

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
BLANCHE RIVER BRIDGE REPLACEMENT  
ROSEGROVE ROAD  
NEW LISKEARD DISTRICT, ONTARIO  
G.W.P. 5146-13-00, SITE NO. 47-085  
Geocres Number: 42A-105**

**Report to:  
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## **FOUNDATION INVESTIGATION AND DESIGN REPORT**

### **BLANCHE RIVER BRIDGE REPLACEMENT**

#### **ROSEGROVE ROAD**

#### **NEW LISKEARD DISTRICT, ONTARIO**

#### **G.W.P. 5146-13-00, SITE NO. 47-085**

#### **Geocres Number: 42A-105**

### **PART 1: FACTUAL INFORMATION**

## **1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted at the existing Blanche River Bridge on Rosegrove Road in the Township of Otto, New Liskeard District, Ontario.

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

Thurber carried out the investigation as a sub-consultant to MMM Group Limited, under the Ministry of Transportation Ontario (MTO) Agreement Number 5014-E-0024.

A 1972 internal report by the MTO Foundations Office (Geocres No. 42A-23) prepared for the then-proposed bridge replacement has been reviewed and the subsurface information incorporated in the preparation of this report. The Borehole Location Plan and Record of Borehole sheets from the 1972 report are enclosed in Appendix E for information.

## **2 SITE DESCRIPTION**

The existing Blanche River Bridge is located on Rosegrove Road, southwest of the community of Kirkland Lake, approximately 3.5 km east of the intersection of Highway 11 and Rosegrove Road. The existing bridge is a three-span structure; the centre span consists of a steel bailey bridge and the two end spans consist of a timber deck supported on wooden rectangular timber beams supported on timber crib abutments. The total bridge length is approximately 30.5 m as per the RFP and the deck is 4 m wide as per the RFP. The existing structure was constructed in 1972 to replace the original bridge and the existing bridge is supported on timber piles.

Blanche River flows from north to south at the bridge location. The areas surrounding the bridge are covered with tall grass, shrubs and frequent trees. The local topography is of low relief with no visible bedrock outcrops.

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

Based on published geological information, the general area of the project is covered by glaciolacustrine sediments of clays and silts deposited during the Pleistocene period. These deposits are mostly varved clays, but massive clays are also present in some areas. Due to the different rates of seasonal deposition during various periods of glaciation, the lower zones of the deposits display typically much thicker varves than in the upper zones. Below the varved clays are glacial outwash deposits of silt, sand and gravel underlain by Precambrian alkalic intrusive rocks.

The soils in the immediate vicinity of the Blanche River have been influenced by the river and consist of modern alluvial deposits including sand, silt, gravel and organic material.

### **3 SITE INVESTIGATION AND FIELD TESTING**

The site investigation and field testing program for this project was carried out in two segments. The first between June 12 and June 13, 2015 and the second between August 6 and August 8, 2015. The program consisted of drilling and sampling four boreholes (numbered BR-01 to BR-04) to depths ranging from 30.5 to 35.7 m below the existing ground surface or river level. Two boreholes were drilled through the approach embankment near the west and east bridge abutments (BR-01 and BR-04 respectively), and two boreholes were drilled in the river from a barge near the existing west and east bridge piers (BR-02 and BR-03 respectively). A Dynamic Cone Penetration Test (DCPT) was conducted below the sampled portion of Boreholes BR-01 and BR-02 to a depth of 37.9m and 35.4 m, respectively.

Prior to the start of drilling, the borehole locations were marked/staked in the field and utility clearances were obtained. The coordinates and ground surface elevations for the boreholes were derived from topographic plans provided to Thurber by MMM Group Limited. The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

A track-mounted CME 45 hi-torque drill rig was used to advance the Boreholes BR-01 and BR-04 using hollow stem augers. A Diedrich D25 hi-torque track-mounted drill rig and a barge were used to advance BR-02 and BR-03 to a specified depth using casing/wash boring methods. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). Field vane shear testing using an MTO “N” size vane were carried out in very soft to soft cohesive soils.

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

Groundwater conditions in the open boreholes were observed throughout the drilling operations. A standpipe piezometer was installed in Borehole BR-01 to monitor the groundwater level after drilling. The piezometer was decommissioned after final water level reading. The boreholes were backfilled in general accordance with MOE Regulation 903. Completion details of the piezometer and boreholes are summarized in Table 3.1.

**Table 3.1 – Borehole Completion Details**

Foundation Unit	Boreholes	Borehole and DCPT Depth*/Elevation (m)	Piezometer Tip Depth/Elevation (m)	Completion Details
West Abutment	BR-01	37.9* / 235.7	35.1/ 238.5	Sand to 31.4 m, and bentonite holeplug and cuttings from 31.4 m to surface.
West Pier	BR-02	35.4** / 236.2	None installed	Bentonite holeplug from 34.7 m to surface of river bed.
East Pier	BR-03	34.8** / 236.8	None installed	Bentonite holeplug from 34.8 m to surface of river bed.
East Abutment	BR-04	30.5* / 244.1	None installed	Bentonite holeplug and cuttings from 30.5 m to surface.

Notes: \*Borehole depth below existing ground surface

\*\* Borehole Depth below river level at time of drilling

The results of the field drilling and sampling are presented on the Record of Borehole sheets in Appendix A.

#### 4 LABORATORY TESTING

All recovered soil samples were subjected to visual identification (VI) and natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and hydrometer) and plasticity testing (Atterberg Limits). The results of the geotechnical laboratory program are summarized on the Record of Borehole sheets included in Appendix A and on the figures presented 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, a sample of the existing native soil, and a sample of surface water from the river upstream of the bridge were collected. The samples were submitted to AGAT

Laboratories in Mississauga, Ontario for analytical testing of corrosivity parameters and sulphate. The results of the analytical testing are summarized in Section 6 below and are enclosed in Appendix B.

## **5 DESCRIPTION OF SUBSURFACE CONDITIONS**

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing included in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It should be recognized that soil conditions may vary between and beyond the borehole locations.

The MTO Report prepared by the Foundations Office in 1972 describes a foundation investigation that was conducted at the then existing Blanche River Bridge for structure replacement. The locations of the boreholes from the 1972 report (Geocres No. 42A-23) and the Record of Borehole sheets are presented in Appendix E for information. The subsurface information documented in the MTO report was incorporated in the preparation of this report. In general, the information on subsurface conditions is consistent with the subsurface information obtained during the current investigation.

As determined in the current investigation, the soil stratigraphy at the west side of the river comprises a sand fill underlain by layers of silty clay and silty sand to approximately 5.6 m depth. These soils were further underlain by a very soft to stiff, varved clayey silt to silty clay extending to as much as 33.5 m depth. On the east side of the river, the varved clayey silt to silty clay was encountered immediately below the topsoil or thin river bed deposit and the clay extended to a depth of 25.7 m in Borehole BR-03. Adjacent Borehole BR-04 was terminated in this varved clay deposit at the depth of 30.5 m. The clayey silt to silty clay was underlain by a cohesionless deposit ranging in composition from a silt to gravel. A layer of gravelly sand till was encountered in one borehole (Borehole BR-02) at 33.3 m depth. More detailed description of the individual strata are presented below.

