 / 197	o	
		8	SS	44		o	
195.9 / 9.8	END OF BOREHOLE at 9.8m.				196		

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

ONTMT4S 1180.GPJ 2012TEMPLATE(MTO).GDT 2/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NIP-06

METRIC

WP#	124-90-01	LOCATION	N 5 432 054.4 E 213 447.6	ORIGINATED BY	ES
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.09.17 - 2011.09.18	CHECKED BY	LRB

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						
	Continued From Previous Page										
	BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.										

+ 3, × 3: Numbers refer to Sensitivity

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

ONTMT4S 1180.GPJ 2012TEMPLATE(MTO).GDT 2/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No NIP-07

METRIC

WP#	124-90-01	LOCATION	N 5 432 056.8 E 213 431.7	ORIGINATED BY	RK
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2011.09.21 - 2011.09.21	CHECKED BY	LRB

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
205.3 / 0.0	**SAND**, trace to some gravel, trace silt Compact to Dense Grey-Brown Moist	1	SS	17	205	
		2	SS	15	204	9 88 3 (SI+CL)
		3	SS	16		
		4	SS	17	203	
		5	SS	19	202	
					201	
		6	SS	32	200	2 93 5 (SI+CL)
		7	SS	38	199	
		8	SS	42	198, 197	18 76 6 (SI+CL)
195.6		9	SS	42	196	
9.8	END OF BOREHOLE AT 9.8m.					

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/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+ 3, × 3: Numbers refer to Sensitivity

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

ONTMT4S 1180.GPJ 2012TEMPLATE(MTO).GDT 2/4/13

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NIP-08

METRIC

WP#	124-90-01	LOCATION	N 5 432 031.8 E 213 299.6	ORIGINATED BY	ES
HWY	11/17	BOREHOLE TYPE	Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.09.12 - 2011.09.17	CHECKED BY	LRB

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
184.9						
0.0	**COBBLES** and **BOULDERS**, some sand and gravel (FILL)	1	CORE			
		2	CORE		184	
		3	CORE		183	
182.6 / 2.3	Gravelly **SAND**, occasional cobbles, Dense, Grey, Wet	1	SS	48	182	
		2	SS	34	181	
	No recovery	3	SS	44		
		4	SS	43	180	
178.8 / 6.1	**SAND**, trace gravel, trace silt, Compact to Dense, Grey, Wet	5	SS	26	179	1 94 5 (SI+CL)
					178	
177.0 / 7.9	Gravelly **SAND**, occasional cobbles, Very Dense, Grey, Wet	6	SS	34	177	
	No recovery. Cored through cobbles and boulders.	7	SS	100/ .050	176	
					175	

Water level symbol shown at approx. elev. 184.3.

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

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 NIP-08

METRIC

WP# 124-90-01 | LOCATION N 5 432 031.8 E 213 299.6 | ORIGINATED BY ES

HWY 11/17 | BOREHOLE TYPE Casing | COMPILED BY MFA

DATUM Geodetic | DATE 2011.09.12 - 2011.09.17 | CHECKED BY LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Gravelly **SAND**, occasional cobbles Very Dense Grey Wet									
		8	SS	60	174					
					173					
		9	SS	69						
					172					
171.7 13.3	**SILT**, trace to some clay, trace to some sand Very Dense Grey Moist									
		10	SS	91	171		0	18	80	2
					170					
		11	SS	89			0	4	82	14
					169					
		12	SS	100	168					
					167					
		13	SS	63			0	0	95	5
					166					
					165					

Continued Next Page

Legend: 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 (%)

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NIP-08

METRIC

WP# 124-90-01 LOCATION N 5 432 031.8 E 213 299.6 ORIGINATED BY ES

HWY 11/17 BOREHOLE TYPE Casing COMPILED BY MFA

DATUM Geodetic DATE 2011.09.12 - 2011.09.17 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Continued From Previous Page									
	SILT, trace to some clay, trace to some sand Very Dense Grey Moist	14	SS	59		~24				
					164					
					163					
					162					
		15	SS	51		~18	0	2	90	8
					161					
					160					
					159					
		16	SS	87		~19				
					158					
157.8 / 27.1	Clayey **SILT** Hard Grey Moist									
					157					
					156					
		17	SS	40		~18 (wP–wL ~18–20)	0	0	69	31
					155					

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NIP-08

METRIC

WP# 124-90-01 LOCATION N 5 432 031.8 E 213 299.6 ORIGINATED BY ES

HWY 11/17 BOREHOLE TYPE Casing COMPILED BY MFA

DATUM Geodetic DATE 2011.09.12 - 2011.09.17 CHECKED BY LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
154.4 / 30.5	**SILT**, some clay Very Dense to Dense Grey Moist				154					
					153					
		18	SS	52		~19				
					152					
					151					
					150					
		19	SS	67		~20	0	0	87	13
					149					
					148					
					147					
		20	SS	42		~20				
					146					
					145					

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NIP-08

METRIC

WP# 124-90-01 | LOCATION N 5 432 031.8 E 213 299.6 | ORIGINATED BY ES

HWY 11/17 | BOREHOLE TYPE Casing | COMPILED BY MFA

DATUM Geodetic | DATE 2011.09.12 - 2011.09.17 | CHECKED BY LRB

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILT, some clay Very Dense Grey Moist				144			
		21	SS	68		~20		0 0 89 11
142.6 / 42.4	**SAND**. coarse grained, some gravel, trace silt, occasional cobbles Very Dense Grey Wet				143, 142, 141			
		22	SS	141		~15		16 73 11 (SI+CL)
	Cobbles and boulders				140, 139, 138			
		23	SS	100/ .150	137, 136	~19		
135.8 / 49.1	**METASEDIMENTARY BEDROCK** fresh, strong to very strong, blackish-grey Some sub-vertical fractures	1	RUN		135		FI >15 >5	RUN #1 TCR=98% SCR=95% RQD=95% UCS=77MPa (average)

Continued Next Page

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

+ 3, × 3: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No NIP-08

METRIC

WP# 124-90-01	LOCATION N 5 432 031.8 E 213 299.6	ORIGINATED BY ES
HWY 11/17	BOREHOLE TYPE Casing	COMPILED BY MFA
DATUM Geodetic	DATE 2011.09.12 - 2011.09.17	CHECKED BY LRB

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 From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	REMARKS
	METASEDIMENTARY BEDROCK fresh, strong to very strong, blackish-grey			
		2	RUN	RUN #2 TCR=100% SCR=100% RQD=100% UCS=107MPa (average)
		3	RUN	RUN #3 TCR=100% SCR=100% RQD=100% UCS=141MPa (average)
		4	RUN	RUN #4 TCR=100% SCR=100% RQD=100% UCS=184MPa (average)
		5	RUN	RUN #5 TCR=100% SCR=100% RQD=100% UCS=129MPa (average)
		6	RUN	RUN #6 TCR=100% SCR=100% RQD=100% UCS=127MPa (average)
		7	RUN	RUN #7 TCR=100% SCR=100% RQD=100% UCS=111MPa (average)
125.5 59.4	END OF BOREHOLE at 59.4m Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.			

Elevation scale: 134, 133, 132, 131, 130, 129, 128, 127, 126

Unit weight column values (top to bottom): 2, 1, 1, 2, 1, 2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 3, 1, 1

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No NIP-08

METRIC

WP#	124-90-01	LOCATION	N 5 432 031.8 E 213 299.6	ORIGINATED BY	ES
HWY	11/17	BOREHOLE TYPE	Casing	COMPILED BY	MFA
DATUM	Geodetic	DATE	2011.09.12 - 2011.09.17	CHECKED BY	LRB

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						
	Continued From Previous Page										
	WATER LEVEL READINGS:										

DATE	DEPTH (m)	ELEV. (m)
Oct.28/11	0.5	184.4
Nov.15/11	0.5	184.4
Nov.22/11	0.7	184.2

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

15 20 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RW-01

METRIC

W.P. 647-89-00	LOCATION Nipigon Bridge West Approach N 5 431 964.9 E 213 131.4		ORIGINATED BY SLL
HWY 11/17	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY MFA
DATUM Interpolated from Geodetic	DATE 2012.07.17 - 2012.07.17		CHECKED BY KS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
208.8							
0.0	**ASPHALT:**(50mm)						
0.1	**SAND**, some gravel to gravelly, trace silt Compact to Dense Brown Moist					208	
			1	SS	17		
			2	SS	47	207	
	occasional cobbles		3	SS	33	206	25 68 7 (SI+CL)
			4	SS	41	205	
			5	SS	48	204	22 71 7 (SI+CL)
						203	
			6	SS	18	202	
201.3 7.5	**SAND**, trace gravel Compact Brown Moist					201	
			7	SS	12	200	
	trace silt		8	SS	23		
199.0 9.8	END OF BOREHOLE AT 9.8m.						

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

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No RW-01

METRIC

W.P.	647-89-00	LOCATION	Nipigon Bridge West Approach N 5 431 964.9 E 213 131.4	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MFA
DATUM	Interpolated from Geodetic	DATE	2012.07.17 - 2012.07.17	CHECKED BY	KS

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						
	Continued From Previous Page										
	BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND 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 RW-02

METRIC

W.P.	647-89-00	LOCATION	Nipigon Bridge West Approach N 5 432 039.9 E 213 190.7	ORIGINATED BY	SLL
HWY	11/17	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	MFA
DATUM	Interpolated from Geodetic	DATE	2012.07.15 - 2012.07.15	CHECKED BY	KS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%) (approx.)	UNIT WEIGHT kN/m³	GR	SA	SI	CL
188.0							188						
0.0	**SAND**, some gravel Compact Brown Moist												
187.4 0.6	**SAND**, trace gravel, trace silt Compact Brown Moist												
			1	SS	21		187	~3					
			2	SS	13		186	~4		0	97	3 (SI+CL)	
			3	SS	13		185	~4					
			4	SS	17		184	~6					
	Wet		5	SS	12		183	~16		1	94	5 (SI+CL)	
	Grey		6	SS	22		182 / 181	~18					
	Dense		7	SS	45		180 / 179	~18		10	88	2 (SI+CL)	
			8	SS	29			~15					
178.2 9.8	END OF BOREHOLE AT 9.8m.												

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

REMARKS & GRAIN SIZE DISTRIBUTION (%)

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 RW-02

METRIC

W.P. 647-89-00
LOCATION Nipigon Bridge West Approach N 5 432 039.9 E 213 190.7
ORIGINATED BY SLL

HWY 11/17
BOREHOLE TYPE Hollow Stem Augers
COMPILED BY MFA

DATUM Interpolated from Geodetic
DATE 2012.07.15 - 2012.07.15
CHECKED BY KS

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						
	Continued From Previous Page										
	BOREHOLE OPEN TO 6.2m AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.9m, THEN SAND CUTTINGS TO SURFACE.										

+ 3 , × 3 : Numbers refer to Sensitivity

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

Appendix B

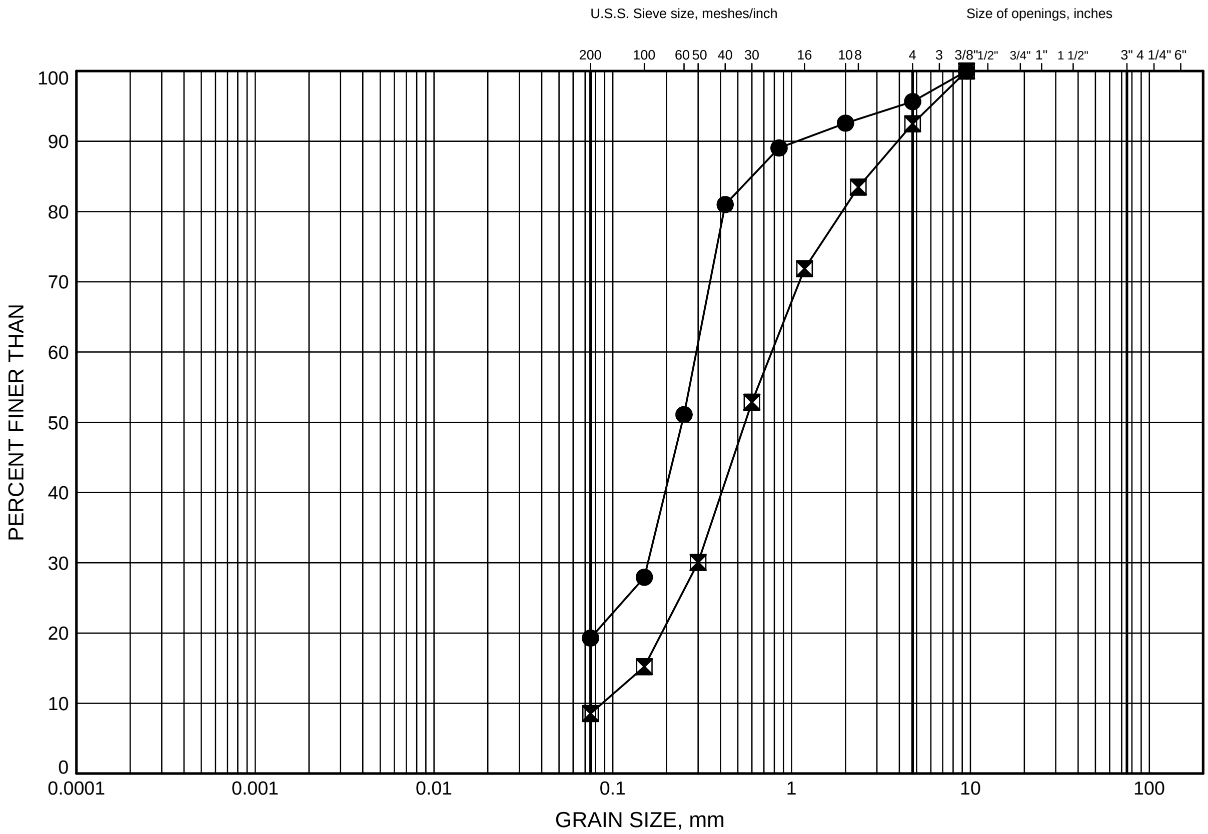
Laboratory Test Results
(Current Investigation)

