

**FOUNDATION INVESTIGATION REPORT
STURGEON RIVER BRIDGE REPLACEMENT
HIGHWAY 599
DISTRICT OF THUNDER BAY, ONTARIO
G.W.P. 6109-10-00, SITE NO: 48W-8**

Geocres Number: 52J-9

Report to:

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September 15, 2014
File:19-5308-40

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the Sturgeon River Bridge on Highway 599 in the District of Thunder Bay, Ontario.

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

Thurber carried out the investigation as a sub-consultant to WSP Canada Inc, under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0012.

2 SITE DESCRIPTION

The Sturgeon River Bridge is located on Highway 599, approximately 100 km north of Ignace, which is situated along Highway 17 between Dryden and Thunder Bay, Ontario. The existing bridge is a single span structure approximately 18.6 m long and 9.8 m wide, supported on rock-filled timber crib abutments. Each of the timber crib abutments is approximately 6.0 m high and 3.0 m by 12.8 m in plan.

The Sturgeon River meanders in a north-westerly direction out of Sturgeon Lake. The lands immediately surrounding the bridge site consist of forested areas.

Photographs in Appendix C show the general nature of the site and the existing bridge.

The site lies within the Wabigoon Subprovince of the Superior Province of the Canadian Shield. The area is underlain by granitic igneous and metamorphic rocks of the Early Precambrian, covered by a thin discontinuous layer of drift.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between September 10 and 16, 2011, and comprised drilling and sampling of six boreholes, identified as Boreholes SRB-01 to SRB-06.

Boreholes SRB-02 to SRB-05 were drilled adjacent to the existing bridge abutments and terminated in bedrock at depths of 8.5 m to 11.4 m following recovery of approximately 3.0 m of rock core. Boreholes SRB-01 and SRB-06 were drilled at the bridge approaches: Borehole SRB-01 was terminated at 7.6 m depth, and Borehole SRB-06 was terminated upon auger refusal at 5.5 m depth. The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling. The coordinates and ground surface elevations for the boreholes were estimated from topographic plans provided by WSP Canada Inc.

A truck mounted CME 75 drill rig was used to advance the boreholes using a combination of NW casing/ wash boring techniques and NQ rock coring equipment. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). All rock cores were logged and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and Fracture Indices (FI) were determined.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil and rock samples for transporting to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Groundwater conditions observed after completion of drilling may have been affected by water introduced into the boreholes during wash boring and coring operations. Standpipe piezometers were installed in two boreholes to monitor the groundwater level after drilling. The piezometers were subsequently decommissioned on October 28, 2012 and the boreholes without piezometers were backfilled in general accordance with MOE Regulation 903. Completion details of the piezometers and boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Foundation Unit	Boreholes	Piezometer Tip Depth/ Elevation (m)	Completion Details
North Approach	SRB-01	None installed	Borehole backfilled with holeplug to 0.15 m then asphalt to surface.
North Abutment	SRB-02	None installed	Borehole backfilled with holeplug from 8.7 m to 0.15 m then asphalt to surface.
	SRB-03	6.1/ 401.7	Borehole backfilled with cuttings from 11.4 m to 6.1 m, filter sand from 6.1 m to 4.3 m, holeplug from 4.3 m to 0.30 m, concrete from 0.30 m to 0.15 m, then asphalt to surface.
South Abutment	SRB-04	None installed	Borehole backfilled with holeplug from 9.4 m to 0.30 m, concrete to 0.15 m, then asphalt to surface.
	SRB-05	7.0/ 401.3	Borehole backfilled with cuttings from 8.5 m to 7.0 m, filter sand from 7.0 m to 5.2 m, holeplug from 5.2 m to 0.30 m, concrete from 0.30 m to 0.15 m, then asphalt to surface.
South Approach	SRB-06	None installed	Borehole backfilled with holeplug from 5.5 m to 0.30 m, concrete to 0.15 m, then asphalt to surface.

4 LABORATORY TESTING

All 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). The results of this testing program are summarized on the Record of Borehole sheets included in Appendix A and on the figures presented in Appendix B.

Bedrock core samples were subjected to geological logging. Point load tests were carried out on selected samples of intact bedrock in the laboratory to evaluate the unconfined compressive strength (UCS) of the bedrock. The UCS values of the rock assessed from the point load test data are reported on the borehole logs in Appendix A.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing included 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. It must be recognized that soil conditions may vary between and beyond borehole locations.

The site stratigraphy typically comprises an asphalt surface overlying granular embankment fill, underlain by native sand and gravel deposits, locally sand and silt. Bedrock was encountered below the sand and gravel layer. More detailed descriptions of the individual strata are presented below.

5.1 Asphalt

Asphalt was encountered on the roadway surface in all boreholes drilled. The asphalt was 25 to 40 mm thick.

5.2 Embankment Fill

Cohesionless embankment fill typically consisting of sand with trace to some gravel and silt was encountered beneath the asphalt in all boreholes. Locally the fill graded to sandy gravel and gravelly sand. Cobbles and boulders were encountered in the fill, as indicated on the borehole logs. The base of the granular fill was encountered at depths of 4.3 to 4.6 m (Elev. 403.2 to 403.9).

SPT N-values recorded in the fill typically ranged from 11 to 31 blows/0.3 m penetration, indicating a generally compact condition. N-values of 8 and 9 blows/0.3 m were obtained in the lower portion of the fill in Boreholes SRB-04 and SRB-05, indicating a loose condition. N-values of 70 blows/0.3 m to 50 blows for no penetration were recorded on cobbles and boulders in the fill in five boreholes.

Moisture contents ranged between 6% and 20%.

Samples of fill underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A and on the grain size distribution curves shown on Figures B1 and B2 of Appendix B.

