FOUNDATION INVESTIGATION REPORT
PINE RIVER BRIDGE REPLACEMENT
HIGHWAY 61, DISTRICT OF THUNDER BAY, ONTARIO
W.P. 6098-10-01, SITE #48W-105

Geocres Number: 52A-196

Report to

Hatch Mott MacDonald

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

January 15, 2015
File: 19-1605-121

TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

Appendices

FOUNDATION INVESTIGATION REPORT
PINE RIVER BRIDGE REPLACEMENT
HIGHWAY 61, DISTRICT OF THUNDER BAY, ONTARIO
W.P. 6098-10-01, SITE #48W-105

Geocres Number: 52A-196

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the proposed replacement of the Pine River Bridge on Highway 61, in the Thunder Bay District, Ontario.

The purpose of the investigation was to explore the subsurface conditions at the site, and based on the data obtained, to provide a borehole location plan, record of borehole sheets, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

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

2 SITE DESCRIPTION

The bridge site is located on Highway 61 approximately 39 km south of Thunder Bay. The Pine River flows meandering easterly into the Lake Superior. The existing bridge is a single span structure with a span length of 24.4 m. A total length of 40.9 m between the ends of the wing walls and 11.1 m bridge deck width was indicated on the archive design drawings dated July 1949. The existing approach embankments are approximately 4.5 m in height.

The land surrounding the site is treed and undulating with low hills in the vicinity. Photographs of the bridge and surrounding area are presented in Appendix C.

The site lies within the physiographical region known as the Animikie Basin of the Southern Province, which is characterized by sedimentary rock of the Rove Formation. According to Ontario Geological Survey (OGS) data, the bedrock at this site generally consists of black shale, siltstone, greywacke and limestone. The bedrock is overlain by glaciolacustrine and quiet basin deposits of the Pleistocene age consisting of silts and clays with minor sands.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing at this site were carried between October 29 and November 3, 2014. A total of four boreholes, denoted as PINE-01, PINE-02, PINE-05, and PINE-06, were advanced to depths ranging from 9.8 m to 45.0 m below the existing highway embankment. Two dynamic cone penetration tests denoted PINE-03 and PINE-04 were advanced to 24.1 m each, to supplement the sampled borehole information. Details of the borehole locations, drilling depths and completion details are summarized in Table 3.1 below. It is noted that the investigation was programmed on the basis of a bridge rehabilitation anticipated at the time of drilling.

Table 3.1 – Field Work Summary

Location	Boreholes	Drilling and Coring Depth/ Base of Hole Elevation (m)	Completion Details
South Approach	PINE -01	9.8 / 205.3	Borehole backfilled with bentonite holeplug and cuttings to 0.3 m, concrete mix to 0.05 m then asphalt to surface.
South Abutment	PINE-02	45.0 / 170.0	Borehole backfilled with bentonite holeplug to 36.6 m, holeplug and cuttings to 0.3 m, concrete to 0.1 m, then asphalt patch to surface.
	PINE-03	24.1 / 190.9	Dynamic cone penetration test.
North Abutment	PINE-04	24.1 / 190.9	Dynamic cone penetration test.
	PINE-05	32.3 / 182.7	Borehole backfilled with bentonite holeplug to 4.6 m, cuttings to 0.3 m, concrete to 0.1 m then asphalt cold patch to surface. Moved 1.5 m north, augered to12.2 m (Elev. 202.8) and installed standpipe piezometer consisting of 19 mm diameter Schedule 40 PVC pipe with a 3 m slotted screen.
North Approach	PINE-06	10.2 / 204.9	Borehole backfilled with bentonite holeplug and cuttings to 0.3 m, dry cement to 0.1 m then asphalt cold patch to surface.

The locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawings included in Appendix D.

All boreholes were advanced using a CME55 truck-mounted drill rig in combination with hollow stem augers and NW casing/tri-cone methods to advance the boreholes in the overburden. Samples of the encountered soils were obtained from the boreholes at selected intervals using a split spoon sampler in

conjunction with Standard Penetration Testing (SPT). The field vane in the N-size was used to obtain in-situ undrained shear strength of the cohesive soils.

Borehole PINE-02 was advanced through a till layer with cobbles and boulders (above bedrock) by coring using rock coring equipment in NQ size. Coring was continued to a depth of 5.2 m into the underlying bedrock. All rock cores were logged, and the values of Total Core Recovery (TCR), Solid Core Recovery (SCR) and Rock Quality Designation (RQD) 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 and processed the recovered soil and rock samples for transport to Thurber's laboratory for further examination and testing. The ground surface elevations at the boreholes and borehole locations were obtained from the drawings provided from HMM.

Groundwater conditions in the open boreholes were observed during the drilling operations. A standpipe piezometer consisting of 19 mm PVC pipe with a slotted screen was installed adjacent to Borehole PINE-05. Following the final water level reading, the piezometer was decommissioned in general accordance with MOE Regulation 903.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets included in Appendix A. Selected samples were also subjected to grain size analysis and Atterberg Limits testing, and the results of this testing program are summarized on the Record of Borehole sheets in Appendix A and shown on the figures included in Appendix B.

Point load tests (PLT) were performed on selected intact rock core samples. Unconfined compressive strengths (UCS) of the rock cores correlated from the PLT results are shown on the Record of Borehole sheets in Appendix A and the results of the testing are enclosed in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A presenting details of the encountered soils. The model of the soil stratigraphy is illustrated on the "Borehole Locations and Soil Strata" drawing in Appendix D.

An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

The subsurface stratigraphy encountered below the existing embankment fill at the site generally consists of glaciolacustrine cohesive and cohesionless deposits underlain by a glacial till and bedrock. The cohesive deposits consist of silty clays and clayey silts extending to depths between 26.8 m and 27.7 m. A cohesionless deposit of silt to clayey silt extends to the clayey silt till encountered at 34.3 m depth on the south side and to sandy gravel encountered at 30.6 m depth on the north side. The

limestone bedrock was encountered at approximately 39.8 m depth in Borehole PINE-02 located on the south side of the river. Descriptions of the individual strata are presented below.

5.1 Asphalt

Asphalt pavement was encountered in all sampled boreholes, i.e., Boreholes PINE-01, PINE-02, PINE-05 and PINE-06. The thickness of the asphalt ranged from 50 to 225 mm.

5.2 Embankment Fill

Embankment fill was encountered below the asphalt in all sampled boreholes. The thickness of the fill ranged from 2.0 m to 4.1 m, with the base of the fill between Elev. 213.0 and Elev. 210.7.

The fill was in general cohesionless. The proportions of sand and gravel varied within the fill, and the material is classified as sand and gravel to gravelly sand. The fill contains varying fine fractions (silt and clay) and occasional cobbles.

In Boreholes PINE-01, the cohesionless fill extended to 2.3 m depth (Elev. 212.8) and was underlain by 1.3 m of clayey silt fill to a depth of 3.6 m (Elev. 211.5). This cohesive fill is probably the native silty clay reworked during embankment construction.

SPT 'N' values recorded in the cohesionless fill ranged from 9 to 52 blows per 0.3 m penetration, indicating a loose to very dense relative density. SPT values of 4 and 8 blows per 0.3 m of penetration were obtained in the clayey silt fill indicating a firm consistency.

Moisture contents of the granular fill ranged from 3 to 11% with typical values between 3 and 6%. The values of moisture content in cohesive fill were 25 and 34%.

The results of grain size analyses conducted on fill samples are provided on the Record of Borehole sheets in Appendix A, and are illustrated in Figure B1 of Appendix B. The results are summarized as follows:

Gravel	30 to 42%
Sand	50 to 54%
Silt & Clay	7 to 18%.

5.3 Upper Silty Clay

A reddish brown silty clay was encountered directly below the fill in all boreholes drilled at this site. The thickness of the upper silty clay fully penetrated in Borehole PINE-02 and PINE-05 were 8.6 m and 10.5 m, respectively. The lower boundary of the layer was encountered at 12.6 m and 14.8 m (Elev. 202.4 and 200.2) in Borehole PINE-02 and PINE-05, respectively. Boreholes PINE-01 and PINE-06 were terminated in the silty clay deposit at depths of 9.8 m (Elev. 205.3) and 10.2 m (Elev. 204.9).

SPT 'N' values recorded in the silty clay varied between zero blows per 0.3 m penetration (Weight of Rod to Weight of Hammer) to 21 blows per 0.3 m of penetration, however, typically the N values ranged from 3 to 6 blows per 0.3 m of penetration. The value of 21 blows per 0.3 m of penetration in the lower zone of the silty clay in Borehole PINE-05 indicate the probable presence of silt/clayey silt interlayers within this deposit. Field vane shear tests (VST) measured undrained shear strengths ranging from 34 to 85 kPa. Based on the SPT and VST data, the consistency of the silty clay varied from very soft to stiff, typically being firm.

