THURBER ENGINEERING LTD.

DETAILED FOUNDATION INVESTIGATION REPORT
CRYSTAL RIVER BRIDGE REPLACMENT AND DETOUR BRIDGE
HIGHWAY 599, DISTRICT OF THUNDER BAY,
UNSURVEYED TERRITORY, ONTARIO
LATITUDE: 49.6951°, LONGITUDE: -91.2348°
W.P. 6088-17-01, SITE No. 41S-098

GEOCRES Number: 52G-20

Report

to

HATCH

Date: May 14, 2020
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1. INTRODUCTION

This report presents the factual data obtained from a detailed foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the Crystal River Bridge and construction of a temporary detour bridge and approach embankments at the site. The Crystal River Bridge is located on Highway 599, north of Ignace, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the Crystal River bridge site and the detour bridge site, to the west of the existing bridge, and based on the data obtained, to provide a borehole location plan, stratigraphic profiles, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by the Ministry of Transportation (MTO), Northwest Region, to carry out this foundation investigation under the MTO Agreement Number 6017-E-0022, Assignment #10.

2. SITE DESCRIPTION

The site is located on Highway 599, 46.8 km north of Highway 17 at Ignace, in Unsurveyed Territory, Thunder Bay District, Ontario. The existing bridge allows Crystal River to flow under Highway 599 from east to west. Highway 599 runs in a general north-south direction at the bridge site.

The Ontario Structure Inspection Manual (OSIM) report prepared by MTO on November 15, 2017 indicates that the existing structure is a three-span, steel girder bridge with a cast-in-place concrete deck, built in 1965. The inspection report indicates that the bridge deck is approximately 21.5 m long and 10 m wide. Based on a survey plan of the site provided by MTO, the ground surface elevation of Highway 599 at the existing bridge is approximately Elevation 421.3 m. The

existing bridge is supported on timber piles at the abutments and piers. Measurements collected in May 2018 indicate that the surface water level of Crystal River was at approximate Elevation 417.9 m at the bridge.

An existing foundation investigation for the original bridge entitled, “Proposed Structure at Relocated Crystal River and Secondary Hwy. 599, District #20, Fort William, Ont.”, Geocres No. 52G00-005, dated September 30, 1964, shows that the alignment of Crystal River was diverted during construction of the original bridge. Portions of the former channel continue to exist to the north of the bridge, on both sides of the highway. The possible location of the former channel under the highway is shown on the Borehole Locations and Soil Strata drawings in Appendix D. Based on previous contract packages provided by MTO, the bridge was previously rehabilitated around 1990, which included a new concrete deck and new steel barrier rails.

The lands surrounding the bridge site are predominantly heavily forested, with marshy conditions along the river floodplain, particularly near the original channel on the west side of the highway. Bedrock outcrops are exposed within 30 m of the bridge at the northwest quadrant, immediately north of the marshy area.

Photographs of the bridge and surrounding area are presented in Appendix C. No obvious indications of road settlement were observed, and the existing Highway 599 embankment slopes appeared to be performing satisfactorily.

Based on published geological information, the bridge lies within an area consisting of a glacial fluvial outwash deposits of gravel and sand. Based on local geological maps, the bedrock in the area is identified as tonalite to granodiorite.

3. INVESTIGATION PROCEDURES

The field investigation for the detour bridge was carried out between April 23 and May 2, 2019 and consisted of drilling and sampling ten (10) boreholes, labeled 19-01 to 19-10, and conducting six (6) hand probes. The boreholes were drilled to depths ranging from approximately 0.5 to 23.3 m (Elevation 421.0 to 397.0 m). Boreholes 19-01, 19-02, 19-09 and 19-10 were drilled near the locations of the proposed abutments for the replacement bridge, with Boreholes 19-05 and 19-06A / 19-06B drilled at the Highway 599 south and north approaches to the bridge respectively. Boreholes 19-03A / 19-03B and 19-04 were drilled for the south and north abutments of the detour bridge, with Boreholes 19-07 and 19-08 drilled along the south and north detour embankments respectively. Due to wet and marshy conditions near the estimated location of the north detour bridge abutment, Borehole 19-04 was relocated approximately 15 m north of the north abutment.

Six (6) hand probes, labelled P1 to P6, were conducted within the marshy area to investigate the approximate depth of soft / organic soil in this location.

The borehole logs from the foundation investigations are included in Appendix A. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata drawings included in Appendix D.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from field measurements and the topographic drawings provided to Thurber by MTO. The coordinate system MTM NAD 83, Zone 15 was used for the boreholes.

A rubber tracked CME 55 drill rig was used to advance the boreholes using solid stem augers and NW casing. Soil samples were obtained in the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). NQ coring methods were used to advance the abutment boreholes (19-01, 19-02, 19-03B, 19-04, 19-09 and 19-10) at least 3 m into bedrock and collect rock cores. Dynamic Cone Penetration Tests (DCPTs) were also conducted at Borehole 19-06B, and adjacent to Borehole 19-07.

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

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

A piezometer was installed in Borehole 19-03A to permit measurement of the groundwater level. The piezometer was decommissioned on May 2, 2019 in general accordance with Ontario Regulation 903 as amended.

Completion details of the boreholes are summarized in Table 3.1.

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Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
19-01	23.3 / 398.0	-	Backfilled with bentonite and cuttings from 23.3 to 0.3 m, cement from 0.3 to 0.15 m, then asphalt to surface.
19-02	23.2 / 398.0	-	Backfilled with bentonite and cuttings from 23.2 to 0.15 m, then asphalt to surface.
19-03A / 19-03B	22.1 / 397.0	16.6 / 402.5	Backfilled with sand from 19.5 to 3.7 m, bentonite from 3.7 m to 1.2 m, then cuttings to surface.
19-04	8.9 / 410.4	-	Borehole caved to 2.1 m, then backfilled with bentonite and cuttings from 2.1 m to surface.
19-05	9.8 / 411.6	-	Borehole caved to 3.4 m, then backfilled with bentonite and cuttings from 3.4 m to 0.2 m, cement from 0.2 m to 0.15 m, then asphalt to surface.
19-06A	3.9 / 417.5	-	Backfilled with bentonite and cuttings from 3.9 m to 0.15 m, then asphalt to surface.
19-06B	9.4 / 411.9	-	Backfilled with cuttings from 9.4 m to 0.15 m, then asphalt to surface.
19-07	9.8 / 409.7	-	Borehole caved to 2.1 m, then backfilled with bentonite and cuttings from 2.1 m to surface.
19-08	0.5 / 421.0	-	Backfilled with cuttings from 0.5 m to surface.
19-09	23.2 / 398.0	-	Borehole caved to 2.1 m, then backfilled with bentonite and concrete to 0.3 m, cement from 0.3 to 0.15 m, then asphalt to surface.
19-10	22.3 / 398.9	-	Borehole caved to 2.1 m, then backfilled with bentonite and cuttings to 0.3 m, cement from 0.3 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/or hydrometer), where appropriate. Point load tests were conducted on the rock cores. The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, samples of the native soil from Borehole 19-01 at the existing south abutment and 19-10 from the existing north abutment were collected as well as a surface water sample from the upstream side of the bridge. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix B.

5. SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the Borehole Locations and Soil Strata Drawings included in Appendix D. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered at the boreholes consisted of asphalt and granular fill, underlain by native deposits of silty sand to sandy silt, and a relatively thick deposit of sand. The boreholes and hand probes located within a marshy area along the proposed detour route also encountered surficial topsoil or peat at the ground surface. The marshy area extended to approximately 25 m north of the river. There may be other marshy areas along the detour route that were not visible due to snow cover during the investigation. Other soft alluvial organic soils may be present along the alignment of the former river channel. The overburden soils are underlain by granodiorite bedrock. Descriptions of the individual strata are presented below.

5.1 Asphalt and Concrete

A 90 to 125 mm thick layer of asphalt was encountered at the ground surface in Boreholes 19-01, 19-02, 19-06A, 19-09 and 19-10. The asphalt was underlain by a 175 to 200 mm thick layer of concrete in Boreholes 19-01, 19-02, 19-09 and 19-10, which were drilled through the concrete approach slab for the existing bridge.

5.2 Road Base and Embankment Fill

Road base and embankment fill was encountered below the asphalt and concrete in Boreholes 19-01, 19-02, 19-05, 19-06A, 19-09 and 19-10. The fill typically consisted of sand to sand and gravel, with boulders and cobbles. At the south approach to the bridge, the upper granular fill was underlain by a lower sandy silt fill in Boreholes 19-01, 19-05 and 19-09.

The upper road base and granular fill consisted of sand, gravelly sand, sand and gravel, and boulders and cobbles, and this fill extended to depths ranging from 0.7 to 4.5 m (Elev. 420.7 to 416.7 m).

The granular fill was compact to very dense, with SPT ‘N’ values ranging from 11 to 62 blows for 0.3 m of penetration. The boulder and cobble zones within the granular fill (at Boreholes 19-02 and 19-06A) were very dense, with SPT ‘N’ values of 100 blows per 0.05 to 100 blows per 0.175 m of penetration. The measured moisture content in the granular fill ranged from 2 to 10%.

The lower sandy silt fill encountered in Boreholes 19-01, 19-05 and 19-09 extended to depths ranging from 1.9 to 2.4 m (Elevation 419.5 to 418.9 m) and was 0.6 to 1.2 m thick.

The sandy silt fill was compact to dense, with SPT ‘N’ values ranging from 11 to 47 blows for 0.3 m of penetration. The measured moisture content in the sandy silt fill ranged from 15 to 22%.

The results of grain size analyses conducted on selected samples of the granular fill and sandy silt fill are illustrated on Figures B1 and B2 of Appendix B. The results are summarized as follows:

Soil Particle	Sand to Sand and Gravel Fill (%)	Sandy Silt Fill (%)
Gravel	9 to 39	0 to 2
Sand	50 to 83	25 to 36
Silt and Clay	8 to 11	-
Silt	-	54 to 66
Clay	-	8 to 9

5.3 Topsoil and Peat

A 50 to 100 mm thick layer of topsoil was encountered at the ground surface at Boreholes 19-03A, 19-04, 19-07 and 19-08, which were drilled along the proposed detour route.

At the hand probe locations, P1 to P6, the depth to the base of the surficial peat or topsoil ranged from 150 to 300 mm, as shown on the table below.

Hand Probe Location	Depth of Peat or Topsoil (mm)
P1	250
P2	200
P3	200
P4	300
P5	150
P6	150

A 0.9 m thick layer of buried peat was also encountered below the fill in Borehole 19-10 at a depth of 4.1 m, extending to a depth of 5.0 m (Elev. 416.2 m). The peat contained some sand and rootlets and was loose, with an SPT 'N' value of 5 blows per 0.3 m of penetration. The measured moisture content of the peat was 110%.

There may be other marshy areas with peat along the detour route that could not be identified due to snow cover. Other buried organic alluvial material may be present along the former river channel.

5.4 Gravelly Sand and Sandy Gravel

A layer of gravelly sand with some organics and trace silt was encountered below the topsoil in Boreholes 19-04 and 19-08. The gravelly sand layer was 0.6 m thick in Borehole 19-04 and extended to a depth of 0.7 m (Elev. 418.6 m). In Borehole 19-08, the gravelly sand layer was

0.4 m thick and was underlain by possible large boulders or bedrock at a depth of 0.5 m (Elev. 421.0 m). A 1.3 m thick lower layer of sandy gravel with trace silt and containing boulders was also encountered in Borehole 19-04 above the bedrock at a depth of 4.1 m (Elev. 415.2 m).

The SPT 'N' values recorded in the gravelly sand and sandy gravel layers ranged from 1 to 37 blows per 0.3 m penetration, indicating the surficial layer to be very loose and the deeper layer to be dense. In Borehole 19-08, the SPT 'N' value was 100 blows per 0.175 m penetration, due to refusal on the underlying potential layer of cobbles and boulders or bedrock. The measured moisture content ranged from 12 to 30%.

The results of grain size analyses conducted on a sample of the deeper sandy gravel deposit are illustrated on Figure B3 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	63
Sand	30
Silt and Clay	7

5.5 Sandy Silt to Silty Sand

A deposit of native cohesionless soil ranging from silty sand to sandy silt was encountered in Boreholes 19-02, 19-03A, 19-04, 19-07, 19-09 and 19-10 below the fill, topsoil, gravelly sand and peat layers. The sandy silt to silty sand also contained trace to some gravel and trace clay. The thickness of this deposit ranged from approximately 0.1 to 4.2 m and extended to depths of 0.2 to 8.7 m (Elevation 418.9 to 412.5 m). Deeper zones of silty sand and sand and silt were also encountered in Borehole 19-01 (0.9 m thick) at a depth of 18.8 m (Elev. 402.4 m) and in Borehole 19-10 (1.5 m thick) at a depth of 10.2 m (Elev. 411.0 m).

SPT 'N' values measured in the sandy silt to silty sand deposits ranged from 1 to 20 blows for 0.3 m of penetration, indicating that the deposit is very loose to compact. The measured moisture contents in the deposit ranged from 10 to 60%.

The results of grain size analyses conducted on samples of the sandy silt to silty sand deposit, and the silt layer are illustrated on Figure B4 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 13
Sand	21 to 76
Silt and Clay	22 to 56
Silt	35 to 70
Clay	5 to 6

5.6 Sand

A relatively thick deposit of native sand containing trace to some gravel and trace silt was encountered below the fill or sandy silt to silty sand layers. The thickness of the sand deposit ranged from 10.8 to 17.6 m and extended to depths of 17.8 to 19.7 m (Elevation 402.4 to 401.3 m), where bedrock was encountered in the majority of the boreholes. Boreholes 19-05 and 19-07 were terminated within the sand at depths of 9.8 m (Elev. 411.6 to 409.7 m). A Dynamic Cone Penetration Test (DCPT) conducted adjacent to Borehole 19-07 was driven to a depth of 11.0 m (Elev. 408.4 m) and terminated within the sand deposit. Occasional layers of silty sand to sandy silt (described in Section 5.5) were encountered within the sand deposit, and a 1.5 m thick layer of boulders and sand was encountered within the sand at a depth of 10.2 m (Elev. 411.1 m) in Borehole 19-09.