Soil Particles	Sand Fill	Sandy Gravel to Gravelly Sand Fill
Gravel %	2 to 17	36 to 70
Sand %	61 to 85	26 to 55
Silt & Clay %	3 to 22	4 to 9

5.3 Sand, Gravel, and Sand and Silt

Native cohesionless deposits were encountered below the embankment fill in all boreholes. These deposits comprised sand with some gravel and silt at the north abutment and south

approach, gravel with trace to some sand at the south abutment, and sand and silt at the north approach. Occasional cobbles and locally boulders were encountered in the sand/gravel, notably above the underlying bedrock in Borehole SRB-03.

The thickness of the native deposits ranged between 0.9 and 4.1 m, with a lower boundary at depths of 5.5 to 8.4 m (Elev. 403.0 to 399.4). Borehole SRB-01 was terminated in the sand at 7.6 m depth (Elev. 400.2).

SPT N-values in the sand and gravel varied widely from 7 to 33 blows/0.3 m, indicating a loose to dense relative density. Several SPT N-values of 50 blows for less than 0.15 m of penetration were recorded, at the bedrock surface in Borehole SRB-02, on a boulder in Borehole SRB-03, and in very dense sand in Borehole SRB-06.

Moisture contents in the sand and gravel deposits ranged from 5% to 15%.

Samples of the deposit underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A, and on the grain size distribution curves shown on Figures B3 and B4 of Appendix B.

Soil Particles	Sand to Sand and Silt	Gravel
Gravel %	4 to 16	89 to 91
Sand %	51 to 65	8 to 10
Silt & Clay %	9 to 45	1

5.4 Bedrock

Bedrock was proven in Boreholes SRB-02 to SRB-05 by recovery of 2.5 to 3.0 m of bedrock core. Auger refusal on probable bedrock was encountered in Borehole SRB-06. The depth and elevations of the bedrock surface are summarized in Table 5.1.

The bedrock recovered in the core samples was described as white and black granodiorite with pink intrusions.

The Total Core Recovery (TCR) of all samples was 100%. The measured Rock Quality Designation (RQD) ranged from 88% to 100%, indicating good to typically excellent rock quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m core, was 2 or less.

The unconfined compressive strength of the rock interpreted from point load tests conducted on the recovered cores ranged from 142 to 211 MPa, indicating a very strong rock.

Table 5.1 – Depths and Elevations of Bedrock

Borehole	Top of Bedrock	
	Depth (m)	Elevation
SRB-02	6.2	401.6
SRB-03	8.4	399.4
SRB-04	6.4	401.8
SRB-05	5.5	402.8
SRB-06	5.5	403.0*

* Probable bedrock, not proven by coring.

5.5 Water Levels

Where possible, water levels were monitored in the open boreholes during drilling operations. Wash boring and rock coring methods were used to advance the boreholes and therefore water levels recorded during or upon completion of drilling may not reflect natural groundwater levels. Standpipe piezometers were installed in two boreholes to monitor the groundwater level after completion. The water levels observed in the open boreholes upon completion and measured in the piezometers are summarized in Table 5.2.

Table 5.2 – Water Level Measurements

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
SRB-01	September 16, 2011	4.5	403.3	In open borehole
SRB-02	September 14, 2011	4.8	403.0	In open borehole
SRB-03	September 10, 2011	4.8	403.0	In open borehole
	September 16, 2011	4.2	403.6	In piezometer
	December 1, 2011	4.9	402.9	In piezometer
	October 28, 2012	4.3	403.5	In piezometer
SRB-04	September 10, 2011	4.3	403.9	In open borehole
SRB-05	September 11, 2011	4.5	403.8	In open borehole
	September 16, 2011	4.6	403.7	In piezometer
	December 1, 2011	4.9	403.4	In piezometer
	October 28, 2012	4.1	404.2	In piezometer
SRB-06	September 11, 2011	4.6	403.9	In open borehole

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

The preliminary GA drawing provided by WSP Canada Inc indicates a water level at Elev. 404.3 in the Sturgeon River (undated) and a normal high water level at Elev. 404.6. Archive design drawings of the existing bridge indicate a water level at Elev. 402.6 in March 1960.

6 MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. The coordinates and the ground surface elevations for the boreholes were established based on topographic survey information provided by WSP Canada Inc.

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

Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied a truck mounted CME-75 drill rig and conducted the drilling, sampling and in-site testing operations. The drilling operations were supervised by Mr. George Azzopardi of Thurber.

Overall supervision of the field program was conducted by Mr. Mark Farrant P.Eng. Interpretation of the data and preparation of the report were carried out by Ms. Rocio Palomeque Reyna and Ms. Mei Cheong, P.Eng.

The report was 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.

Murray R. Anderson, M.Eng., P.Eng.
Senior Foundations Engineer



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



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

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

EXPLANATION OF ROCK LOGGING TERMS


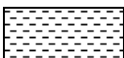



ROCK WEATHERING CLASSIFICATION

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		Field Estimation of Hardness*
	(MPa)	(psi)	
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.

RECORD OF BOREHOLE No SRB-01

1 OF 1

METRIC

W.P. 6082-09-01 LOCATION Sturgeon River Bridge N 5 549 165.5 E 653 619.4 ORIGINATED BY GA
 HWY 599 BOREHOLE TYPE Casing/Coring COMPILED BY AN
 DATUM Geodetic DATE 2011.09.16 - 2011.09.16 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
407.8								20	40	60	80	100									
0.0	ASPHALT: (40mm)																				
	SAND, some gravel, trace silt Compact to Very Dense Brown Wet (FILL)		1	SS	28		407								o						
	Occasional cobbles		2	SS	25										o					15 80 5 (SI+CL)	
			3	SS	70		406								o						
	Boulder (300mm) at 2.3m		4	SS	50/ 0.00		405														
	Boulder (275mm) at 3.1m		5	SS	50/ 0.075										o						
							404														
403.4																					
4.4	SAND and SILT, trace clay, trace gravel Dense to Compact Grey Wet		6	SS	33		403								o					4 51 36 9	
							402														
			7	SS	22		401								o						
400.2																					
7.6	END OF BOREHOLE AT 7.6m. BOREHOLE OPEN TO 7.6m, WATER OBSERVED AT 4.5m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH HOLEPLUG FROM 7.6m TO 0.15m, THEN ASPHALT TO SURFACE.																				