### **5.1 Topsoil**

A thin layer of topsoil was encountered at the surface of Borehole BR-04, which was drilled adjacent to the existing roadway. The topsoil layer had a thickness of 75 mm at the borehole location. Topsoil thickness may vary in other areas of the site and this limited data should not be used for estimating purposes.

### **5.2 Embankment Fill**

Embankment fill was encountered in Borehole BR-01, which was drilled adjacent to the bridge approach on the west side of the river. The fill consisted of brown sand with trace to some silt and gravel and trace organic inclusions at shallow depths including roots and rootlets. The thickness of the fill was 2.2 m with an underside elevation of 271.4.

SPT 'N' values recorded in the embankment fill ranged from 4 to 10 blows per 0.3 m penetration, indicating a loose to compact relative density. Moisture contents of the fill materials ranged from 3% to 15%.

### 5.3 Silty Clay with Sand

A layer of silty clay with sand was encountered in BR-01 beneath the embankment fill. The deposit was brown to grey in colour. Trace gravel and occasional oxidized silt seam were noted in this layer. This layer was 1.9 m thick with a base depth at 4.1 m (Elev. 269.5).

SPT 'N' values recorded in this layer were 3 and 6 blows per 0.3 m penetration indicating a soft to firm consistency. Moisture contents in this layer ranged between 19 and 25%. The results of grain size analyses conducted on a sample of this soil are presented in Figure B1, and Atterberg Limits test results are presented in Figure B10 in Appendix B. The results are summarized in the following table.

Soil Particles	%
Gravel	0
Sand	44
Silt	34
Clay	22
Soil Property	%
Liquid Limit	26
Plasticity Index	10

The results of the Atterberg Limits tests indicate that the silty clay is of low plasticity (CL).

### 5.4 Sand

A deposit of sand was encountered beneath the silty clay with sand layer in Borehole BR-01 and below the river bed in Boreholes BR-02 and BR-03. The thickness of the deposit ranged from 0.1 m to 1.5 m with the lower boundary between 1.9 m and 5.6 m (Elev. 269.7 to 268.0). The deposit contains predominantly sand with some silt, trace to some gravel, and trace clay. Wood fibres were noted in this deposit in the samples retrieved from the river bed.

SPT 'N' values recorded in this deposit varied between 1 and 2 blows per 0.3 m of penetration indicating a very loose relative density. Natural moisture contents of the deposit ranged from 35 to 51%.

The results of a grain size analyses conducted on a sample of the sand are provided on the Record of Borehole sheets in Appendix A, and are illustrated in Figure B2 of Appendix B. The results of the grain size analyses are summarized in the following table.

Soil Particles	%
Gravel	0
Sand	73
Silt	17
Clay	10

### 5.5 Varved Clayey Silt to Silty Clay

A deposit of varved clayey silt to silty clay with trace sand was encountered in all boreholes drilled on site. The deposit underlies the sand in Boreholes BR-01, BR-02, and BR-03, and the topsoil in BR-04 and was typically grey in colour. In Boreholes BR-03 and BR-04, trace of organic inclusions (roots and rootlets) were noted at shallow depths. Occasional clay, silt and sand seams were noted at different depths in this deposit.

In Boreholes BR-02 and BR-03, a layer of very loose to loose silt with some clay and trace to some sand was encountered within the clayey silt / silty clay deposit. This layer ranged in thickness from 0.5 to 1.2 m with an underside between 19.6 m and 20.5 m depths (Elev. 252.0 and 251.1).

Where fully penetrated in Boreholes BR-01, BR-02, and BR-03, the clayey silt / silty clay was 23.8 m to 28.2 m thick and extended to depths of 25.7 m to 33.5 m (Elev. 245.9 to 240.1). Borehole BR-04 was terminated in this deposit at a depth of 30.5 m (Elev. 244.1).

The undrained in-situ vane shear strength was measured to be between 20 to 73 kPa. SPT 'N' values recorded in this deposit ranged from 0 (weight of rod or hammer) to 8 blows per 0.3 m penetration, typically ranging from 0 to 3 blows per 0.3 m of penetration. In conjunction with measured field vane shear strengths, the clayey silt / silty clay was found to have a soft to stiff consistency. Moisture contents in the clayey silt / silty clay ranged between 15% and 67% with most values ranging between 24 % and 51%. The grain size analyses conducted on samples are presented in Figure B3, B4, and B5, and Atterberg Limits test results are presented in Figure B11 and B12 in Appendix B. The results are summarized in the following table.

Soil Particles	%
Gravel	0
Sand	0 to 2
Silt	24 to 81
Clay	19 to 76
Soil Property	%
Liquid Limit	26 to 60
Plasticity Index	7 to 33

The results of the Atterberg Limits tests indicate that the plasticity of this deposit varies from low to high.

### 5.6 Silt to Sandy Silt

Deposits of sandy silt and silt were encountered in Borehole BR-01 and BR-03 underlying the varved clayey silt / silty clay deposit. Borehole BR-01 was terminated in the sandy silt at a depth of 35.7 m (Elev. 237.9). Where fully penetrated in BR-03, the deposit had a thickness of 6.1 m with the base at a depth of 31.8 m (Elev. 239.8). The deposits were grey in colour and contained trace to some clay.

SPT 'N' values recorded in these deposits varied between 9 and 21 blows per 0.3 m of penetration, indicating a loose to compact relative density. Natural moisture contents of the deposits ranged from 27% to 29%. The results of grain size analyses conducted on samples of the silt to sandy silt are provided on the Record of Borehole sheets in Appendix A, and are illustrated in Figure B6 of Appendix B. The results of the grain size analyses are summarized in the following table.

Soil Particles	Sandy Silt %	Silt %
Gravel	0	0
Sand	32	4
Silt	58	91
Clay	10	5

Below the sampled depth of Borehole BR-01, a DCPT was carried out to practical refusal (i.e., 100 blows per 0.3 m penetration) from a depth of 35.7 m to 37.9 m (Elev. 237.9 to 235.7).

## 5.7 Gravel

A layer of gravel with some sand and trace silt was encountered in BR-02 and BR-03. The deposit ranged in thickness from 1.6 to 2 m with the base between 33.3 m and 33.4 m depth (Elev. 238.3).

SPT 'N' values recorded in this layer were 26 and 28 blows per 0.3 m penetration, indicating a compact relative density. Moisture contents in this layer were measured at 5%. The results of grain size analysis conducted on a sample are presented in Figure B7. The results are summarized in the following table.

Soil Particles	%
Gravel	85
Sand	14
Silt & Clay	1

## 5.8 Gravelly Sand Till

A grey gravelly sand till containing some silt and clay was encountered in Borehole BR-02 underlying the gravel deposit. The borehole was terminated in the gravelly sand till layer at a depth of 34.7 m (Elev. 236.9).

SPT 'N' value recorded in this layer was 107 blows per 0.3 m penetration indicating a very dense relative density. The moisture content measured in this layer was 12%. The results of grain size analysis conducted on a sample of the till are presented in Figure B8. The results are summarized in the following table.