SPT 'N' values measured in the sand deposit ranged from 2 to 35 blows for 0.3 m of penetration, indicating that the deposit is very loose to dense. The measured moisture contents in the deposit ranged from 3 to 29%.

The results of grain size analyses conducted on samples of the sand are illustrated on Figures B5, B6 and B7 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 16
Sand	81 to 98
Silt and Clay	2 to 17

5.7 Bedrock

The overburden soils described above are underlain by granodiorite bedrock. The bedrock was grey in colour with red veins and is generally described as moderately to slightly weathered. Bedrock was proved by coring 3.5 to 4.3 m in Boreholes 19-01, 19-02, 19-03B, 19-04, 19-09 and 19-10. Borehole 19-08 was terminated a depth of 0.5 m (Elev. 421.0 m) on possible bedrock, and was located in close proximity to a bedrock outcrop. A Dynamic Cone Penetration Test (DCPT)

conducted at Borehole 19-06B was driven until refusal on possible bedrock at a depth of 9.4 m (Elev. 411.9 m). A sloping bedrock surface may be present on the north side of the river.

Table 5.1 summarizes the depths and elevations to the top of the bedrock at the existing bridge and detour bridge locations. Photographs of the rock cores are included in Appendix B.

Table 5.1 - Depths and Elevations of Top of Bedrock

Bridge	Location	Borehole	Top of Bedrock	
			Depth Below Existing Grade Level (m)	Elevation (m)
Existing Highway 599 Bridge	South Abutment	19-01	19.7	401.6
		19-09	19.7	401.5
	North Abutment	19-02	19.5	401.7
		19-10	18.8	402.4
	North Approach	19-06B	9.4*	411.9*
Detour Bridge	South Abutment	19-03A/B	17.8	401.3
	North Abutment	19-04	5.4	413.9
	North Approach	19-08	0.5*	421.0*

* Possible top of bedrock based on DCPT or split spoon refusal; bedrock not confirmed

Total Core Recovery (TCR) in the bedrock ranged from 63 to 100%, and Solid Core Recovery (SCR) ranged between 63% and 100%. The Rock Quality Designation (RQD) determined from the recovered from the cores ranged between 0 and 100%, but was typically between 25 and 67%, which indicates poor to fair rock quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to 7, with occasional broken zones with FI of greater than 10.

Average unconfined compressive strengths (UCS) of the rock ranged between 142 and 305 MPa, indicating the rock is very strong to extremely strong. These estimated rock strength values are interpreted from point load tests that were conducted on rock cores recovered from the boreholes. A summary of the point load tests results are presented in Appendix B.

5.8 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the piezometer installed in Borehole 19-03A upon completion of drilling. A summary of the water level measurements is provided in Table 5.2 below:

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Table 5.2 - Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
19-03A	May 1, 2019 May 2, 2019	0.9 0.9	418.2 418.2	Piezometer
19-05	April 26, 2019	3.4	418.0	Open borehole
19-07	April 26, 2019	2.1	417.3	Open borehole
19-09	April 28, 2019	2.1	419.2	Open borehole
19-10	April 30, 2019	2.1	419.1	Open borehole

The groundwater level should be anticipated to reflect the local river water level. The water level of Crystal River in May 2018 was measured at Elevation 417.9 m at the existing bridge.

Groundwater levels are short-term observations and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

Two samples of the native soil, and a sample of the river water from Crystal River were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 - Analytical Test Results

Parameter	Units (soil)	Units (water)	Test Results		
			19-01, SS#5, 3.0 to 3.7 m	19-10, SS#6, 6.1 to 6.7 m	CRB East Side
			Native Sand	Native Sandy Silt	River Water
Sulphide	%	µg/L	<0.02	<0.02	<6
Chloride	µg/g	mg/L	39	8.3	0.53
Sulphate	µg/g	mg/L	6.2	1.9	0.82
pH	no unit	no unit	7.70	8.67	7.27
Conductivity	uS/cm	uS/cm	110	103	47

Parameter	Units (soil)	Units (water)	Test Results		
			19-01, SS#5, 3.0 to 3.7 m	19-10, SS#6, 6.1 to 6.7 m	CRB East Side
			Native Sand	Native Sandy Silt	River Water
Resistivity	ohms.cm	ohms.cm	9100	9700	21,300 (calculated)
Redox Potential	mV	mV	395	355	164

7. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. The northing and easting coordinates and ground surface elevations were estimated based on field measurements relative to the topographic plans provided by MTO.

RPM Drilling of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Mr. Kevin Kweon of Thurber. The overall supervision of the field program was conducted by Mr. Mark Farrant, P.Eng. of Thurber. Geotechnical laboratory testing was carried out in Thurber's geotechnical laboratory.

Interpretation of the field data and preparation of this report was carried out by Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Mark Farrant, P.Eng.
Geotechnical Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

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

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

UNIFIED SOILS CLASSIFICATION

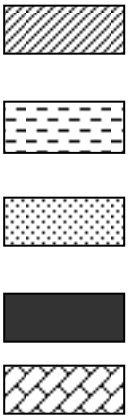
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels,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

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

SYMBOLS



CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

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

TERMS

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

STRENGTH CLASSIFICATION

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

THURBER

Ministry of Transportation
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RECORD OF BOREHOLE No 19-01 1 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 082.2 E 215 685.1 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solider Stem Augers/NW Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.23 - 2019.04.24 LATITUDE 49.694795 LONGITUDE -91.235297 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
421.3	GROUND SURFACE											
0.0	**ASPHALT** (125mm)											
0.1												
421.0	**CONCRETE** (175mm)											
0.3	**SAND**, trace gravel, trace silt Compact Brown Moist (FILL)		2	SS	28					○		9 83 8 (SI+CL)
420.1												
1.2	Sandy **SILT**, trace clay, oxidized Compact to Dense Brown with Black Staining Moist (FILL)		3	SS	45					○		0 32 60 8
419.1												
2.2	**SAND**, trace to some gravel, trace silt, occasional cobbles Compact Brown Wet		4	SS	13					○		
			5	SS	10	▽				○		
			6	SS	14					○		12 84 4 (SI+CL)
	becoming grey		7	SS	22					○		
	loose		8	SS	6					○		
			9	SS	13					○		

ELEVATION SCALE: 421, 420, 419, 418, 417, 416, 415, 414, 413, 412

Continued Next Page

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

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-01 2 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 082.2 E 215 685.1 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solider Stem Augers/NW Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.23 - 2019.04.24 LATITUDE 49.694795 LONGITUDE -91.235297 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										
	SAND, trace gravel, trace silt Compact to Dense Grey Wet						411				
			10	SS	15		410		○		0 97 3 (SI+CL)
			11	SS	35		409		○		
			12	SS	31		408		○		
			13	SS	18		407				
			14	SS	14		406				
							405				
			15	SS	34		404		○		16 81 3 (SI+CL)
402.4	some gravel						403				
18.8	Silty **SAND**, trace gravel Dense Grey Wet						402		○		
401.6										FI	
19.7	**BEDROCK (GRANODIORITE)**, moderately weathered, extremely to		1	RUN						>10	RUN #1 TCR=100%
	Continued Next Page										

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

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

ONTMT4S2 MTO-24621.GPJ 2017TEMPLATE(MTO).GDT 7/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-01 3 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 082.2 E 215 685.1 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solider Stem Augers/NW Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.23 - 2019.04.24 LATITUDE 49.694795 LONGITUDE -91.235297 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										
	very strong, grey with red veins highly fractured zone from 19.7m to 20.1m		2	RUN			401			7	SCR=100% RQD=0% UCS=300MPa (Average)
										1	RUN #2 TCR=100% SCR=100% RQD=0% UCS=268MPa (Average)
	sub vertical fracture (200mm) at 21.0m, (375mm), and (50mm) at 22.0m		3	RUN			400			2	
										2	
										4	
	becoming red granite at 22.1m									1	RUN #3 TCR=100% SCR=100% RQD=44% UCS=216MPa (Average)
	becoming grey granite schist with red veins at 22.3m						399			5	
	sub vertical fracture (500m) at 22.7m		4	RUN						2	RUN #4 TCR=100% SCR=100% RQD=25% UCS=168MPa (Average)
398.0										3	
23.3	END OF BOREHOLE AT 23.3m BOREHOLE BACKFILLED WITH BENTONITE AND CUTTINGS TO 0.3m, CEMENT TO 0.15m AND ASPHALT TO SURFACE.									2	

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

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

ONTMT4S2 MTO-24621.GPJ 2017TEMPLATE(MTO).GDT 7/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-02 1 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 111.4 E 215 693.9 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.25 - 2019.04.25 LATITUDE 49.695059 LONGITUDE -91.235181 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
421.2	GROUND SURFACE										
0.0	**ASPHALT** (125mm)										
0.1 / 420.9	**CONCRETE** (200mm)										
0.3	**BOULDER** and **SAND** (FILL)		1	GS							
419.8											
1.4	Gravelly **SAND**, some silt, occasional cobbles Compact Brown Moist (FILL)		2	SS	14				○		
			3	SS	15						
418.2											
3.0	**BOULDERS** and **COBBLES** Very Dense (FILL)		4	SS	100/ 0.075						
416.7											
4.5	Sandy **SILT**, some gravel, trace clay, organic stains, contains rootlets Loose Dark Brown Wet		5	SS	9	▽			○		13 21 60 6
415.6											
5.6	Silty **SAND** Compact to Loose Grey Wet		6	SS	20				○		
			7	SS	8				○		
412.5											
8.7	**SAND**, trace silt, trace gravel Loose to Compact Grey Wet		8	SS	10				○		1 96 3 (SI+CL)

421 420 419 418 417 416 415 414 413 412

Continued Next Page

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

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

ONTMT4S2 MTO-24621.GPJ 2017TEMPLATE(MTO).GDT 7/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-02 2 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 111.4 E 215 693.9 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.25 - 2019.04.25 LATITUDE 49.695059 LONGITUDE -91.235181 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							20 40 60 80 100	20 40 60		
	SAND, trace silt, trace gravel Loose to Compact Grey Wet						411				
			9	SS	8		410		○		
			10	SS	8		409		○		
			11	SS	11		408		○		9 89 2 (SI+CL)
			12	SS	9		407		○		
			13	SS	7		406				
			14	SS	8		405		○		0 98 2 (SI+CL)
401.7							404			FI	
19.5	**BEDROCK (GRANODIORITE)**, slightly weathered, very to extremely strong, grey		1	RUN			403			2	RUN #1 TCR=100% SCR=100% RQD=54%
							402			0	

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 19-02 3 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 111.4 E 215 693.9 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.25 - 2019.04.25 LATITUDE 49.695059 LONGITUDE -91.235181 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										
	highly broken zone (100mm) at 19.5m						401			0	UCS=244MPa (Average)
										2	
	sub vertical fracture (100mm) at 20.7m									>10	
			2	RUN			400			2	RUN #2 TCR=77% SCR=77% RQD=32% UCS=300MPa (Average)
										4	
										1	
										5	
							399			2	RUN #3 TCR=100% SCR=100% RQD=32% UCS=196MPa (Average)
			3	RUN						3	
398.0										1	
23.2	END OF BOREHOLE AT 23.2m. BOREHOLE BACKFILLED WITH BENTONITE AND CUTTINGS TO 0.15m, AND THEN ASPHALT TO SURFACE.						398				

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

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

ONTMT4S2 MTO-24621.GPJ 2017TEMPLATE(MTO).GDT 7/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-03A

1 OF 3

METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 087.7 E 215 672.1 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solider Stem Augers/NW Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.29 - 2019.05.01 LATITUDE 49.694843 LONGITUDE -91.235477 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
419.1	GROUND SURFACE										
0.0	**TOPSOIL** (75mm)										
0.1											
0.2	Silty **SAND**, trace gravel, contains rootlets Loose Brown Moist		1	SS	4		419				
	SAND, trace to some gravel, trace silt, occasional cobbles Compact to Loose Brown Moist		2	SS	10		418				10 86 4 (SI+CL)
			3	SS	8		417				
	becoming grey		4	SS	4		416				
			5	SS	6		415				
			6	SS	6		414				
			7	SS	4		413				4 91 5 (SI+CL)
			8	SS	10		412				
			9	SS	6		411				
							410				

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-03A 2 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 087.7 E 215 672.1 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solider Stem Augers/NW Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.29 - 2019.05.01 LATITUDE 49.694843 LONGITUDE -91.235477 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
	Continued From Previous Page											
	SAND, trace to some gravel, trace silt Loose to Compact Grey Wet						409					
			10	SS	12		408			○		0 98 2 (SI+CL)
			11	SS	8		407			○		
			12	SS	16		406			○		
			13	SS	15		405			○		0 97 3 (SI+CL)
			14	SS	15		404			○		
401.3							403					
17.8	Due to poor rock recovery, moved 5m south to core rock at location of 19-03B. Bedrock data refers to 19-03B. **BEDROCK (GRANODIORITE)**, slightly weathered, extremely to very strong, grey with red veins highly broken zone (27mm) at 18.3m		1	RUN			402			○	FI 3 6 2	RUN #1 TCR=67% SCR=67% RQD=17% UCS=252MPa (Average)
							401				2	
			2	RUN			400				1 1 >10	RUN #2 TCR=88% SCR=88% RQD=38% UCS=305MPa (Average)
	sub horizontal fractures (50mm) at 19.6 and 20.1m											

Continued Next Page

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

20
15 ⊕ 5 (%) STRAIN AT FAILURE
10

ONTMT4S2 MTO-24621.GPJ 2017TEMPLATE(MTO).GDT 7/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-03A 3 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 087.7 E 215 672.1 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solider Stem Augers/NW Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.29 - 2019.05.01 LATITUDE 49.694843 LONGITUDE -91.235477 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page									
	highly broken zone (250m) at 20.2m						399			>10
										7
										1
			3	RUN			398			1
397.0										2
										2
22.1	END OF BOREHOLE AT 22.1m Well installation 19-03A consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2019.05.01 0.9 418.2 2019.05.02 0.9 418.2									