Sensitivity of the silty clay, calculated as a ratio of undisturbed strength to remoulded strength, ranged from 3 to 10, suggesting that the silty clay is of normal to high sensitivity.

The results of grain size analyses conducted on samples of the upper silty clay are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B2 of Appendix B. The results are summarized as follows:

Gravel	0%
Sand	0% to 6%
Silt	51% to 65%
Clay	35% to 49%

The results of Atterberg Limits tests conducted on samples of the upper silty clay are provided on the Record of Borehole sheets in Appendix A and are illustrated in Figure B5 of Appendix B. The results indicated that the deposit has liquid limits ranging from 34 to 39% and plasticity indices ranging from 13 to 18%., suggesting low to medium plasticity of the deposit. Natural moisture contents of the silty clay ranged from 23 to 40%.

5.4 Clayey Silt

A layer of brown clayey silt underlies the silty clay on the south side of the river. Trace of stratification was noted in this deposit. The deposit was 3.0 m thick with the lower boundary at 15.6 m depth (Elev.199.4).

One SPT 'N' value recorded in the clayey silt was 2 blows per 0.3 m penetration. Field vane shear tests (VST) measured undrained shear strengths of 38 to 63 kPa. Based on the SPT and VST data, the consistency of the silty clay varied from very soft to stiff.

Natural moisture contents of 22 to 38% were measured on samples of this deposit.

5.5 Lower Silty Clay

A layer of brown silty clay underlies the clayey silt in Borehole PINE-02 and the upper silty clay in Borehole PINE-05. The thickness of the deposit was approximately 12 m, and the base of the lower silty clay was encountered between 27.7 m and 26.8 m depth (Elev. 187.3 and 188.2).

SPT 'N' values recorded in the silty clay varied from 1 blows per 0.3 m penetration to 13 blows per 0.3 m of penetration, typically ranging from 5 to 8 blow per 0.3 m of penetration. A blow count of 1 blows per 0.3 m of penetration was obtained at Elev. 190 m in Borehole PINE-05. Undrained shear strengths ranging from 66 kPa to in excess of 100 kPa were measured by field vane shear tests (VST). Based on the SPT and VST data, the consistency of the silty clay varied from firm to very stiff.

Sensitivity of the silty clay ranged from 2 to 6, suggesting that the silty clay is, generally, of normal sensitivity to sensitive.

The results of grain size analyses conducted on four samples of the silty clay are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B3 of Appendix B. The results are summarized as follows:

Gravel	0%
Sand	0% to 5%
Silt	22% to 31%
Clay	69% to 76%.

The results of Atterberg Limits tests conducted on samples of the lower silty clay are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B6 of Appendix B. The liquid limits ranged from 62 to 64% and plasticity indices ranged from 36 to 38%., suggesting high plasticity of the deposit. Natural moisture contents of the silty clay ranged from 32 to 51%.

5.6 Silt to Clayey Silt

In Boreholes PINE-02 and PINE-05, a silt with some clay to clayey silt was encountered underlying the lower silty clay below the depth of 27.7 m and 26.8 m. The deposit was dark greyish brown and varied in thickness from 3.8 m and 6.6 m. The lower boundary of the deposit was between 34.3 m and 30.6 m depth (Elev. 180.7 and 184.4).

SPT 'N' values recorded in the silt layer ranged from 7 to 19 blows per 0.3 m penetration, indicating a loose to compact relative density. Natural moisture contents were measured to be between 31 and 57%.

5.7 Sandy Gravel

A layer of dark grey sandy gravel was encountered in Borehole PINE-05 below 30.6 m depth (Elev. 184.4). The layer contained trace of silt and occasional cobbles. The borehole was advanced into this deposit for 1.7 m and terminated at 32.3 m depth (Elev. 182.7) upon encountering artesian groundwater.

The sandy gravel was very dense as indicated by one SPT 'N' value of more than 100 blows per 0.3 m penetration recorded at the base of the deposit. A natural moisture content of 10% was measured on one sample of this deposit.

The results of a grain size analysis conducted on one sample of the sandy gravel are provided on the Record of Borehole sheets in Appendix A and are plotted in Figure B4 of Appendix B. The results are summarized as follows:

Gravel	65%
Sand	27%
Silt & Clay	8%.

5.8 Clayey Silt Till

A layer of clayey silt till was encountered below the silt to clayey silt in Borehole PINE-02. The clayey silt till was dark greyish brown in colour and contained cobbles and boulders. The frequency of occurrence of the cobbles and boulders in this deposit increased significantly below 37.5 m depth (Elev. 177.5), and the borehole was advanced further by coring to confirm anticipated bedrock. The till layer was fully penetrated in that borehole and was 5.5 m thick. The lower boundary of the till was at 39.8 m depth (Elev. 175.2).

One SPT 'N' value recorded in the deposit was 24 blows per 0.3 m penetration, indicating a very stiff consistency. A natural moisture content of 22% was obtained for one sample of this deposit.

5.9 Bedrock

Bedrock was encountered beneath the bouldery zone in the clayey silt till at 39.8 m depth (Elev.175.2).

The bedrock is described as limestone, moderately weathered to fresh with trace of calcite, grey with light grey specking. Highly fractured zones were encountered in the bedrock below 42.2 m depth. Clay infilling and possible sand and clay seams were inferred during coring operations near the end of the borehole (in Runs 3 and 4).

In the two upper rock cores, the measured Total Core Recovery (TCR) was 100% and 88%, and the Rock Quality Designation (RQD) was 100% and 77%, indicating good to excellent rock quality. In the two lower rock cores, the measured TCR was 50% and 25%, with an RQD of 0% for both cores, indicating a very poor rock quality.

Borehole PINE-02 was terminated at 45.0 m depth (Elev. 170.0 m).

The unconfined compressive strength (UCS) of the rock, estimated from the results of point load tests conducted on the rock core samples, ranges from 67 to 119 MPa, indicating a strong to very strong intact rock. Average values of 71 and 94 MPa were obtained for core runs #1 and #2. The point load test results are included on the Record of Borehole sheets in Appendix A, and the point load test sheet with details of testing is enclosed in Appendix B.

5.10 Water Levels

The water levels in the boreholes were measured upon completion of drilling operations. Since water was used during the wash-boring and coring operations, the measured water levels may not reflect prevailing groundwater levels at the site.

An artesian water condition was noted upon completion of drilling in Boreholes PINE-02 and PINE-05. The water head of 2.1 m and 1.7 m above the ground level/embankment grade was measured at the commencement of removal of casings from those boreholes at approximately 45.0 m and 32 m depth. It is probable that the sandy gravel and bouldery zone of the till or fractured bedrock are water bearing strata in this area. The artesian water was sealed at the source, and the boreholes were decommissioned.

Borehole PINE-05P was drilled adjacent to Borehole PINE-05 to install a standpipe piezometer for monitoring of groundwater level after drilling. The water levels measured in the open boreholes upon completion of drilling and in the piezometer are summarized in Table 5.1.

Table 5.1: Water Level Measurements

Boreholes	Date	Water Level Depth/Elevation
PINE -01	Nov. 2, 2014	Borehole open to 6.1 m and dry.
PINE-02	Oct. 30, 2014	Upon completion of rock coring, artesian water condition observed in bedrock; water head at 2.1 m above the road level. Borehole sealed and decommissioned.
PINE-05	Oct. 31, 2014	Artesian condition observed in sandy gravel at 32.3 m depth (Elev. 182.7); water head at 1.7 m above the road level. Borehole sealed and decommissioned.
		Piezometer installed to 12.2 m depth:
	Nov. 1, 2014	2.0 / 213.0
	Nov. 2, 2014	2.3 / 212.7
	Nov. 3, 2014	2.3 / 212.7
PINE-06	Nov. 3, 2014	Borehole open to 3.7 m and dry.

The approximate water level in the river shown on the preliminary GA drawing is at Elev. 209.0 on July 6/2012. The water level in the river and groundwater levels are expected to fluctuate seasonally and are subject to precipitation patterns, and may vary from the levels presented above.

6 MISCELLANEOUS

Eastern Ontario Diamond Drilling supplied the drill rig and conducted the drilling, sampling and in-situ testing operations. A truck-mounted CME #55 drill rig was used for the duration of the investigation.