Soil Particles	%
Gravel	22
Sand	44
Silt & Clay	31

Below the sampled depth of Borehole BR-02, a DCPT was carried out to practical refusal (100 blows per 0.3 m) from a depth of 34.7 m to 35.4 m (Elev. 236.9 to 236.2).

## 5.9 Sand

A layer of brown sand containing trace silt was encountered in Borehole BR-03 underlying the gravel deposit. The borehole was terminated in the sand at a depth of 34.8 m (Elev. 236.8).

SPT 'N' values recorded in this layer ranged from 44 blows per 0.3 m penetration to 100 blows per 0.05 m penetration, indicting a dense to very dense relative density. Moisture content measured in this layer was 25%. The grain size analyses conducted on samples are presented in Figure B9. The results are summarized in the following table.

Soil Particles	%
Gravel	0
Sand	96
Silt & Clay	4

## 5.10 Water Levels

Where possible, water levels were monitored in the open boreholes during drilling operations. Boreholes BR-02 and BR-03 were drilled in the river, and wash boring methods were used to advance the boreholes; therefore water levels recorded during or upon completion of drilling may not reflect natural groundwater levels. A standpipe piezometer was installed in one borehole to monitor the groundwater level after completion of drilling. The water levels measured in the piezometer and during drilling are summarized in Table 5.1.

**Table 5.1 – Water Level Measurements**

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
BR-01	July 14, 2015	2.8	270.8	In piezometer
	July 27, 2015	1.7	271.9	
BR-02	August 7, 2015	0	271.6*	Open borehole
BR-03	August 8, 2015	0	271.6*	Open borehole
BR-04	June 13, 2015	2.9	271.7	Open borehole

\* Water level in the river

The topographic plan provided by MMM indicates the water level in Blanche River at Elev. 272.0 on May 29, 2015.

The water levels presented in Table 5.1 are short-term readings and seasonal fluctuations of the groundwater and river water levels are to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

## 6 CORROSIVITY AND SULPHATE TEST RESULTS

A soil sample collected from the native clay and a sample of the water from the 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	
			BR-4 SS3 – Soil (1.5 m to 2.1 m)	Blanche River Water
Sulphide	%	mg/L	0.02	<0.05
Chloride	µg/g	mg/L	29	13.4
Sulphate	µg/g	mg/L	47	11.8
pH	pH Units	pH Units	7.98	7.44
Electrical Conductivity	mS/cm	µS/cm	0.222	-
Resistivity	ohm.cm	ohm.cm	4500	5880
Redox Potential	mV	mV	234	308
Langlier Index	-	-	-	-0.85
Total Hardness (as CaCO <sub>3</sub> )	-	mg/L	-	59.7
Total Dissolved Solids	-	mg/L	-	76
Alkalinity (as CaCO <sub>3</sub> )	-	mg/L	-	50

## 7 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field and relative to the topographic plans provided by MMM Group Limited.

Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied a track-mounted CME-45 hi-torque drill rig and conducted the drilling, sampling and in-situ testing operations for the boreholes near the bridge abutments. Walker Drilling Limited of Utopia, Ontario supplied and operated a Diedrich D25 hi-torque drill rig and a barge to conduct the drilling, sampling and in-situ testing operations for the boreholes at the existing bridge piers. The drilling operations were supervised by Mr. Amir Fereidouni and Ms. Eckie Siu of Thurber. Geotechnical laboratory testing was carried out by Thurber in its MTO-approved laboratory.

Overall supervision of the field program was carried out by Mr. Stephane Loranger, CET. The report was prepared by Ms. Deanna Pizycki, EIT and Ms. Anna Piascik, P.Eng.

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

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### **BLANCHE RIVER BRIDGE REPLACEMENT**

#### **ROSEGROVE ROAD**

#### **NEW LISKEARD DISTRICT, ONTARIO**

#### **G.W.P. 5146-13-00, SITE NO. 47-085**

#### **Geocres Number: 42A-105**

## **PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

### **8 GENERAL**

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical recommendations for the proposed replacement of the existing Blanche River Bridge on Rosegrove Road in the Township of Otto, New Liskeard District, Ontario.

At present, the bridge carries Rosegrove Road over Blanche River on a three-span structure constructed in 1972. The bridge has a total length of approximately 30.5 m and a deck width of 4.0 m. The centre span, 21.5 m in length, consists of a steel bailey bridge; the two end/outer spans both 4.5 m in length consist of a timber deck supported on wooden rectangular timber beams and timber crib abutments.

The MTO Foundations Report, Geocres No. 42A - 23, dated April 1972, indicated that the original bridge piers were supported on two rows of #14 timber piles with 17 piles at each pier. At that time, the report recommended replacement of the piled foundations due to significant decay and damage of the piles.

As shown on the General Arrangement drawing dated February 2003 enclosed in Appendix G, the existing bridge is supported on 2 m x 7.0 m timber crib abutments, and two piers located in the river. The piers are founded on ten 300 mm diameter timber piles. The piles are cross-braced above the surface and outfitted with lumber ice guards. Wing walls extend from the piers to the north/upstream side of the river and each wall is supported on four timber piles. Gabion baskets surround the east abutment.

The MTO Inspection Report prepared for this bridge indicated deterioration of the abutment walls, structural steel coatings, barrier posts, piers, and pier caps. Movements of the abutment walls, pier bearings, and pier shafts/columns/pile bents were noted. It is understood that the replacement of the structure is required.

The discussions and recommendations presented in this report are based on information shown in the Preliminary General Arrangement drawing for the replacement of Blanche River Structure dated February 2016 provided by MMM Group Limited (MMM) and on the factual data obtained during the course of this investigation.

The preliminary General Arrangement drawing indicates that the replacement bridge will be a single span modular panel bridge with a total length of 39.6 m and a width of 4.2 m supported on the concrete foundation pads.

The existing road grade will be raised by 1.2 m at the east abutment and by 1.4 m at the west abutment. The replacement bridge will be constructed on the same horizontal alignment as the existing structure.

## **9 STRUCTURE FOUNDATIONS**

In summary, the site is underlain by an extensive deposit of varved clayey silt / silty clay. At the west side of the river, the sand fill is underlain by layers of silty clay and silty sand to approximately 5.6 m depth. These soils were further underlain by a very soft to stiff, varved clayey silt / silty clay extending to as much as 33.5 m depth. On the east side of the river, the varved cohesive deposit was encountered immediately below the topsoil or thin river bed sediment and the clay extending to a depth of 25.7 m in Borehole BR-03. Adjacent Borehole BR-04 was terminated in this deposit at the depth of 30.5 m. Underlying the varved clay was a cohesionless deposit ranging in composition from silt to gravel and grading to a very dense gravelly sand till. Boreholes BR-02 and BR-03 were terminated in the dense to very dense cohesionless deposit at depths of 35.4 m and 34.8 m (Elev. 236.2 and 236.8), where practical refusal to further penetration by cone and tricone was encountered.