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SRB-02

1 OF 1

METRIC

W.P. 6082-09-01 LOCATION Sturgeon River Bridge N 5 549 160.3 E 653 612.7 ORIGINATED BY GA
 HWY 599 BOREHOLE TYPE Coring/NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.09.14 - 2011.09.14 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
407.8														
0.0	ASPHALT: (40mm)													
	SAND, trace gravel, trace silt, occasional cobbles Compact Brown Moist (FILL)		1	SS	24		407							
			2	SS	18									10 84 6 (SI+CL)
			3	SS	19		406							
			4	SS	12									
	Boulders from 2.9m to 3.7m		5	SS	50/ 0.00		405							
							404							
403.2														
4.6	SAND, some gravel, some silt Dense Grey Wet		6	SS	30		403							16 65 19 (SI+CL)
							402							
401.6			7	SS	50/ 0.075									
6.2	BEDROCK, granodiorite, white and black with pink intrusions		1	RUN			401							RUN #1 TCR=100% SCR=100% RQD=100% UCS=177MPa (Average)
			2	RUN			400							RUN #2 TCR=100% SCR=100% RQD=100% UCS=164MPa (Average)
	Horizontal joints at 8.1m, 8.3m and 8.6m		3	RUN										RUN #3 TCR=100%
399.1														SCR=100% RQD=100% UCS=145MPa (Average)
8.7	END OF BOREHOLE AT 8.7m. BOREHOLE OPEN TO 8.7m, WATER OBSERVED AT 4.8m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH HOLEPLUG FROM 8.7m TO 0.15m, THEN ASPHALT TO SURFACE.													

ONTMT4S 0840.GPJ 2012TEMPLATE(MTO).GDT 7/31/14

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

+³, ×³: Numbers refer to Sensitivity

METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES <div>NUMBER TYPE "N" VALUES</div>	GROUND WATER CONDITIONS	ELEVATION SCALE
	Continued From Previous Page				DYNAMIC CONE PENETRATION RESISTANCE PLOT <div>20 40 60 80 100</div>
					SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE
					WATER CONTENT (%) <div>P L W</div>
396.4	BEDROCK, granodiorite, white and black with pink intrusions	[Pattern]	2 RUN	[Pattern]	397
11.4	END OF BOREHOLE AT 11.4m. BOREHOLE OPEN TO 11.4m AND WATER LEVEL AT 4.8m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.				
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Sep.16/11 4.2 403.6 Dec.01/11 4.9 402.9 Oct.28/12 4.3 403.5				

+³, ×³: Numbers refer to Sensitivity

METRIC

SOIL PROFILE			SAMPLES		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES
408.2	ASPHALT: (40mm)				
0.0	Sandy GRAVEL to Gravelly SAND, trace silt Compact Brown Wet (FILL) Occasional cobbles		1	SS	20
			2	SS	17
	Boulder (200mm) at 1.5m		3	SS	50/ 0.00
			4	SS	14
			5	SS	9
403.7	GRAVEL, trace to some sand, trace silt Compact Brown to Grey Wet Occasional cobbles		6	SS	25
4.6					
401.8	BEDROCK, granodiorite, white and black				
6.4	Horizontal joint at 6.4m		1	RUN	
			2	RUN	
	Sub-horizontal joint at 9.1m				
	Horizontal joint at 9.3m				
398.8	END OF BOREHOLE AT 9.4m. BOREHOLE OPEN TO 9.4m AND WATER LEVEL AT 4.3m.				
9.4					

+³, ×³: Numbers refer to Sensitivity

ONTMT4S 0840.GPJ 2012TEMPLATE(MTO).GDT 7/31/14

RECORD OF BOREHOLE No SRB-04

2 OF 2

METRIC

W.P. 6082-09-01 LOCATION Sturgeon River Bridge N 5 549 138.1 E 653 604.4 ORIGINATED BY GA
 HWY 599 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2011.09.10 - 2011.09.10 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W P	W	W L	WATER CONTENT (%)		
	Continued From Previous Page													
	BOREHOLE BACKFILLED WITH HOLEPLUG FROM 9.4m TO 0.3m, CONCRETE FROM 0.3m TO 0.15m, THEN ASPHALT TO SURFACE.													

RECORD OF BOREHOLE No SRB-05

1 OF 2

METRIC

W.P. 6082-09-01 LOCATION Sturgeon River Bridge N 5 549 141.2 E 653 599.8 ORIGINATED BY GA
HWY 599 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2011.09.11 - 2011.09.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
408.3								20 40 60 80 100					
0.0	ASPHALT: (40mm)												
	SAND, some silt, trace to some gravel Compact Brown Wet (FILL)		1	SS	20		408						
			2	SS	23		407						2 85 13 (SI+CL)
	Occasional cobbles		3	SS	18								
			4	SS	50/ 0.00		406						
	Gravelly		5	SS	8		405						
403.7							404						
4.6	GRAVEL, trace to some sand Loose Brown to Grey Wet		6	SS	7		403						91 8 1 (SI+CL)
402.8													
5.5	BEDROCK, granodiorite, white and black Horizontal joint at 5.5m		1	RUN			402						RUN #1 TCR=100% SCR=100% RQD=97% UCS=169MPa (Average)
	Horizontal joint at 7.2m						401						RUN #2 TCR=100% SCR=100% RQD=100% UCS=211MPa (Average)
	Sub-horizontal joint at 7.4m and 7.7m		2	RUN			400						
399.7													
8.5	END OF BOREHOLE AT 8.5m. BOREHOLE OPEN TO 8.5m AND WATER LEVEL AT 4.5m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Sep.16/11 4.6 403.7												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 10 5 0
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SRB-05