Nipigon River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B1a

Sand Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NIP-01	2.59	206.12
⧗	NIP-05	1.83	205.75

Date February 2013

WP# 124-90-01

THURBER

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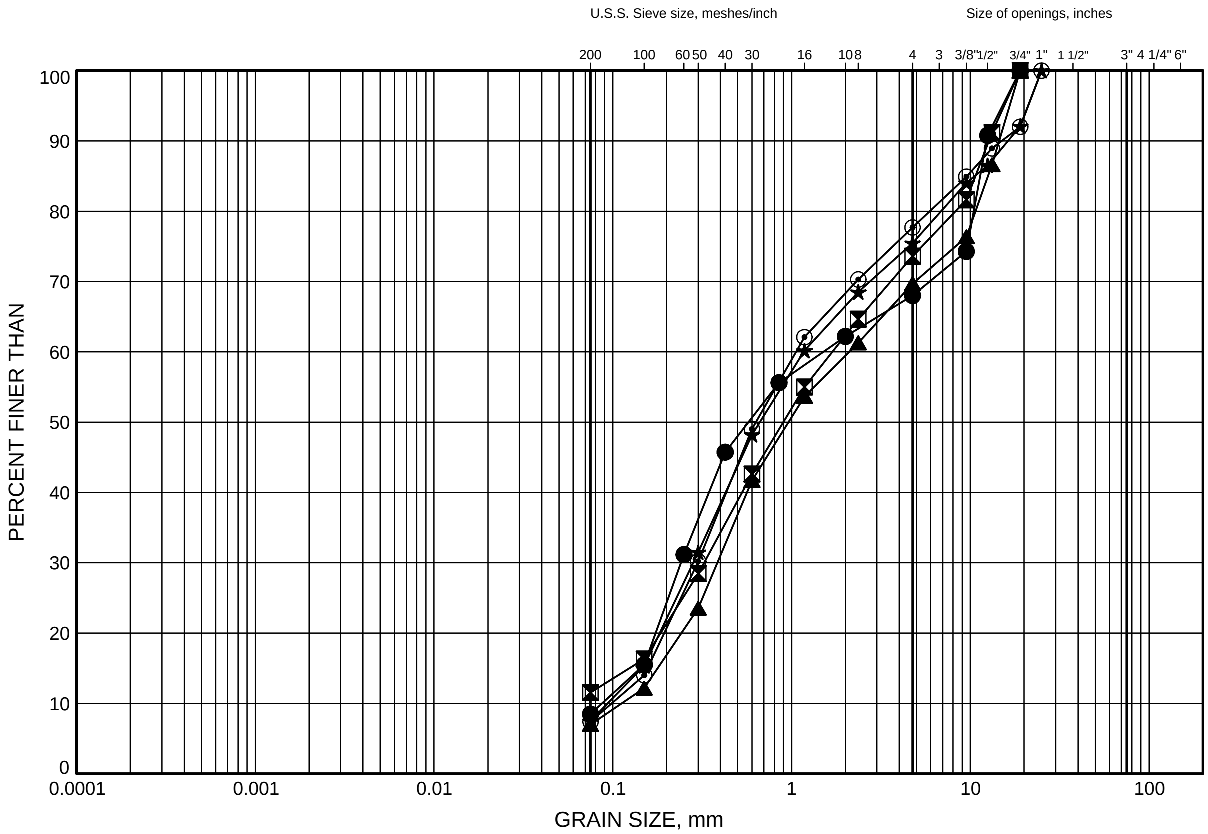
Chkd. KS

Nipigon River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B1b

Gravelly Sand Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NIP-01	7.92	200.79
⧗	NIP-02	3.35	205.54
▲	NIP-02	7.92	200.97
★	RW-01	2.59	206.19
⊙	RW-01	4.88	203.90

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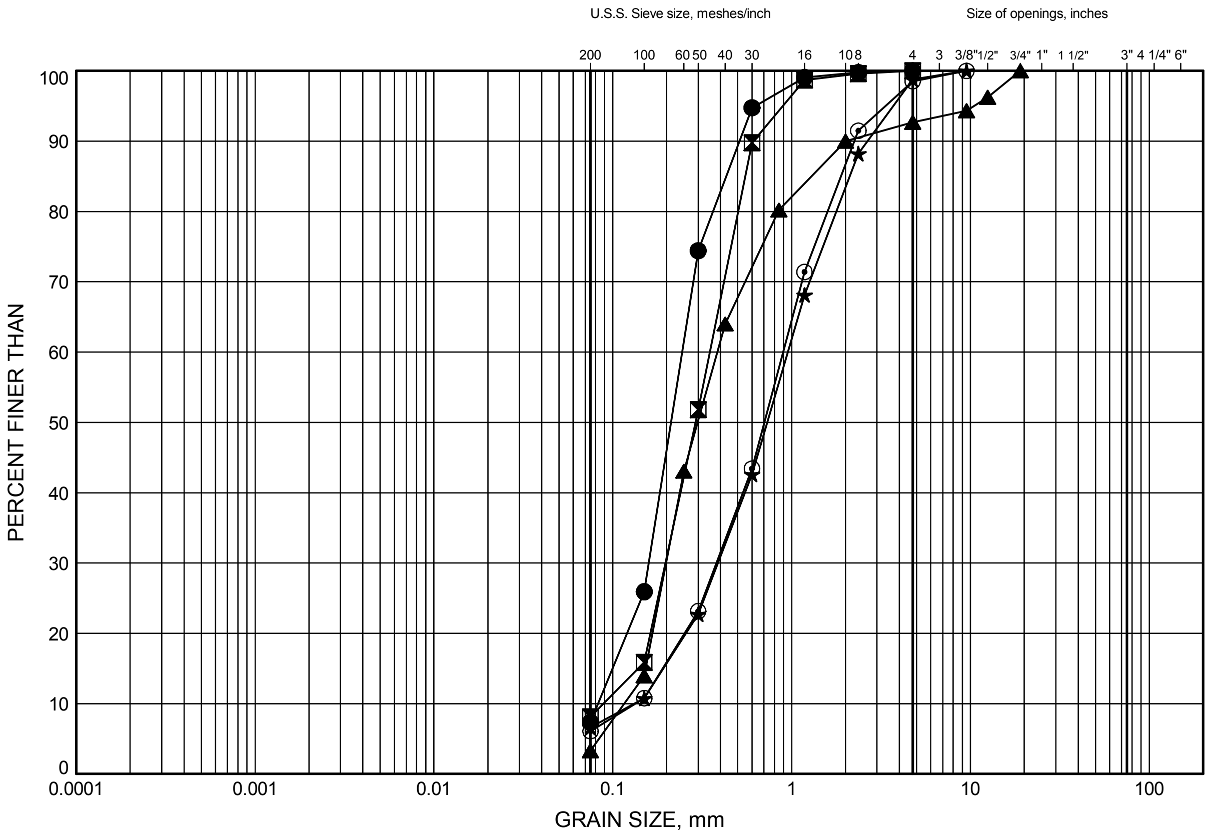
Nipigon River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B2

Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NIP-02	20.12	188.77
⧗	NIP-02	32.31	176.58
▲	NIP-03	6.40	181.36
★	NIP-05	6.40	201.18
⊙	NIP-05	12.50	195.08

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WP# 124-90-01

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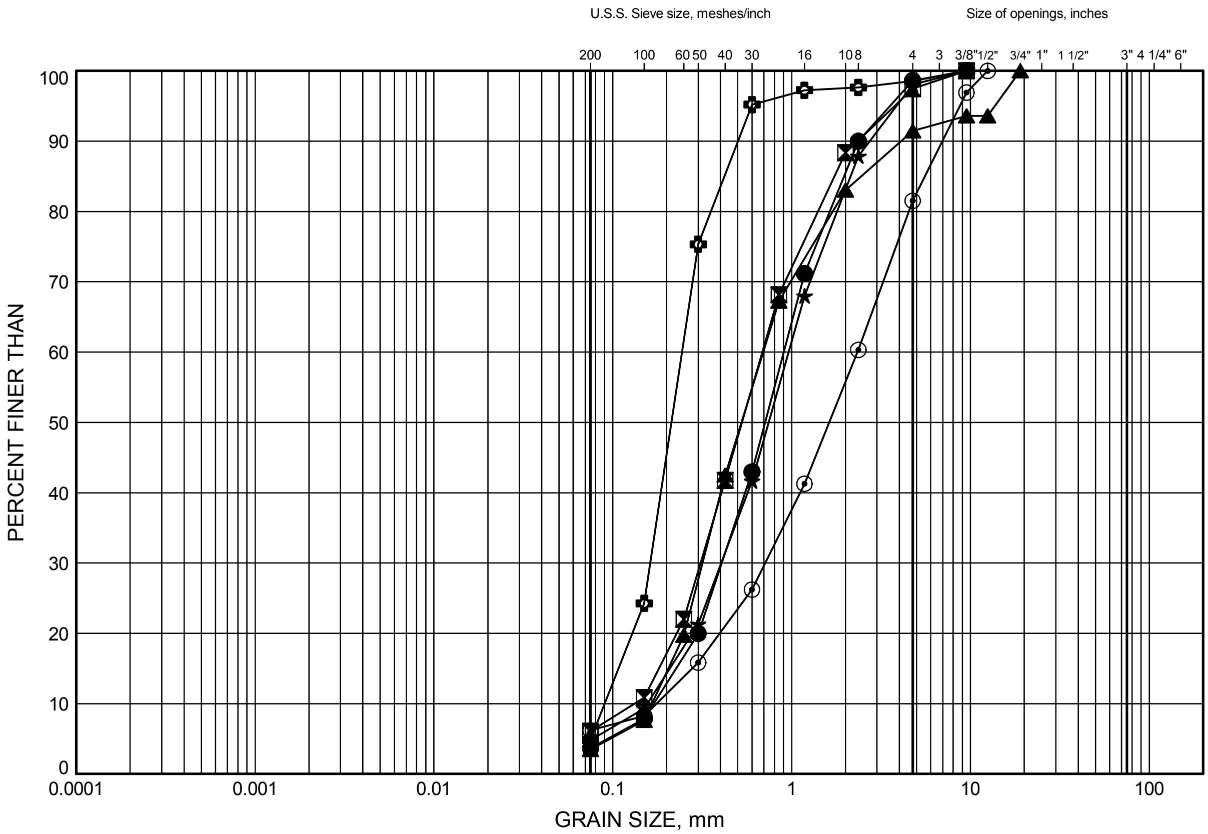
GRAIN SIZE DISTRIBUTION - THURBER 1180.GPJ 2/4/13

Nipigon River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B3

Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NIP-06	1.83	203.86
⧗	NIP-06	6.40	199.29
▲	NIP-07	1.07	204.25
★	NIP-07	4.88	200.44
⊙	NIP-07	7.92	197.40
✿	NIP-08	6.40	178.52

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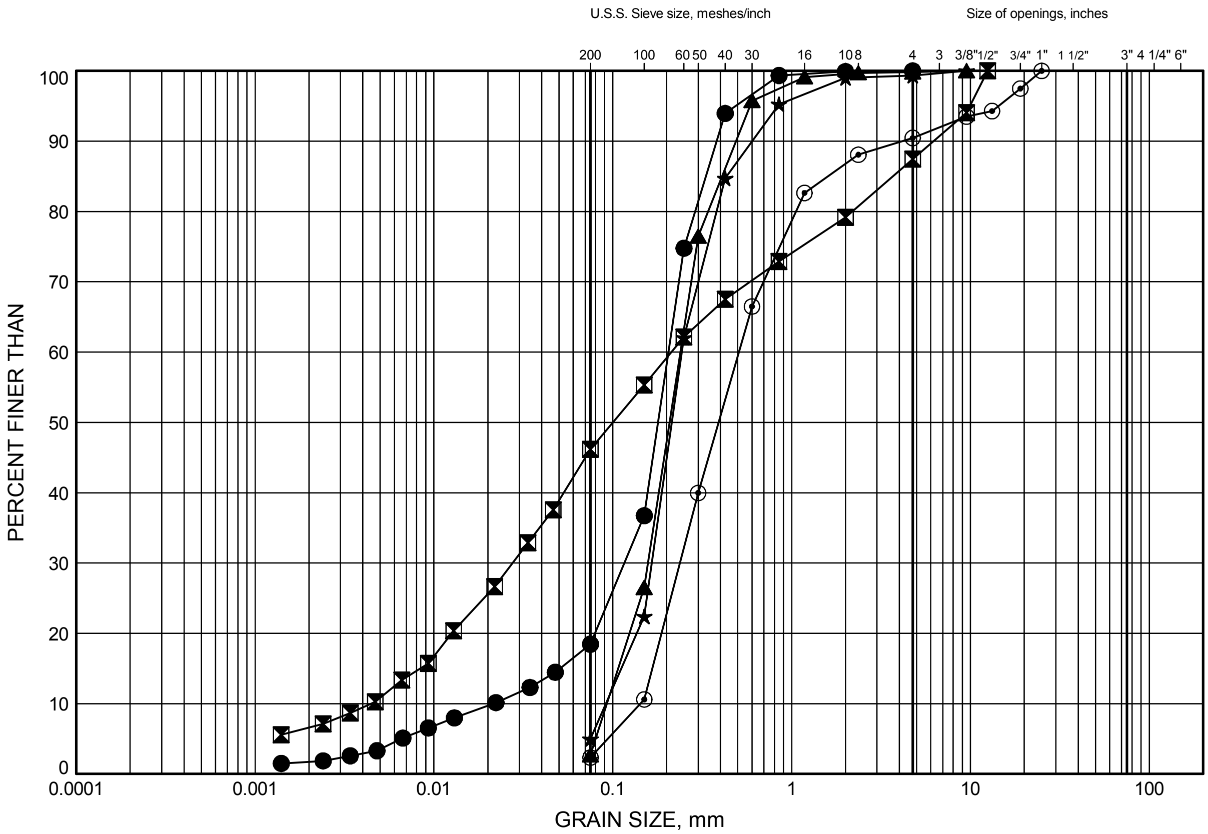
GRAIN SIZE DISTRIBUTION - THURBER 1180.GPJ 2/4/13