The drilling and sampling operations were supervised in the field by Mr. Matthew Whalen of Thurber. Mr. Mark Farrant, P.Eng. directed the field operations.

The report was prepared by Ms. Anna Piascik, P.Eng., and reviewed by Mr. Murray Anderson, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects.

THURBER ENGINEERING LTD.

Anna Piascik, P.Eng.
Senior Geotechnical Engineer

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

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

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

▼ Water Level

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

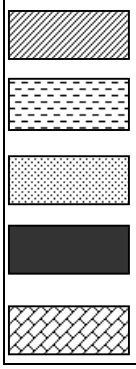
ROCK WEATHERING CLASSIFICATION

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.

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

SYMBOLS



CLAYSTONE

SILTSTONE

SANDSTONE

COAL

BEDROCK

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

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 % 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.

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-01 1 OF 2 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 499.9 E 339 427.6 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2014.11.02 - 2014.11.02 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
215.1	GROUND SURFACE										
0.0	**ASPHALT:** (50mm)						215				
0.0	Gravelly **SAND**, some silt Compact Dark Brown Moist (FILL)		1	SS	30						
			2	SS	27		214				
			3	SS	18						30 52 18 (SI+CL)
212.8							213				
2.3	Clayey **SILT**, trace gravel, occasional sand lenses Firm Reddish Brown Moist (FILL)		4	SS	8						
			5	SS	4		212				
211.5											
3.6	Silty **CLAY**, with silt lenses Firm to Stiff Reddish Brown Moist						211	6.2			
			6	SS	4						0 0 65 35
							210	4.2			
			7	SS	3		209				
							208	8.9			
	Trace silt seams		8	SS	3						0 0 57 43
							207	5.2			
	Brown		9	SS	3		206				
205.3								5.6			
9.8	END OF BOREHOLE AT 9.8m.										

Continued Next Page

+ ^{3}, × ^{3} : Numbers refer to Sensitivity

$\frac{20}{15 \cdot 10 \cdot 5}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-01 2 OF 2 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 499.9 E 339 427.6 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2014.11.02 - 2014.11.02 CHECKED BY MEF

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	BOREHOLE OPEN TO 6.1m AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.3m, DRY CONCRETE MIX TO 0.05m, THEN ASPHALT TO SURFACE.										

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

$\frac{20}{15 \cdot 10 \cdot 5}$ (%) STRAIN AT FAILURE

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-02 1 OF 5 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 318.3 E 339 426.0 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN

DATUM Geodetic DATE 2014.10.29 - 2014.10.30 CHECKED BY MEF

ELEV / DEPTH	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, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
215.0	GROUND SURFACE										
0.0	**ASPHALT:** (125mm)										
0.1	**SAND** and **GRAVEL**, trace silt, occasional cobbles Compact to Dense Brown Moist to Dry (FILL)		1	SS	37				○		36 54 10 (SI+CL)
			2	SS	29		214		○		
			3	SS	16		213		○		
			4	SS	10		212		○		
			5	SS	14		211		○		
211.0											
4.0	Silty **CLAY** Firm to Stiff Reddish Brown Moist		6	SS	5		210		○		
			7	SS	3		209		○		
	Wet		8	SS	12		208	4.1 +	○		
							207	6.9 +	○		
	Trace gravel from 8.8m to 10.1m		9	SS	18		206		○		
							205				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-02 2 OF 5 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 318.3 E 339 426.0 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN

DATUM Geodetic DATE 2014.10.29 - 2014.10.30 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Soft to Firm		10	SS	4		204				0 0 65 35
	Trace silt seams		11	SS	11		203	2.9			
202.4											
12.6	Clayey **SILT**, trace stratifications Very Soft to Stiff Brown Moist to Wet		12	SS	2		202	3.3			
							201	4.3			
199.4			13	SS	9		200				
15.6	Silty **CLAY**, trace sand Stiff Brown Moist		14	SS	7		199	2.3			0 5 22 73
	Occasional lenses of sand Firm Dark Greyish Brown		15	SS	5		198				
							197				
							196				
							195				

Continued Next Page

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

$\frac{20}{15}$ 5 (%) STRAIN AT FAILURE

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-02 3 OF 5 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 318.3 E 339 426.0 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN

DATUM Geodetic DATE 2014.10.29 - 2014.10.30 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Occasional sand seams Dark Grey and Brown Stratified		16	SS	5				○		
							194				
							193				
			17	SS	8		192		○		0 0 26 74
								2.7 +			
							191				
	Occasional silt seams Wet						190				
			18	SS	5		189		○		
								1.7 +			
187.3							188				
27.7	**SILT**, some clay to clayey, trace sand Loose Dark Greyish Brown Wet						187				
			19	SS	9		186		○		
							185				

Continued Next Page

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

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

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-02 4 OF 5 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 318.3 E 339 426.0 ORIGINATED BY MNW
HWY 61 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
DATUM Geodetic DATE 2014.10.29 - 2014.10.30 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Clayey with stratifications, occasional sand seams Wet						184				
							183				
			20	SS	7						
	Trace of gravel						182				
180.7							181				
34.3	Clayey **SILT**, trace sand, trace gravel, occasional cobbles and boulders Very Stiff Dark Greyish Brown Moist (TILL)						180				
							179				
			21	SS	24		178				
	Frequent cobbles and boulders, borehole cored below 37.5m depth						177				
							176				
175.2							175				
39.8	**LIMESTONE**										

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-02 5 OF 5 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 318.3 E 339 426.0 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN

DATUM Geodetic DATE 2014.10.29 - 2014.10.30 CHECKED BY MEF

ELEV / DEPTH	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 (20 40 60 80 100): ○ 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	LIMESTONE, trace calcite, moderately weathered to fresh, grey: (BEDROCK)		1	RUN							RUN #1 TCR=100% SCR=100% RQD=100% UCS=70.7MPa (Average)
	Clay infilling at 40.6m		2	RUN			174				RUN #2 TCR=88% SCR=88% RQD=77% UCS=94.4MPa (Average)
	Highly fractured below 42.2m		3	RUN			173 172				RUN #3 TCR=50% SCR=13% RQD=0%
	Possible seams of sand and clay below 43m depth		4	RUN			171				RUN #4 TCR=25% SCR=0% RQD=0%
170.0											
45.0	END OF BOREHOLE AT 45.0m. WATER LEVEL AT 2.1m ABOVE ROAD SURFACE ON COMPLETION OF DRILLING AND REMOVAL OF NQ CASING. BOREHOLE BACKFILLED WITH HOLEPLUG TO 36.6m, HOLEPLUG AND CUTTINGS TO 0.3m, CONCRETE TO 0.1m, THEN ASPHALT PATCH TO SURFACE.						170				

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

20
15 5
10
(%) STRAIN AT FAILURE

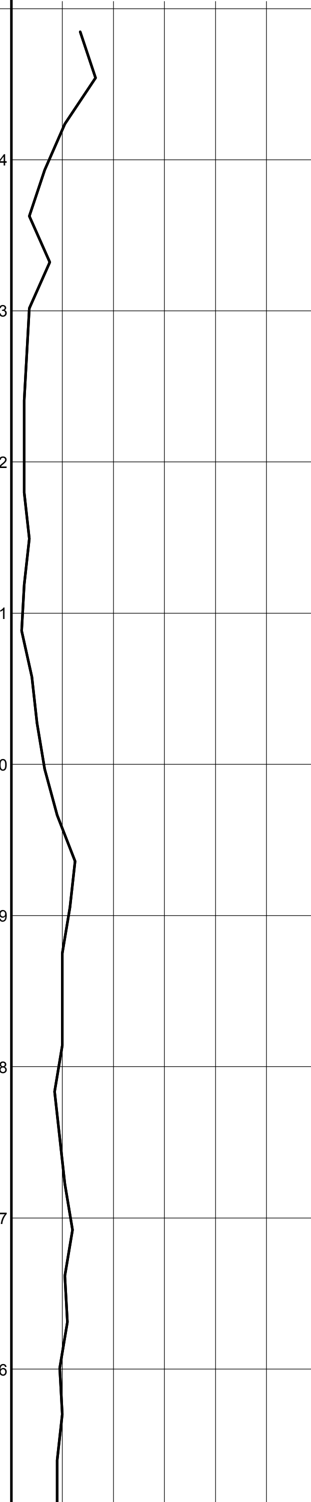
ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

RECORD OF BOREHOLE No PINE-03

METRIC

WP#	6098-10-01	LOCATION	Pine River Bridge N 5 325 516.0 E 339 433.0	ORIGINATED BY	MNW
HWY	61	BOREHOLE TYPE	Dynamic Cone Penetration Test	COMPILED BY	AN
DATUM	Geodetic	DATE	2014.11.02 - 2014.11.02	CHECKED BY	MEF