RUN #3
TCR=100%
SCR=100%
RQD=67%
UCS=224MPa
(Average)

+ ³, × ³: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

ONTMT4S2 MTO-24621.GPJ 2017TEMPLATE(MTO).GDT 7/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-04 1 OF 1 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 135.4 E 215 693.8 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY BH

DATUM Geodetic DATE 2019.05.02 - 2019.05.02 LATITUDE 49.695274 LONGITUDE -91.235189 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
419.3	GROUND SURFACE										
0.0	**TOPSOIL** (100mm)										
0.1	Gravelly **SAND** some organics, trace silt Very Loose Dark Brown Wet		1	SS	1		419		○		
418.6											
0.7	Silty **SAND**, trace gravel, trace clay, trace organic, contains rootlets Loose to Very Loose Dark Brown Wet		2	SS	5		418		○		5 55 35 5
	some topsoil		3	SS	1				○		
417.1							417				
2.2	Silty **SAND**, some to trace gravel, trace organics Loose to Very Loose Brown Wet		4	SS	6				○		
			5	SS	3		416		○		
415.2							415				
4.1	Sandy **GRAVEL**, trace silt, contains boulders Dense Grey Wet		6	SS	37				○		63 30 7 (SI+CL)
413.9							414			FI	
5.4	**BEDROCK (GRANODIORITE)**, moderately weathered, very strong, grey highly broken zone (325mm) at 5.4m and (300mm) at 5.7m sand interbeds (300mm) at 5.7m		1	RUN						>10 3 2 1 1	RUN #1 TCR=75% SCR=75% RQD=38% UCS=209MPa (Average)
	sub vertical fractures (300mm) at 7.2m, and (50mm) at 7.6m		2	RUN			413 412			2 2 1 1	RUN #2 TCR=100% SCR=100% RQD=65% UCS=234MPa (Average)
410.4			3	RUN			411			1 2	RUN #3 TCR=100% SCR=100% RQD=89%
8.9	END OF BOREHOLE AT 8.9m. BOREHOLE OPEN TO 2.1m. BOREHOLE BACKFILLED WITH MIX OF BENTONITE AND CUTTINGS TO SURFACE.										UCS=142MPa (Average)

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

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

ONTMT4S2 MTO-24621.GPJ 2017TEMPLATE(MTO).GDT 7/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-05 1 OF 2 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 067.5 E 215 678.7 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solider Stem Augers/NW Casting COMPILED BY BH

DATUM Geodetic DATE 2019.04.26 - 2019.04.26 LATITUDE 49.694662 LONGITUDE -91.235382 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
421.4	GROUND SURFACE						421				
0.0	**ASPHALT** (100mm)										
0.1	**SAND** and **GRAVEL**, trace silt Dense Brown		1	SS	36						
420.7	Moist										
0.7	(FILL)										
	Sandy **SILT**, trace gravel, trace clay, oxidized Dense to Compact Brown Dry		2	SS	47		420				0 25 66 9
419.5	(FILL)		3	SS	27						
1.9	**SAND**, some to trace gravel, trace silt, occasional cobbles Compact Brown Moist		4	SS	20		419				12 85 3 (SI+CL)
	becoming wet		5	SS	19		418				
	becoming grey		6	SS	10		417				
			7	SS	11		416				
			8	SS	11		415				7 88 5 (SI+CL)
			9	SS	8		414				
	loose						413				
411.6							412				
9.8	END OF BOREHOLE AT 9.8m.										

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-05 2 OF 2 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 067.5 E 215 678.7 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solider Stem Augers/NW Casting COMPILED BY BH

DATUM Geodetic DATE 2019.04.26 - 2019.04.26 LATITUDE 49.694662 LONGITUDE -91.235382 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 + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	w_P w w_L 20 40 60	γ kN/m³	GR SA SI CL
	Continued From Previous Page										
	BOREHOLE OPEN TO 3.4m AND WET AT 3.4m. BOREHOLE BACKFILLED WITH BENTONITE AND CUTTINGS TO 0.2m, CEMENT TO 0.15m, AND ASPHALT TO SURFACE.										

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

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

ONTMT4S2 MTO-24621.GPJ 2017TEMPLATE(MTO).GDT 7/16/19

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-06A 1 OF 1 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 125.4 E 215 699.6 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.26 - 2019.04.26 LATITUDE 49.695185 LONGITUDE -91.235106 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 (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
421.4	GROUND SURFACE										
0.0	**ASPHALT** (90mm)										
0.1	**SAND** and **GRAVEL**, some silt Very Dense to Compact Brown Dry (FILL)		1	SS	62		421				39 50 11 (SI+CL)
			2	SS	28						
419.9							420				
1.4	**BOULDERS**, some sand Very Dense Grey (FILL)		3	SS	100/ 0.125						
			4	SS	100/ 0.050		419				
			5	SS	100/ 0.050						
417.5							418				
3.9	END OF BOREHOLE AT 3.9m UPON REFUSAL ON BOULDERS. BOREHOLE BACKFILLED WITH BENTONITE AND CUTTINGS TO 0.15m AND ASPHALT TO SURFACE.										

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

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

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THURBER

RECORD OF BOREHOLE No 19-06B 1 OF 2 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 126.3 E 215 700.0 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Wash Boring/Dynamic Cone COMPILED BY BH

DATUM Geodetic DATE 2019.05.01 - 2019.05.01 LATITUDE 49.695193 LONGITUDE -91.235100 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
421.4	GROUND SURFACE										
0.0							421				
							420				
							419				
							418				
							417				
416.2							416				
5.2	Dynamic cone penetration testing from 5.2m to 9.4m.						415				
							414				
							413				
411.9							412				
9.4	END OF BOREHOLE AT 9.4m UPON DYNAMIC CONE REFUSAL ON POSSIBLE BEDROCK REFUSAL.										

Continued Next Page

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

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

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RECORD OF BOREHOLE No 19-06B 2 OF 2 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 126.3 E 215 700.0 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Wash Boring/Dynamic Cone COMPILED BY BH

DATUM Geodetic DATE 2019.05.01 - 2019.05.01 LATITUDE 49.695193 LONGITUDE -91.235100 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										
	BOREHOLE BACKFILLED WITH BENTONITE AND CUTTINGS TO 0.15m AND ASPHALT TO SURFACE.										

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

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

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RECORD OF BOREHOLE No 19-07 1 OF 2 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 072.6 E 215 667.0 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solid Stem Augers/NW Casing/Dynamic Cone COMPILED BY BH

DATUM Geodetic DATE 2019.04.26 - 2019.04.26 LATITUDE 49.694705 LONGITUDE -91.235546 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
419.4	GROUND SURFACE						
0.0	**TOPSOIL** (60mm)						
0.1	Silty **SAND**, trace gravel, trace organics, contains rootlets Compact Brown Moist		1	SS	15		
			2	SS	11		
418.0						▽	
1.4	**SAND**, some to trace silt, trace gravel Very Loose to Loose Brown Wet		3	SS	6		
			4	SS	2		
			5	SS	7		
			6	SS	4		
			7	SS	10		
			8	SS	8		
			9	SS	7		
409.7							
9.8	END OF BOREHOLE AT 9.8m.						

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
	0	83	17	(SI+CL)
	0	91	9	(SI+CL)
	0	98	2	(SI+CL)

Continued Next Page

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

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

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RECORD OF BOREHOLE No 19-07 2 OF 2 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 072.6 E 215 667.0 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solid Stem Augers/NW Casing/Dynamic Cone COMPILED BY BH

DATUM Geodetic DATE 2019.04.26 - 2019.04.26 LATITUDE 49.694705 LONGITUDE -91.235546 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										
	BOREHOLE OPEN TO 2.1m AND WET AT 2.1m. BOREHOLE BACKFILLED WITH MIX OF BENTONITE AND CUTTINGS TO SURFACE.						409 408				

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

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

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RECORD OF BOREHOLE No 19-08 1 OF 1 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 153.3 E 215 702.8 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE SPT COMPILED BY BH

DATUM Geodetic DATE 2019.05.02 - 2019.05.02 LATITUDE 49.695436 LONGITUDE -91.235068 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa 20 40 60 80 100 (○ 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
421.5	GROUND SURFACE										
0.0 / 0.1	**TOPSOIL** (50mm)										
	Gravelly **SAND**, trace silt		1	SS	100/ 0.075				○		
421.0	Compact						421				
0.5	Brown Wet										
	END OF BOREHOLE AT 0.5m. SPOON REFUSAL ON POSSIBLE BEDROCK. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.										

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

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

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THURBER

RECORD OF BOREHOLE No 19-09 1 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 083.5 E 215 682.0 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.27 - 2019.04.28 LATITUDE 49.694806 LONGITUDE -91.235339 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
421.3	GROUND SURFACE										
0.0	**ASPHALT** (125mm)										
421.0 0.3	**CONCRETE** (175mm)										
	SAND, some gravel to gravelly Compact Brown Moist (FILL)		2	SS	22				○		
419.4			3	SS	11				○		2 36 54 8
1.8	Sandy **SILT**, trace gravel, trace clay, oxidized Compact Brown										
418.9 2.4	Moist (FILL)		4	SS	18	▽			○		
	Silty **SAND**, trace gravel Compact Brown Wet		5	SS	16				○		2 76 22 (SI+CL)
416.7											
4.6	**SAND**, trace gravel, trace silt Compact Brown Wet		6	SS	11				○		
			7	SS	16				○		
			8	SS	16				○		
			9	SS	26				○		0 98 2 (SI+CL)

421 420 419 418 417 416 415 414 413 412

Continued Next Page

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

15 20 10 5 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 19-09 2 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 083.5 E 215 682.0 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.27 - 2019.04.28 LATITUDE 49.694806 LONGITUDE -91.235339 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 (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
411.1	Continued From Previous Page										
10.2	**BOULDERS** and **SAND** Compact Grey Wet		10	SS	11		411				
409.5							410				
11.7	**SAND**, trace gravel, trace silt Compact Grey Wet		11	SS	15		409				0 98 2 (SI+CL)
			12	SS	15		408				
			13	SS	12		407				
	loose		14	SS	9		406				
			15	SS	15		405				0 97 3 (SI+CL)
401.5							404				
19.7	**BEDROCK (GRANODIORITE)**,						403			FI	RUN #1 TCR=100%
							402			5	

Continued Next Page

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

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

ONTMT4S2 MTO-24621.GPJ 2017TEMPLATE(MTO).GDT 7/16/19

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RECORD OF BOREHOLE No 19-09 3 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 083.5 E 215 682.0 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.27 - 2019.04.28 LATITUDE 49.694806 LONGITUDE -91.235339 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										
	moderately weathered, extremely strong, reddish brown to grey sub vertical fractures (75mm) at 19.7m and (50mm) at 20.3m vertical fractures (75mm) at 19.9m highly broken zone (100mm) at 19.9m		1	RUN			401			0 1 7 0	SCR=100% RQD=53% UCS=263MPa (Average) RUN #2 TCR=63% SCR=63% RQD=50% UCS=255MPa (Average)
	sub vertical fractures (50mm) at 21.3m		2	RUN			400			1 0 0	
	sub vertical fracture (25mm) at 22.1m		3	RUN			399			1 3 0	RUN #3 TCR=100% SCR=100% RQD=89% UCS=284MPa (Average)
398.0										1	
23.2	END OF BOREHOLE AT 23.2m BOREHOLE OPEN TO 2.1m AND WET AT 2.1m. BOREHOLE BACKFILLED WITH BENTONITE AND CUTTINGS TO 0.3m, CEMENT TO 0.15m AND ASPHALT TO SURFACE.										

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

(%) STRAIN AT FAILURE

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Ontario

THURBER

RECORD OF BOREHOLE No 19-10 1 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 109.3 E 215 696.5 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solider Stem Augers/NW Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.30 - 2019.04.30 LATITUDE 49.695040 LONGITUDE -91.235144 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
421.2	GROUND SURFACE										
0.0	**ASPHALT**(125mm)										
420.9 0.1	**CONCRETE** (175mm)										
0.3	**SAND** and **GRAVEL**, some silt, contains cobbles and boulders Compact to Dense Brown Dry to Moist (FILL)		1	SS	24		421		○		38 52 10 (SI+CL)
			2	SS	35		420		○		
			3	SS	13		419				
	becoming wet		4	SS	11	▽	418		○		
417.1											
4.1	**PEAT**, some sand, contains rootlets Loose Dark Brown Wet		5	SS	5		417			110	
416.2									○		
5.0	Silty **SAND**, trace gravel, oxidized Loose Grey Wet						416				
415.6											
5.6	Sandy **SILT**, trace clay, organic staining Compact Grey Wet		6	SS	12		415		○		0 24 70 6
414.1											
7.2	**SAND**, trace gravel, trace silt Compact Grey Wet		7	SS	16		414				
							413		○		
			8	SS	13		412				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

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THURBER

RECORD OF BOREHOLE No 19-10 2 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 109.3 E 215 696.5 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solider Stem Augers/NW Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.30 - 2019.04.30 LATITUDE 49.695040 LONGITUDE -91.235144 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										
411.0											
10.2	**SILT** and **SAND** Compact Grey Wet		9	SS	11		411		○		0 44 51 5
409.5							410				
11.7	**SAND**, trace to some gravel, trace silt Compact Grey Wet		10	SS	11		409		○		
			11	SS	10		408		○		
			12	SS	15		407		○		12 84 4 (SI+CL)
			13	SS	11		406				
			14	SS	11		405				
402.4							404				
18.8	**BEDROCK (GRANODIORITE)**, slightly weathered, very to extremely strong, grey with red veins		1	RUN			403			FI 3 0 2	RUN #1 TCR=100% SCR=100% RQD=81% UCS=221MPa (Average) RUN #2 TCR=73% SCR=73%
	sub vertical fracture (175mm) at 19.8m						402				

Continued Next Page

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

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

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RECORD OF BOREHOLE No 19-10 3 OF 3 METRIC

W.P. 6088-17-01 LOCATION Crystal River Bridge N 5 507 109.3 E 215 696.5 ORIGINATED BY KK

DIST Thunder Bay HWY 599 BOREHOLE TYPE Solider Stem Augers/NW Coring COMPILED BY BH

DATUM Geodetic DATE 2019.04.30 - 2019.04.30 LATITUDE 49.695040 LONGITUDE -91.235144 CHECKED BY MEF

SOIL PROFILE			SAMPLES			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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
			2	RUN			401			4 3	RQD=24% UCS=280MPa (Average)
	sand layer (300mm) at 20.4m									2	
	sub vertical fracture (100mm) at 20.9m and at 21.9m									3	RUN #3 TCR=100% SCR=100% RQD=60% UCS=154MPa (Average)
							400			2	
			3	RUN						3	
398.9										2	
							399			3	
22.3	END OF BOREHOLE AT 22.3m. BOREHOLE OPEN TO 2.1m AND WET AT 2.1m. BOREHOLE BACKFILLED WITH CUTTINGS AND BENTONITE 0.3m, CEMENT TO 0.15m, ASPHALT TO SURFACE.										