The water level in the Blanche River was indicated on the base plan at Elev. 272.0 on May 29, 2015. Groundwater level in the piezometer installed in Borehole BR-01 on the west side of the river was measured at 1.7 m depth (Elev. 271.9) on June 27, 2015. The groundwater level will be influenced by the water level in the river.

The following foundation options were considered for the support of this bridge:

- spread footings placed on native soil,
- spread footings placed on engineered fill, and
- driven steel H-piles.

Recommendations for design of the feasible foundation alternatives are presented in the following sections together with the corresponding geotechnical design parameters. A preferred foundation alternative from a geotechnical perspective is recommended.

### **9.1 Spread Footings on Native Soils**

Given the low strength and highly compressible nature of the varved silty clay/clayey silt encountered immediately below the embankment fill, significant depth to a competent foundation stratum and the

relatively high river water level, spread footings placed on native soils to support the abutments will be designed at a comparatively low geotechnical resistance.

## 9.2 Spread Footings on Engineered Fill Materials

Supporting modular bridge abutments on concrete foundation placed on granular fill pads can be considered at this site. The preliminary General Arrangement drawing indicates the existing road grade at Elev. 275.7 at the east bridge abutments and at Elev. 275.4 at the west abutment. The underside of the footings at approximately Elev. 274.0 and 273.7 at the east and west abutments, respectively, are shown on the drawing.

The footings should be constructed on a granular engineered fill pad at least 1 m in thickness. The engineered fill should consist of OPSS Granular “A” or Granular B Type II placed in 150 mm lifts and compacted to 100% of its SPMDD at  $\pm 2\%$  of optimum moisture content. The top of the engineered fill pad should be at least 1 m wider than the footprint of the spread footing. The engineered fill pad should be placed on the native soils.

The following values of factored Geotechnical Resistance at ULS and Geotechnical Reaction may be used for design of footings approximately 3.0 m in width and placed on properly compacted granular fill as noted above, at or below Elev. 274:

Factored Geotechnical Resistance at ULS (kPa) -	150 kPa
Geotechnical Reaction at SLS (kPa) -	60 kPa.

The grade raise of 1.5 m at the abutments will cause settlements in the order of 25 mm to 35 mm. Given that the footings will be supported in the approach fills, they will settle along with the embankments and the serviceability of the modular bridge is not expected to be affected.

The values of a Factored Geotechnical Resistance at ULS was assessed assuming a Consequence Factor equal to 1 (Typical), and a Resistance Factor equal to 0.5 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2014. The Geotechnical Reaction at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

The geotechnical resistance quoted above is for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance should be calculated as illustrated in the CHBDC 2014 Clause 6.10.3 and Clause 6.10.4.

The lateral resistance of the footings founded on engineered fill may be computed using an unfactored friction coefficient of 0.6. This is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance.

Given that distress and erosion noted at the existing abutments, placement of new abutments some distance behind the existing timber cribs would be beneficial. In addition, proper design of the erosion protection will have to be implemented.

### 9.3 Driven H-Pile Foundations

A system of driven steel H-piles developing resistance primarily through shaft friction could be considered to support the bridge loads.

#### 9.3.1 Axial Resistance

Given the soft and compressible nature of the soils directly below the shallow existing embankment fill, friction piles will have to be driven to significant depths into that deposit to develop adequate resistance. The geotechnical resistances recommended for HP 310x110 piles driven to Elev. 254 and Elev. 245.0 in the soft to stiff silty clay/clayey silt are presented in Table 9.1.

**Table 9.1 – Geotechnical Resistance and Reaction for Driven HP310x110 Piles**

Foundation Element	Pile Tip Depth/Elevation (m)	Factored Geotechnical Resistance at ULS (kN) per pile	Geotechnical Reaction at SLS (kN) per pile
East Abutment	20.0 / 254.0	300	200
West Abutment	29.0 / 245.0	450	300

The pile length was estimated assuming a pile cut-off at Elev. 274.0. The recommended pile tip elevation is considered approximate and the actual tip elevation required to develop the design resistance will need to be confirmed by monitoring during installation.

Oversize materials (e.g. greater than 75 mm nominal diameter) should not be used for any new fill through which the piles will be driven.

#### 9.3.2 Pile Installation

Pile installation should be in accordance with OPSS 903.

Pile driving at both abutments should be controlled in accordance with Standard Drawing SS103-11 (Hiley Formula) and an ultimate pile resistance should be specified by the designer. The Hiley formula need not be used until the piles are within 2.0 m of the design pile tip elevation. The appropriate pile driving note is “Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance of “R” kN per pile. “R” should have a minimum value of twice the design load at ULS.

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

Pile tip protection should not be used for driven H-piles developing resistance through shaft friction at this site.

The alignment of the H-piles should be carefully selected to be outside of the footprint of the existing crib abutments and away from the river banks.

The existing piles supporting the existing piers and located in the river may be cut off at the level of the river channel base.

### 9.3.3 Pile Lateral Resistance

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

$$\begin{aligned} k_s &= 67 s_u / D \quad (\text{kN/m}^3) \\ p_{ult} &= 9 s_u \quad (\text{kPa}) \end{aligned}$$

where

$$\begin{aligned} s_u &= \text{undrained shear strength of the soil (kPa)} \\ D &= \text{pile width or diameter in metres.} \end{aligned}$$

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

$$\begin{aligned} k_s &= n_h z / D \quad (\text{kN/m}^3) \\ p_{ult} &= 3 \gamma' z K_p \quad (\text{kPa}) \end{aligned}$$

where

$$\begin{aligned} z &= \text{depth of embedment of pile (m)} \\ D &= \text{pile width or diameter (m)} \\ n_h &= \text{coefficient related to soil relative density (kN/m}^3\text{)} \\ \gamma' &= \text{effective unit weight (kN/m}^3\text{)} \\ K_p &= \text{passive earth pressure coefficient.} \end{aligned}$$

The above equations and recommended parameters summarized in Table 9.2, below, may be used to analyze the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

**Table 9.2 – Soil Parameters for Lateral Pile Resistance**

Soil Unit	Elevation (m)		$\gamma'$ (kN/m <sup>3</sup> )	$n_h$ (kN/m <sup>3</sup> )	$K_p$	$S_u$ (kPa)
	Top	Bottom				
West Abutment – Borehole BR-01						
Sand Fill	273.6*	271.4	20	1,500*	1.3*	-
Silty Clay	271.4	269.5	8	-	2.8	20
Sand	269.5	268.0	9	2,000	2.9	-
Silty Clay/Clayey Silt	268.0	241.0	10	-	2.8	40
East Abutment – Borehole BR-04						
Silty Clay/Clayey Silt	274.5*	263.0	8	-	2.8*	20
Silty Clay/Clayey Silt	263.0	244.1	10	-	2.8	40

Note: \* Top of fill at the existing bridge; top of pile may vary.  $K_p$  accounts for 2H:1V fill slope.

\*\* Pile tip elevations may vary at pile locations.

The spring constant,  $K_s$ , for analysis may be obtained from the expression:

$$K_s = k_s L D \text{ (kN/m)},$$

where  $k_s$  = coefficient of horizontal subgrade reaction (kN/m<sup>3</sup>),

$D$  = pile width (m), and

$L$  = length (m) of the pile segment or element used in the analysis.