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						
215.0	GROUND SURFACE										
0.0	**ASPHALT:** (125mm)										
0.1	Start DCPT at 0.1m.						214, 213, 212, 211, 210, 209, 208, 207, 206, 205				



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 PINE-03 2 OF 3 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 516.0 E 339 433.0 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2014.11.02 - 2014.11.02 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

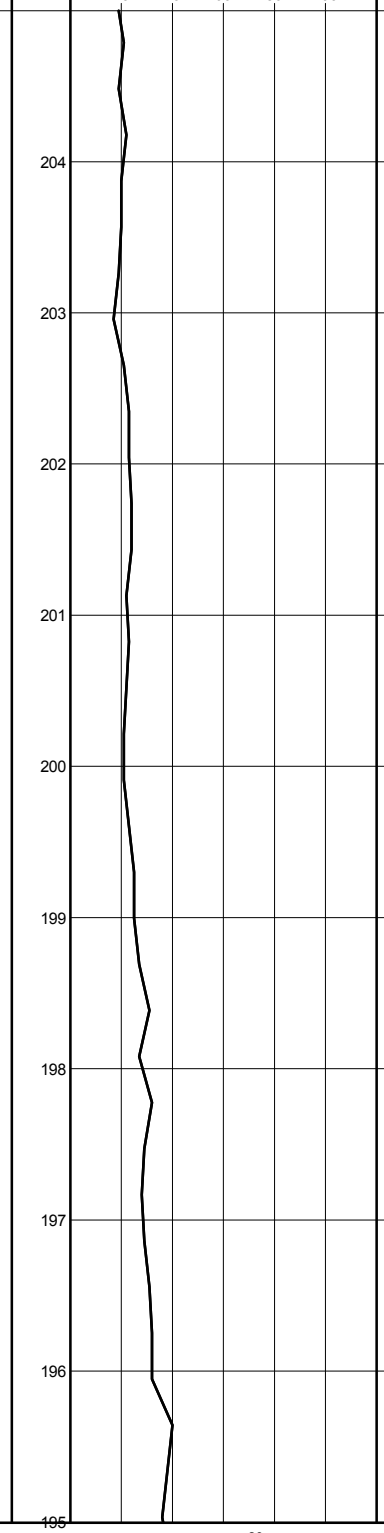
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m^3

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



Continued Next Page

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

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

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-03 3 OF 3 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 516.0 E 339 433.0 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2014.11.02 - 2014.11.02 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60	γ kN/m^3	GR SA SI CL
	Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	w_P w w_L		
							194				
							193				
							192				
190.9							191				
24.1	END OF DCPT AT 24.1m.										

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

20
15 5
10
(%) STRAIN AT FAILURE

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-04 1 OF 3 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 547.1 E 339 435.7 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2014.11.02 - 2014.11.02 CHECKED BY MEF

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
215.0	GROUND SURFACE										
0.0	Start DCPT from surface										

Continued Next Page

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

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

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-04 2 OF 3 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 547.1 E 339 435.7 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2014.11.02 - 2014.11.02 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	w_P w w_L WATER CONTENT (%) 20 40 60	γ kN/m^3	GR SA SI CL
	Continued From Previous Page						204				
							203				
							202				
							201				
							200				
							199				
							198				
							197				
							196				
							195				

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 PINE-04 3 OF 3 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 547.1 E 339 435.7 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2014.11.02 - 2014.11.02 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100 ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	w_P w w_L 20 40 60	γ kN/m^3	GR SA SI CL
	Continued From Previous Page										
							194				
							193				
							192				
190.9							191				
24.1	END OF DCPT AT 24.1m.										

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

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

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-05 1 OF 4 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 544.8 E 339 442.7 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN

DATUM Geodetic DATE 2014.10.31 - 2014.10.31 CHECKED BY MEF

ELEV / DEPTH	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, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
215.0	GROUND SURFACE										
0.0	**ASPHALT:** (225mm)										
0.2	**SAND** and **GRAVEL**, trace silt Loose to Very Dense Brown Dry (FILL)		1	SS	52				○		
			2	SS	29		214		○		42 50 8 (SI+CL)
			3	SS	19		213		○		
			4	SS	11	▼	212		○		
			5	SS	9		211		○		
210.7											
4.3	Silty **CLAY**, trace sand Firm to Stiff Reddish Brown Moist		6	SS	6		210		○		
	Trace rootlets and wood fragments to 5.3m depth										
			7	SS	3		209		○		
							208	5.1 +			
	Trace gravel between 7.6m to 10.0m		8	SS	4		207		⊢○⊣		0 6 58 36
								3.8 +			
	Occasional stratifications		9	SS	6		206		○		
							205				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-05 2 OF 4 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 544.8 E 339 442.7 ORIGINATED BY MNW
HWY 61 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
DATUM Geodetic DATE 2014.10.31 - 2014.10.31 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Wet		10	SS	3		204				
	Occasional silt lenses		11	SS	2		203				
	With silt layers		12	SS	21		202				
200.2							201				
14.8	Silty **CLAY** Stiff Brown Moist		13	SS	13		200				
	Lenses of sand		14	SS	8		199				0 0 31 69
			15	SS	7		198				
							197				
							196				
							195				

Continued Next Page

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

$\frac{20}{15 \cdot 10 \cdot 5}$ (%) STRAIN AT FAILURE

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-05 3 OF 4 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 544.8 E 339 442.7 ORIGINATED BY MNW
HWY 61 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
DATUM Geodetic DATE 2014.10.31 - 2014.10.31 CHECKED BY MEF

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 ● QUICK TRIAXIAL + FIELD VANE × 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		16	SS	8						
							194	4.2			
							193				
			17	SS	8		192				
							191				
							190				
	With saturated silt layers, dilatent		18	SS	1		189				0 0 24 76
188.2											
26.8	**SILT**, some clay to clayey, trace sand, trace gravel, occasional seams of silty clay Compact Dark Greyish Brown Moist						188				
							187				
	Trace sand seams		19	SS	19		186				
							185				

Continued Next Page

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

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

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-05 4 OF 4 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 544.8 E 339 442.7 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN

DATUM Geodetic DATE 2014.10.31 - 2014.10.31 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
184.4											
30.6	Sandy **GRAVEL**, trace silt, trace cobbles Very Dense Dark Grey Moist						184				
182.7			20	SS	109		183		○		65 27 8 (SI+CL)
32.3	END OF BOREHOLE AT 32.3m DUE TO ARTESIAN CONDITIONS. WATER LEVEL MEASURED IN CASING AT 1.7m ABOVE ROAD SURFACE. BOREHOLE BACKFILLED WITH HOLEPLUG TO 4.6m, CUTTINGS TO 0.3m, CONCRETE TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE. MOVED 1.5m NORTH AND AUGERED TO 12.2m FOR INSTALLATION OF PIEZOMETER. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 13.0m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov 01/14 2.0 213.0 Nov 02/14 2.3 212.7 Nov 03/14 2.3 212.7										

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

$\frac{20}{15 \cdot 10 \cdot 5}$ (%) STRAIN AT FAILURE

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No PINE-06 1 OF 2 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 563.2 E 339 441.2 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2014.11.03 - 2014.11.03 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
215.1	GROUND SURFACE										
0.0	**ASPHALT:** (125mm)						215				
0.1	**SAND** and **GRAVEL**, trace silt Compact Dark Brown Moist (FILL)		1	SS	23				○		
			2	SS	29		214		○		
	Burnt wood (150mm) at 2.0m		3	SS	21				○		41 52 7 (SI+CL)
213.0							213		○		
2.1	Silty **CLAY**, trace sand Firm to Stiff Reddish Brown Moist to Wet		4	SS	7				○		
	With lenses of silt		5	SS	5		212		○		
							211	5.3 +	○		
			6	SS	3				○		
							210	4.4 +			
			7	SS	4		209		○		
							208	6.8 +			
			8	SS	3				○		
							207	5.6 +			
	Brown										
			9	SS	0		206		e		0 0 51 49

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 PINE-06 2 OF 2 METRIC

WP# 6098-10-01 LOCATION Pine River Bridge N 5 325 563.2 E 339 441.2 ORIGINATED BY MNW

HWY 61 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2014.11.03 - 2014.11.03 CHECKED BY MEF

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
204.9							205	5.6			
10.2	END OF BOREHOLE AT 10.2m. BOREHOLE OPEN TO 3.7m AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.3m, DRY CEMENT TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.										