Nipigon River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B4

Sand to Silty Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NIP-05	20.12	187.46
⧗	NIP-05	21.64	185.94
▲	RW-02	1.83	186.14
★	RW-02	4.88	183.09
⊙	RW-02	7.92	180.05

GRAIN SIZE DISTRIBUTION - THURBER 1180.GPJ 2/4/13

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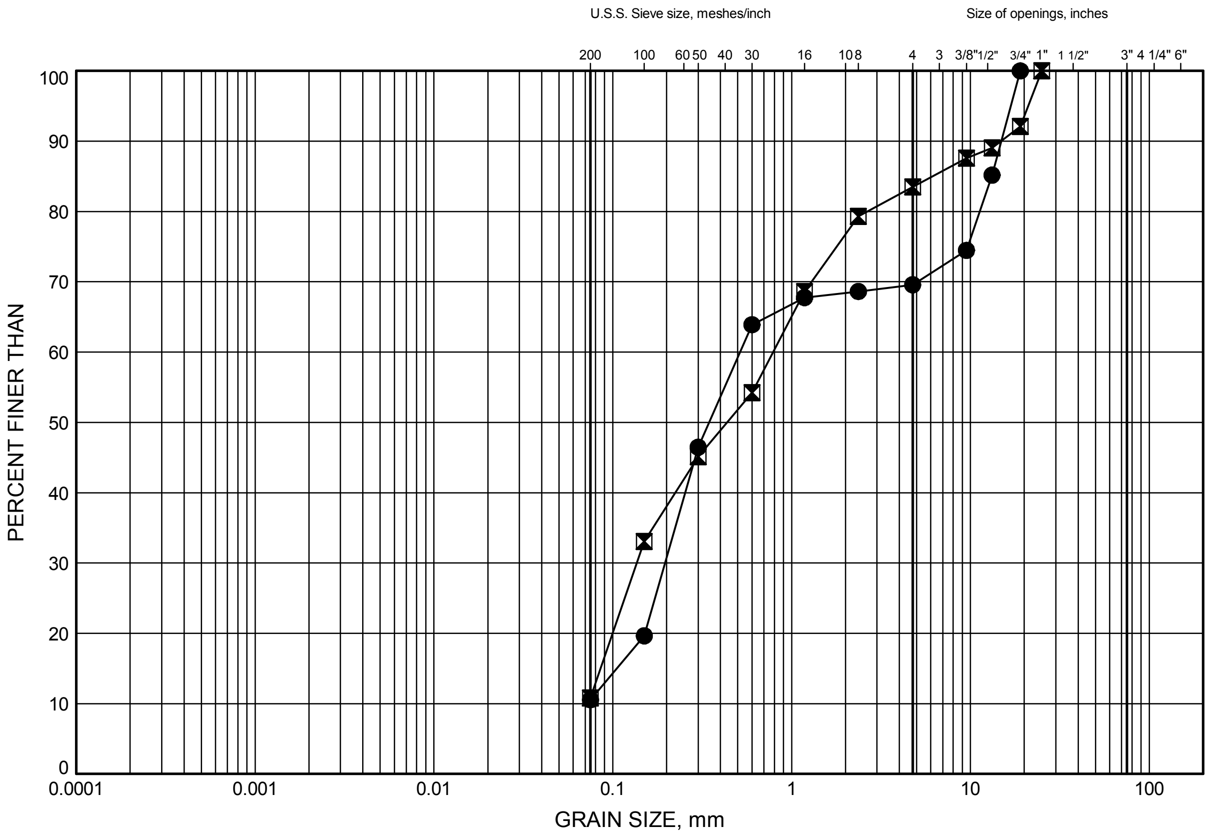
Nipigon River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B5

Sand to Gravelly Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NIP-04	52.04	135.66
⧗	NIP-08	44.42	140.50

Date February 2013

WP# 124-90-01

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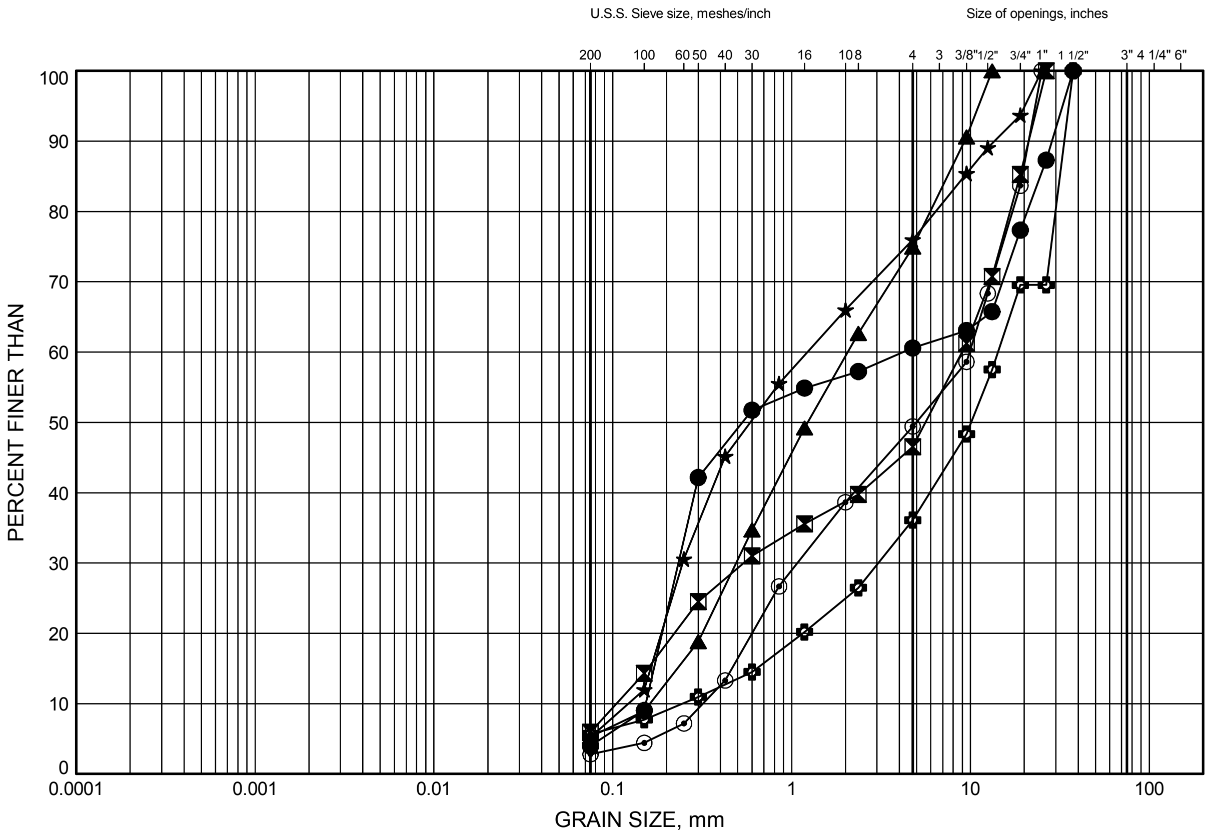
GRAIN SIZE DISTRIBUTION - THURBER 1180.GPJ 2/4/13

Nipigon River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B6

Gravelly Sand to Sandy Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NIP-02	13.94	194.95
⧗	NIP-02	26.21	182.68
▲	NIP-02	35.36	173.53
★	NIP-03	9.45	178.31
⊙	NIP-03	18.59	169.17
✿	NIP-04	15.44	172.26

GRAIN SIZE DISTRIBUTION - THURBER 1180.GPJ 2/4/13

Date February 2013

WP# 124-90-01

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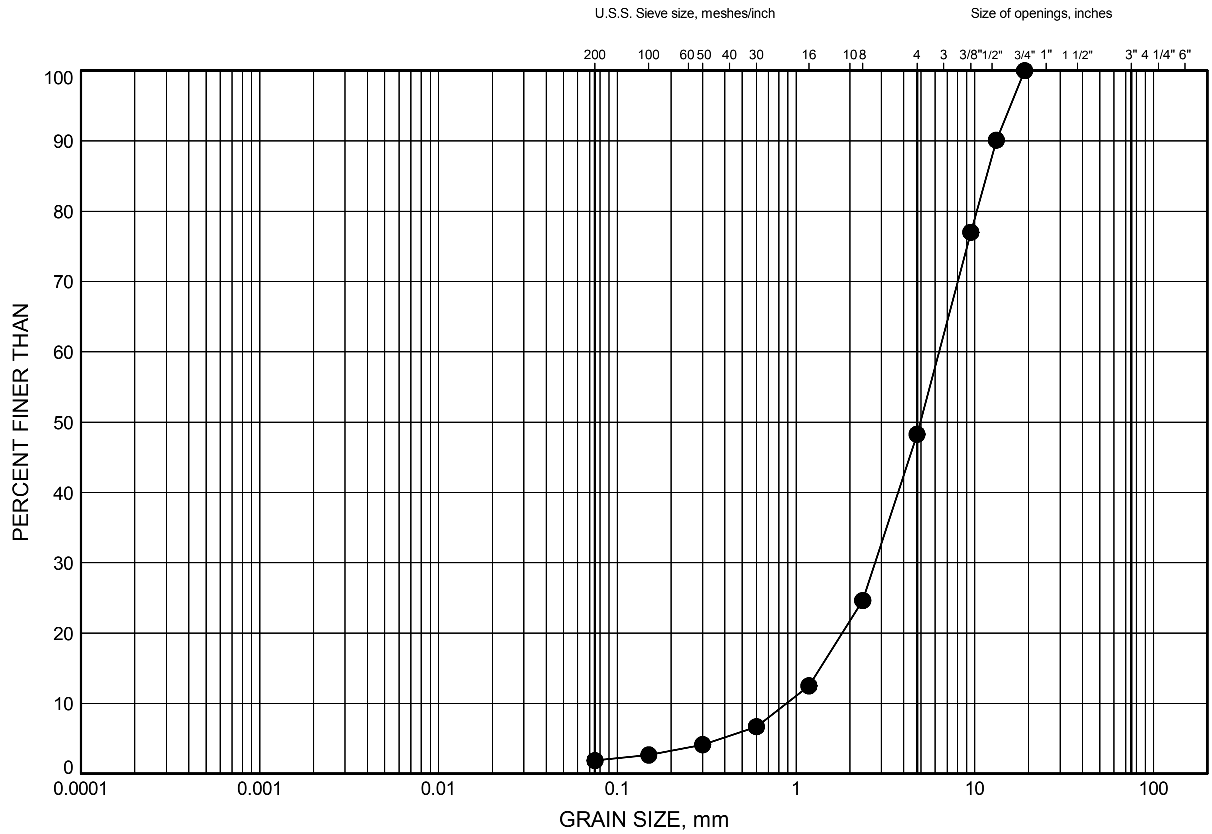
Nipigon River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B7

Gravelly Sand to Sandy Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NIP-05	17.07	190.51