The ultimate lateral resistance,  $P_{ult}$ , may be obtained from the expression,  $P_{ult} = p_{ult} L D$ . This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements.

The modulus of subgrade reaction and ultimate lateral resistance may have to be reduced, based on the pile spacing. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in Table 9.3. Intermediate values may be obtained by linear interpolation.

**Table 9.3 – Subgrade Reaction Reduction Factors for Pile Spacing**

Condition	Pile Spacing, Centre to Centre	Reduction Factor
Pile group oriented <i>perpendicular</i> to direction of loading	4D	1.0
	1D	0.5
Pile group oriented <i>parallel</i> to direction of loading	8D	1.0
	6D	0.7
	4D	0.4
	3D	0.25

In the case of conventional abutments, i.e. not integral type, horizontal loads may be resisted by means of battered piles.

#### 9.4 Recommended Foundation

From a geotechnical perspective and based on the subsurface conditions, steel H-piles driven into the stiff silty clay/clayey silt is the preferred foundation option at this site. Supporting the replacement bridge on concrete footings placed on granular fill pad will require future bridge maintenance and jacking up of the abutments to compensate for the consolidation settlements.

#### 9.5 Frost Cover

The depth of frost penetration at this site is approximately 2.4 m. If piles are used, the base of pile caps must be provided with a minimum of 2.4 of earth cover as protection against frost action.

If it is not practical to provide 2.4 m of earth cover, consideration can be given to augmenting the frost protection using expanded polystyrene insulation (EPS). Typically, 25 mm of EPS can be considered equivalent to 600 mm of earth cover. If EPS is used, it must be provided with long term protection against erosion, environmental degradation and spills.

Concrete slab foundations for modular bridges may be founded on an engineered fill pad with a minimum embedment of 0.5 m.

### 10 ABUTMENT BACKFILL AND LATERAL EARTH PRESSURES

If any new backfill is placed behind the modified abutments, it should be placed in accordance with OPSS 902. All backfill material should consist of Granular A, Granular B Type II or Granular B Type III material meeting the specifications of OPSS.PROV 1010. Compaction equipment to be used adjacent to the walls should be restricted in accordance with OPSS.PROV 501.

Lateral earth pressures acting on the abutment walls may be assumed to be distributed triangularly and to be governed by the characteristics of the wall backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p_h = K (\gamma h + q)$$

Where:  $p_h$  = horizontal pressure on the wall at depth  $h$  (kPa)

$K$  = earth pressure coefficient

$\gamma$  = unit weight of retained soil

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

$q$  = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill and the existing material adjacent to the wall. Typical values are given in table, below.

**Table 10.1 – Earth Pressure Coefficients (K)**

Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I or Existing Granular Fill $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.38*	0.31	0.46*
At Rest (Restrained Wall)	0.43	-	0.47	-
Passive	3.7	-	3.3	-

\* For wing walls.

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

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

In accordance with Clause 6.12.3 of the CHBDC, 2014, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I, or at a depth of 1.7 m for Granular A or Granular B Type II.

## 11 SEISMIC CONSIDERATIONS

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 1
- Zonal Velocity Ratio 0.05
- Acceleration Related Seismic Zone 2
- Zonal Acceleration Ratio 0.10

- Peak Horizontal Ground Acceleration 0.08

The soil profile type at this site has been classified as Type III. Therefore, according to Table 4.4 of the CHBDC, a Site Coefficient “S” (ground motion amplification factor) of 1.5 could be used in seismic design.

Based on review of the SPT and DCPT data, the foundation clayey soils at this site are not expected to be prone to liquefaction during seismic events.

## **12 SCOUR AND EROSION CONTROL**

The existing forward slopes appear to be experiencing erosion, as shown on the photograph enclosed in Appendix C. Adequate scour and erosion protection should be established to ensure that the forward slopes at the bridge, and the river bank slopes on both sides of the bridge, are protected. The design of the scour and erosion protection works should be undertaken by a specialist in this field.

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

## **13 EXCAVATION AND GROUNDWATER CONTROL**

Excavation for works associated with the construction of the new abutments is expected to extend through the existing granular embankment fill and into the native deposits located near the river water level. The excavation of the existing crib foundations may also be required. Removal of the existing crib foundations below the river water level will be difficult and is not recommended.

All excavations should be carried out in accordance with OPSS 902 and the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the approach fill within the depth of excavation may be classed as Type 3 soil above the water table and Type 4 below the water level.

The groundwater level is expected to be largely governed by the water level in the river. If excavation below the river level is required, a combination of a water-tight sheetpile enclosure (cofferdam) and pumping from filtered sumps will be needed to maintain dry excavations during construction. The design of the dewatering system is the responsibility of the contractor. The contractor should retain a dewatering specialist to design the appropriate cofferdam and dewatering system.

The selection of the method of excavation is the responsibility of the Contractor and should be based on the Contractor’s experience, equipment and interpretation of the site conditions. The existing timber cribs could contain rock fill material. It is anticipated that a hydraulic excavator will be suitable to use at this site. Provision should be made for handling of pavement materials, potential obstructions in the fill, and cobbles and boulders.

## 14 TEMPORARY PROTECTION SYSTEM

The design of the temporary protection system is typically the responsibility of the Contractor, as per OPSS PROV 539.

If required, the protection system should be design for Performance Level 2 (maximum 25 mm horizontal deflection). Temporary protection system may consist of steel soldier pile and timber lagging walls or continuous sheet pile walls.

The following parameters may be used in the design:

$\gamma$	=	20 kN/m <sup>3</sup> (embankment fill and native soils)
$\gamma_w$	=	10 kN/m <sup>3</sup>
$K_a$	=	0.33 (road embankment fill)
	=	0.39 (clayey silt / silty clay)
$K_p$	=	2.6 (clayey silt / silty clay)

Full hydrostatic pressure should be considered assuming a water level equal to the design river water level. The actual pressure distribution acting on the protection system is a function of the construction sequence and the relative flexibility of the wall. All temporary protection systems should be designed by a Professional Engineer experienced in such designs.

The existing embankment fill and underlying native soils may contain occasional cobbles and boulders, which may interfere with installation of soldier piles or sheet piles. The Contractor should be advised of potential obstructions in the fill and native soils during installation. Suggested text for an NSSP on “Installation of Roadway Protection System” is included in Appendix F.

## 15 CORROSION & SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the embankment fill soil and the river water indicate the following:

- The potential for sulphate attack on concrete foundations from the surrounding soil or surface water is considered to be negligible due to the low concentration of sulphate in the samples tested.
- The potential for soil or water corrosion on metal structural elements is considered to be mild to moderate.
- Appropriate protection measures are recommended to address the mild to moderate potential for corrosion on metal structure elements.

## 16 APPROACH EMBANKMENTS

The existing approach embankments vary in height and could be as high as 2 m near the abutments. No evidence of instability of the existing approach embankments were noted during the time of the foundation investigation, although, settlements at the abutments were evident. These settlements could

be related to the river bank erosion leading to undermining of the timber cribs and loss/washout of the abutment fill.