2 OF 2

METRIC

W.P. 6082-09-01 LOCATION Sturgeon River Bridge N 5 549 141.2 E 653 599.8 ORIGINATED BY GA
 HWY 599 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2011.09.11 - 2011.09.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
	Continued From Previous Page																
	Dec.01/11 4.9 403.4																
	Oct.28/12 4.1 404.2																

RECORD OF BOREHOLE No SRB-06

1 OF 1

METRIC

W.P. 6082-09-01 LOCATION Sturgeon River Bridge N 5 549 132.9 E 653 597.8 ORIGINATED BY GA
HWY 599 BOREHOLE TYPE NW Casing COMPILED BY AN
DATUM Geodetic DATE 2011.09.11 - 2011.09.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)								
								20 40 60 80 100					w _P w w _L								
408.5								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE													
0.0		ASPHALT: (25mm)																			
		SAND, some gravel, some silt Compact Brown Damp (FILL)		1	SS	23		408							○						
				2	SS	18									○						
								407													
				3	SS	16									○			17 61 22 (SI+CL)			
		Wet																			
				4	SS	17		406							○						
				5	SS	11		405							○						
403.9								404													
4.6		SAND, some silt Very Dense Brown Wet		6	SS	50/ 0.150									○						
403.0																					
5.5		END OF BOREHOLE AT 5.5m UPON REFUSAL ON PROBABLE BEDROCK. BOREHOLE OPEN TO 5.5m AND WATER LEVEL AT 4.6m. BOREHOLE BACKFILLED WITH HOLEPLUG FROM 5.5m TO 0.3m, CONCRETE FROM 0.3m TO 0.15m, THEN ASPHALT TO SURFACE.																			

ONTMT4S 0840.GPJ 2012TEMPLATE(MTO).GDT 7/31/14

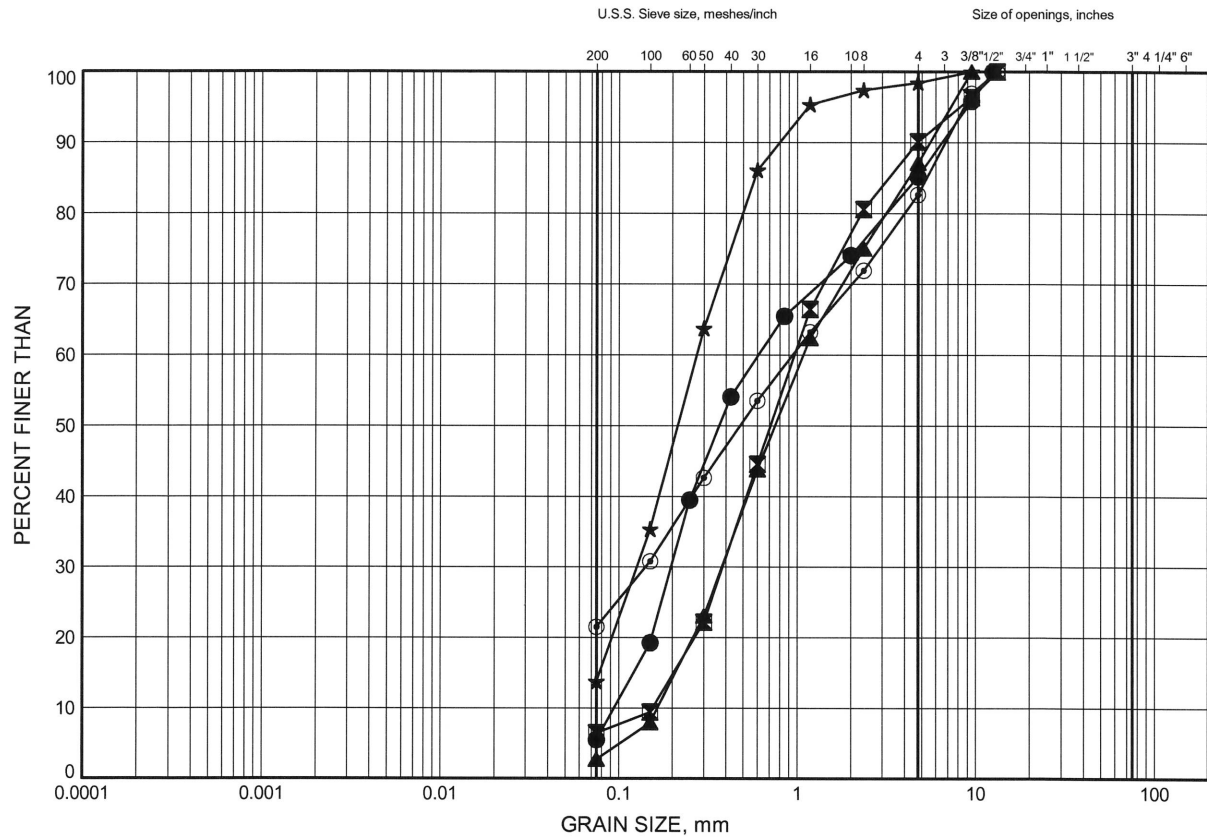
Appendix B

Laboratory Test Results

Sturgeon River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-01	1.07	406.73
⊠	SRB-02	1.07	406.75
▲	SRB-03	0.46	407.36
★	SRB-05	1.07	407.20
⊙	SRB-06	1.83	406.69