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

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

ONTMT4S 5121.GPJ 2012TEMPLATE(MTO).GDT 12/23/14

Appendix B

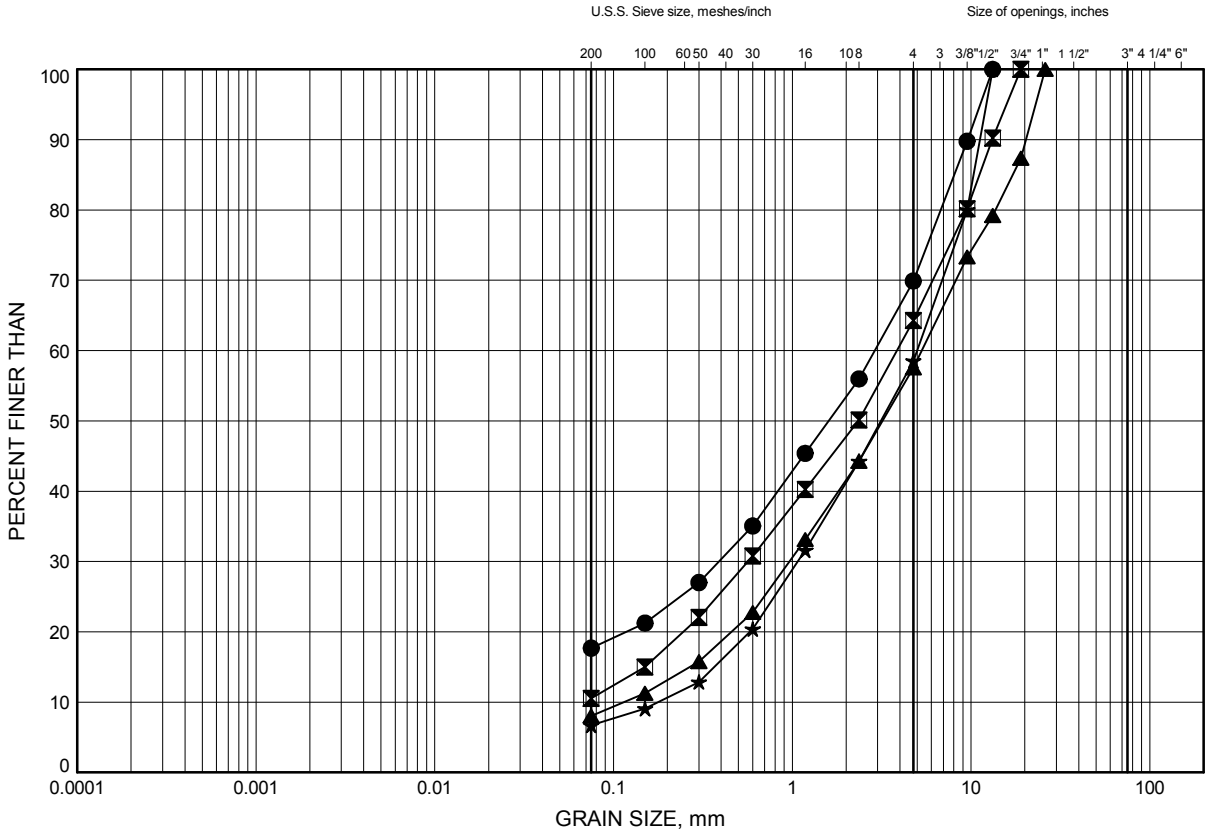
Laboratory Test Results

Pine River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND & GRAVEL TO GRAVELLY SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PINE-01	1.83	213.27
⊠	PINE-02	0.38	214.62
▲	PINE-05	1.07	213.93
★	PINE-06	1.75	213.34

Date December 2014

WP# 6098-10-01

THURBER

Prep'd AN

Chkd. AP

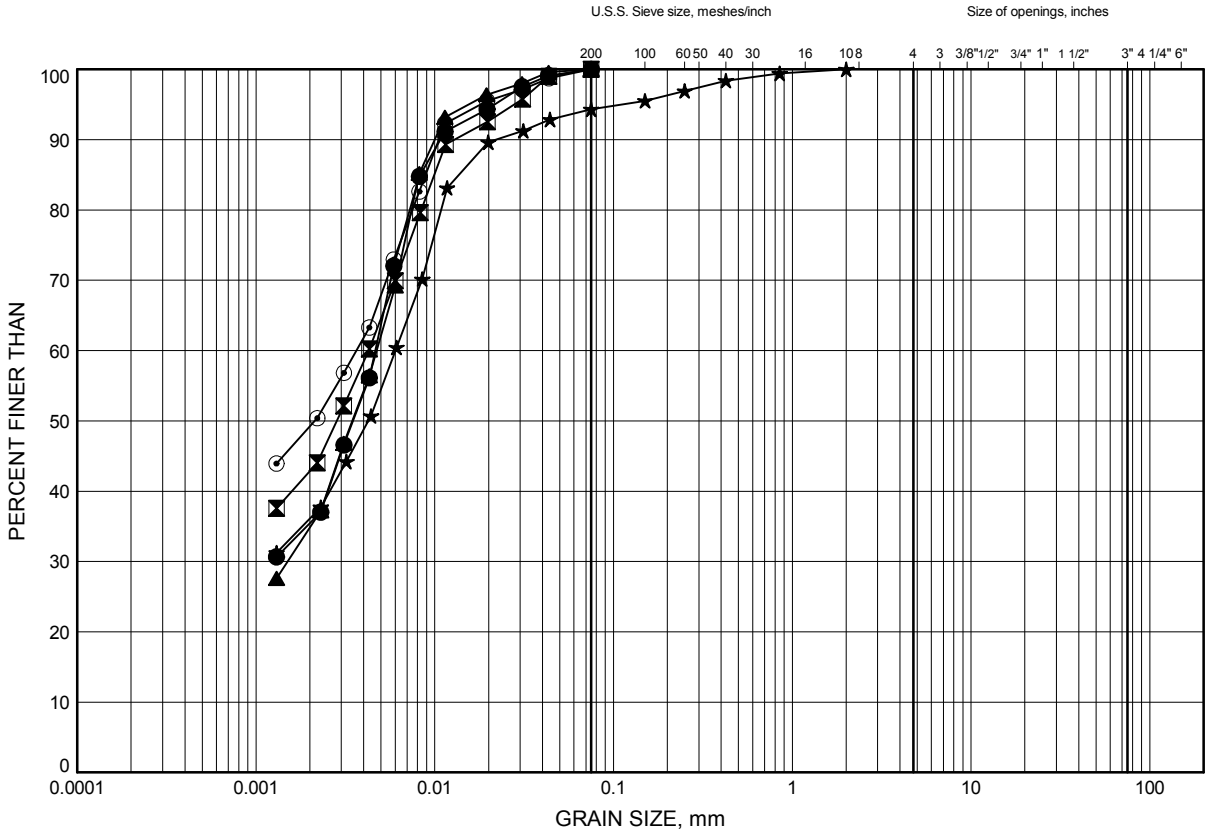
GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 12/5/14

Pine River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B2

Upper SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PINE-01	4.88	210.22
⊠	PINE-01	7.92	207.17
▲	PINE-02	10.97	204.02
★	PINE-05	7.92	207.07
⊙	PINE-06	9.45	205.65