Based on the preliminary General Arrangement drawing, the grade of the existing embankments will be raised by as much as 1.5 m at the bridge abutments. The loading imposed by the additional fill will induce up to 35 mm of settlement, which may meet a tolerance level for the embankment settlement; however, periodic maintenance of the road will be required. The majority of the settlements will occur in the first six months following the fill placement.

In view of the soil conditions at this site, stability issues are not anticipated for the approach embankments.

## **17 CONSTRUCTION CONCERNS**

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

- Seasonal fluctuations of the groundwater and river water levels are to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall, which may impact the construction.
- Rock fill may be present as fill in the timber cribs, as well as occasional cobbles and boulders may be present in the existing embankment fill and native soils. Cobbles and boulders may interfere with excavations or installation of temporary protection system.

## 18 CLOSURE

Engineering analysis and preparation of the report were carried out by Ms. Anna Piascik, P.Eng. The report was reviewed by Mr. Alastair Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

### Thurber Engineering Ltd.

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Review Principal



**Appendix A**  
**Record of Borehole Sheets**

## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



### 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

### 5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level  
 Shear Strength Determination by Pocket Penetrometer

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

## EXPLANATION OF ROCK LOGGING TERMS


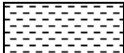



### ROCK WEATHERING CLASSIFICATION

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

### DISCONTINUITY SPACING

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

### SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

### STRENGTH CLASSIFICATION

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

### TERMS

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

# 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			

# RECORD OF BOREHOLE No BR-01

1 OF 4

METRIC

GWP# 5146-13-00 LOCATION Blanche River Bridge N 5 321 626.6 E 374 167.8 ORIGINATED BY AHF  
 HWY Local / Rosegrove Rd. BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2015.06.12 - 2015.06.13 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE				WATER CONTENT (%) w <sub>p</sub> w      w <sub>L</sub>				GR	SA	SI	CL
273.6	GROUND SURFACE							20	40	60	80	100							
0.0	<b>SAND</b> , trace to some silt, trace to some gravel, trace organics (roots and rootlets) Loose to Compact Brown Moist (FILL)		1	SS	7		273							○					
			2	SS	10									○					
			3	SS	4		272							○					
271.4																			
2.2	Silty <b>CLAY</b> and <b>SAND</b> , trace gravel, occasional oxidized silt seam Soft to Firm Brown to Grey		4	SS	6		271							○					
			5	SS	3									○					
							270							○					
269.5																			
4.1	<b>SAND</b> , some silt, some gravel, trace clay Very Loose Grey Wet		6	SS	1		269							○					
268.0							268												
5.6	Clayey <b>SILT</b> to silty <b>CLAY</b> , trace sand: (varved) Firm to Stiff Grey		7	SS	1									○					
							267												
								4.0											
			8	SS	1		266							○					
							265	3.5											
			9	SS	1									○					
							264												

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15  
 10  
 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BR-01

2 OF 4

METRIC

GWP# 5146-13-00 LOCATION Blanche River Bridge N 5 321 626.6 E 374 167.8 ORIGINATED BY AHF  
 HWY Local / Rosegrove Rd. BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2015.06.12 - 2015.06.13 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100						
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W <sub>p</sub> W W <sub>L</sub> WATER CONTENT (%) 20 40 60						
			10	SS	1		263	3.6						
							262	3.8						
			11	SS	1		261							0 0 54 46
							260	4.5						
			12	SS	1		259	2.5						
							258							
			13	SS	1		257	3.3						
							256							0 0 43 57
			14	SS	0		255							
							254	4.0						
			15	SS	1									

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BR-01

3 OF 4

METRIC

GWP# 5146-13-00 LOCATION Blanche River Bridge N 5 321 626.6 E 374 167.8 ORIGINATED BY AHF  
 HWY Local / Rosegrove Rd. BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2015.06.12 - 2015.06.13 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Continued From Previous Page		16	SS	0												
							253										
							252										
							251										
			17	SS	0		250									0 0 59 41	
							249										
							248										
			18	SS	2		247										
							246										
							245										
			19	SS	4		244									0 0 75 25	

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BR-01

4 OF 4

METRIC

GWP# 5146-13-00 LOCATION Blanche River Bridge N 5 321 626.6 E 374 167.8 ORIGINATED BY AHF  
 HWY Local / Rosegrove Rd. BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2015.06.12 - 2015.06.13 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page													
240.1			20	SS	2									
33.5	Sandy <b>SILT</b> , some clay Compact Grey Wet													
237.9			21	SS	21									0 32 58 10
35.7	End of sampling at 35.7m and start of DCPT.													
235.7														
37.9	END OF BOREHOLE AND DCPT AT 37.9m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.  WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2015.06.14 2.8 270.8 2015.06.27 1.7 271.9													

ONTMT4S 19-5161-252.GPJ 2015TEMPLATE(MTO).GDT 10/21/15

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15 10 5 0  
 (%) STRAIN AT FAILURE

## METRIC

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No BR-02

2 OF 4

METRIC

GWP# 5146-13-00 LOCATION Blanche River Bridge N 5 321 618.7 E 374 186.7 ORIGINATED BY ES  
 HWY Local / Rosegrove Rd. BOREHOLE TYPE NW Casing/Tricone/Dynamic Cone Penetration Test COMPILED BY MFA  
 DATUM Geodetic DATE 2015.08.06 - 2015.08.07 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
								20 40 60 80 100									20 40 60			
	Continued From Previous Page		8	SS	2		261	8.0 +					○							
			9	SS	2		260	8.0 +					○							
			10	SS	2		259	8.0 +					○							
			11	SS	2		258	9.0 +					○							
			12	SS	3		257	10.0 +					○							
			13	SS	2		256						○							
			14	SS	4		255	8.0 +					○							
							254						○							
							253	14.0 +												
252.4 19.3	SILT, some clay, trace sand Very Loose Grey Wet						252						○							

Continued Next Page

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

# RECORD OF BOREHOLE No BR-02

3 OF 4

METRIC

GWP# 5146-13-00 LOCATION Blanche River Bridge N 5 321 618.7 E 374 186.7 ORIGINATED BY ES  
 HWY Local / Rosegrove Rd. BOREHOLE TYPE NW Casing/Tricone/Dynamic Cone Penetration Test COMPILED BY MFA  
 DATUM Geodetic DATE 2015.08.06 - 2015.08.07 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				GR	SA	SI	CL
Continued From Previous Page								○ UNCONFINED      + FIELD VANE	w <sub>p</sub> w      w <sub>L</sub>								
								● QUICK TRIAXIAL      × LAB VANE									
251.1																	
20.5	Silty <b>CLAY</b> to Clayey <b>SILT</b> , trace sand: (varved) Firm to Stiff Grey		15	SS	1		251										
							250		9.0								
			16	SS	2												
							249										
									6.7								
							248										
							247										
			17	SS	7												
							246										
									8.0								
							245										
							244										
			18	SS	3												
							243										
									5.5								
							242										

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15  
 10  
 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BR-02

4 OF 4

METRIC

GWP# 5146-13-00 LOCATION Blanche River Bridge N 5 321 618.7 E 374 186.7 ORIGINATED BY ES  
 HWY Local / Rosegrove Rd. BOREHOLE TYPE NW Casing/Tricone/Dynamic Cone Penetration Test COMPILED BY MFA  
 DATUM Geodetic DATE 2015.08.06 - 2015.08.07 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
	Continued From Previous Page															
240.3																
31.3	GRAVEL, some sand, trace silt Compact Grey Wet		19	SS	28											85 14 1 (SI+CL)
238.3																
33.3	Gravelly SAND, some silt, some clay Very Dense Grey Moist (TILL)															
236.9			20	SS	107											25 44 31 (SI+CL)
34.7	End of sampling at 34.7m and start of DCPT.															
236.2																
35.4	END OF BOREHOLE AT 35.4m UPON DCPT REFUSAL. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE OF CREEK BED.															