Date May 2014
W.P. 6082-09-01

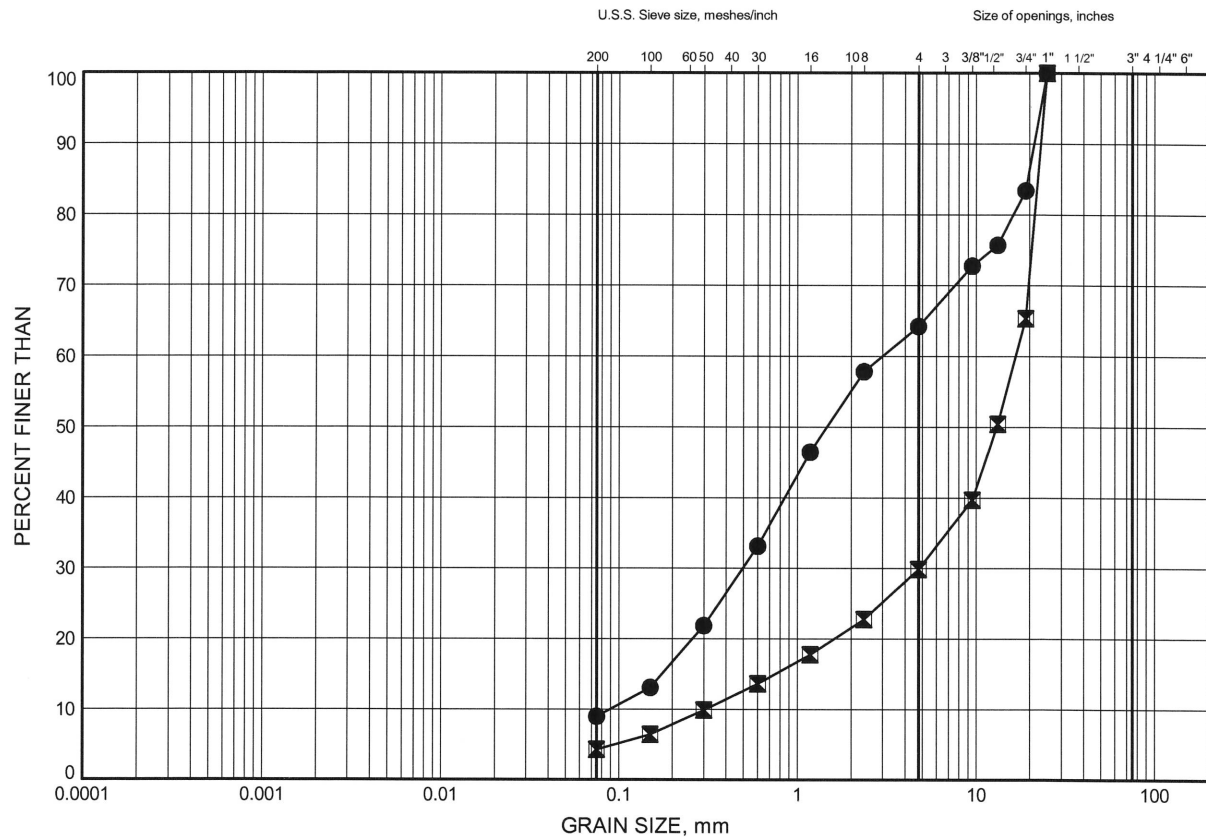


Prep'd AN
Chkd. MRA

Sturgeon River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B2

GRAVELLY SAND TO SANDY GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-03	3.35	404.46
⊠	SRB-04	1.07	407.18

Date May 2014
W.P. 6082-09-01

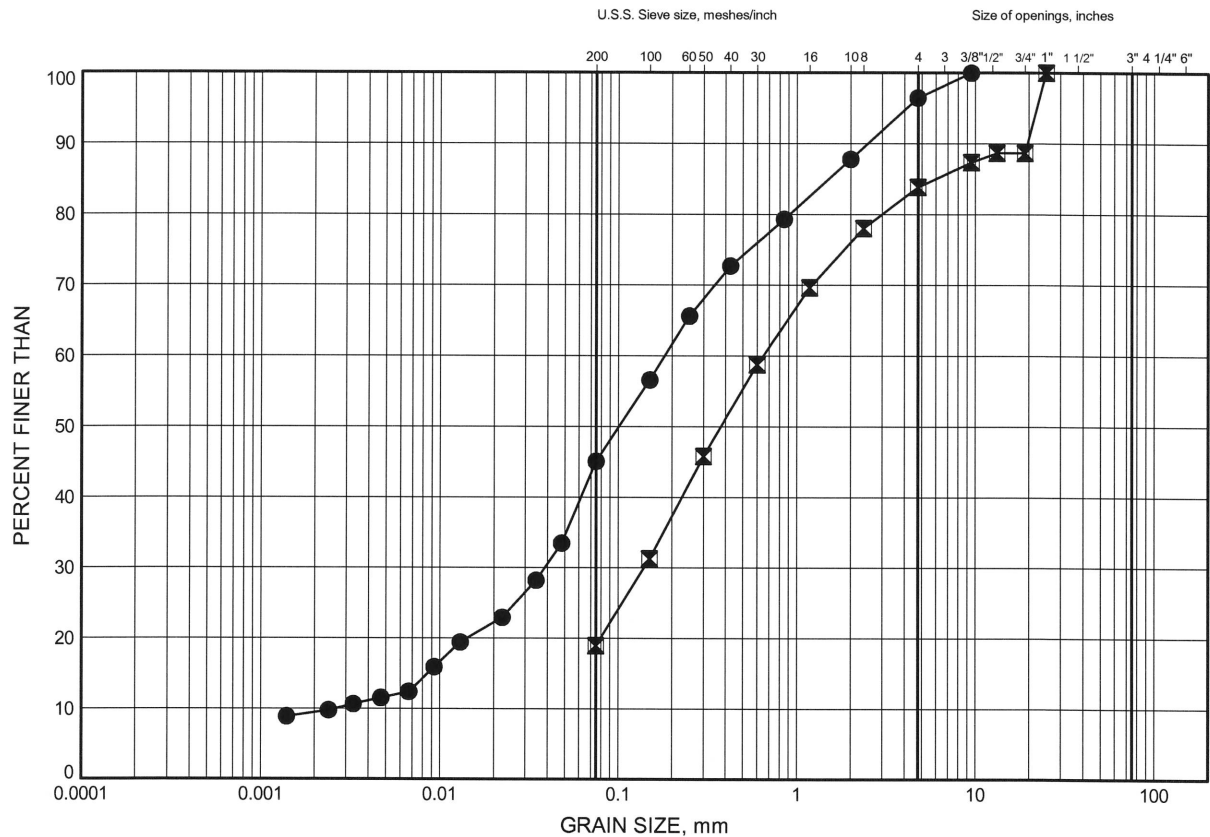


Prep'd AN
Chkd. MRA

Sturgeon River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND TO SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-01	4.88	402.92
▲	SRB-02	4.88	402.94