Date February 2013

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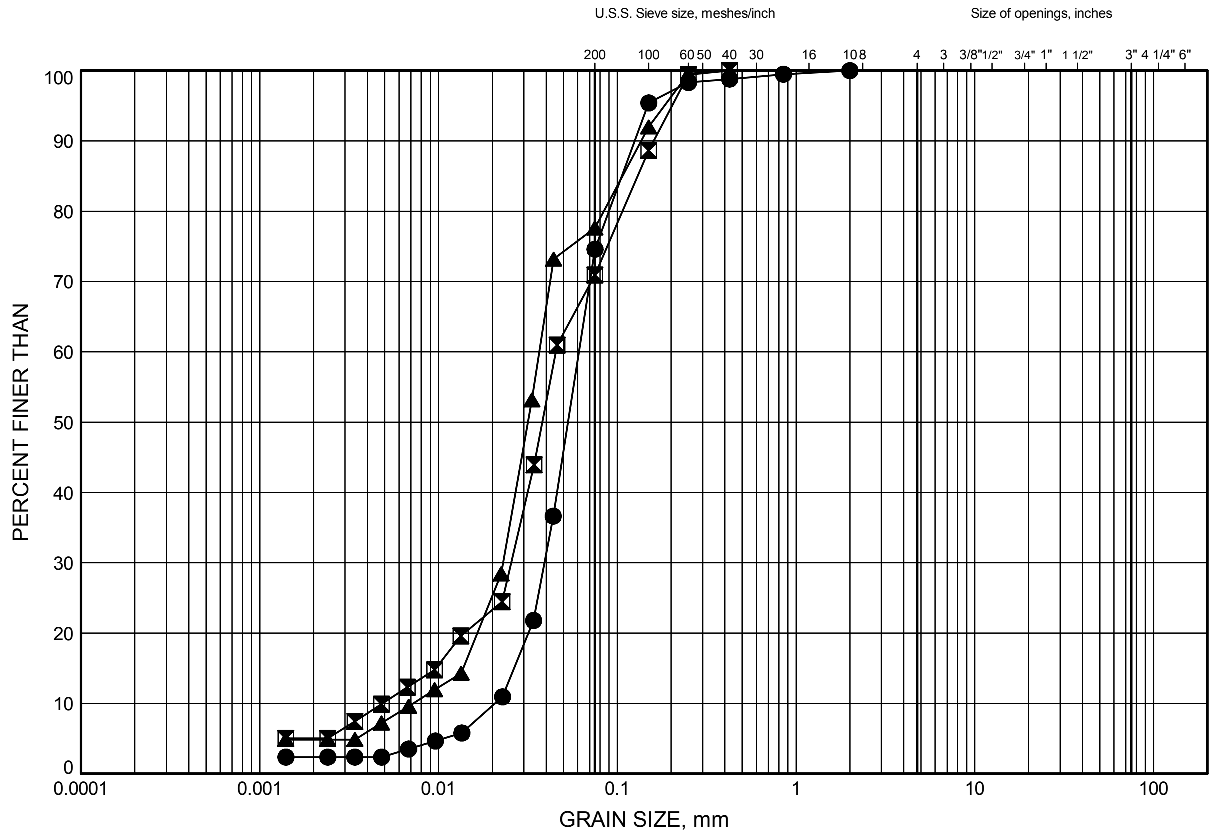
GRAIN SIZE DISTRIBUTION - THURBER 1180.GPJ 2/4/13

Nipigon River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B8

Sandy Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NIP-02	41.45	167.44
⧗	NIP-03	23.16	164.60
▲	NIP-03	29.26	158.50

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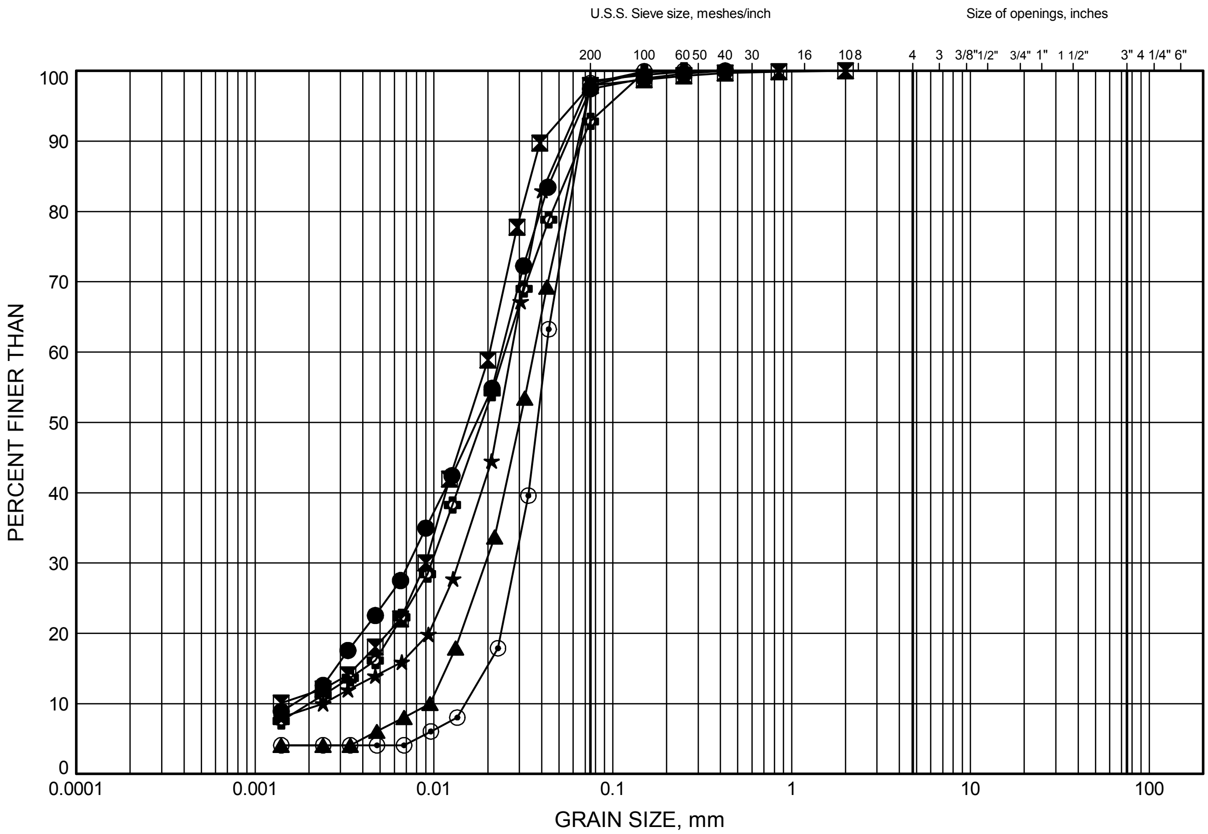
Nipigon River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B9

Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NIP-03	38.40	149.36
⧗	NIP-04	22.48	165.22
▲	NIP-04	26.14	161.56
★	NIP-04	29.95	157.75
⊙	NIP-04	34.52	153.18
✿	NIP-05	33.83	173.75

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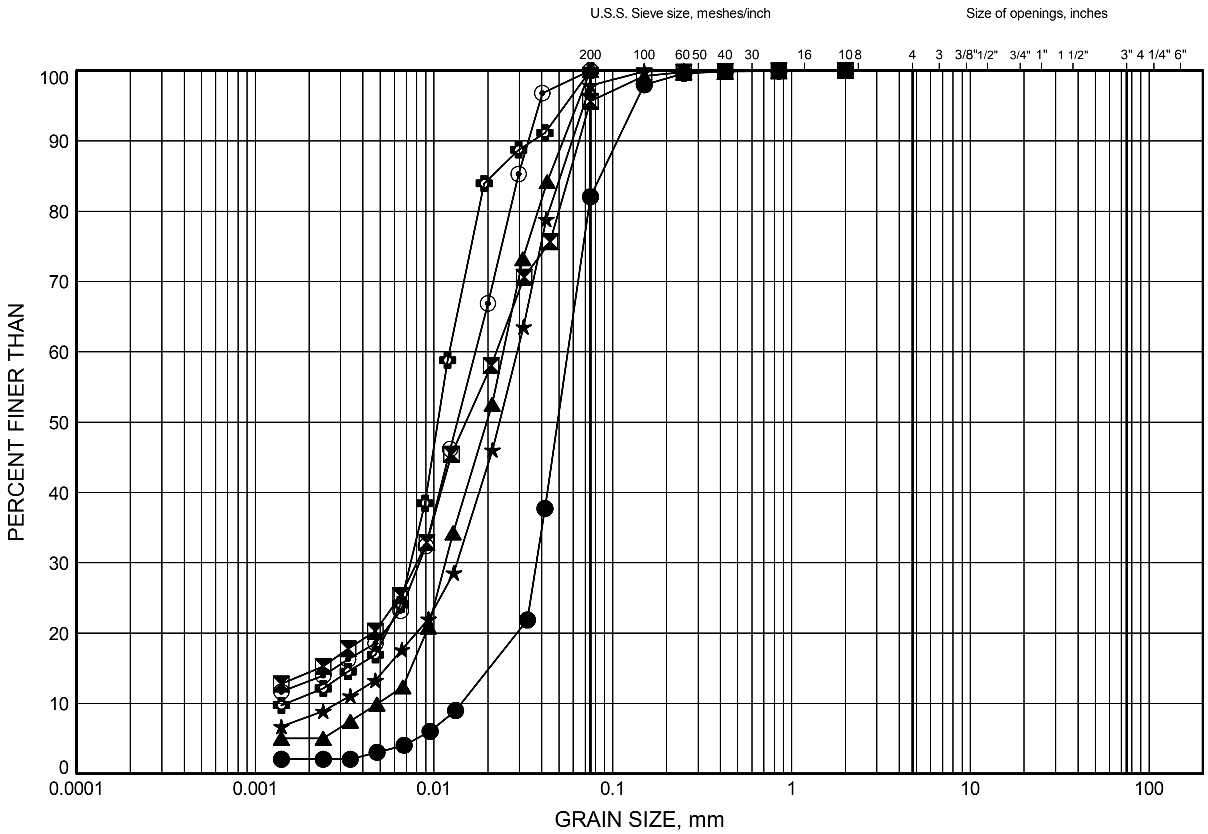
Nipigon River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B10

Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NIP-08	14.02	170.90
⧗	NIP-08	15.51	169.41
▲	NIP-08	18.59	166.33
★	NIP-08	23.16	161.76
⊙	NIP-08	35.36	149.56
✿	NIP-08	41.45	143.47

GRAIN SIZE DISTRIBUTION - THURBER 1180.GPJ 2/4/13

Date February 2013

WP# 124-90-01

THURBER

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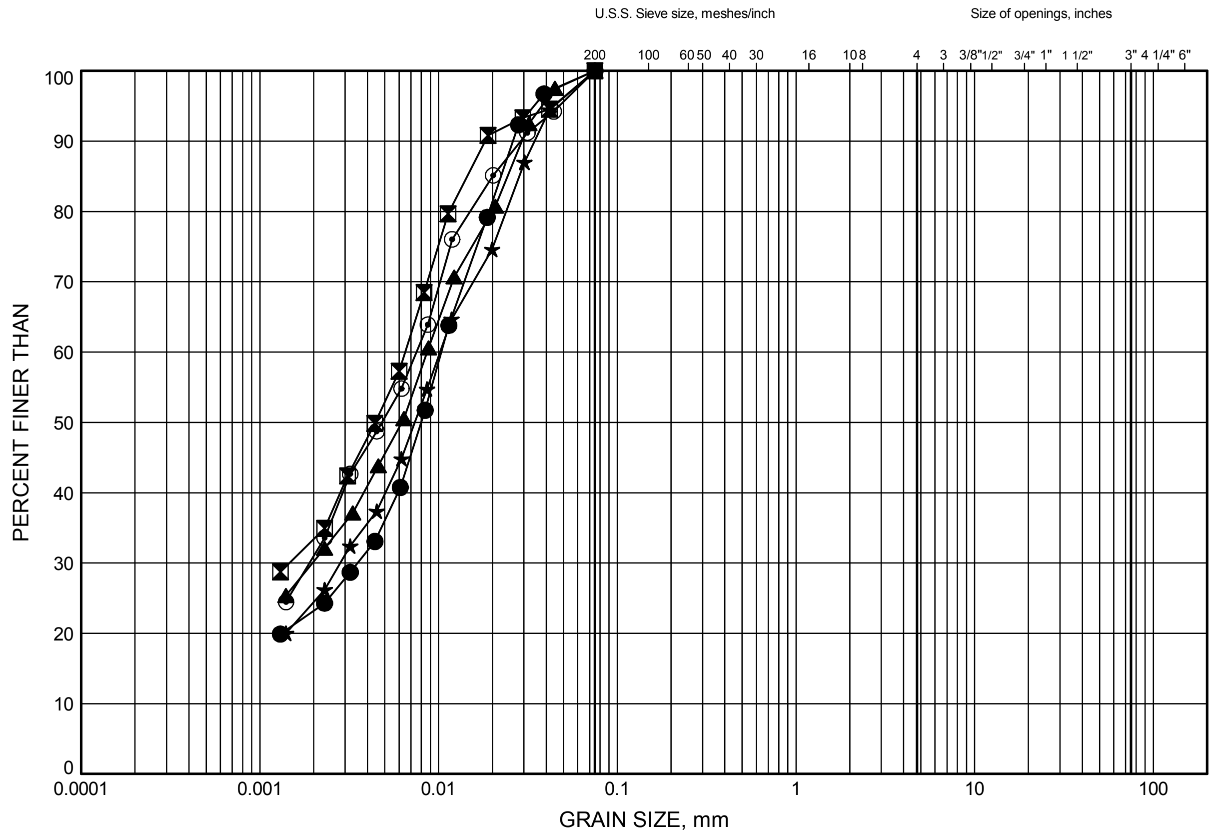
Nipigon River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B11

Clayey Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NIP-03	41.45	146.31
⧗	NIP-03	50.60	137.16
▲	NIP-04	45.95	141.75
★	NIP-05	24.69	182.89
⊙	NIP-08	29.26	155.66