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

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

ONTMT4S2 MTO-24621.GPJ 2017TEMPLATE(MTO).GDT 7/16/19

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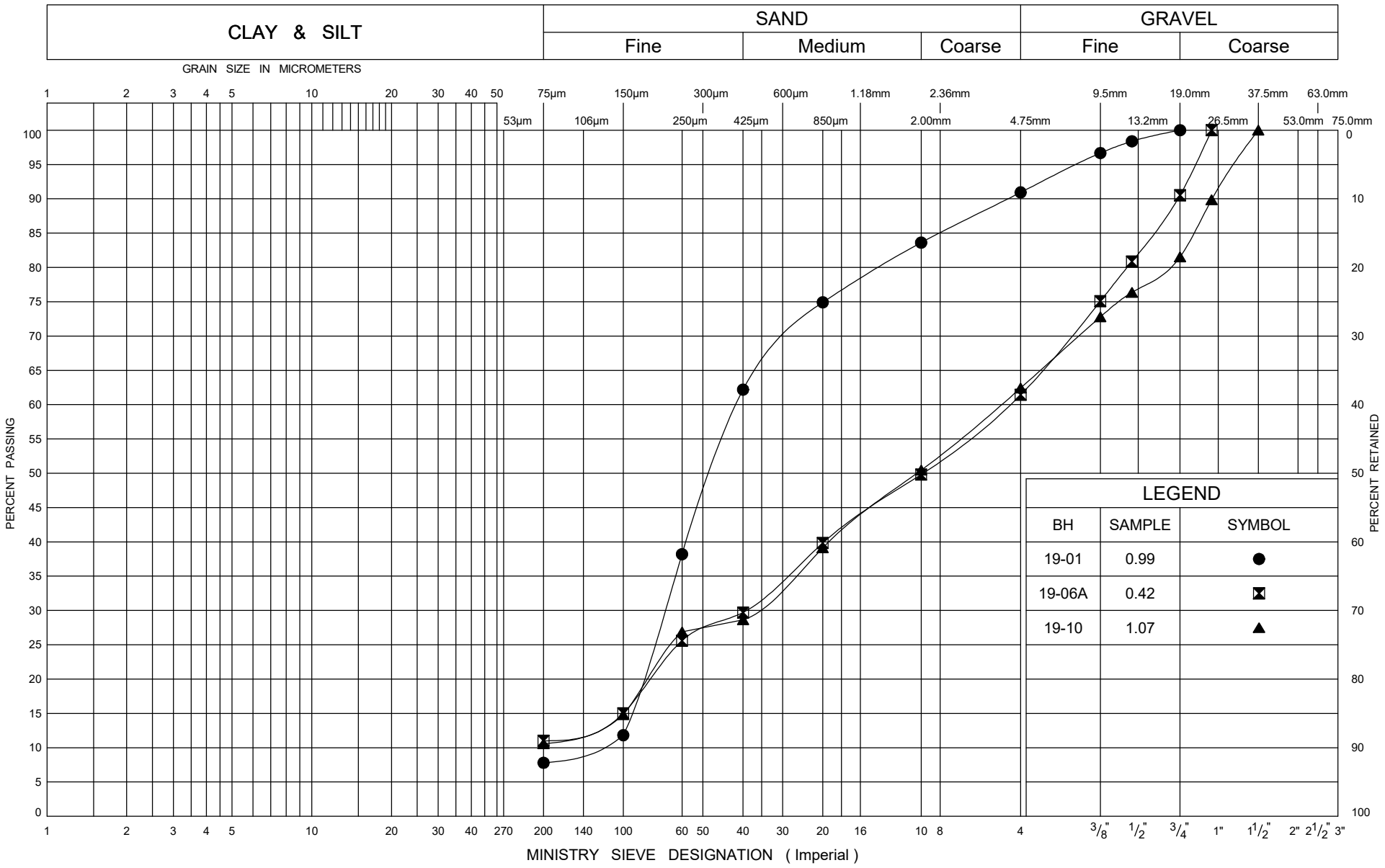
Appendix B