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
15  
10  
5  
0  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BR-03

1 OF 4

METRIC

GWP# 5146-13-00 LOCATION Blanche River Bridge N 5 321 625.1 E 374 200.6 ORIGINATED BY ES  
 HWY Local / Rosegrove Rd. BOREHOLE TYPE NW Casing/Tricone COMPILED BY MFA  
 DATUM Geodetic DATE 2015.08.07 - 2015.08.08 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT		UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20    40    60    80    100	W <sub>P</sub> W      W <sub>L</sub>				
SHEAR STRENGTH kPa								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE		WATER CONTENT (%)			
271.6	RIVER SURFACE												GR   SA   SI   CL
0.0	<b>WATER</b>												
269.8													
1.8	<b>SAND</b> , some silt, trace clay, trace gravel, trace wood fibres Very Loose Brown Wet		1	SS	2								
	Clayey <b>SILT</b> to silty <b>CLAY</b> , trace sand, vavred Very Soft to Stiff Grey		2	SS	1								0   0   66   34
			3	SS	4								0   0   79   21
	Occasional silt seams		4	SS	3								
			5	SS	1								0   0   57   43
			6	SS	3								
			7	SS	1								
			8	SS	1								

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15  
 10  
 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BR-03

2 OF 4

METRIC

GWP# 5146-13-00 LOCATION Blanche River Bridge N 5 321 625.1 E 374 200.6 ORIGINATED BY ES  
 HWY Local / Rosegrove Rd. BOREHOLE TYPE NW Casing/Tricone COMPILED BY MFA  
 DATUM Geodetic DATE 2015.08.07 - 2015.08.08 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
			9	SS	0		261	9.0						
							260							
			10	SS	2		259	7.0						
							258	8.0						
			11	SS	3		257							
							256	10.0						
			12	SS	8		255	6.0						
							254							
			13	SS	3		253	6.7						
							252							
252.6			14	SS	6									
19.1	SILT, some sand, some clay													
252.0	Loose													
19.6	Grey													
	Wet													

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15  
 10  
 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BR-03

3 OF 4

METRIC

GWP# 5146-13-00 LOCATION Blanche River Bridge N 5 321 625.1 E 374 200.6 ORIGINATED BY ES  
 HWY Local / Rosegrove Rd. BOREHOLE TYPE NW Casing/Tricone COMPILED BY MFA  
 DATUM Geodetic DATE 2015.08.07 - 2015.08.08 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)									
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE													
	Continued From Previous Page							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>						
	Silty <b>CLAY</b> to Clayey <b>SILT</b> , trace sand, occasional silt seams: (varved) Firm Grey		15	SS	2		251														
									9.0												
			16	SS	0		250														
							249		7.0												
							248														
							247														
			17	SS	7																
245.9							246		10.0												
25.7	<b>SILT</b> , some sand, trace clay Compact Grey Wet																				
							245														
							244														
			18	SS	20													0	4	91	5
							243														
							242														

Continued Next Page

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

## METRIC

ELEV. DEPTH	SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT  W <sub>P</sub>	NATURAL MOISTURE CONTENT  W	LIQUID LIMIT  W <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100					
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100					
	Continued From Previous Page											kN/m <sup>3</sup>	GR SA SI CL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL MOISTURE      LIQUID CONTENT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE				w <sub>p</sub> w      w <sub>L</sub>				
	Continued From Previous Page							20	40	60	80	100				
	occasional sand and clay seams						241									
		19	SS	9			240									
239.8																
31.8	GRAVEL, some sand, trace silt Compact Grey Wet															
		20	SS	26			239									
238.3																
33.4	SAND, trace gravel, trace silt Dense Brown Wet						238									
		21	SS	44												
236.8							237									
34.8	END OF BOREHOLE AT 34.8m UPON TRICONE REFUSAL. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE OF CREEK BED.				0.050											

ONTMT4S 19-5161-252.GPJ 2015TEMPLATE(MTO).GDT 10/21/15

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No BR-04

1 OF 4

METRIC

GWP# 5146-13-00 LOCATION Blanche River Bridge N 5 321 619.6 E 374 214.8 ORIGINATED BY AHF  
 HWY Local / Rosegrove Rd. BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2015.06.13 - 2015.06.13 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
274.6	GROUND SURFACE							20 40 60 80 100						
0.0	TOPSOIL: (75mm)							20 40 60 80 100						
0.1	Clayey <b>SILT</b> to silty <b>CLAY</b> , trace sand, trace organics (roots and rootlets in upper 0.5m zone): (varved) Soft to Stiff Brown to 0.5m depth then Grey		1	SS	3		274							
			2	SS	2		273							0 0 24 76
			3	SS	2		272							
	becoming grey		4	SS	5		271							
			5	SS	1		270							0 0 76 24
			6	SS	0		269							
			7	SS	0		268							
			8	SS	0		267							0 0 52 48
			9	SS	0		266							
							265							

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15  
 10  
 (%) STRAIN AT FAILURE

## METRIC

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No BR-04

3 OF 4

METRIC

GWP# 5146-13-00 LOCATION Blanche River Bridge N 5 321 619.6 E 374 214.8 ORIGINATED BY AHF  
 HWY Local / Rosegrove Rd. BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2015.06.13 - 2015.06.13 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100						
			16	SS	1									
							254		3.3					
							253							
							252							
			17	SS	0		251		2.6					
							250							
							249							
			18	SS	0		248							
							247		2.2					
							246							
			19	SS	1		245							

Continued Next Page

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

RECORD OF BOREHOLE No BR-04

4 OF 4

METRIC

GWP# 5146-13-00 LOCATION Blanche River Bridge N 5 321 619.6 E 374 214.8 ORIGINATED BY AHF  
 HWY Local / Rosegrove Rd. BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2015.06.13 - 2015.06.13 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
	Continued From Previous Page															
244.1																
30.5	END OF BOREHOLE AT 30.5m. WATER LEVEL AT 2.9m UPON COMPLETION.															