Date December 2014

WP# 6098-10-01

THURBER

Prep'd AN

Chkd. AP

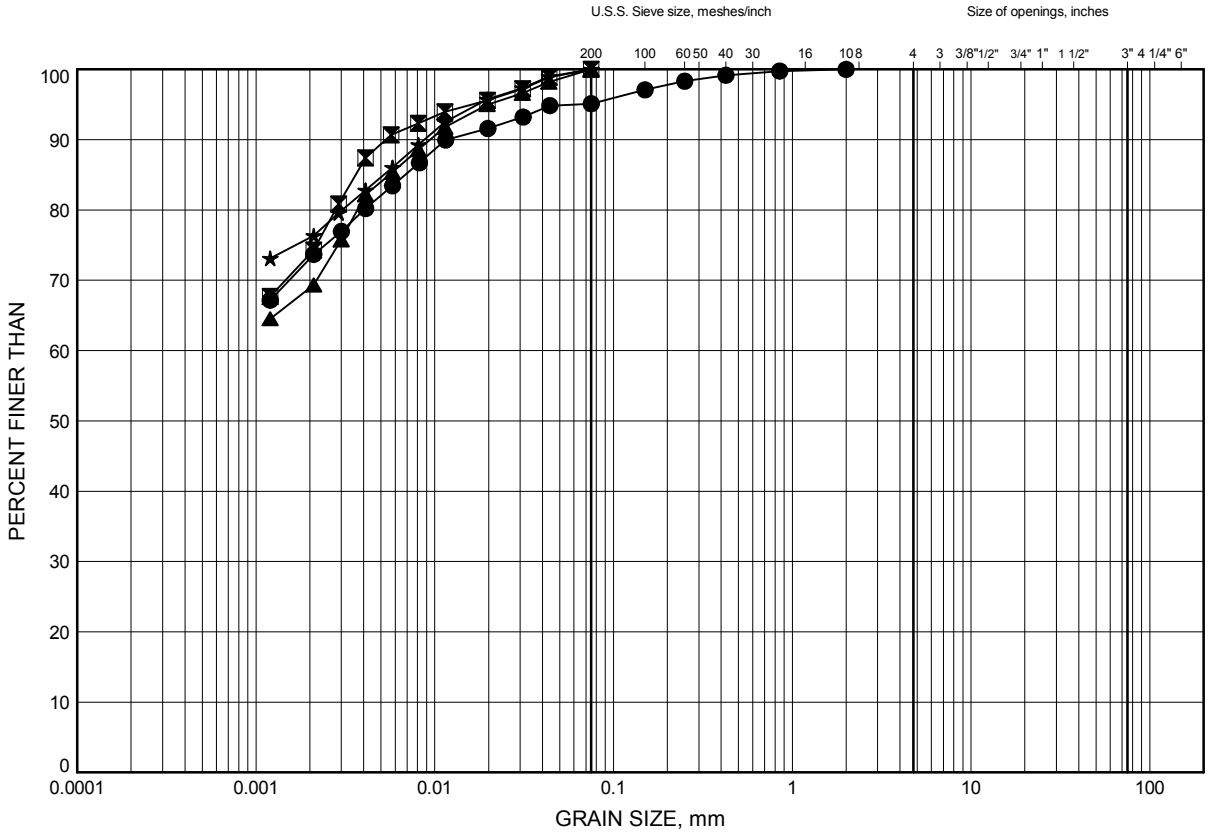
GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 12/5/14

Pine River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B3

Lower SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PINE-02	17.07	197.93
⊠	PINE-02	23.16	191.83
▲	PINE-05	17.07	197.93
★	PINE-05	26.21	188.78

Date December 2014

WP# 6098-10-01

THURBER

Prep'd AN

Chkd. AP

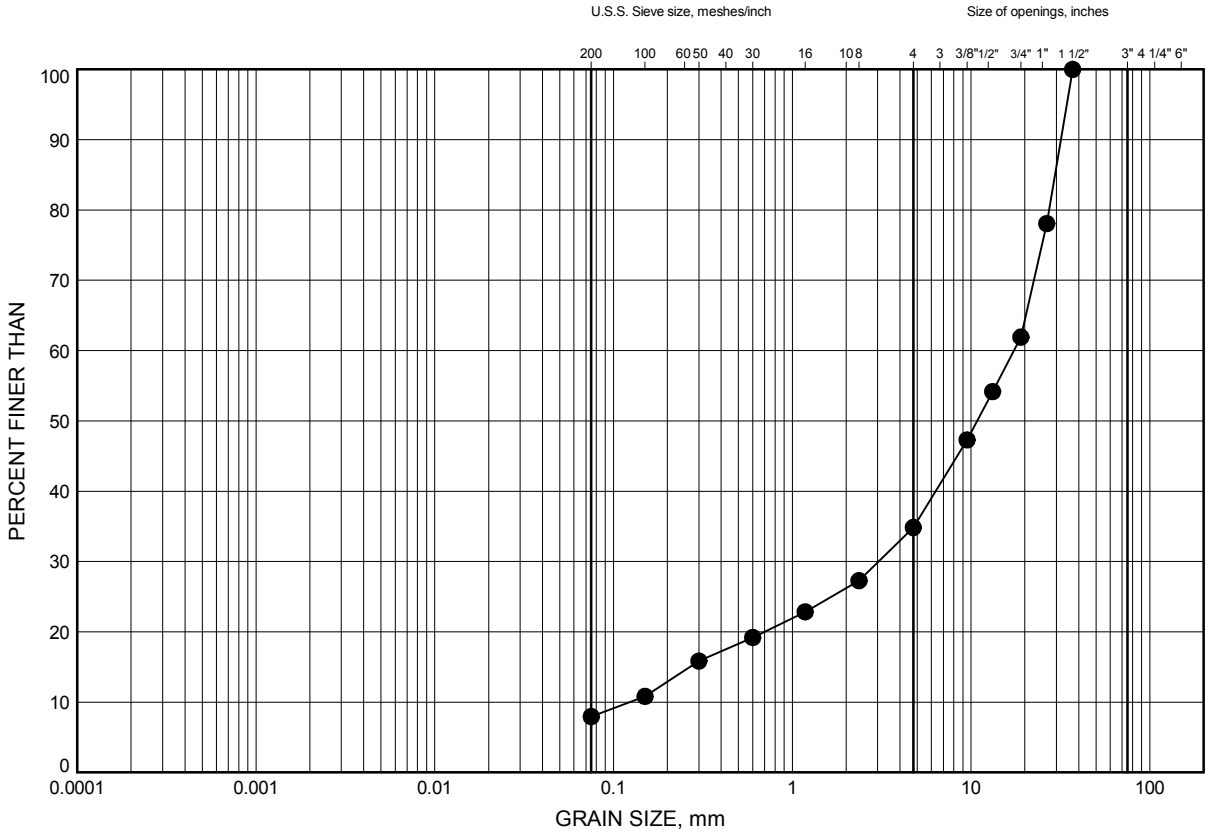
GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 12/5/14

Pine River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B4

SANDY GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PINE-05	32.16	182.84

Date December 2014

WP# 6098-10-01

THURBER

Prep'd AN

Chkd. AP

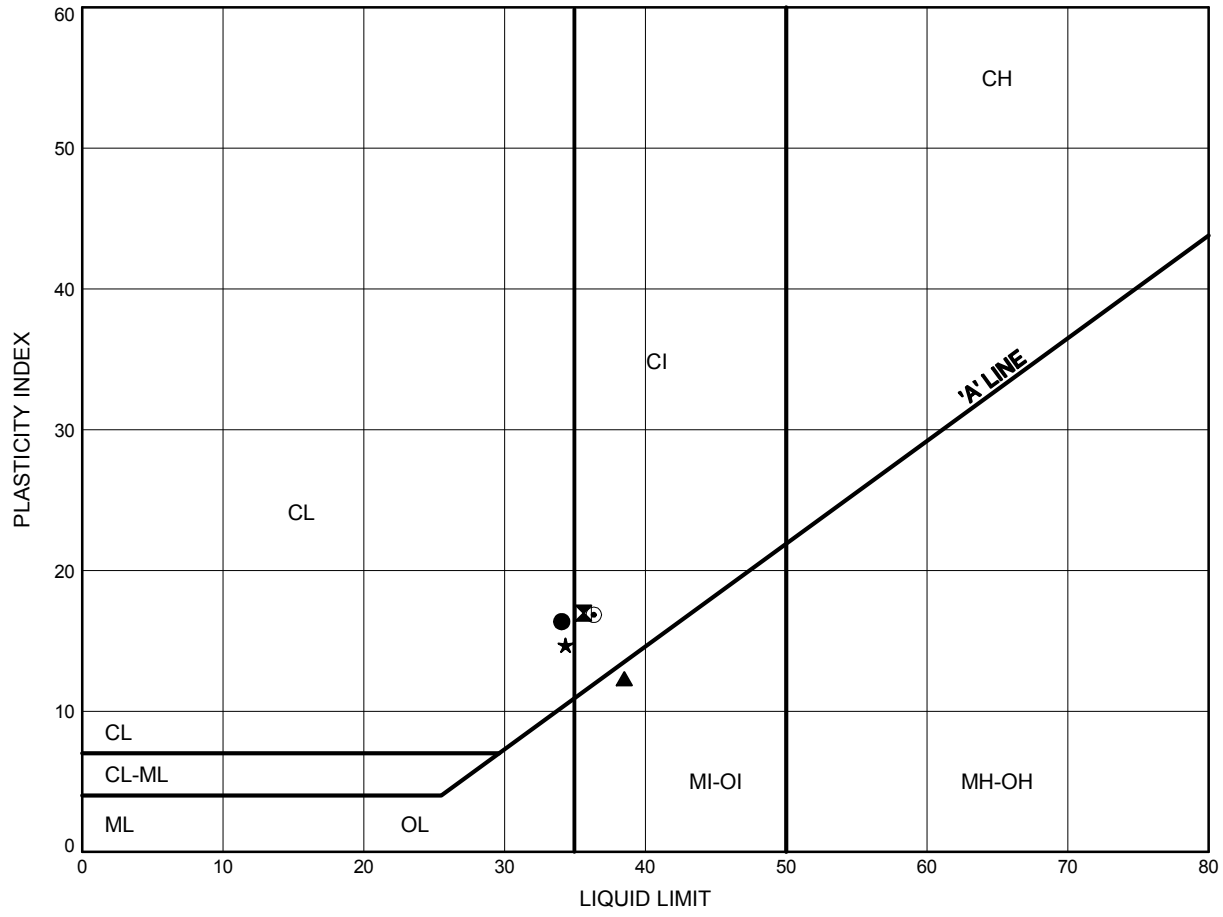
GRAIN SIZE DISTRIBUTION - THURBER 5121.GPJ 12/5/14