Geotechnical Laboratory Test Results



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GRAIN SIZE DISTRIBUTION

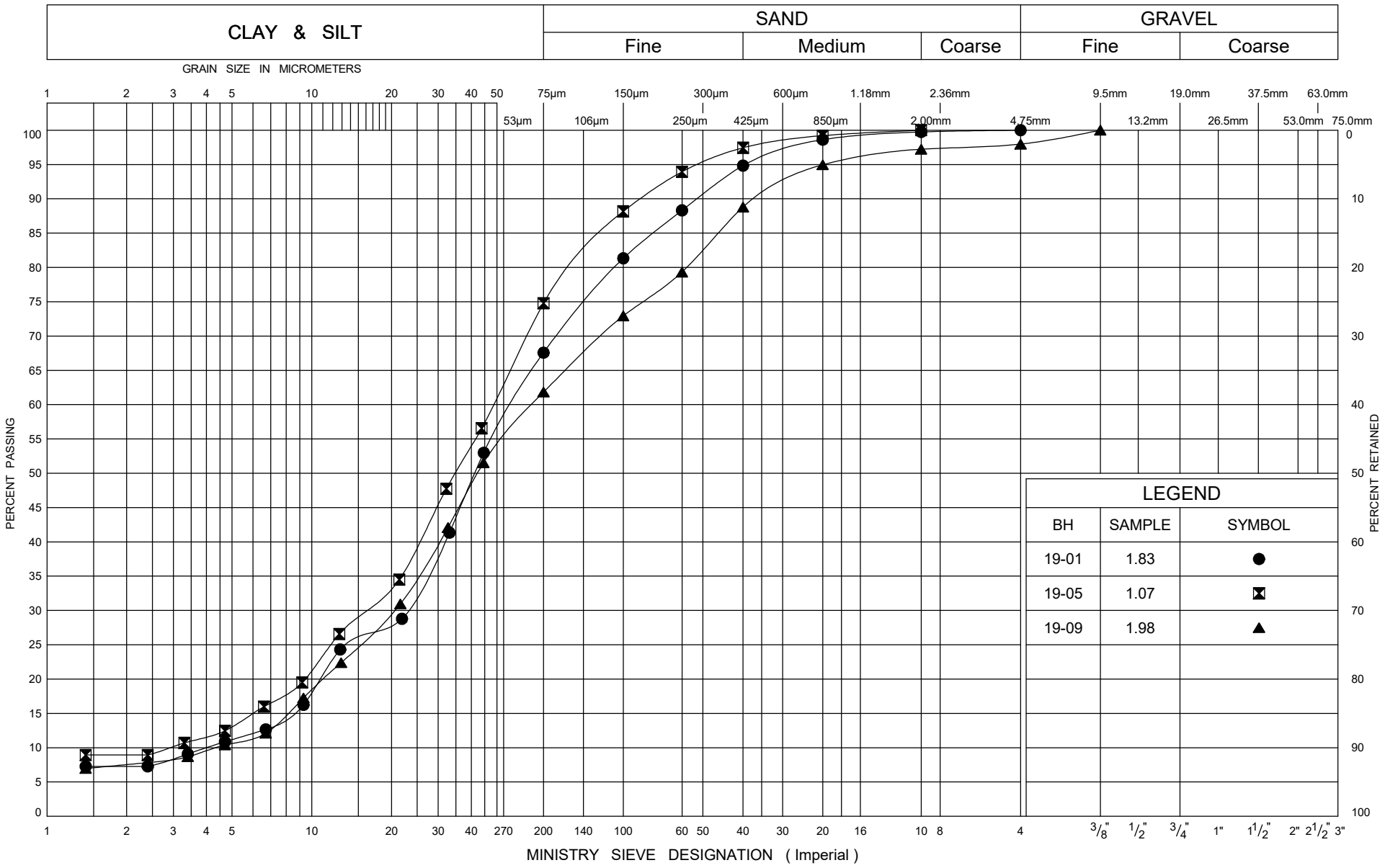
Granular Fill

FIG No B1

W P 6088-17-01

Crystal River Bridge

ONTARIO MOT GRAIN SIZE 2 MTO-24621.GPJ ONTARIO MOT.GDT 7/15/19



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GRAIN SIZE DISTRIBUTION

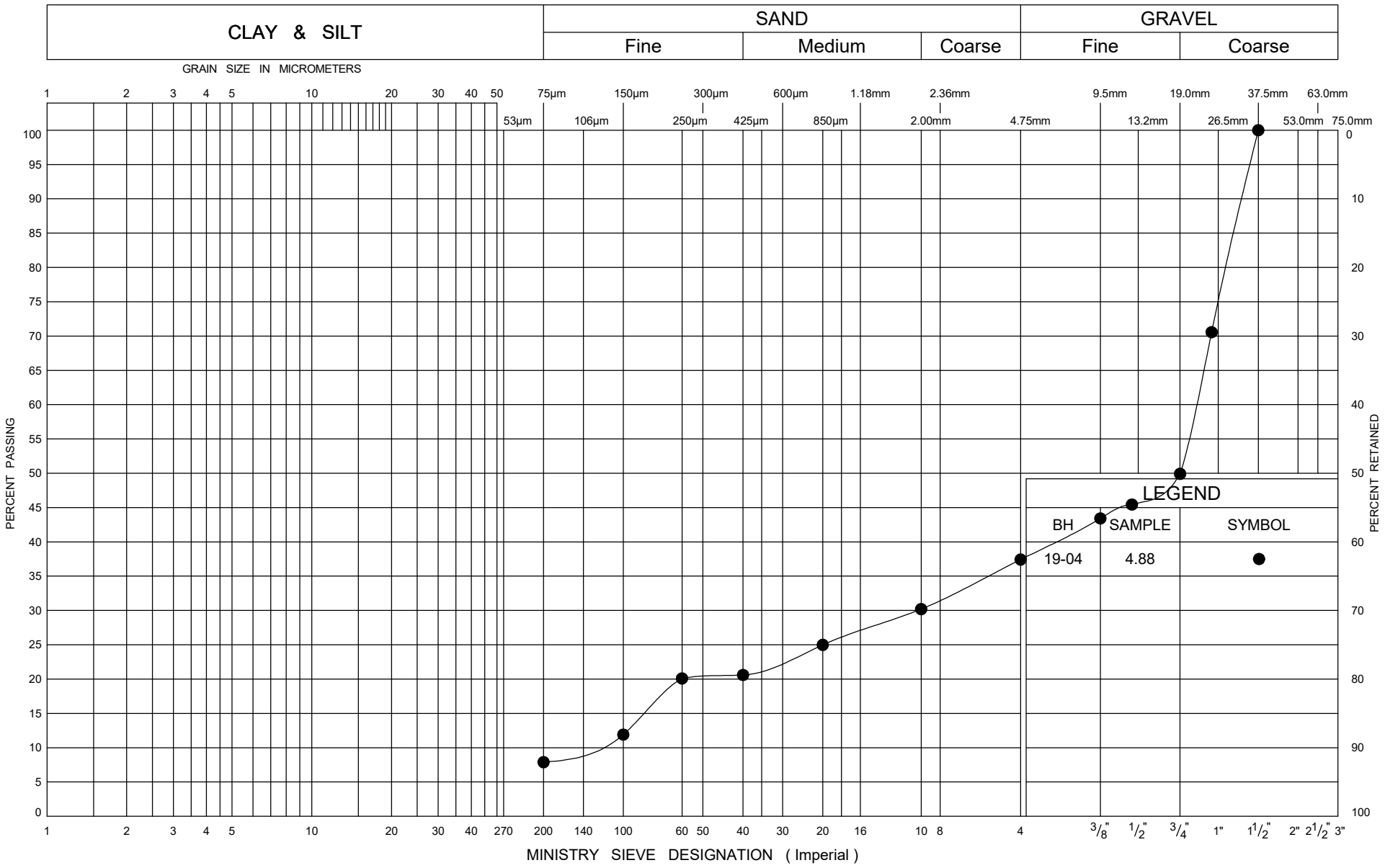
Sandy SILT Fill

FIG No B2

W P 6088-17-01

Crystal River Bridge

ONTARIO MOT GRAIN SIZE 2 MTO-24621.GPJ ONTARIO MOT.GDT 7/15/19



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GRAIN SIZE DISTRIBUTION

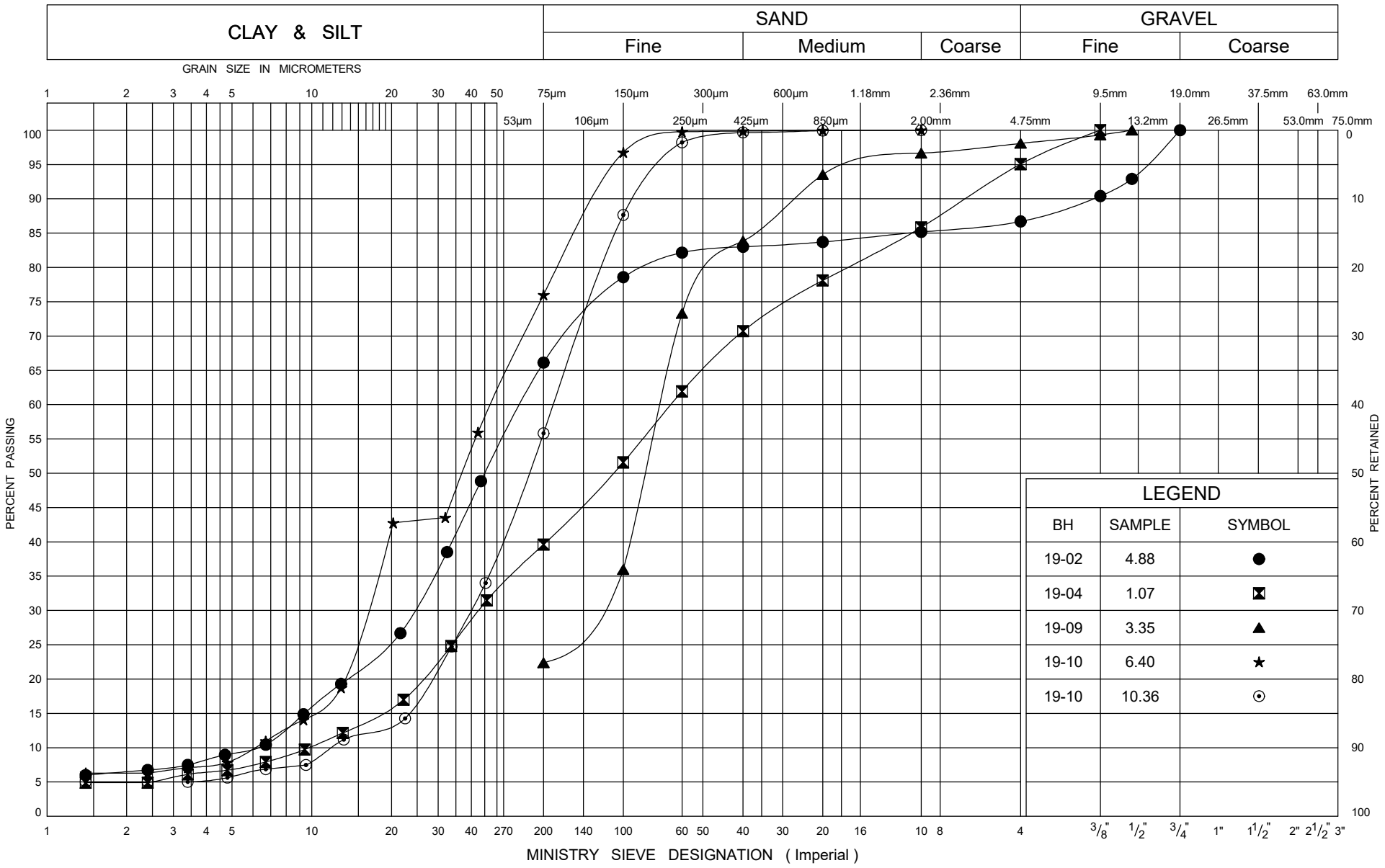
Sandy GRAVEL

FIG No B3

W P 6088-17-01

Crystal River Bridge

ONTARIO MOT GRAIN SIZE 2 MTO-24621.GPJ ONTARIO MOT.GDT 7/15/19



ONTARIO MOT GRAIN SIZE 2 MTO-24621.GPJ ONTARIO MOT.GDT 7/15/19

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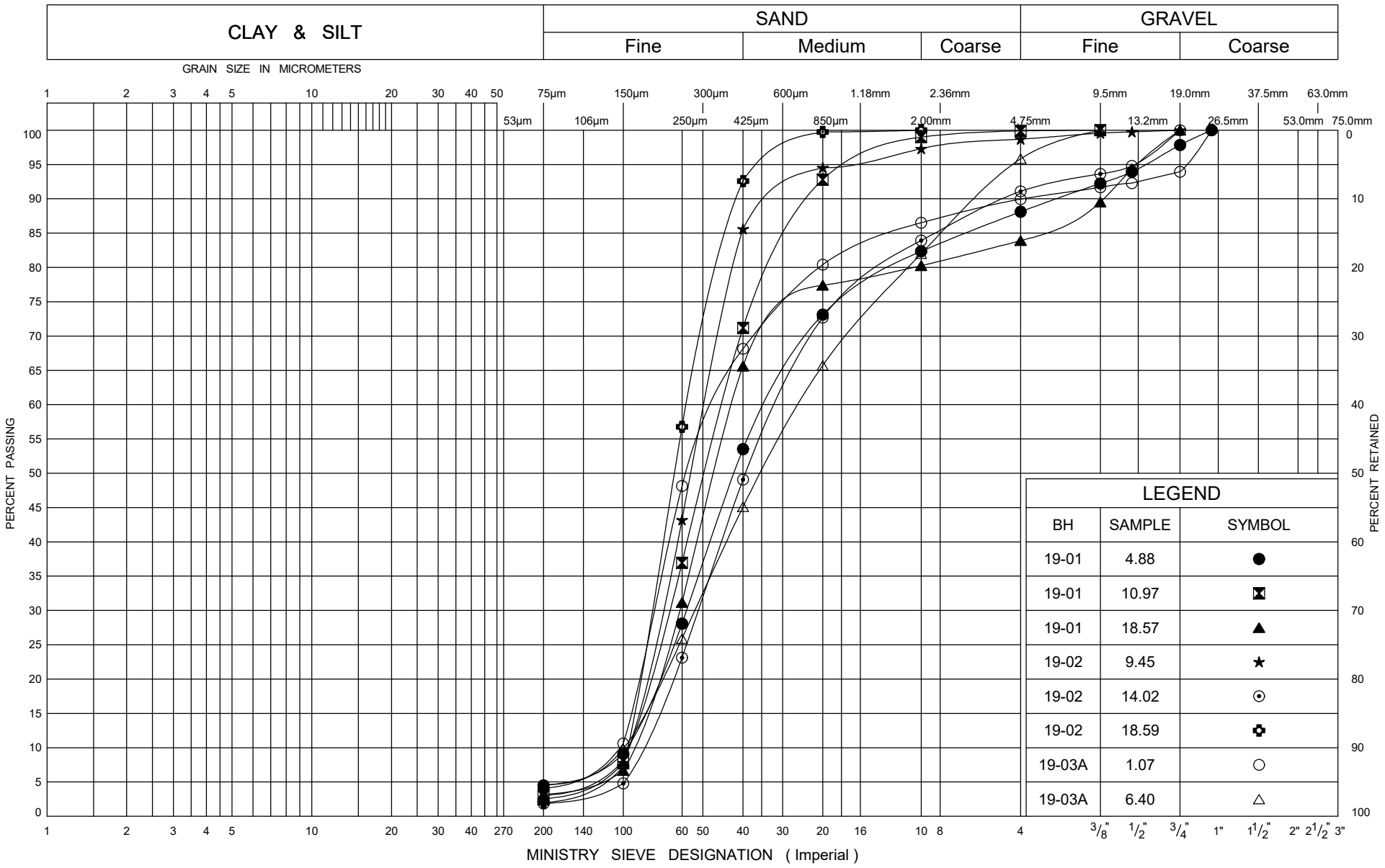
GRAIN SIZE DISTRIBUTION

Sandy SILT to Silty SAND

FIG No B4

W P 6088-17-01

Crystal River Bridge



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

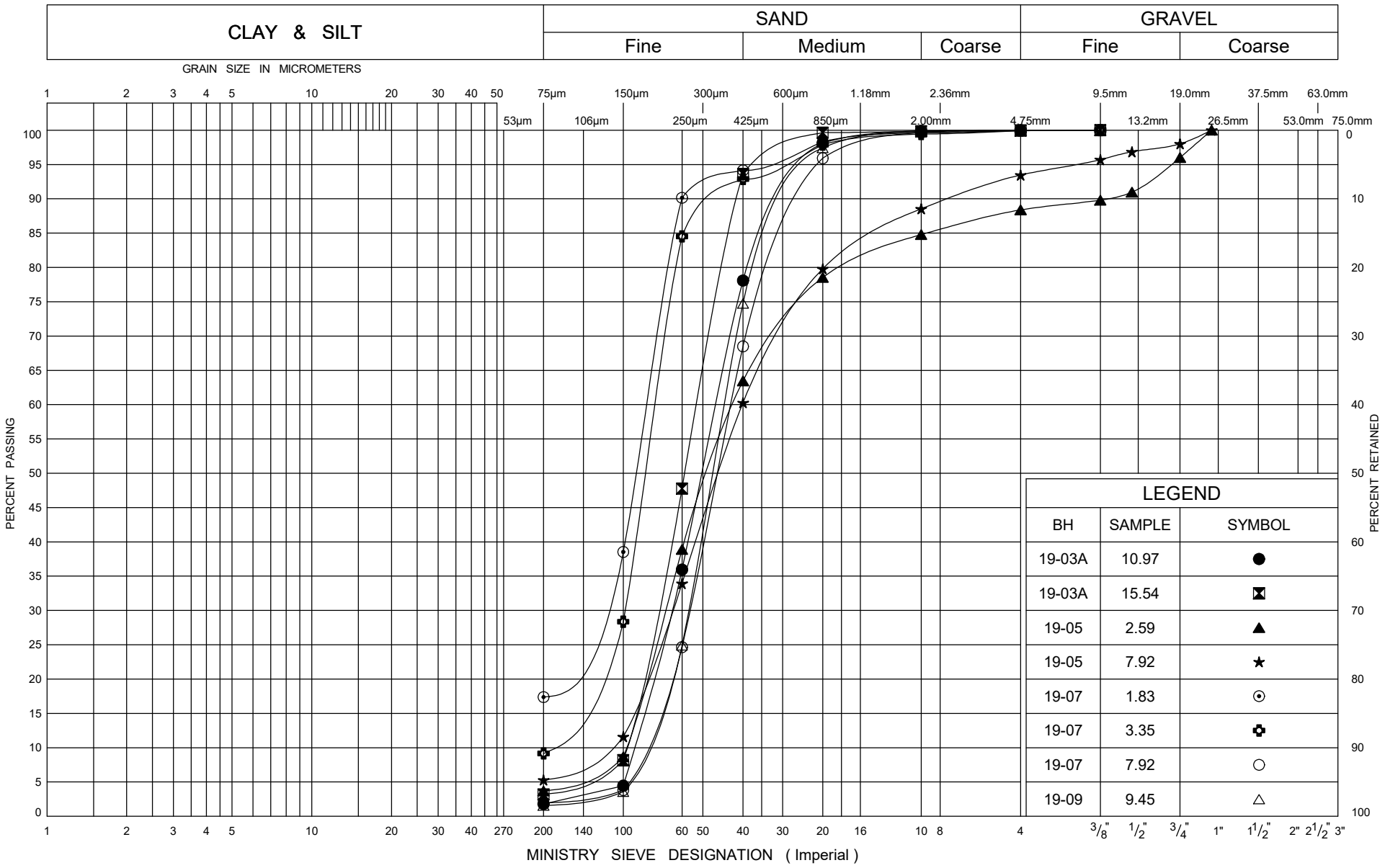
SAND

FIG No B5

W P 6088-17-01

Crystal River Bridge

ONTARIO MOT GRAIN SIZE 2 MTO-24621.GPJ ONTARIO MOT.GDT 7/15/19



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

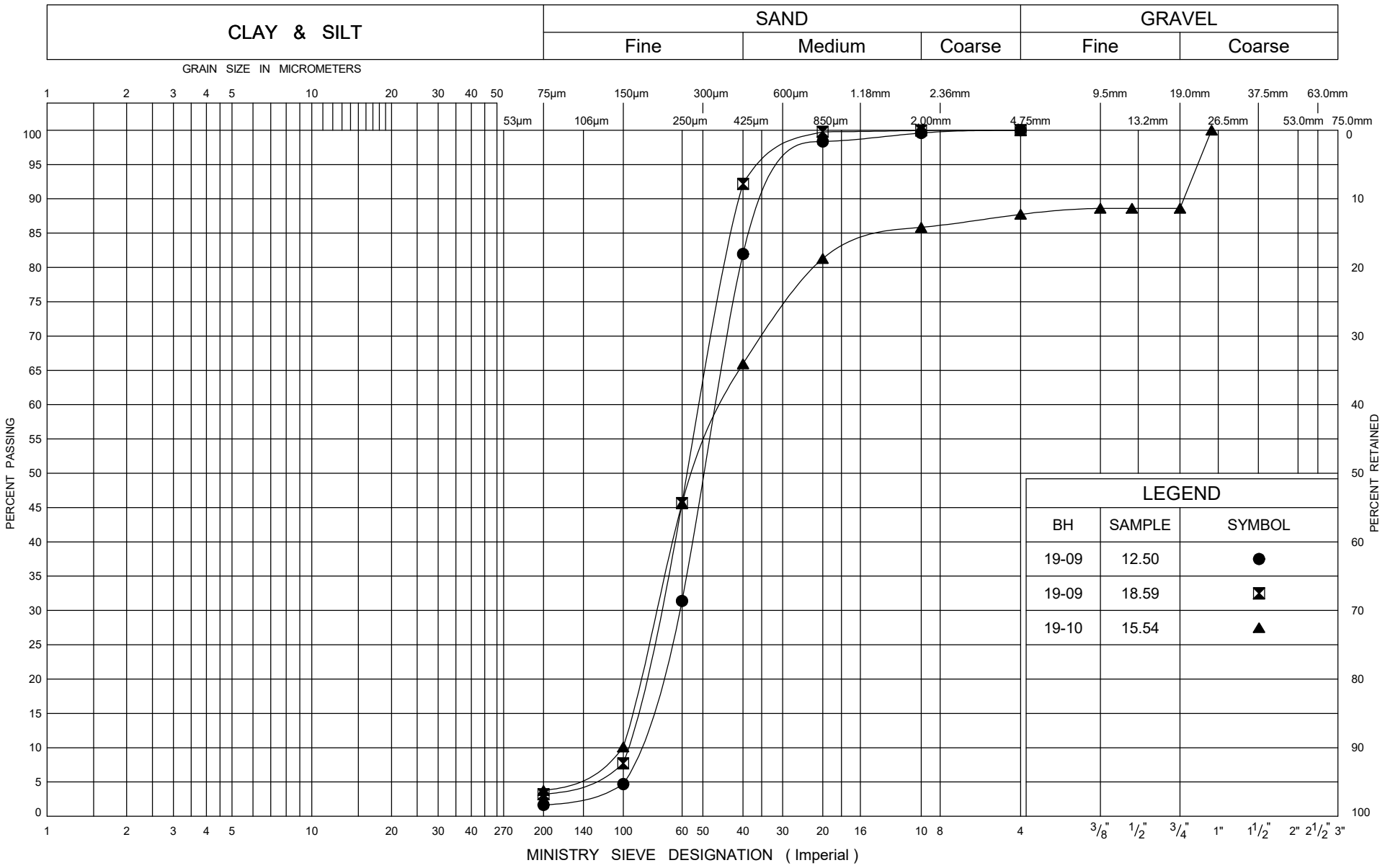
SAND

FIG No B6

W P 6088-17-01

Crystal River Bridge

ONTARIO MOT GRAIN SIZE 2 MTO-24621.GPJ ONTARIO MOT.GDT 7/15/19



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

SAND

FIG No B7

W P 6088-17-01

Crystal River Bridge

ONTARIO MOT GRAIN SIZE 2 MTO-24621.GPJ ONTARIO MOT.GDT 7/15/19

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	24621	**Date Drilled:**	24-Apr-19
Client:	Hatch	**Date Tested:**	08-May-19
Project Name:	Crystal River Bridge	**Tester:**	KK
Core Size:	NQ **BH No :** 19-01	**Reviewed by:**	MEF