Date February 2013

WP# 124-90-01

THURBER

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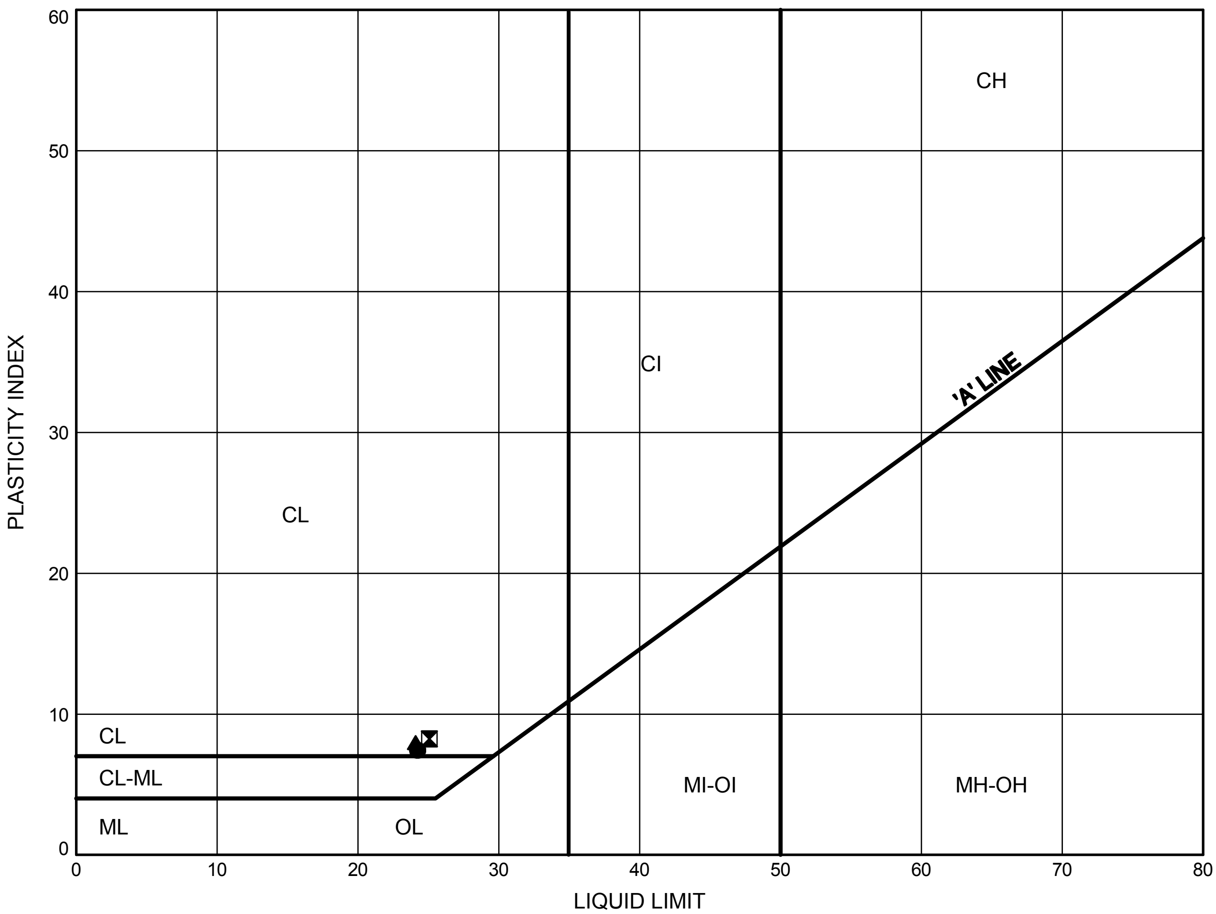
GRAIN SIZE DISTRIBUTION - THURBER 1180.GPJ 2/4/13

Nipigon River Bridge

ATTERBERG LIMITS TEST RESULTS

FIGURE B12

Clayey Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NIP-03	41.45	146.31
⧗	NIP-04	45.95	141.75
▲	NIP-08	29.26	155.66

THURBALT 1180.GPJ 2/4/13

Date February 2013

WP# 124-90-01

THURBER

Prep'd MFA

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Appendix C

Borehole Logs
(Previous Investigation)

RECORD OF BOREHOLE No 93-1

METRIC

W.P. 647 - 89 - 02 LOCATION STA. 26 + 500 O/S 5.0 m LT. OF ℄ HWY. 11/17 WBL ORIGINATED BY T K&M V

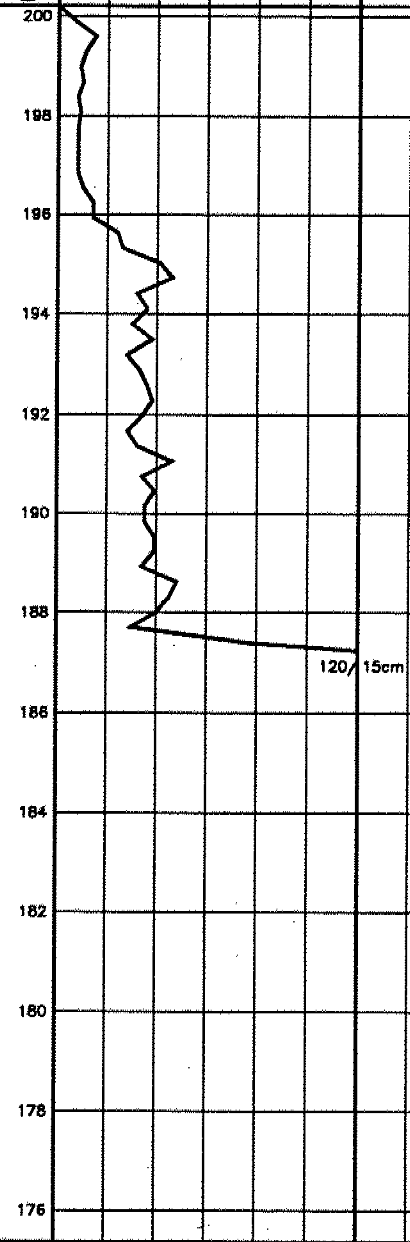
DIST 19 HWY 11/17 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 93 10 20 TO 93 10 23 CHECKED BY M V

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
200.2	Ground Surface				
0.0	SAND, Trace of Silt, Loose to Compact	1	SS	8	
		2	SS	6	
		3	SS	7	
		4	SS	7	
		5	SS	11	
		6	SS	22	0 95 (5)
		7	SS	23	
		8	SS	23	
		9	SS	20	
		10	SS	23	
		11	SS	25	
	Trace of Gravel, Very Dense	12	SS	54	3 93 (4)
		13	SS	52	
		14	SS	109	
183.6 / 16.6	GRAVELLY SAND, Trace of Silt, Occasional Cobbles, Very Dense	15	SS	89	34 61 (5)
180.5 / 19.7	SAND, Trace of Silt, Very Dense	16	SS	94	0 92 (8)
		17	SS	129	
		18	SS	139	
175.4 / 24.8	End of Borehole	19	SS	103	

Ground water level shown at approx. elev. 184.6.

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 (%) 10 20 30

UNIT WEIGHT γ kN/m^3

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 93-2

METRIC

W.P. 647 - 89 - 02 LOCATION STA. 26 + 545.6 O/S 2.5 m LT. OF ℄ HWY. 11/17 WBL ORIGINATED BY M V

DIST 19 HWY 11/17 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & BW CASING COMPILED BY M V

DATUM GEODETIC DATE 93 10 27 TO 93 10 29 CHECKED BY M V

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
197.1	Ground Surface						
0.0	SAND, Trace of Silt, Compact to Dense					196	
		1	SS	19			
		2	SS	15		194	
		3	SS	18		192	0 97 (3)
		4	SS	22			
		5	SS	21		190	
		6	SS	38		188	
		7	SS	44		186	
		8	SS	49	▼	184	
	Very Dense	9	SS	153			
		10	SS	64	/15cm	182	
	Some Gravel	11	SS	115	P1	180	24 68 (8)
		12	SS	40		178	
176.5		13	SS	85			10 83 (7)
20.6	GRAVELLY SAND, Trace of Silt, Occasional Cobbles, Very Dense; Boulders					176	
		14	SS	112			
		15	SS	110		174	55 39 (6)
		16	SS	59		172	
170.8							
26.3	SANDY SILT, Very Dense					170	
		17	SS	156	/25cm		
						168	
166.6 / 30.5							

Continued

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

Continued

RECORD OF BOREHOLE No 93-2 2 OF 2 METRIC

W.P. 647 - 89 - 02 LOCATION STA. 26 + 545.6 O/S 2.5 m LT. OF ℄ HWY. 11/17 WBL ORIGINATED BY M V

DIST 19 HWY 11/17 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & BW CASING COMPILED BY M V

DATUM GEODETIC DATE 93 10 27 TO 93 10 29 CHECKED BY M V

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
166.6	Continued										
166.3			18	SS	100	/13cm					
30.8	End of Borehole										

*Note: Groundwater Conditions

Date	Elevation
10 29	184.1
10 30	184.15
10 31	184.15

93 10 29

* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	184.1

$+^3, \times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 93-3

METRIC

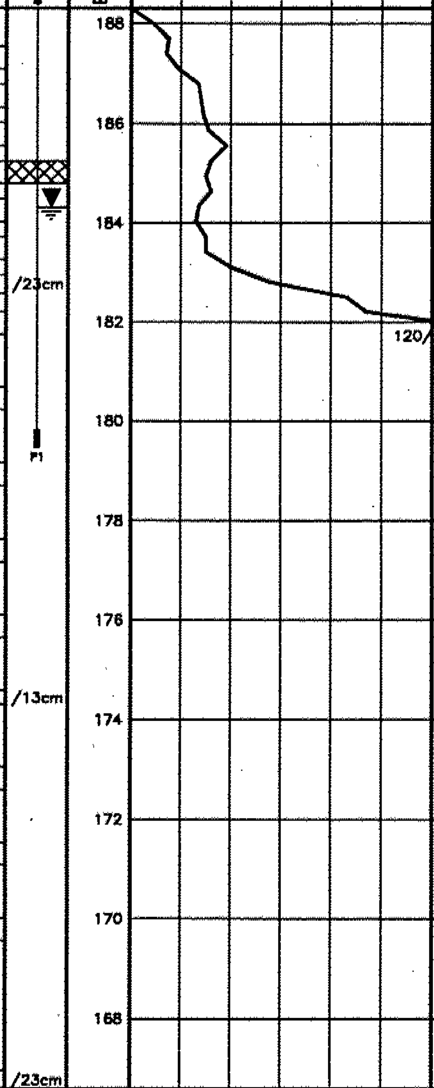
W.P. 647 - 89 - 02 LOCATION STA. 26 + 605 O/S 5.0 m LT. OF ℄ HWY. 11/17 WBL ORIGINATED BY M V

DIST 19 HWY 11/17 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 93 10 20 CHECKED BY M V

ELEV / DEPTH	DESCRIPTION	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
188.3	Ground Surface	
0.0	SAND, Trace of Silt, Compact to Very Dense	0 98 (2)
182.1 / 6.2	GRAVELLY SAND, Trace of Silt, Occasional Cobbles, Very Dense	52 41 (7)
180.0 / 8.3	SAND, Trace of Silt, Trace of Gravel, Dense to Very Dense	3 93 (4)
171.7 / 16.6	SANDY SILT, Very Dense	0 12 (88)
166.6 / 21.7	End of Borehole	

NUMBER	TYPE	'N' VALUES
1	SS	18
2	SS	18
3	SS	20
4	SS	17
5	SS	19
6	SS	24
7	SS	128 /23cm
8	SS	125
9	SS	113
10	SS	19
11	SS	65
12	SS	44
13	SS	100 /13cm
14	SS	100
15	SS	112
16	SS	83
17	SS	139 /23cm



WATER CONTENT (%) 10 20 30 — UNIT WEIGHT γ kN/m³

* Note: Groundwater Conditions

Date	Elevations
10 21	184.3
10 23	184.0
10 25	183.9
10 27	183.9
10 29	184.1
10 31	184.1

93 10 20

* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	184.2

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

RECORD OF BOREHOLE No 93-4 1 OF 1 METRIC

W.P. 647 - 89 - 02 LOCATION STA. 26 + 672.5 O/S 6.1 m RT. OF ℄ HWY. 11/17 WBL ORIGINATED BY M V

DIST 19 HWY 11/17 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V

DATUM GEODETIC DATE 93 10 29 & 93 10 30 CHECKED BY M V

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
186.0	Ground Surface						
0.0	Organics						
	SAND, Trace of Silt, Trace of Gravel, Compact to very Dense	1	SS	54	▼	184	
		2	SS	30			
						182	
		3	SS	18			
					P1	180	
		4	SS	32			
177.6		5	SS	67		178	
8.4	GRAVELLY SAND, Trace of Silt, Occasional Cobbles, Very Dense	6	SS	61			20 74 (6)
						176	
		7	SS	97			
						174	
		8	SS	102	/15cm		42 51 (7)
171.6		9	SS	111	/15cm	172	
14.4	SAND, Trace of Silt, Very Dense	10	SS	97	/15cm		
169.5						170	
18.5	SANDY SILT to SILT, Occasional Clayey Silt Layers, Very Dense	11	SS	63			
						168	
		12	SS	93			0 35 (65)
		13	SS	152	/23cm	166	
		14	SS	81			
						164	
162.7		15	SS	51			
23.3	End of Borehole						

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 (%) 10 20 30. Unit Weight γ kN/m³.