Pine River Bridge

ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Upper SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PINE-01	4.88	210.22
⊠	PINE-01	7.92	207.17
▲	PINE-02	10.97	204.02
★	PINE-05	7.92	207.07
⊙	PINE-06	9.45	205.65

Date December 2014

WP# 6098-10-01

THURBER

Prep'd AN

Chkd. AP

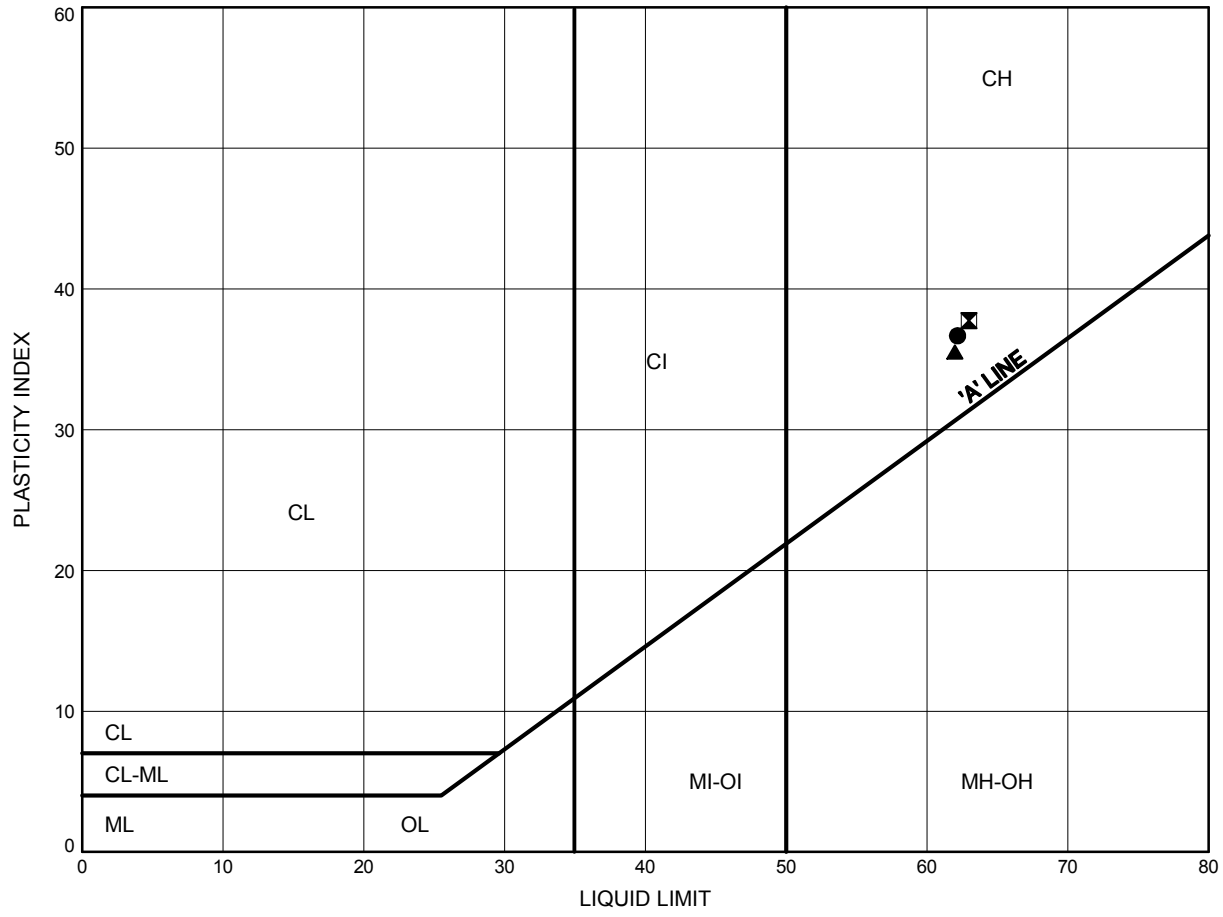
THURBALT 5121.GPJ 12/10/14

Pine River Bridge

ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Lower SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PINE-02	17.07	197.93
⊠	PINE-02	23.16	191.83
▲	PINE-05	26.21	188.78

Date December 2014

WP# 6098-10-01

THURBER

Prep'd AN

Chkd. AP

THURBALT 5121.GPJ 12/10/14

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

POINT LOAD TEST SHEET

Job No :	19-1605-121	**Client :**	HMM
		Date Drilled :	10/30/2014
Project Name :	Pine River Bridge	**Date Tested :**	11/17/2014
Core Size :	NQ **BH No :** Pine-02	**Tester :**	ISP

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (kPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	40.1	D	26400.0	47.1	200.0	74.8	Limestone	Strong
2	1	40.8	D	24960.0	47.2	200.0	66.6	Limestone	Strong
3	2	41.2	ial or Diame	31160.0	47.1	72.6	118.9	Limestone	Very Strong
4	2	41.8	D	31800.0	47.1	200.0	69.9	Limestone	Strong
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

Appendix C

Site Photographs

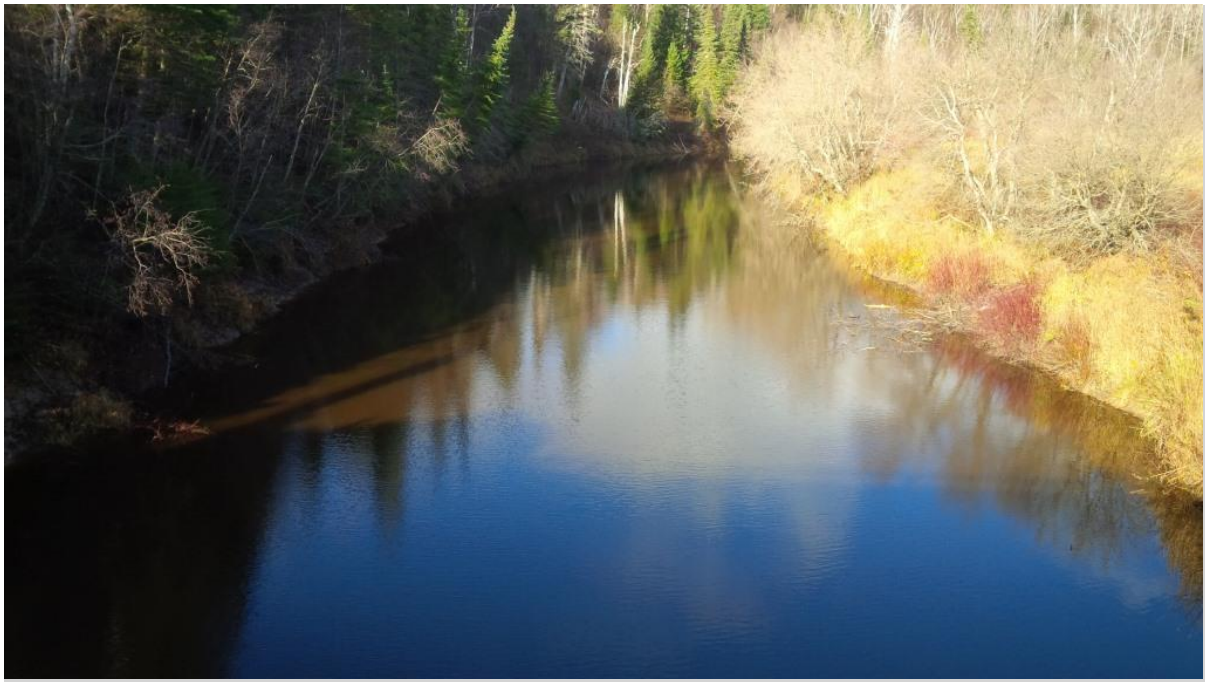
Photograph 1 - Pine River Bridge Looking North