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	19.7	D	29.9	47.0	81.4	12.5	299.8	Granodiorite	Extremely Strong
2	2	20.2	D	21.5	47.4	68.5	8.9	212.7	Granodiorite	Very Strong
3	2	20.4	D	32.8	47.5	67.3	13.5	323.8	Granodiorite	Extremely Strong
4	3	20.9	D	22.5	47.3	76.4	9.3	222.4	Granodiorite	Very Strong
5	3	21.3	D	22.3	47.4	53.0	9.2	220.6	Granodiorite	Very Strong
6	3	21.9	D	20.9	47.5	56.7	8.6	205.6	Granodiorite	Very Strong
7	4	22.2	D	14.9	47.5	83.8	6.1	146.7	Granodiorite	Very Strong
8	4	22.5	D	15.7	47.3	70.1	6.5	155.8	Granodiorite	Very Strong
9	4	23.2	D	20.4	47.4	62.8	8.4	201.6	Granodiorite	Very Strong
10										
11										
12										
13										
14						**RUN#1 AVG=**		**299.8**		Extremely Strong
15						**RUN#2 AVG=**		**268.3**		Extremely Strong
16						**RUN#3 AVG=**		**216.2**		Very Strong
17						**RUN#4 AVG=**		**168.1**		Very Strong
18										
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* 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.

* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	24621	**Date Drilled:**	25-Apr-19
Client:	Hatch	**Date Tested:**	21-May-19
Project Name:	Crystal River Bridge	**Tester:**	BS
Core Size:	NQ **BH No :** 19-02	**Reviewed by:**	MEF

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	19.6	D	27.0	47.4	73.4	11.1	266.3	Granodiorite	Extremely Strong
2	1	20.0	D	23.4	47.5	76.4	9.6	231.0	Granodiorite	Very Strong
3	1	20.3	D	21.9	47.5	78.8	9.0	216.5	Granodiorite	Very Strong
4	1	20.6	D	26.7	47.4	76.4	11.0	263.9	Granodiorite	Extremely Strong
5	2	21.2	D	33.6	47.2	80.9	14.0	335.0	Granodiorite	Extremely Strong
6	2	21.5	D	30.0	47.5	88.2	12.3	295.9	Granodiorite	Extremely Strong
7	2	21.9	D	27.1	47.5	76.9	11.1	267.6	Granodiorite	Extremely Strong
8	3	22.5	D	20.1	47.3	81.5	8.3	199.5	Granodiorite	Very Strong
9	3	22.8	D	13.5	47.4	79.1	5.6	133.2	Granodiorite	Very Strong
10	3	23.0	D	25.9	47.5	81.6	10.6	255.3	Granodiorite	Extremely Strong
11										
12										
13										
14						**RUN#1 AVG=**		**244.4**		Very Strong
15						**RUN#2 AVG=**		**299.5**		Extremely Strong
16						**RUN#3 AVG=**		**196.0**		Very Strong
17										
18										
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Last Modified: September 14, 2016

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	24621	**Date Drilled:**	01-May-19
Client:	Hatch	**Date Tested:**	21-May-19
Project Name:	Crystal River Bridge	**Tester:**	BS
Core Size:	NQ **BH No :** 19-03B	**Reviewed by:**	MEF

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	18.3	D	25.3	47.3	78.7	10.5	251.5	Granodiorite	Extremely Strong
2	2	19.5	D	30.0	47.4	80.4	12.3	296.3	Granodiorite	Extremely Strong
3	2	19.8	D	32.3	47.4	47.5	81.6	318.8	Granodiorite	Extremely Strong
4	2	20.2	D	30.5	47.5	77.0	12.5	300.7	Granodiorite	Extremely Strong
5	3	21.0	D	28.7	47.7	79.2	11.7	281.0	Granodiorite	Extremely Strong
6	3	21.4	D	18.5	47.4	79.5	7.6	182.9	Granodiorite	Very Strong
7	3	21.6	D	13.3	47.4	75.9	5.5	131.1	Granodiorite	Very Strong
8	3	22.0	D	30.3	47.5	79.9	12.5	299.3	Granodiorite	Extremely Strong
9										
10										
11										
12										
13										
14						**RUN#1 AVG=**		**251.5**		Extremely Strong
15						**RUN#2 AVG=**		**305.3**		Extremely Strong
16						**RUN#3 AVG=**		**223.5**		Very Strong
17										
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Last Modified: September 14, 2016

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	24621	**Date Drilled:**	02-May-19
Client:	Hatch	**Date Tested:**	21-May-19
Project Name:	Crystal River Bridge	**Tester:**	BS
Core Size:	NQ **BH No :** 19-04	**Reviewed by:**	MEF

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	5.6	D	20.4	47.4	79.3	8.4	201.9	Granodiorite	Very Strong
2	1	6.0	D	26.4	47.4	85.8	10.9	260.9	Granodiorite	Extremely Strong
3	1	6.3	D	26.8	47.3	80.2	81.6	266.2	Granodiorite	Extremely Strong
4	1	6.5	D	10.7	47.2	73.7	4.4	106.2	Granodiorite	Very Strong
5	2	6.9	D	17.5	47.3	68.7	7.2	173.7	Granodiorite	Very Strong
6	2	7.2	D	29.4	47.3	76.5	12.1	291.6	Granodiorite	Extremely Strong
7	2	7.6	D	19.6	47.3	67.4	8.1	194.3	Granodiorite	Very Strong
8	2	7.9	D	30.7	47.3	67.2	12.7	304.2	Granodiorite	Extremely Strong
9	2	8.2	D	20.8	47.4	76.9	8.6	206.0	Granodiorite	Very Strong
10	3	8.5	D	17.2	47.3	80.3	7.1	170.4	Granodiorite	Very Strong
11	3	8.7	D	11.4	47.3	87.8	4.7	112.6	Granodiorite	Very Strong
12										
13										
14						**RUN#1 AVG=**		**208.8**		Very Strong
15						**RUN#2 AVG=**		**234.0**		Very Strong
16						**RUN#3 AVG=**		**141.5**		Very Strong
17										
18										
19										
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Last Modified: September 14, 2016

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	24621	**Date Drilled:**	28-Apr-19
Client:	Hatch	**Date Tested:**	17-May-19
Project Name:	Crystal River Bridge	**Tester:**	BS
Core Size:	NQ **BH No :** 19-09	**Reviewed by:**	MEF

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	19.8	D	24.7	47.6	64.9	10.1	242.5	Granodiorite	Very Strong
2	1	20.1	D	29.7	47.5	74.6	12.2	292.9	Granodiorite	Extremely Strong
3	1	20.5	D	25.7	47.5	73.3	81.6	253.4	Granodiorite	Extremely Strong
4	2	20.9	D	29.2	47.5	75.7	12.0	288.0	Granodiorite	Extremely Strong
5	2	21.2	D	26.3	47.4	76.9	10.8	259.5	Granodiorite	Extremely Strong
6	2	21.5	D	22.2	47.5	85.7	9.1	218.4	Granodiorite	Very Strong
7	3	22.2	D	32.0	47.5	71.7	13.2	316.1	Granodiorite	Extremely Strong
8	3	22.5	D	26.2	47.5	67.6	10.8	258.1	Granodiorite	Extremely Strong
9	3	22.8	D	26.0	47.4	74.9	10.7	257.0	Granodiorite	Extremely Strong
10	3	23.1	D	30.8	47.5	76.1	12.7	303.8	Granodiorite	Extremely Strong
11										
12										
13										
14						**RUN#1 AVG=**		**263.0**		Extremely Strong
15						**RUN#2 AVG=**		**255.3**		Extremely Strong
16						**RUN#3 AVG=**		**283.7**		Extremely Strong
17										
18										
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Last Modified: September 14, 2016

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	24621	**Date Drilled:**	29-Apr-19
Client:	Hatch	**Date Tested:**	13-May-19
Project Name:	Crystal River Bridge	**Tester:**	KK
Core Size:	NQ **BH No :** 19-10	**Reviewed by:**	MEF

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	18.9	D	31.0	47.3	64.5	12.8	307.3	Granodiorite	Extremely Strong
2	1	19.1	D	13.2	47.4	51.7	5.5	130.8	Granodiorite	Very Strong
3	1	19.5	D	22.8	47.5	73.3	81.6	224.5	Granodiorite	Very Strong
4	2	20.1	D	31.1	46.6	74.6	13.2	316.0	Granodiorite	Extremely Strong
5	2	20.5	D	24.7	47.5	58.7	10.2	243.7	Granodiorite	Very Strong
6	3	20.8	D	29.0	47.4	53.3	12.0	287.0	Granodiorite	Extremely Strong
7	3	21.2	D	8.9	47.5	50.5	3.7	87.6	Granodiorite	Strong
8	3	21.6	D	12.3	47.4	55.8	5.1	121.8	Granodiorite	Very Strong
9	3	22.0	D	12.2	47.4	58.6	5.0	120.2	Granodiorite	Very Strong
10										
11										
12										
13										
14						**RUN#1 AVG=**		**220.9**		Very Strong
15						**RUN#2 AVG=**		**279.9**		Extremely Strong
16						**RUN#3 AVG=**		**154.2**		Very Strong
17										
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Last Modified: September 14, 2016

Photo B1: Borehole 19-01 core photo. Run #1 to 4.

Photo B2: Borehole 19-02 core photo. Run #1 to 3.

Photo B3: Borehole 19-03B core photo. Run #1 to 3.

Photo B4: Borehole 19-04 core photo. Run #1 to 3.

Photo B5: Borehole 19-09 core photo. Run #1 to 3.

Photo B6: Borehole 19-10 core photo. Run #1 to 3.

FINAL REPORT

CA15847-MAY19 R1

24621

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS

Client	Thurber Engineering Ltd.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7. Canada
Contact	Mark Farrant
Telephone	905-829-8666 x 228
Facsimile	
Email	mfarrant@thurber.ca
Project	24621
Order Number	
Samples	Soil (2)

LABORATORY DETAILS

Project Specialist	Brad Moore Hon. B.Sc
Laboratory	SGS Canada Inc.
Address	185 Concession St., Lakefield ON, K0L 2H0
Telephone	705-652-2143
Facsimile	705-652-6365
Email	brad.moore@sgs.com
SGS Reference	CA15847-MAY19
Received	05/27/2019
Approved	06/03/2019
Report Number	CA15847-MAY19 R1
Date Reported	06/03/2019

COMMENTS

Temperature of Sample upon Receipt: 9 degrees C
Cooling Agent Present:Yes
Custody Seal Present:Yes

Chain of Custody Number:003201

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SIGNATORIES

Brad Moore Hon. B.Sc

TABLE OF CONTENTS

Client: Thurber Engineering Ltd.
Project: 24621
Project Manager: Mark Farrant
Samplers: Mark Farrant

PACKAGE: **- Corrosivity Index** (SOIL)

Sample Number	5	6
Sample Name	BH19-01, SS#5, 10'-12'	BH19-10, SS#6, 20'-22'
Sample Matrix	Soil	Soil
Sample Date	23/04/2019	30/04/2019

Parameter	Units	RL		Result	Result
Corrosivity Index					
Corrosivity Index	none	1		1	4
Soil Redox Potential	mV	-		395	355
Sulphide	%	0.02		< 0.02	< 0.02
pH	pH Units	0.05		7.70	8.67
Resistivity (calculated)	ohms.cm	-9999		9100	9700

PACKAGE: **- General Chemistry** (SOIL)

Sample Number	5	6
Sample Name	BH19-01, SS#5, 10'-12'	BH19-10, SS#6, 20'-22'
Sample Matrix	Soil	Soil
Sample Date	23/04/2019	30/04/2019

Parameter	Units	RL		Result	Result
General Chemistry					
Conductivity	uS/cm	2		110	103

PACKAGE: **- Metals and Inorganics** (SOIL)

Sample Number	5	6
Sample Name	BH19-01, SS#5, 10'-12'	BH19-10, SS#6, 20'-22'
Sample Matrix	Soil	Soil
Sample Date	23/04/2019	30/04/2019

Parameter	Units	RL		Result	Result
Metals and Inorganics					
Moisture Content	%	0.1		15.2	15.5

Client: Thurber Engineering Ltd.
Project: 24621
Project Manager: Mark Farrant
Samplers: Mark Farrant

PACKAGE: **- Metals and Inorganics** (SOIL)

			Sample Number	5	6	
			Sample Name	BH19-01, SS#5, 10'-12'	BH19-10, SS#6, 20'-22'	
			Sample Matrix	Soil	Soil	
			Sample Date	23/04/2019	30/04/2019	
Parameter	**Units**	**RL**		**Result**	**Result**	
Metals and Inorganics (continued)						
Sulphate	µg/g	0.4		6.2	1.9	

PACKAGE: **- Other (ORP)** (SOIL)

			Sample Number	5	6	
			Sample Name	BH19-01, SS#5, 10'-12'	BH19-10, SS#6, 20'-22'	
			Sample Matrix	Soil	Soil	
			Sample Date	23/04/2019	30/04/2019	
Parameter	**Units**	**RL**		**Result**	**Result**	
Other (ORP)						
Chloride	µg/g	0.4		39	8.3	

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0559-MAY19	µg/g	0.4	<0.4	0	20	95	80	120	102	75	125
Sulphate	DIO0559-MAY19	µg/g	0.4	<0.4	ND	20	97	80	120	100	75	125

Carbon/Sulphur

Method: ASTM E1915-07A | Internal ref.: ME-CA-[ENV]ARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	ECS0041-MAY19	%	0.02	<0.02	14	20	114	80	120			

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0529-MAY19	uS/cm	2	< 0.002	0	10	100	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0529-MAY19	pH Units	0.05	NA	0		100			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS	Insufficient sample for analysis.
RL	Reporting Limit.
↑	Reporting limit raised.
↓	Reporting limit lowered.
NA	The sample was not analysed for this analyte
ND	Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act" published by the Ministry and dated March 9, 2004 as amended.