* Note:

Groundwater Conditions

Date	Elevations
10 29	183.9
10 30	184.0
10 31	183.9

93 10 30

* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	184.0

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 93–5

METRIC

W.P. 647 – 89 – 02 LOCATION STA. 26 + 804.5 O/S 6.3 m RT. OF ℄ HWY. 11/17 WBL ORIGINATED BY M V

DIST 19 HWY 11/17 BOREHOLE TYPE HOLLOW STEM AUGER, BW CASING & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 93 10 25 & 93 10 26 CHECKED BY M V

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
205.0	Ground Surface
0.0	SAND, Trace of Silt, Trace of Gravel, Compact to Dense
195.8 / 9.2	GRAVELLY SAND, Trace of Silt, Occasional Cobbles, Very Dense
187.8 / 17.2	SAND, Some Silt, Dense to Very Dense
184.3 / 20.7	SANDY SILT to SILT, Very Dense
174.5 / 30.5	Continued

SAMPLES

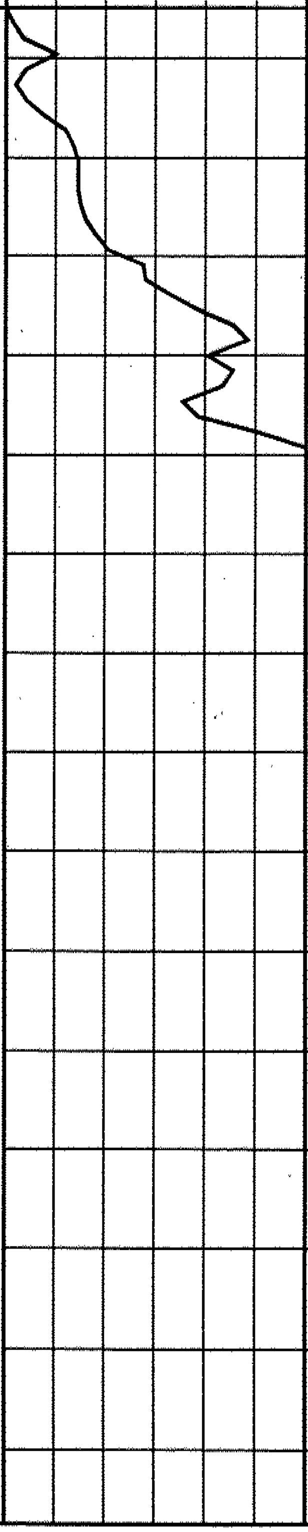
NUMBER	TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	15	
2	SS	25	
3	SS	30	
4	SS	28	
5	SS	42	
6	SS	47	
7	SS	42	
8	SS	48	
9	SS	54	34 62 (4)
10	SS	59	
11	SS	98	
12	SS	36	
13	SS	52	40 54 (6)
14	SS	40	0 80 (20)
15	SS	100/11cm	
16	SS	92/15cm	0 1 (99)
17	SS	102	
18	SS	100/13cm	

GROUND WATER CONDITIONS: piezometer P1

ELEVATION SCALE: 204, 202, 200, 198, 196, 194, 192, 190, 188, 186, 184, 182, 180, 178, 176

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 (%): 10 20 30

UNIT WEIGHT γ kN/m³

Continued

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 15-◇-5 10 (%) STRAIN AT FAILURE

Continued

RECORD OF BOREHOLE No 93-5 — 2 OF 2 — METRIC

W.P. 647 - 89 - 02 | LOCATION STA. 26 + 804.5 O/S 6.3 m RT. OF ℄ HWY. 11/17 WBL | ORIGINATED BY M V

DIST 19 HWY 11/17 | BOREHOLE TYPE HOLLOW STEM AUGER, BW CASING & CONE TEST | COMPILED BY M V

DATUM GEODETIC | DATE 93 10 25 & 93 10 26 | CHECKED BY M V

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
174.5	Continued							
30.5	SANDY SILT to SILT, Occasional Clayey Silt Layers, Very Dense	19	SS	120	/23cm	174		
						172		
		20	SS	162		170		
		21	SS	114	/15cm	168		0 1 (99)
167.4 / 37.6	CLAYEY SILT, Hard					166		
164.9 / 40.1	End of Borehole	22	SS	96				

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 (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

* Note:

Groundwater Conditions

Date	Elevation
10 25	184.0
10 27	184.3
10 29	184.3
10 31	184.3

93 10 26
* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	184.0

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

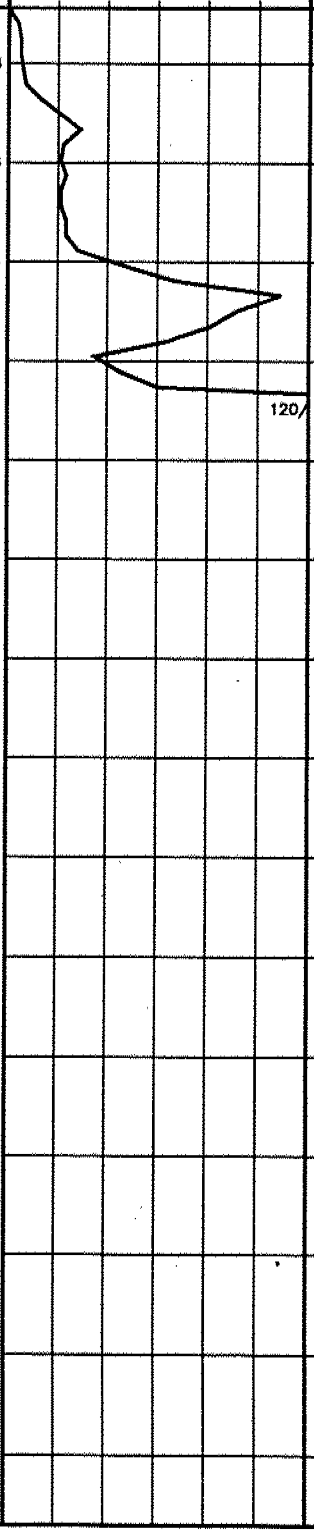
RECORD OF BOREHOLE No 93-6 1 OF 2 METRIC

W.P. 647 - 89 - 02 LOCATION STA. 26 + 840 O/S 6.3 m RT. OF ℄ HWY. 11/17 WBL ORIGINATED BY M V

DIST 19 HWY 11/17 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 93 10 21 & 93 10 22 CHECKED BY M V

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
209.1	Ground Surface					
0.0	SAND, Trace of Silt, Trace of Gravel, Compact to Dense				208	
		1	SS	15		
		2	SS	30	206	0 93 (7)
		3	SS	20	204	
		4	SS	46		
		5	SS	49		
		6	SS	33	202	
		7	SS	44		
		8	SS	23	200	
		9	SS	29		
		10	SS	31		
		11	SS	31	198	
		12	SS	36	196	
		13	SS	38	194	
	Very Dense	14	SS	50		
		15	SS	61	192	7 90 (3)
		16	SS	68		
190.0 / 19.1	GRAVELLY SAND, Trace of Silt, Occasional Cobbles, Very Dense				190	
		17	SS	96		32 64 (4)
		18	SS	100	188	
		19	SS	152	186	
		20	SS	107	184	34 62 (4)
		21	SS	56		
182.1 / 27.0	SAND, Trace of Silt, Trace of Gravel, Very Dense				182	
		22	SS	55		
		23	SS	81	180	
178.6 / 30.5						



GROUND WATER CONDITIONS: P1

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

Continued

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

Continued

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 93-6 METRIC

W.P. 647 - 89 - 02 LOCATION STA. 26 + 840 O/S 6.3 m RT. OF ℄ HWY. 11/17 WBL ORIGINATED BY M V

DIST 19 HWY 11/17 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 93 10 21 & 93 10 22 CHECKED BY M V

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
178.8	Continued										
178.2		•	24	SS	117						
30.9	End of Borehole										

* Note:

Groundwater Conditions

Date	Elevations
10 23	184.8
10 25	184.8
10 27	184.8
10 29	184.8
10 31	184.9

93 10 22

* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	184.7

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

Appendix D

Selected Site Photographs

Photograph 1 – Highway 11/17 at the Nipigon River
(looking east)

Photograph 2 – Highway 11/17 Bridge and CP Bridge over the Nipigon River
(looking southeast)

Photograph 3 – Looking towards east abutment, north side of existing Highway 11/17 Bridge over the Nipigon River

Photograph 4 – Looking towards west abutment, north side of existing Highway 11/17 Bridge over the Nipigon River

Appendix E

List of OPSS and OPSD

1. List of OPSS Documents and OPSD Drawings Referenced in this Report

- OPSS 206
- OPSS 501
- OPSS 539
- OPSS 804
- OPSS 902
- OPSS 903
- OPSD 3101.150
- OPSD 3102.100
- SP 110S13

Appendix F

Drawings titled “Borehole Locations and Soil Strata”

METRIC

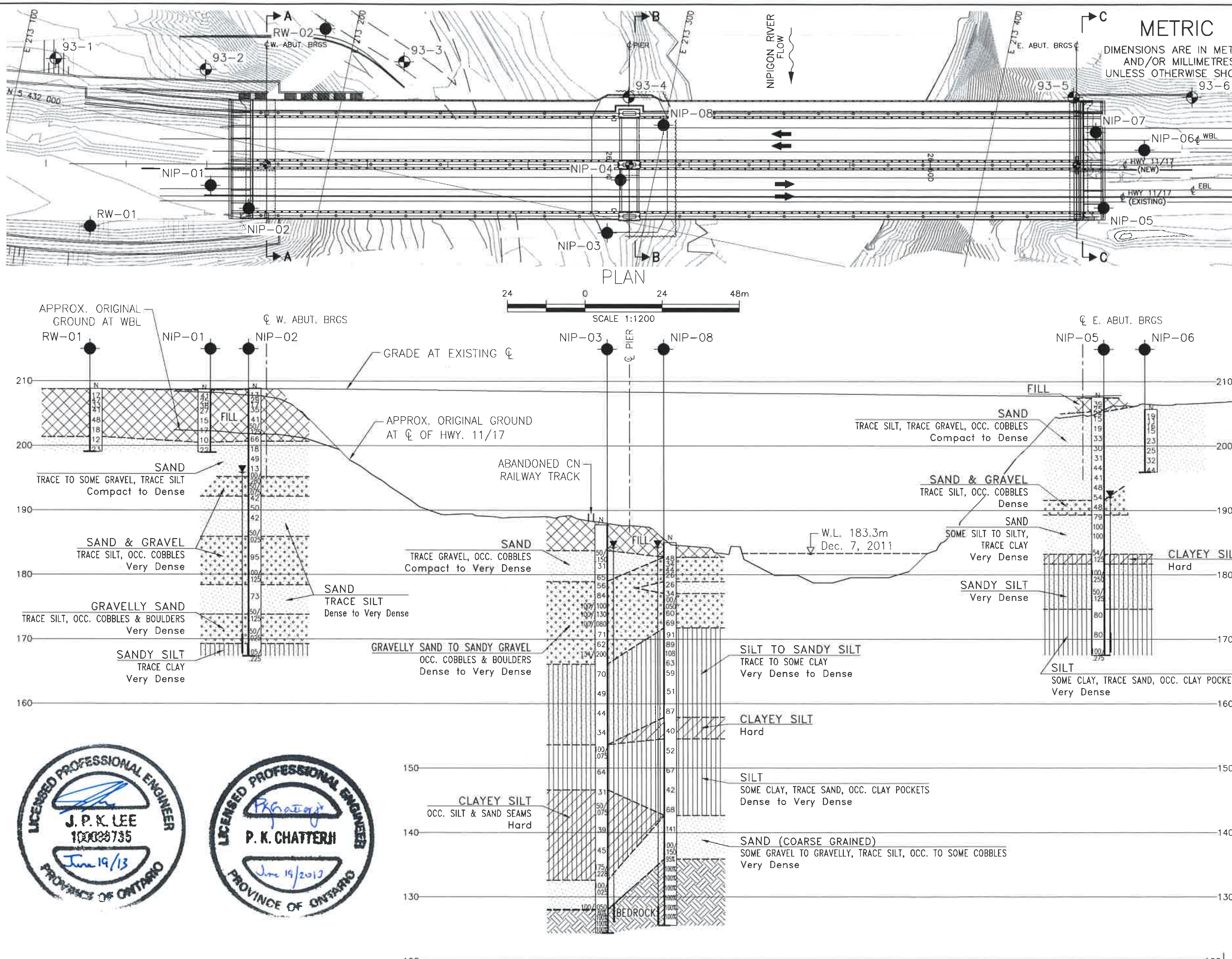
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No 2013-6000
WP No 124-90-01

HWY 11/17
NIPIGON RIVER BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.