FIGURE B4

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

Size of openings, inches

PERCENT FINER THAN

GRAIN SIZE, mm

Grain Size (mm)	Percent Finer Than (%) - Circles	Percent Finer Than (%) - Crosses
0.075	0	0
0.15	1	1
0.3	2	2
0.6	3	3
1.18	4	4
2.5	6	6
5.0	11	9
7.5	19	22
15	27	29
30	43	29
60	81	81
100	100	100

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

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SRB-04	4.88	403.37
☒	SRB-05	4.88	403.39

GRAIN SIZE DISTRIBUTION - THURBER 0840.GPJ 5/14/14

Date May 2014
W.P. 6082-09-01



Prep'd AN
Chkd. MRA

Appendix C

Site Photographs



Photograph 1 – North approach, looking south



Photograph 2 – South approach, looking north



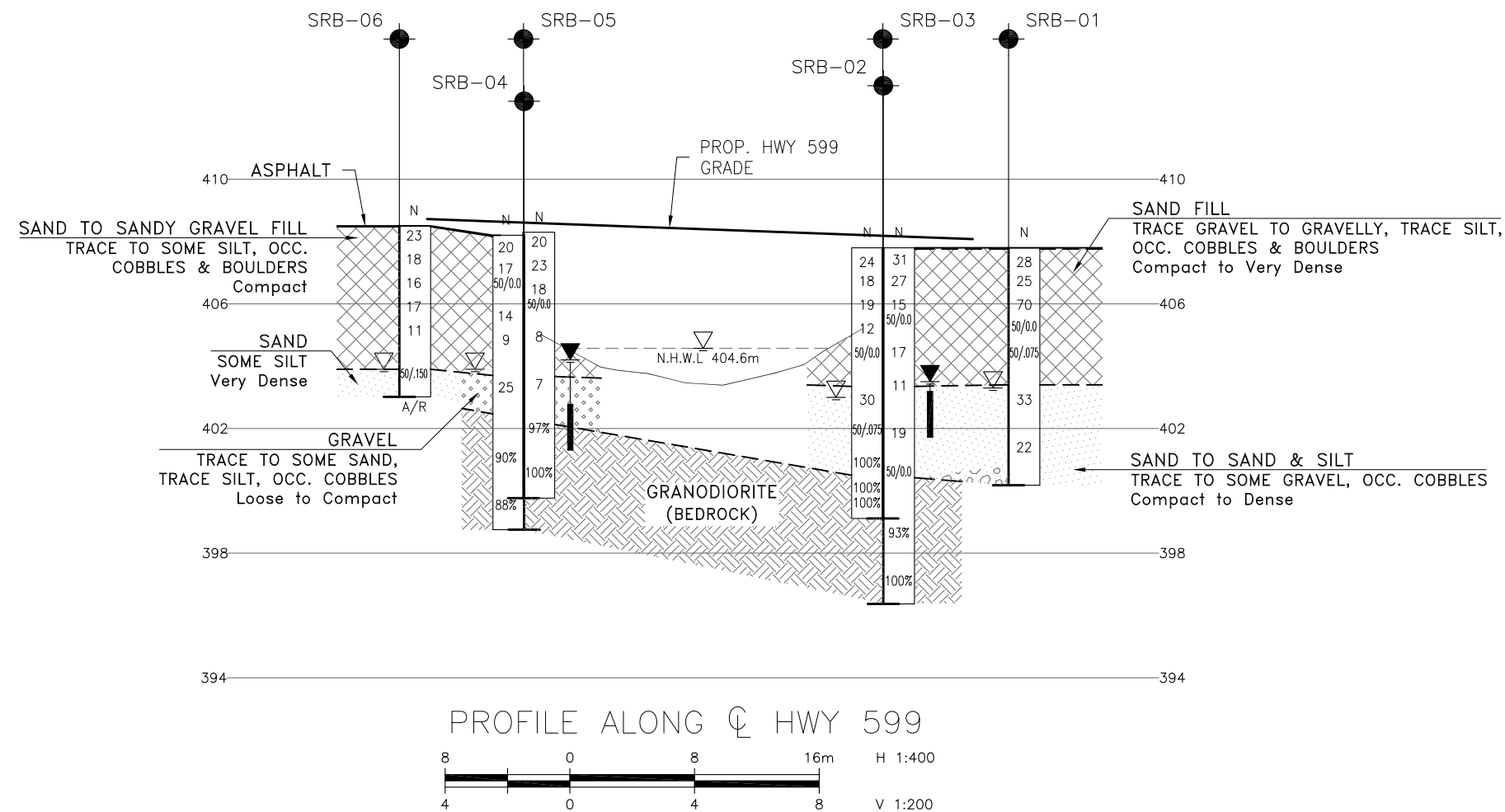
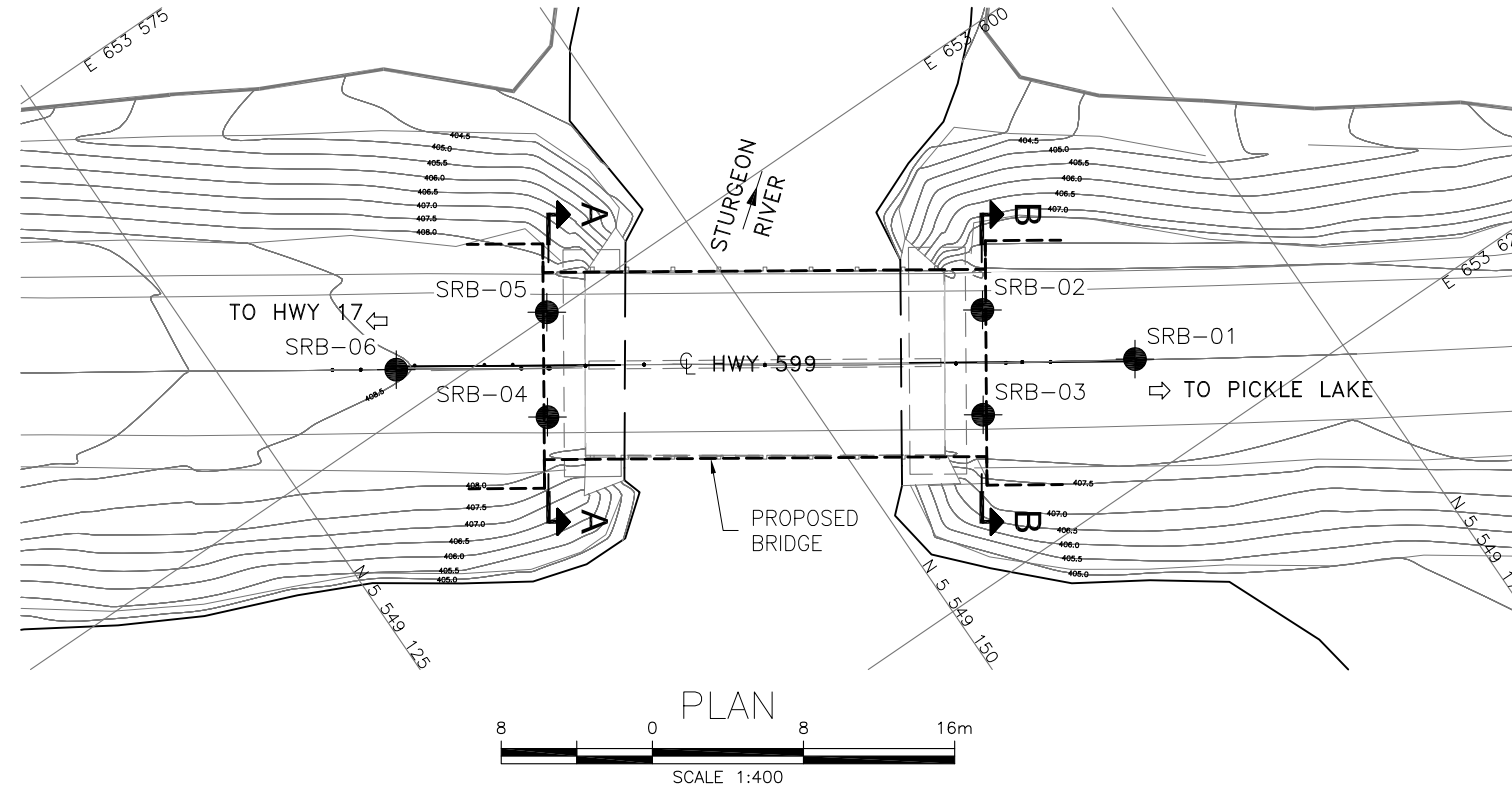
Photograph 3 – South crib abutment