-- End of Analytical Report --

FINAL REPORT

CA13192-MAY19 R

24621

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

CA13192-MAY19 R

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Brad Moore Hon. B.Sc
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7. Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Mark Farrant	Telephone	705-652-2143
Telephone	905-829-8666 x 228	Facsimile	705-652-6365
Facsimile		Email	brad.moore@sgs.com
Email	mfarrant@thurber.ca	SGS Reference	CA13192-MAY19
Project	24621	Received	05/07/2019
Order Number		Approved	05/13/2019
Samples	Water (1)	Report Number	CA13192-MAY19 R
		Date Reported	05/13/2019

COMMENTS

Temperature of Sample upon Receipt: 15 degrees C
Cooling Agent Present:Yes
Custody Seal Present:No

SIGNATORIES

Brad Moore Hon. B.Sc

TABLE OF CONTENTS

FINAL REPORT

CA13192-MAY19 R

Client: Thurber Engineering Ltd.
Project: 24621
Project Manager: Mark Farrant
Samplers: Kevin Kweon

PACKAGE: **- General Chemistry** (WATER)

Sample Number 6
Sample Name CRB East Side
Sample Matrix Water
Sample Date 02/05/2019

Parameter	Units	RL		Result
General Chemistry				
Conductivity	uS/cm	2		47
Redox Potential	mV	-		164
Sulphide	µg/L	6		< 6

PACKAGE: **- Metals and Inorganics** (WATER)

Sample Number 6
Sample Name CRB East Side
Sample Matrix Water
Sample Date 02/05/2019

Parameter	Units	RL		Result
Metals and Inorganics				
Chloride	mg/L	0.04		0.53
Sulphate	mg/L	0.04		0.82

PACKAGE: **- Other (ORP)** (WATER)

Sample Number 6
Sample Name CRB East Side
Sample Matrix Water
Sample Date 02/05/2019

Parameter	Units	RL		Result
Other (ORP)				
pH	no unit	0.05		7.27

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0178-MAY19	mg/L	0.04	<0.04	1	20	91	80	120	105	75	125
Sulphate	DIO0178-MAY19	mg/L	0.04	<0.04	2	20	96	80	120	96	75	125
Chloride	DIO0197-MAY19	mg/L	0.04	<0.04	1	20	94	80	120	93	75	125
Sulphate	DIO0197-MAY19	mg/L	0.04	<0.04	3	20	99	80	120	93	75	125

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0144-MAY19	uS/cm	2	< 2	0	10	101	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 I Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
pH	EWL0144-MAY19	no unit	0.05	NA	0		101			NA		

Redox Potential

Method: SM 2580 I

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Redox Potential	EWL0139-MAY19	mV	no	NA	4	20	103	80	120	NA		

Sulphide by SFA

Method: SM 4500 I Internal ref.: ME-CA-IENVISFA-LAK-AN-008

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High	Spike Recovery (%)	Recovery Limits (%) Low	Recovery Limits (%) High
Sulphide	SKA0066-MAY19	ug/L	6	<0.006	NV	20	99	80	120	NA	75	125

QC SUMMARY

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.
RL Reporting Limit.
↑ Reporting limit raised.
↓ Reporting limit lowered.
NA The sample was not analysed for this analyte
ND Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

-- End of Analytical Report --

THURBER

Appendix C

Site Photographs

Photo C1: South approach to existing bridge looking north along Highway 599.

(Date taken: May 2, 2019)

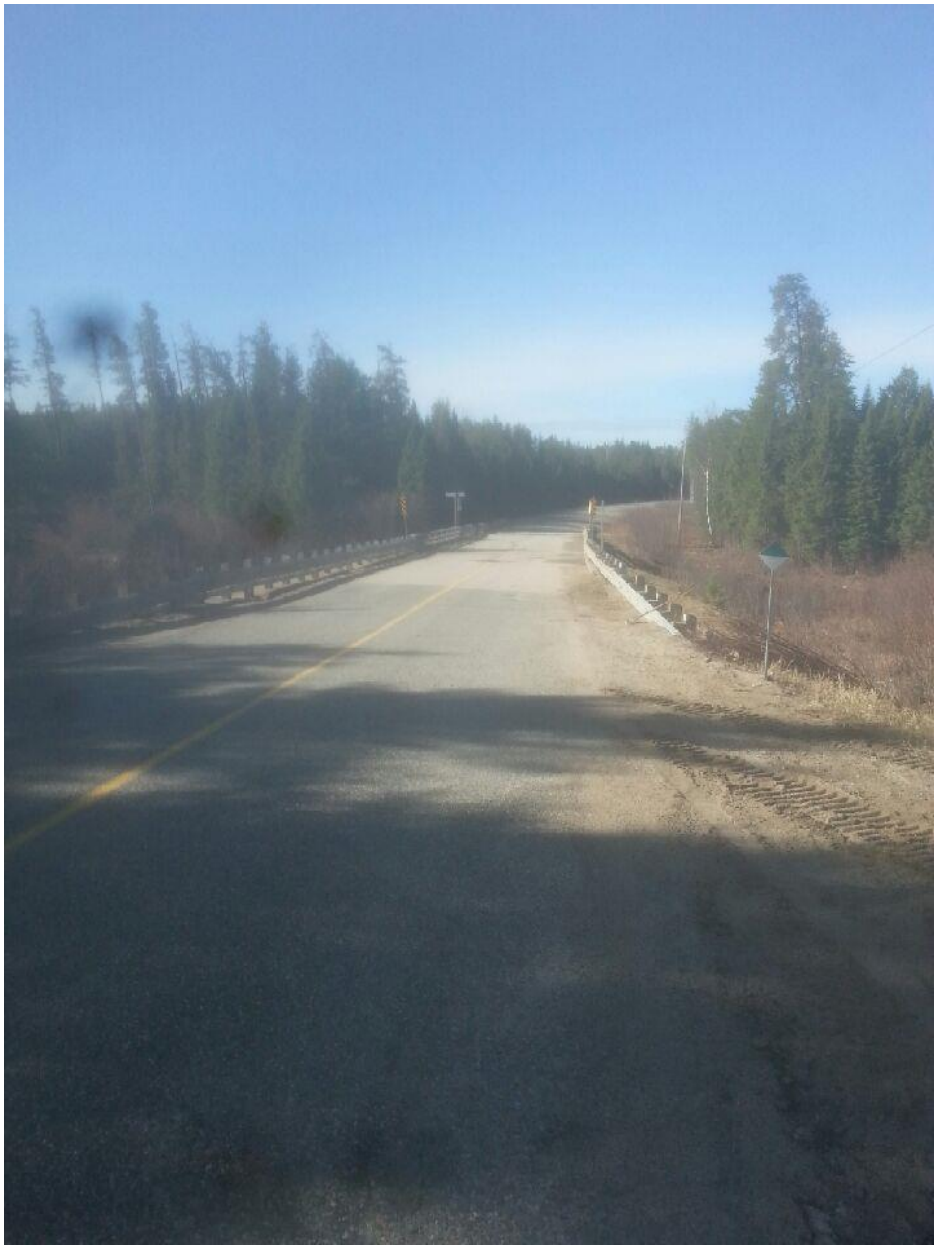


Photo C2: North approach to existing bridge looking south along Highway 599.

(Date taken: May 2, 2019)

THURBER

Photo C3: Looking northeast at west side of existing bridge from southwest corner.

(Date taken: May 1, 2019)

THURBER

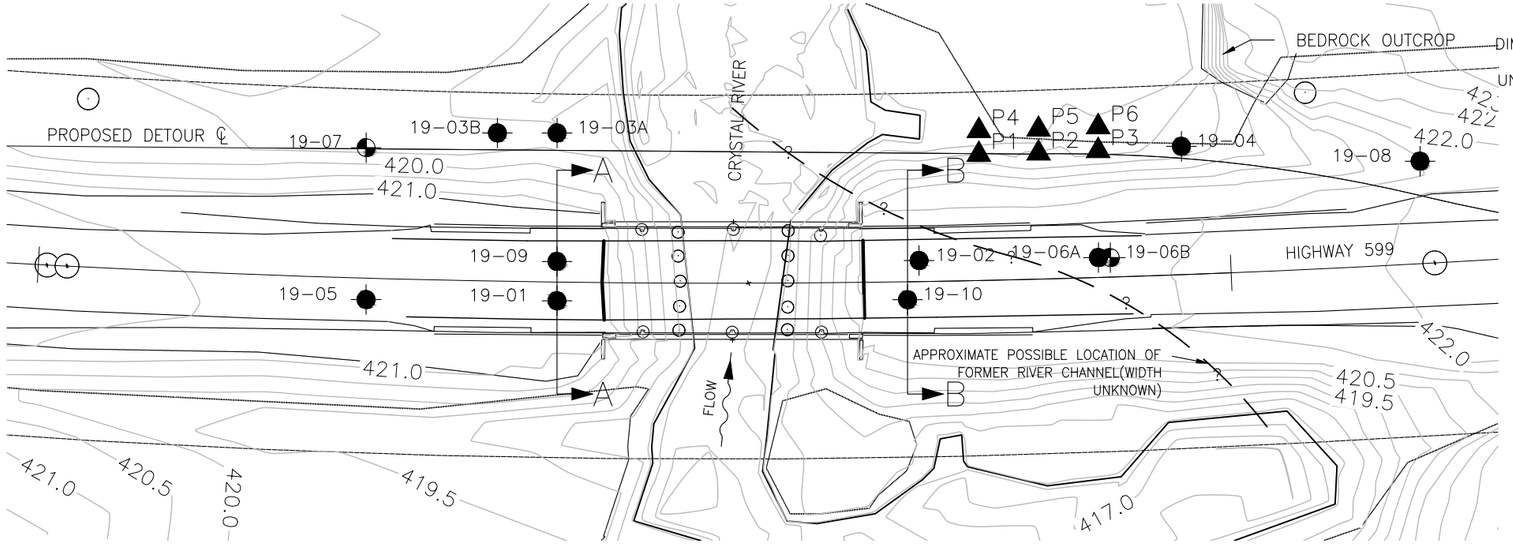
Photo C4: Looking southeast at west side of existing bridge from northwest corner.

(Date taken: May 1, 2019)

THURBER

Appendix D

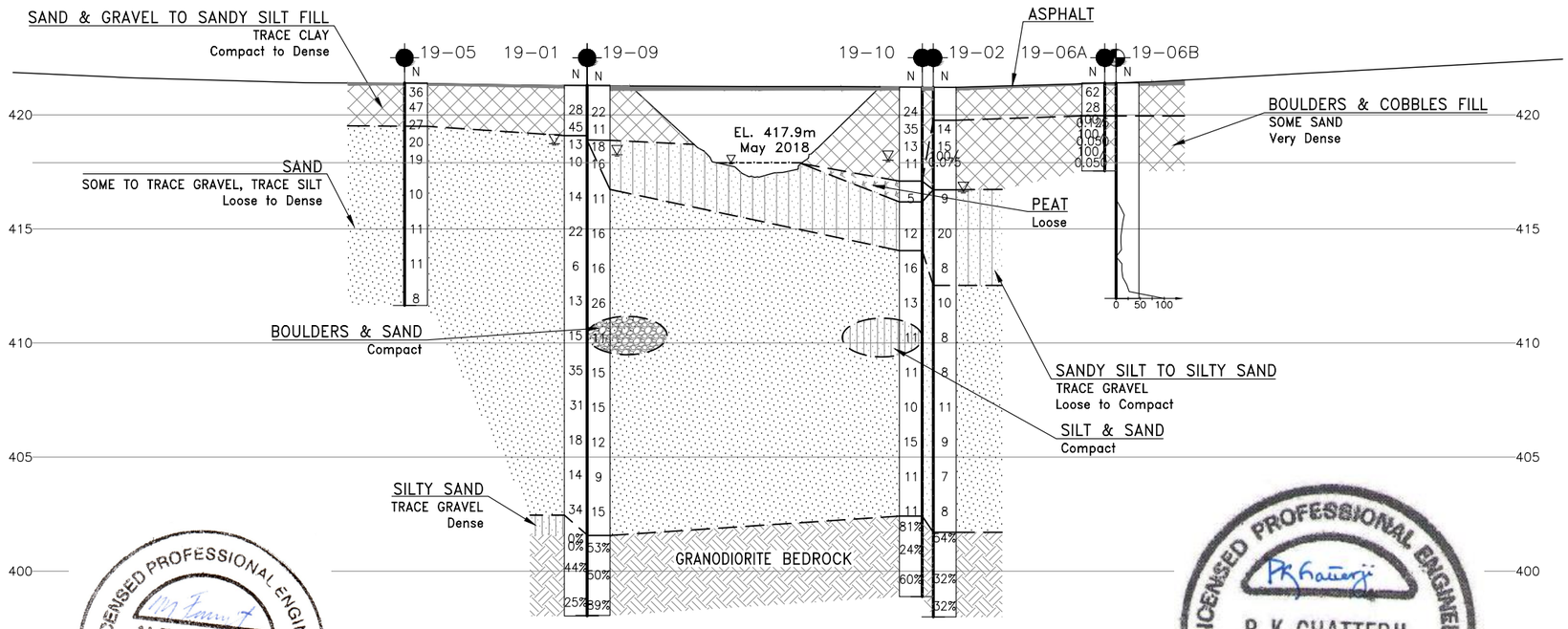
Borehole Locations and Soil Strata Drawings