PROFILE ALONG ℄ OF HIGHWAY 11/17

H 1:1200

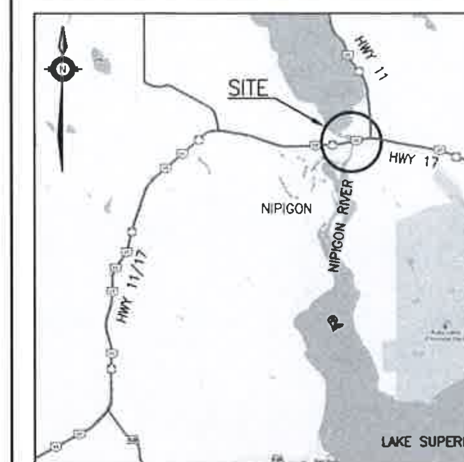
V 1:600

LICENSED PROFESSIONAL ENGINEER J. P. K. LEE 100028735 June 19/13 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER P. K. CHATTERJI June 19/2013 PROVINCE OF ONTARIO

NO	ELEVATION	NORTHING	EASTING
RW-01	208.8	5 431 964.9	213 131.4
RW-02	188.0	5 432 039.9	213 190.7

KEYPLAN



LEGEND

●	Borehole – Current Investigation
⊕	Previous Borehole – 1993 MTO Investigation
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
┬	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
NIP-01	208.7	5 431 984.9	213 165.5
NIP-02	208.9	5 431 980.3	213 178.6
NIP-03	187.8	5 431 995.4	213 289.2
NIP-04	187.7	5 432 012.4	213 290.0
NIP-05	207.6	5 432 034.2	213 438.8
NIP-06	205.7	5 432 054.4	213 447.6
NIP-07	205.3	5 432 056.8	213 431.7
NIP-08	184.9	5 432 031.8	213 299.6
93-1	200.2	5 432 013.8	213 110.3
93-2	197.1	5 432 020.0	213 156.7
93-3	188.3	5 432 034.8	213 216.6
93-4	186.0	5 432 038.2	213 287.3
93-5	205.0	5 432 066.1	213 422.8
93-6	209.1	5 432 073.5	213 458.7

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. 52H-21

REVISIONS	DATE	BY	DESCRIPTION

DESIGN LRB	CHK AEG	CODE	LOAD	DATE JUN. 2013
DRAWN MFA	CHK –	SITE	STRUCT	DWG 1

METRIC

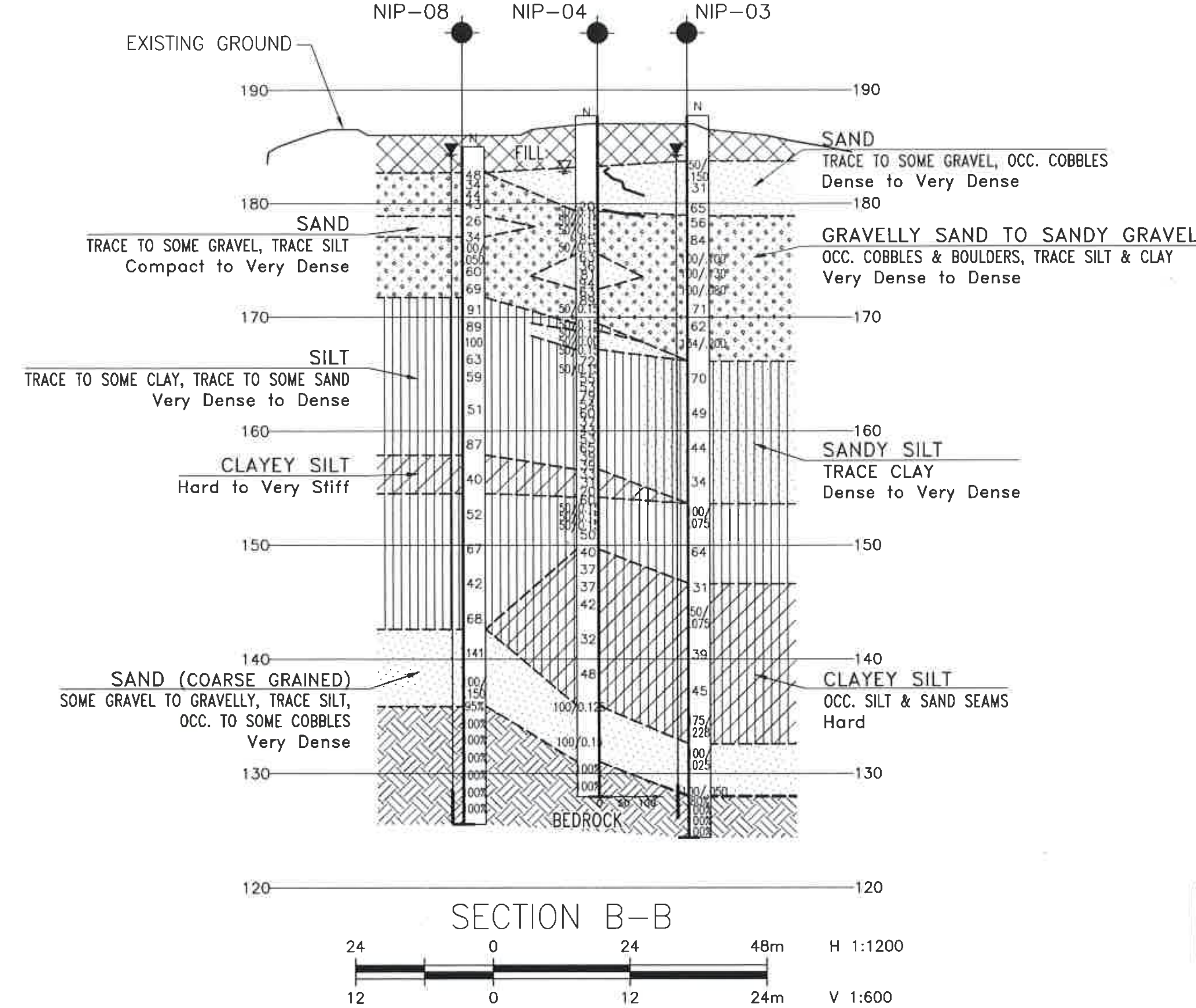
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No 2013-6000
WP No 124-90-01

SHEET

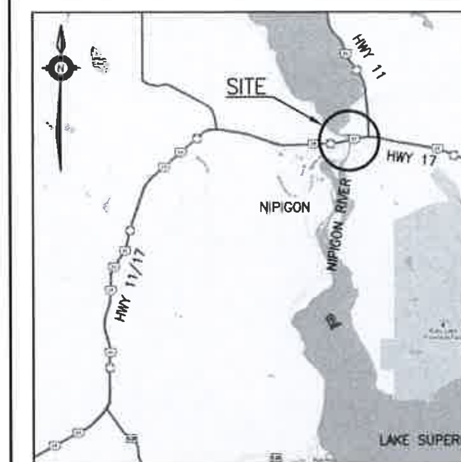
HWY 11/17
NIPIGON RIVER BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

THURBER ENGINEERING LTD.



SECTION B-B

H 1:1200
V 1:600



KEYPLAN

NO	ELEVATION	NORTHING	EASTING
RW-01	208.8	5 431 964.9	213 131.4
RW-02	188.0	5 432 039.9	213 190.7

LEGEND

⯁	Borehole – Current Investigation
⯁	Previous Borehole – 1993 MTO Investigation
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
┃	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

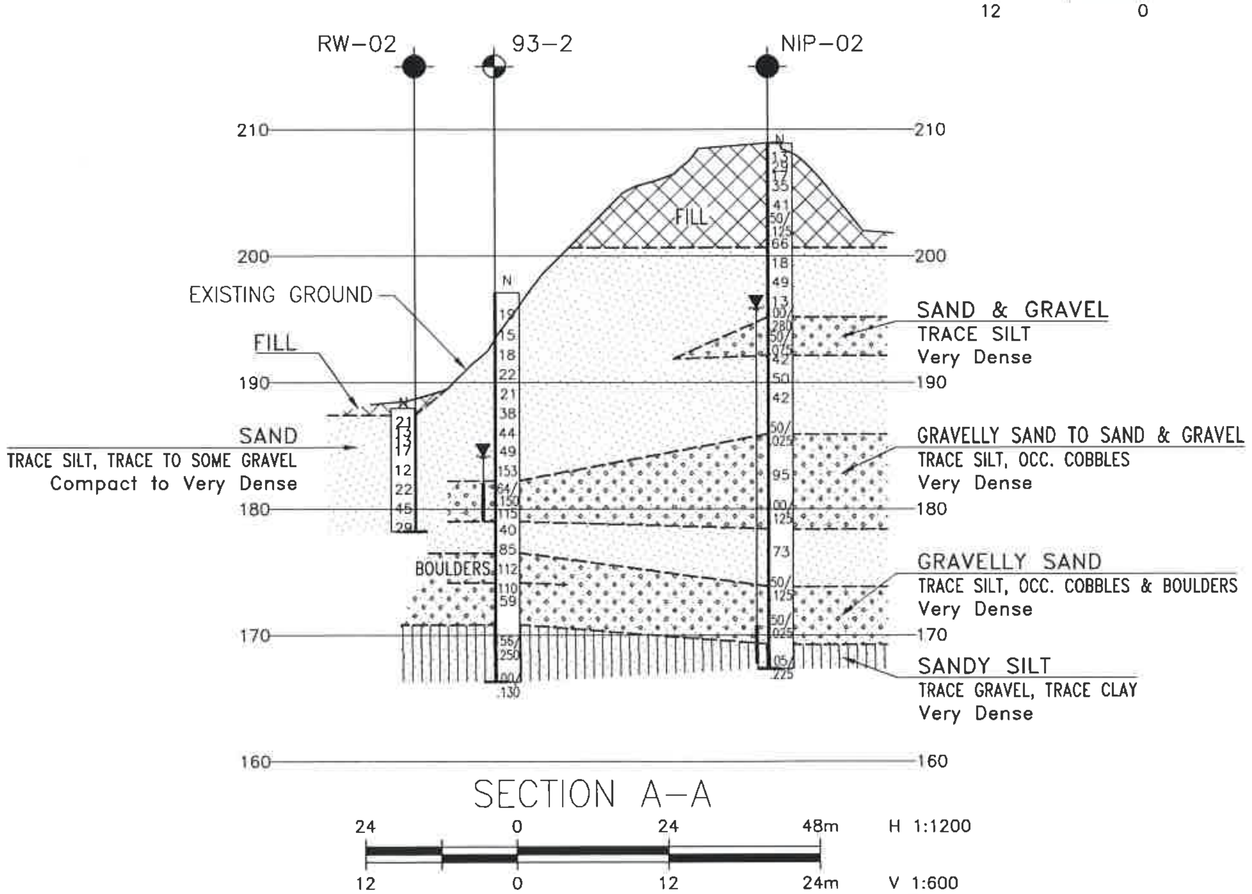
NO	ELEVATION	NORTHING	EASTING
NIP-01	208.7	5 431 984.9	213 165.5
NIP-02	208.9	5 431 980.3	213 178.6
NIP-03	187.8	5 431 995.4	213 289.2
NIP-04	187.7	5 432 012.4	213 290.0
NIP-05	207.6	5 432 034.2	213 438.8
NIP-06	205.7	5 432 054.4	213 447.6
NIP-07	205.3	5 432 056.8	213 431.7
NIP-08	184.9	5 432 031.8	213 299.6
93-1	200.2	5 432 013.8	213 110.3
93-2	197.1	5 432 020.0	213 156.7
93-3	188.3	5 432 034.8	213 216.6
93-4	186.0	5 432 038.2	213 287.3
93-5	205.0	5 432 066.1	213 422.8
93-6	209.1	5 432 073.5	213 458.7

-NOTES-

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

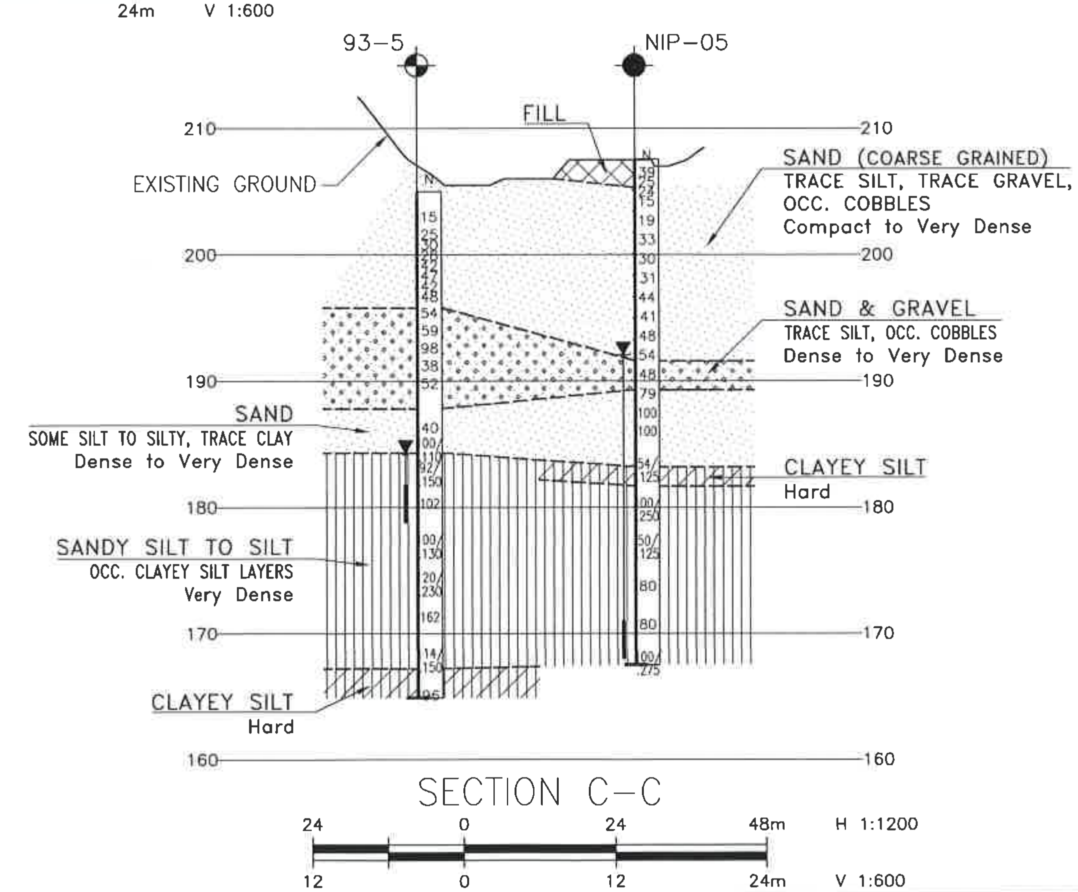
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 52H-21