Photograph 4 – Riverbed on east side of bridge

Appendix D

Borehole Locations and Soil Strata Drawings



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



CONT No
WP No 6082-09-01

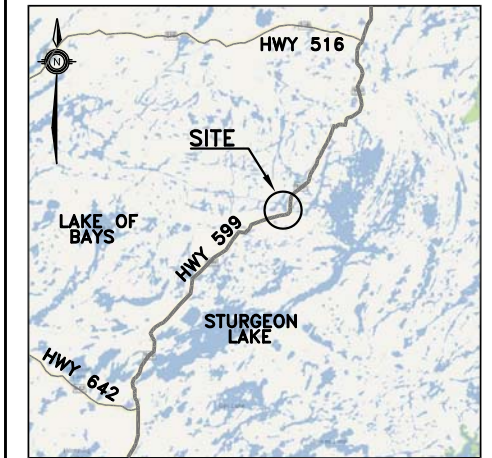
STURGEON RIVER BRIDGE
REPLACEMENT
HIGHWAY 599
BOREHOLE LOCATIONS AND SOIL STRATA



1269 PREMIER WAY, THUNDER BAY (ONTARIO) CANADA, P7B 0A3
TEL: 807 625-6700 | FAX: 807 623-4491 | WWW.WSPGROUP.COM







THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

	Borehole
	Borehole and 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

[illegible]

-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. 52J-9

[illegible]

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



CONT No
WP No 6082-09-01

STURGEON RIVER BRIDGE
REPLACEMENT
HIGHWAY 599
BOREHOLE LOCATIONS AND SOIL STRATA

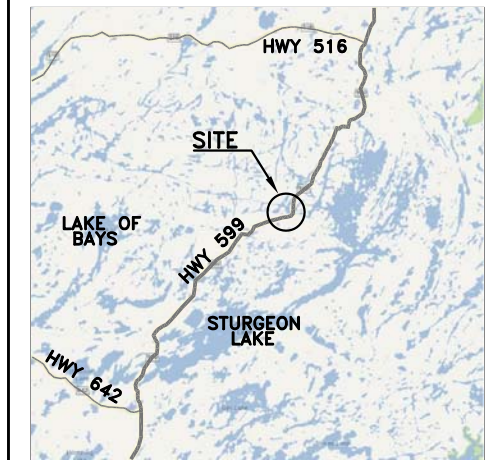
SHEET



1269 PREMIER WAY, THUNDER BAY (ONTARIO) CANADA, P7B 0A3
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THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