PLAN

10 0 10 20m

SCALE 1:500



PROFILE ALONG ℄ HIGHWAY 599

10 0 10 20m H 1:500

2 0 2 4m V 1:250

LICENSED PROFESSIONAL ENGINEER
M.E. FARRANT
100053767
May 14/20
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 14/2020
PROVINCE OF ONTARIO

CONT No
WP No 6088-17-01

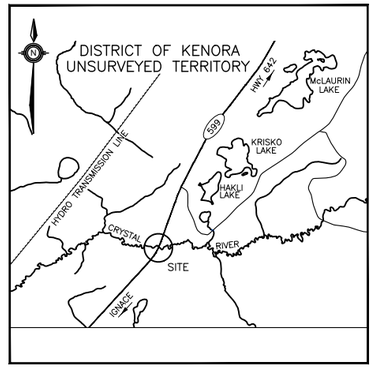
SHEET

HIGHWAY 599
CRYSTAL RIVER
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

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

HATCH

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
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
19-01	421.3	5 507 082.2	215 685.1
19-02	421.2	5 507 111.4	215 693.9
19-03A	419.2	5 507 087.7	215 672.1
19-03B	419.2	5 507 083.2	215 670.2
19-04	419.3	5 507 135.4	215 693.8
19-05	421.4	5 507 067.5	215 678.7
19-06A	421.4	5 507 125.4	215 699.6
19-06B	421.4	5 507 126.3	215 700.0
19-07	419.4	5 507 072.6	215 667.0
19-08	421.5	5 507 153.3	215 702.8
19-09	421.3	5 507 083.5	215 682.0
19-10	421.2	5 507 109.3	215 696.5

-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.
3) Coordinate system is MTM NAD 83 Zone 15.

GEOCRES No. 52G-20

REVISIONS			
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			DWG 1

DATE MAY 2020

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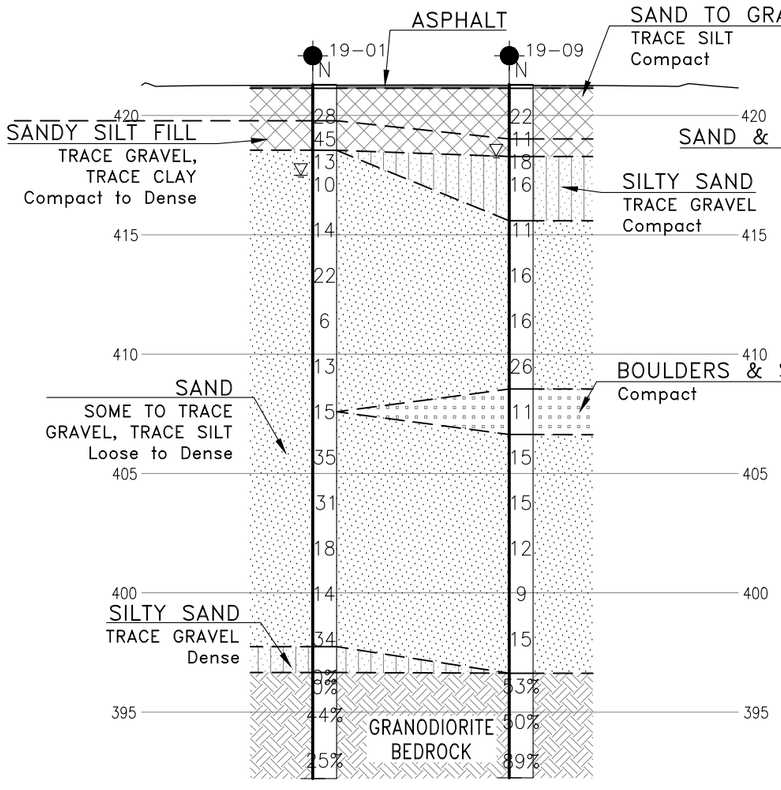
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



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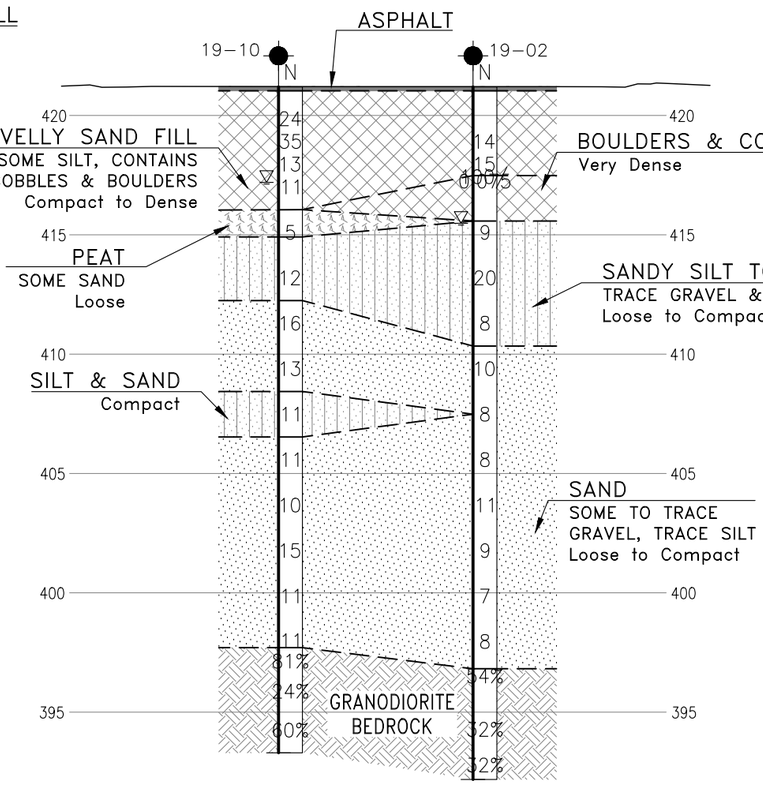
4 0 4 8m V 1:200



SECTION B–B

2 0 2 4m H 1:100
4 0 4 8m V 1:200

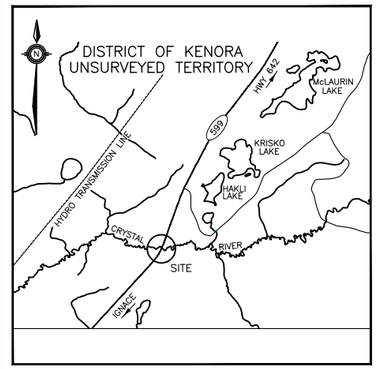
CONT No
WP No 6088-17-01

SHEET

HIGHWAY 599
CRYSTAL RIVER
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH

THURBER ENGINEERING LTD.



KEYPLAN

	LEGEND
●	Borehole
⊕	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
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GEOCRES No. 52G-20

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May 14/20
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REVISIONS		
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DATE MAY 2020
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MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

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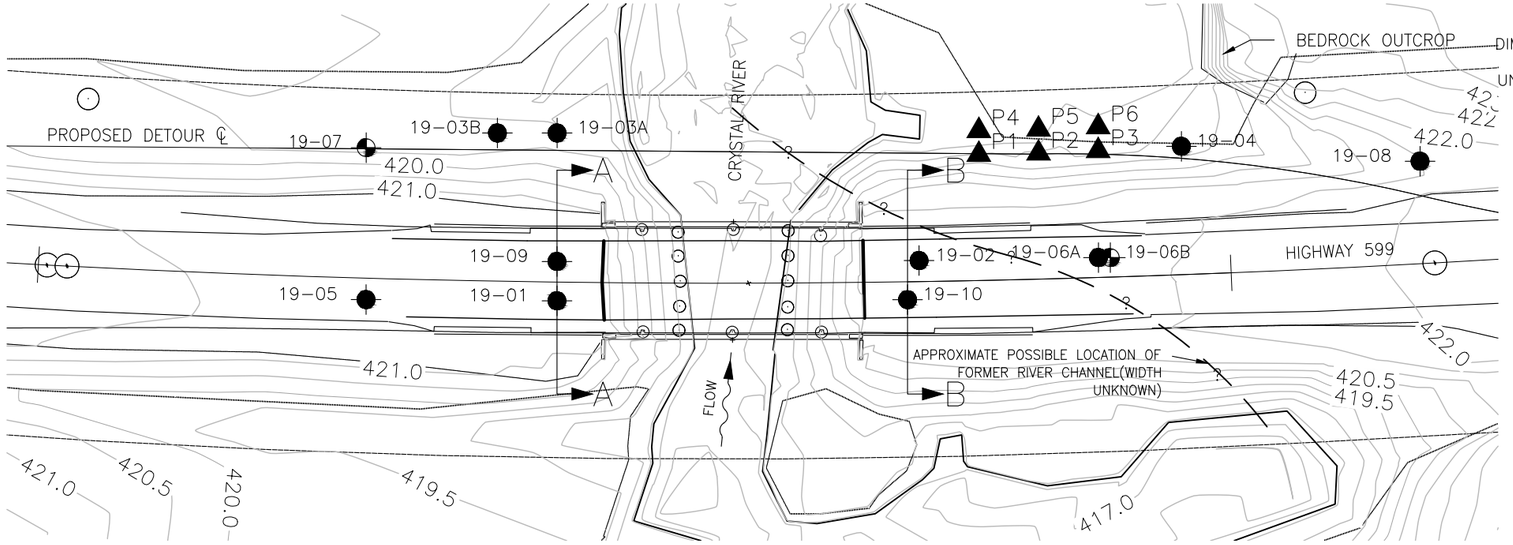
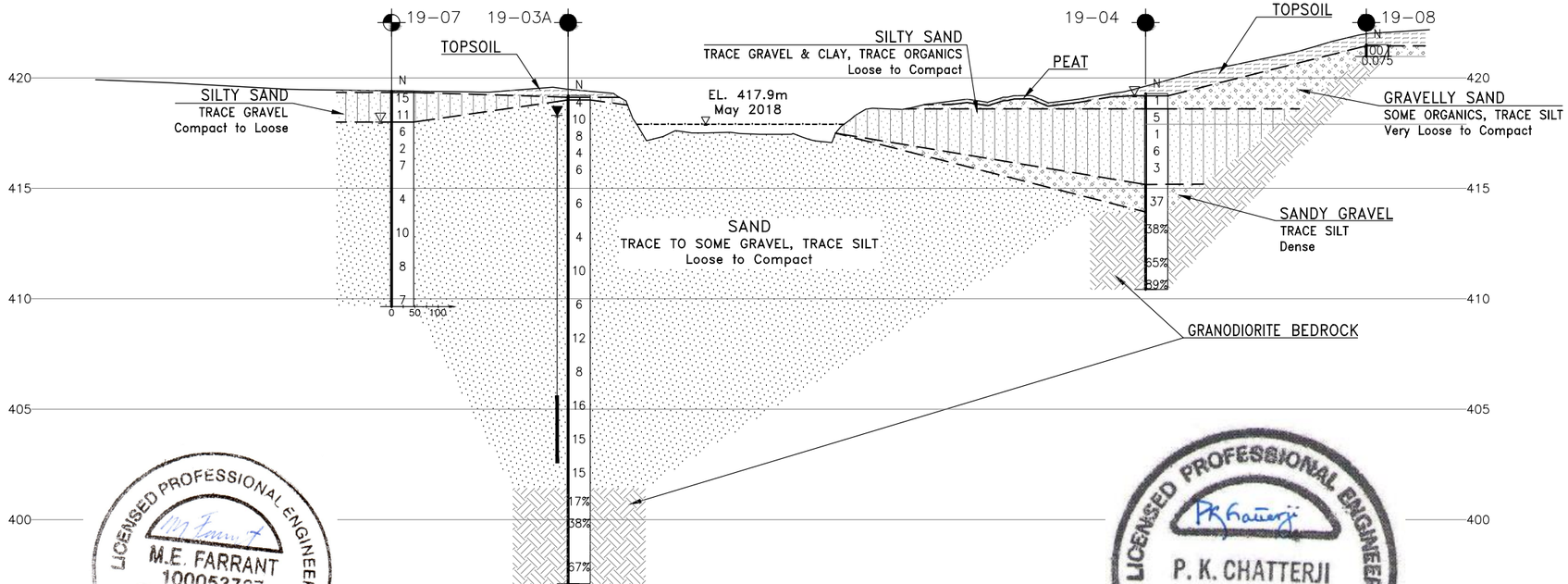


PLAN

10 0 10 20m

SCALE 1:500



PROFILE ALONG ℄ PROPOSED DETOUR

10 0 10 20m H 1:500

2 0 2 4m V 1:250

LICENSED PROFESSIONAL ENGINEER
M.E. FARRANT
100053767
May 14/20
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
May 14/2020
PROVINCE OF ONTARIO

CONT No
WP No 6088-17-01

SHEET

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CRYSTAL RIVER
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

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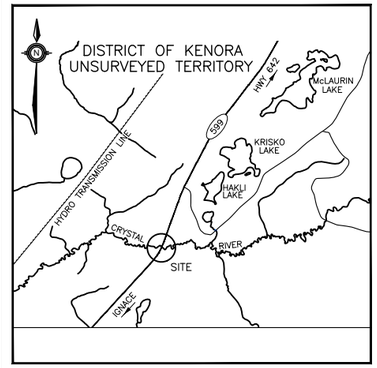
THURBER ENGINEERING LTD.



KEYPLAN

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GEOCRES No. 52G-20

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