SECTION A-A

H 1:1200
V 1:600



SECTION C-C

H 1:1200
V 1:600

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN LRB	CHK AEG	CODE	LOAD	DATE JUN. 2013	
DRAWN MFA	CHK –	SITE	STRUCT	DWG 2	

FILENAME: H:\Drafting\19\1351\180\ed1180-NipigonRiverBridge.dwg
PLOTDATE: 6/19/2013 11:22 AM

Appendix G

**Structural Loads for Foundation Design
(Provided by McCormick Rankin)**

Project: **7898-Nipigon River Bridge _ Pier Fooring Design**

Complete Bridge - Pile Cap Reaction

1.0 Weight of Full Pile-Cap γc= 24 kN/m³

	L= 41.0 m	W= 20.5 m	H= 3.5 m
minus 4 x corner :	L= 6.5 m	W= 2.15 m	H= 3.5 m
	Un-factored W ftg =	-68254 kN	

2.0 Loading effects on the underside pile-cap (= elev 184.0m), Load Combinations considered W ftg

	Comb Case	Max/Min	F1 (F_{Longit}) (kN)	F2 (F_{Trans}) (kN)	F3 ($F_{Z, Vert}$) (kN)	M1 (M_{Trans}) (kN.m)	M2 (M_{Longit}) (kN.m)	M3 (Torsion) (kN.m)
During Construction	DL+SDL	-	*0*	*-1980*	*198534*	*222907*	*-48286*	*32005*
	SLS Case1	Max	*3652*	*615*	*212097*	*288544*	*87741*	*-1880*
		MIN	*-3648*	*-4483*	*195296*	*202191*	*-134424*	*-8988*
	SLS Case2	Max	*4151*	*809*	*212561*	*284128*	*52123*	*28510*
		MIN	*-4148*	*-4326*	*195632*	*197041*	*-198477*	*21803*
	ULS Case1	Max	*6513*	*-1236*	*238438*	*332590*	*153376*	*-3735*
		MIN	*-6519*	*-2650*	*207080*	*242945*	*-216657*	*-15046*
	ULS Case2	Max	*6353*	*1807*	*245841*	*353323*	*155639*	*-3694*
		MIN	*-6349*	*-5769*	*199273*	*213144*	*-226422*	*-16006*
	ULS Case3	Max	*7395*	*3348*	*245682*	*299402*	*187774*	*-428*
		MIN	*-7565*	*-5065*	*190911*	*157903*	*-257382*	*-12372*
	ULS Case4	Max	*6439*	*6925*	*243878*	*167242*	*181348*	*8314*
			-7007	*-5929*	*190404*	*42654*	*-229721*	*2631*
In Service	DL+SDL	-	*0*	*-3916*	*220237*	*211068*	*7175*	*-9307*
	SLS1	Max	*5332*	*-1125*	*235777*	*244270*	*151761*	*66427*
		MIN	*-5352*	*-6781*	*214799*	*188380*	*-182601*	*-77146*
	SLS3	Max	*2811*	*1544*	*231762*	*248733*	*132223*	*32946*
		MIN	*-2791*	*-9622*	*208764*	*171075*	*-117959*	*-50758*
	ULS1	Max	*9956*	*-3073*	*274206*	*265894*	*275300*	*131161*
		MIN	*-10030*	*-5490*	*202095*	*226177*	*-344580*	*-144573*
	ULS2	Max	*9459*	*-90*	*280058*	*286710*	*272829*	*124189*
		MIN	*-9500*	*-8656*	*187688*	*199214*	*-347425*	*-136681*
	ULS3	Max	*10043*	*1506*	*280821*	*292865*	*315748*	*133681*
		MIN	*-10080*	*-10681*	*184465*	*192154*	*-374863*	*-145756*
	ULS4	Max	*5947*	*5216*	*267210*	*304299*	*280439*	*79216*
		MIN	*-5916*	*-14064*	*179529*	*156817*	*-271845*	*-88496*
	ULS9	Max	*0*	*-5355*	*303989*	*286006*	*-63760*	*-10946*
		MIN	*0*	*-5355*	*283513*	*286006*	*-63760*	*-10946*

North Half Bridge - Pile Cap Reaction

3.0 Weight of Half Pile-Cap γc= 24 kN/m³

	L= 23.8 m	W= 20.5 m	H= 3.5 m
minus 2 x corner :	L= 6.5 m	W= 2.15 m	H= 3.5 m
A=464.5m²	Un-factored W ftg =	-39018 kN	

4.0 Loading effects on the underside pile-cap (= elev 184.0m), Load Combinations considered W ftg

	Comb Case	Step Type	F1 (F_{Longit}) (kN)	F2 (F_{Trans}) (kN)	F3 ($F_{Z, Vert}$) (kN)	M1 (M_{Trans}) (kN.m)	M2 (M_{Longit}) (kN.m)	M3 (Torsion) (kN.m)
During Construction	DL	-	*0*	*0*	*111075*	*46792*	*-123326*	*149*
	SLS Case1	Max	*6748*	*2163*	*119819*	*67180*	*193514*	*24465*
		MIN	*-6748*	*-2163*	*104573*	*31549*	*-192027*	*-24505*
	SLS Case2	Max	*3223*	*1009*	*116210*	*58492*	*-1759*	*12203*
		MIN	*-3223*	*-1009*	*109095*	*41862*	*-244903*	*-11903*
	ULS Case1	Max	*14078*	*4370*	*142606*	*89973*	*396085*	*51028*
		MIN	*-14078*	*-4370*	*100158*	*17854*	*-394457*	*-51072*
	ULS Case2	Max	*8087*	*2478*	*147738*	*83589*	*114740*	*30021*
		MIN	*-8087*	*-2478*	*118601*	*42694*	*-423071*	*-29647*
Bridge in Service	DL+SDL	-	*0*	*38*	*121275*	*69341*	*9554*	*815*
	SLS1	Max	*2657*	*1297*	*128674*	*86179*	*114359*	*22773*
		MIN	*-2657*	*-1330*	*120306*	*66069*	*-129090*	*-23009*
	SLS3	Max	*1407*	*2857*	*128127*	*88625*	*70103*	*13295*
		MIN	*-1407*	*-2953*	*113898*	*51267*	*-53430*	*-11679*
	ULS1	Max	*4942*	*496*	*150753*	*93430*	*196759*	*41910*
		MIN	*-4942*	*-468*	*108836*	*75088*	*-232469*	*-42939*
	ULS2	Max	*4710*	*1934*	*150363*	*103571*	*194719*	*40100*
		MIN	*-4710*	*-2016*	*107699*	*71424*	*-234130*	*-41177*
	ULS3	Max	*4999*	*2847*	*152625*	*107324*	*206582*	*42832*
		MIN	*-4999*	*-3131*	*103660*	*66002*	*-235197*	*-43446*
	ULS4	Max	*2924*	*4792*	*140369*	*113421*	*135070*	*27162*
		MIN	*-2924*	*-4832*	*104125*	*47117*	*-116471*	*-24973*
	ULS9	Max	*0*	*51*	*157869*	*93610*	*12898*	*1101*
		MIN	*0*	*51*	*146163*	*93610*	*12898*	*1101*

Project: **7898-Nipigon River Bridge** Dec 21/ 2012

East Abutment FND:

1.0 Completed E Abut Reaction Force

Loading effects on the underside E Abut FND, Load Combinations considered W ftg

Comb Case	Max/Min	F1* (F_{Longit}) (kN)	F2 (F_{Trans}) (kN)	F3 ($F_{Z, Vert}$) (kN)	M1 (M_{Trans}) (kN.m)	M2 (M_{Longit}) (kN.m)	M3 (Torsion) (kN.m)
SLS1	Max	-1841	253	26367	-9215	-1764	
	MIN	1397	-264	22589	-7859	252	
SLS3	Max	-1838	523	24362	-6824	-683	
	MIN	1394	-516	22136	-8907	505	
ULS1	Max	-2276	390	34148	-11860	-3677	
	MIN	1117	-476	20067	-39238	-25	
ULS2	Max	-2231	456	34316	-12108	-3766	
	MIN	1257	-453	23243	-48765	-1719	
ULS3	Max	-2228	709	34094	-10908	-3639	
	MIN	1673	-714	19375	-43276	358	
ULS4	Max	-2252	707	31009	-9166	-1994	
	MIN	1742	-671	20594	-38489	-292	
ULS9	Max	-2002	-36	29581	-10543	-465	
	MIN	1402	-36	20775	-9013	811	

*Note: Earth pressure at the back of the abutment are not accounted. ie. E. press = 0 kPa

2.0 Half (Stg1) E Abut Reaction Force

Loading effects on the underside E Abut FND, Load Combinations considered W ftg

Comb Case	Step Type	F1* (F_{Longit}) (kN)	F2 (F_{Trans}) (kN)	F3 ($F_{Z, Vert}$) (kN)	M1 (M_{Trans}) (kN.m)	M2 (M_{Longit}) (kN.m)	M3 (Torsion) (kN.m)
SLS1	Max	-922	-272	14232	-7492	488	
	MIN	653	-534	12300	-7679	1325	
SLS3	Max	-922	-109	12916	-6683	1058	
	MIN	653	-647	12179	-8581	1378	
ULS1	Max	-1483	-268	18671	-8393	-1341	
	MIN	1147	-626	9747	-8163	367	
ULS2	Max	-1465	-161	18539	-7070	-1118	
	MIN	1101	-667	9645	-8045	411	
ULS3	Max	-1152	-50	18360	-7606	-436	
	MIN	829	-774	9494	-8642	1680	
ULS4	Max	-1200	-129	16275	-6839	468	
	MIN	864	-683	9329	-8777	1764	
ULS9	Max	-1153	-109	15896	-6217	760	
	MIN	816	-647	9795	-9163	1751	

*Note: Earth pressure at the back of the abutment are not accounted. ie. E. press = 0 kPa

Project: **7898-Nipigon River Bridge** Dec 22/ 2012

West Abutment FND:

1.0 Completed W Abut Reaction Force

Loading effects on the underside W Abut FND, Load Combinations considered W ftg

Comb Case	Max/Min	F1* (F_{Longit})	F2 (F_{Trans})	F3 ($F_{Z, Vert}$)	M1 (M_{Trans})	M2 (M_{Longit})	M3 (Torsion)
		(kN)	(kN)	(kN)	(kN.m)	(kN.m)	(kN.m)
SLS1	Max	*1363*	*492*	*27104*	*9061*	*-12528*	
	MIN	*-917*	*-485*	*21033*	*4995*	*-21331*	
SLS3	Max	*959*	*594*	*25342*	*9902*	*-15084*	
	MIN	*-512*	*-549*	*21137*	*4872*	*-21181*	
ULS1	Max	*1996*	*814*	*36171*	*12886*	*-7953*	
	MIN	*-1438*	*-905*	*14939*	*256*	*-20443*	
ULS2	Max	*1984*	*874*	*36605*	*12397*	*-7323*	
	MIN	*1277*	*-858*	*14310*	*1367*	*-21355*	
ULS3	Max	*2022*	*1106*	*36746*	*10807*	*-6973*	
	MIN	*-1464*	*-1096*	*13779*	*-2277*	*-21979*	
ULS4	Max	*2009*	*908*	*34068*	*10285*	*-7461*	
	MIN	*-1406*	*-823*	*13876*	*-286*	*-21839*	
ULS9	Max	*3127*	*-17*	*28614*	*7198*	*-23572*	
	MIN	*-1100*	*-17*	*15995*	*4976*	*-23572*	

*Note: Earth pressure at the back of the abutment are not accounted. ie. E. press = 0 kPa

2.0 Half (Stg1) W Abut Reaction Force

Loading effects on the underside W Abut FND, Load Combinations considered W ftg

Comb Case	Step Type	F1* (F_{Longit})	F2 (F_{Trans})	F3 ($F_{Z, Vert}$)	M1 (M_{Trans})	M2 (M_{Longit})	M3 (Torsion)
		(kN)	(kN)	(kN)	(kN.m)	(kN.m)	(kN.m)
SLS1	Max	*1298*	*-195*	*16097*	*-1820*	*-4780*	
	MIN	*-1022*	*-643*	*12545*	*-3070*	*-9042*	
SLS3	Max	*1310*	*-83*	*14664*	*-1703*	*-6435*	
	MIN	*-1034*	*-655*	*13128*	*-3840*	*-8278*	
ULS1	Max	*1622*	*-169*	*21666*	*-2647*	*-4120*	
	MIN	*-1277*	*-814*	*8602*	*-4022*	*-10921*	
ULS2	Max	*1637*	*-33*	*21598*	*-2391*	*-4121*	
	MIN	*-1292*	*-858*	*8484*	*-3866*	*-10981*	
ULS3	Max	*1548*	*62*	*21518*	*215*	*-4775*	
	MIN	*-1200*	*-941*	*8380*	*-4483*	*-11663*	
ULS4	Max	*1536*	*-41*	*19261*	*-1226*	*-7484*	
	MIN	*-1191*	*-745*	*9294*	*-4389*	*-10566*	
ULS9	Max	*1476*	*-536*	*17172*	*-4420*	*-8064*	
	MIN	*-1131*	*-536*	*9774*	*-6641*	*-10320*	