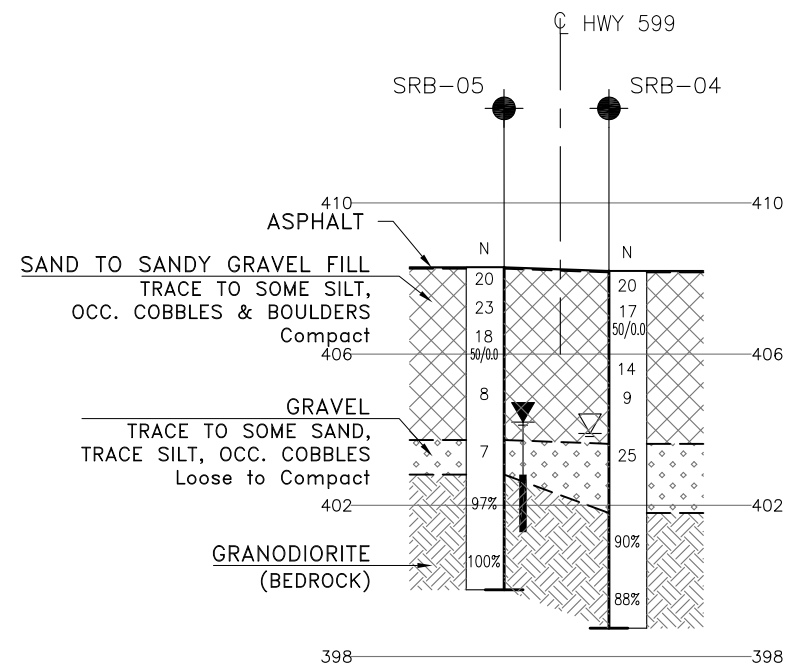
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level During Drilling
	Water Level In Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
SRB-01	407.8	5 549 165.5	653 619.4
SRB-02	407.8	5 549 160.3	653 612.7
SRB-03	407.8	5 549 157.2	653 617.3
SRB-04	408.2	5 549 138.1	653 604.4
SRB-05	408.3	5 549 141.2	653 599.8
SRB-06	408.5	5 549 132.9	653 597.8

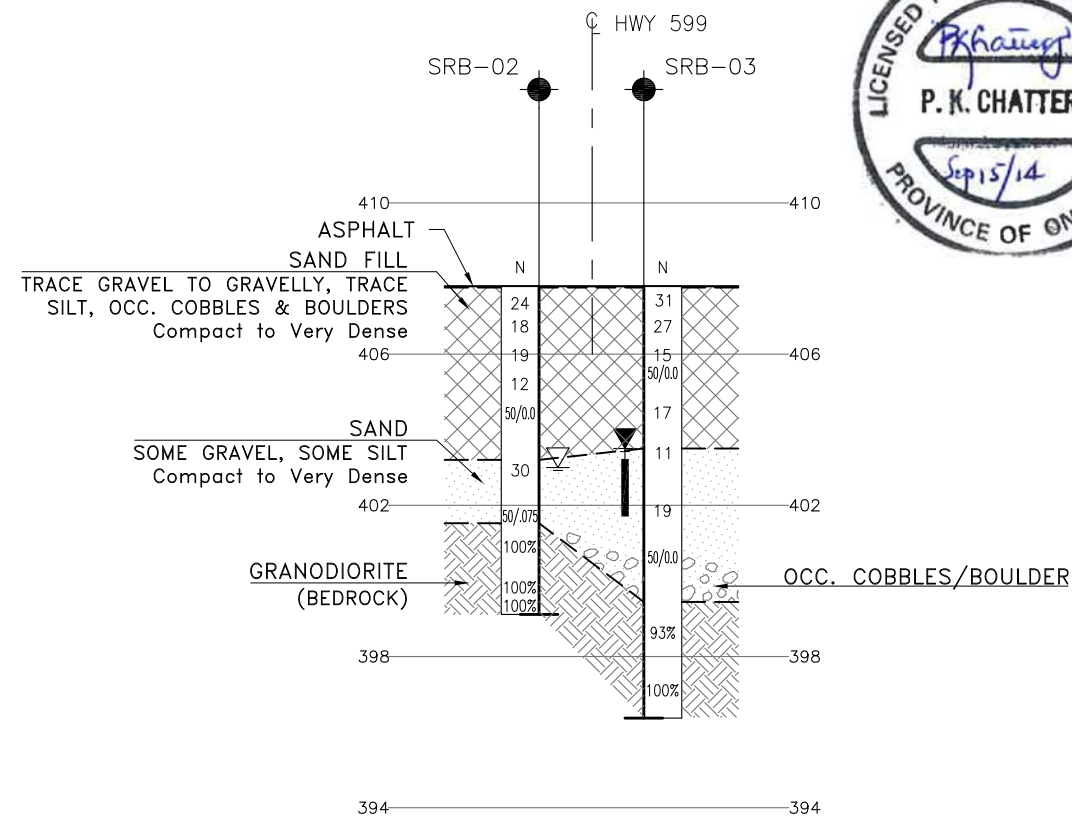
-NOTES-

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

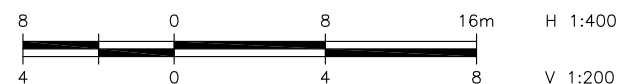
GEOCRIS No. 52J-9



SECTION ALONG A-A



SECTION ALONG B-B



REVISIONS					
DATE	BY	DESCRIPTION			
DESIGN	MRA	CHK	MRA	CODE	LOAD
DRAWN	AN	CHK	PKC	SITE	48W-8
				STRUCT	DWG 2
				DATE	SEP 2014