Photograph 2 – Looking South

Photograph 3 - East Bridge Elevation - Looking at South Abutment

Photograph 4 - East Bridge Elevation - Looking at North Abutment

Photograph 5 - Looking at South Abutment



Photograph 6 - Pine River – Looking West

Photograph 7 - Looking South at South Approach

Photograph 8 – Settlements at Southeast Wingwall

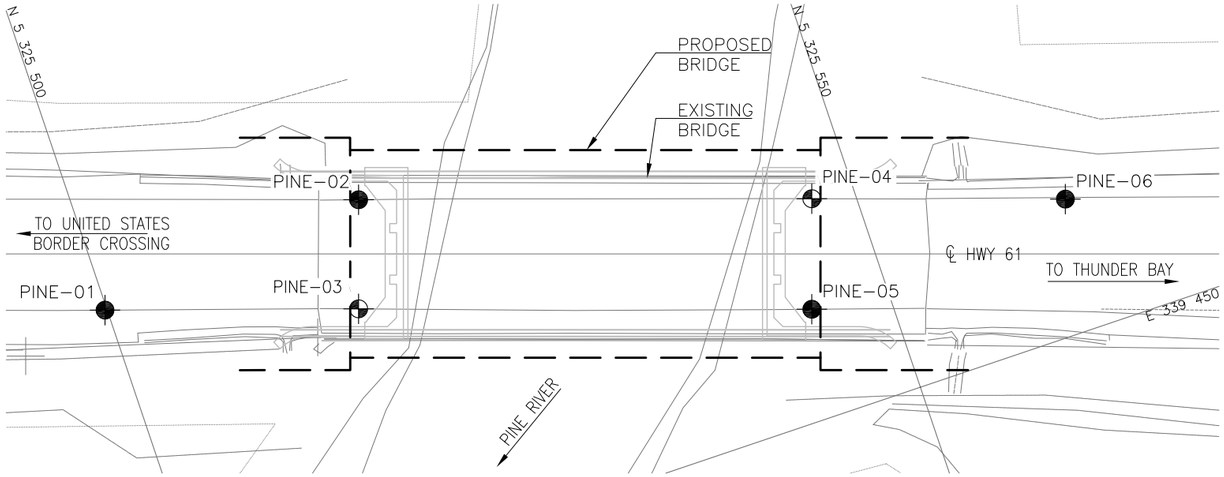
Photograph 9 – Settlements at North Approach – Leaning Guide Rail

Photograph 10 – Settlements/Fractures at the location of South Abutment Wall

Appendix D

Borehole Locations and Soil Strata Drawing

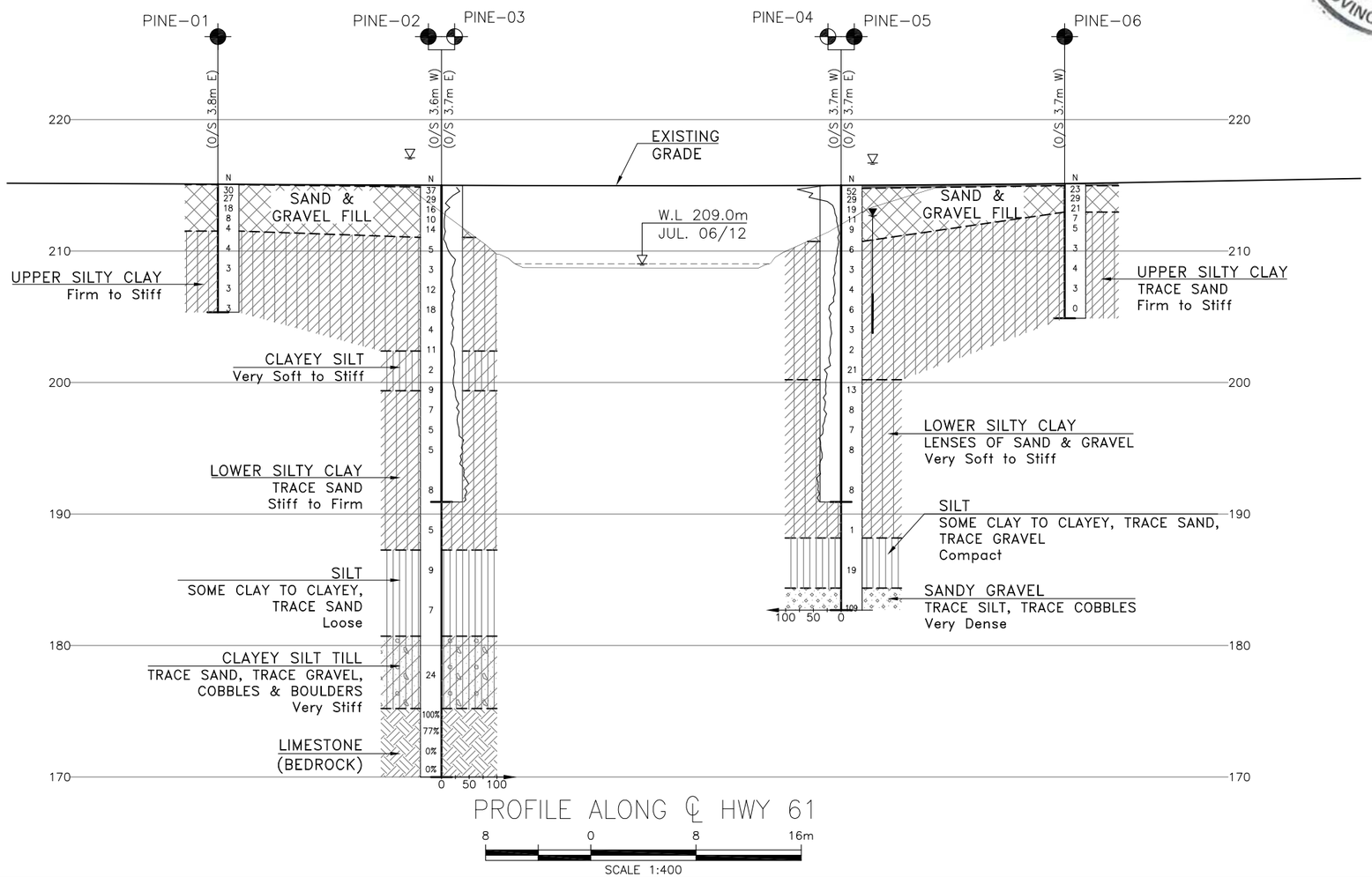
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

8 0 8 16m

SCALE 1:400



PROFILE ALONG ℄ HWY 61

8 0 8 16m

SCALE 1:400

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
M. R. ANDERSON
Jan 15/15
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Jan 15/15
PROVINCE OF ONTARIO

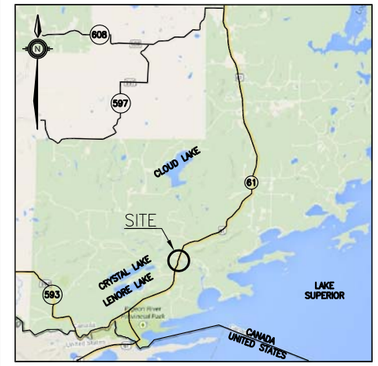
CONT No
WP No 6098–10–01

HIGHWAY 61
PINE RIVER BRIDGE
STRUCTURAL REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 11

Hatch Mott MacDonald

THURBER ENGINEERING LTD.



KEYPLAN

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

NO	ELEVATION	NORTHING	EASTING
PINE–01	215.1	5 325 499.9	339 427.6
PINE–02	215.0	5 325 518.3	339 426.0
PINE–03	215.0	5 325 516.0	339 433.0
PINE–04	215.0	5 325 547.1	339 435.7
PINE–05	215.0	5 325 544.8	339 442.7
PINE–06	215.1	5 325 563.2	339 441.2

-NOTES-

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

GEOCRES No. 52A-196

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN AP	CHK MRA	CODE CAN/CSA S6–06	LOAD CL–625–ONT
DRAWN AN	CHK AP	SITE 48W–105	STRUCT
		DATE JAN 2015	DWG 2

FILENAME: H:\Drafting\19\1625\121\Pine River\tad5121–Plan&Profile (Pine River).dwg
PLOTDATE: 1/16/2015 2:49 PM