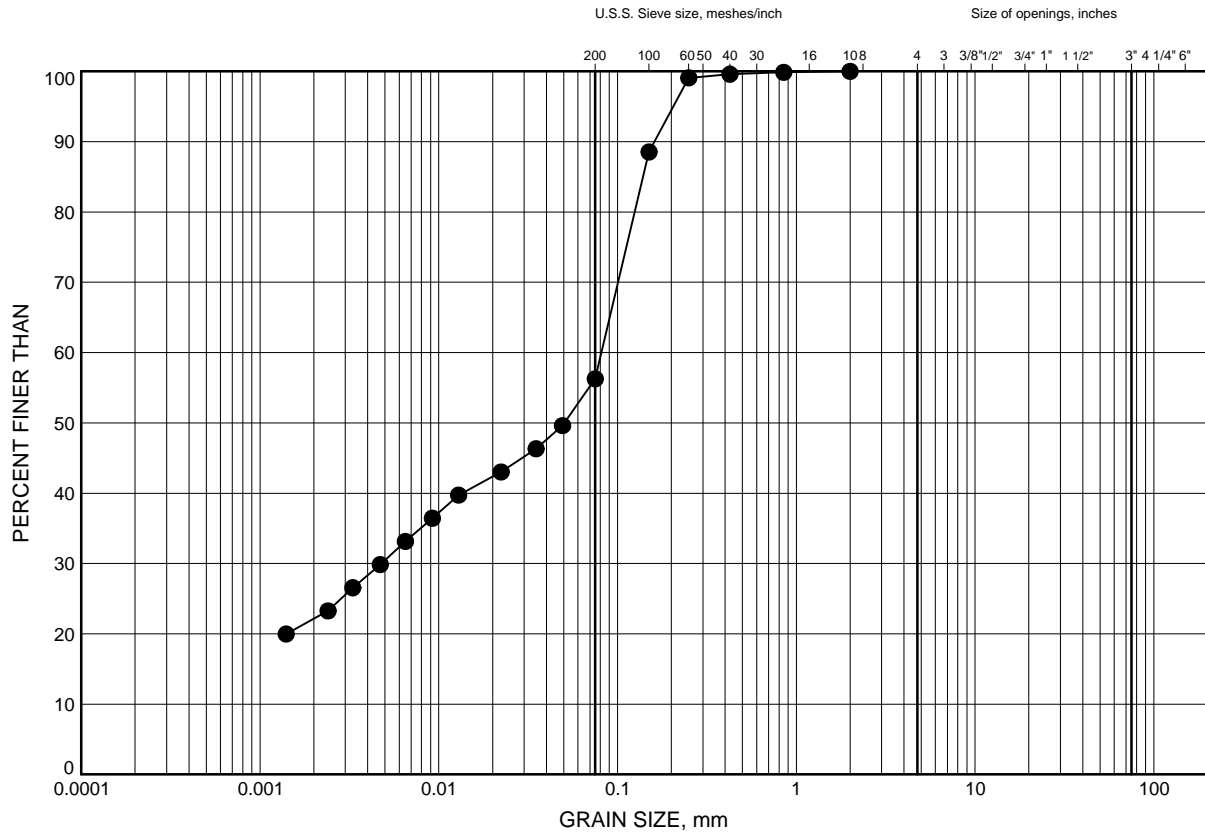
## **Appendix B**

### **Geotechnical and Analytical Laboratory Test Results**

# Blanche River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B1

## Silty CLAY and SAND



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR-01	3.35	270.25

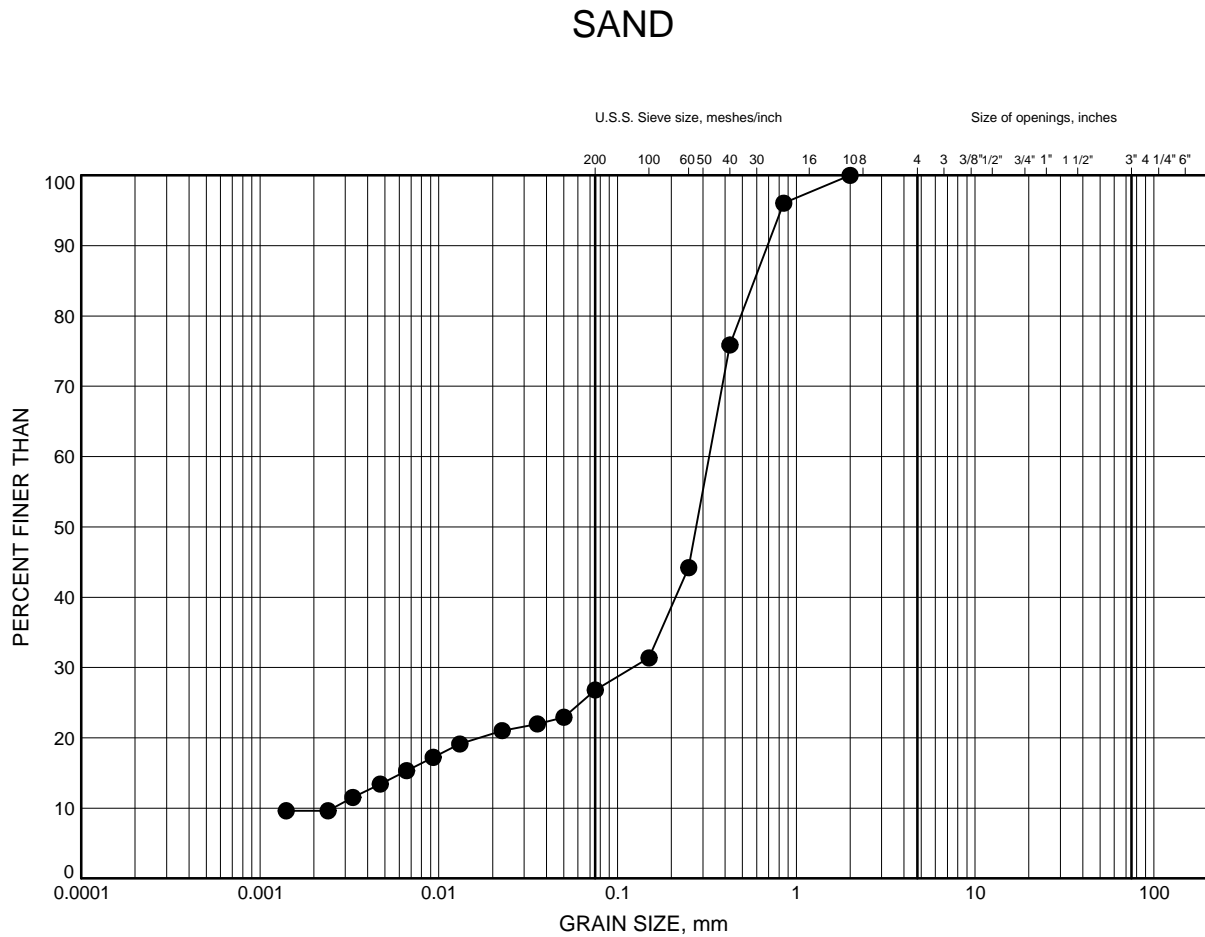
Date October 2015  
GWP# 5146-13-00



Prep'd AN  
Chkd. AMP

# Blanche River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B2



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR-02	2.54	269.10

Date October 2015  
GWP# 5146-13-00

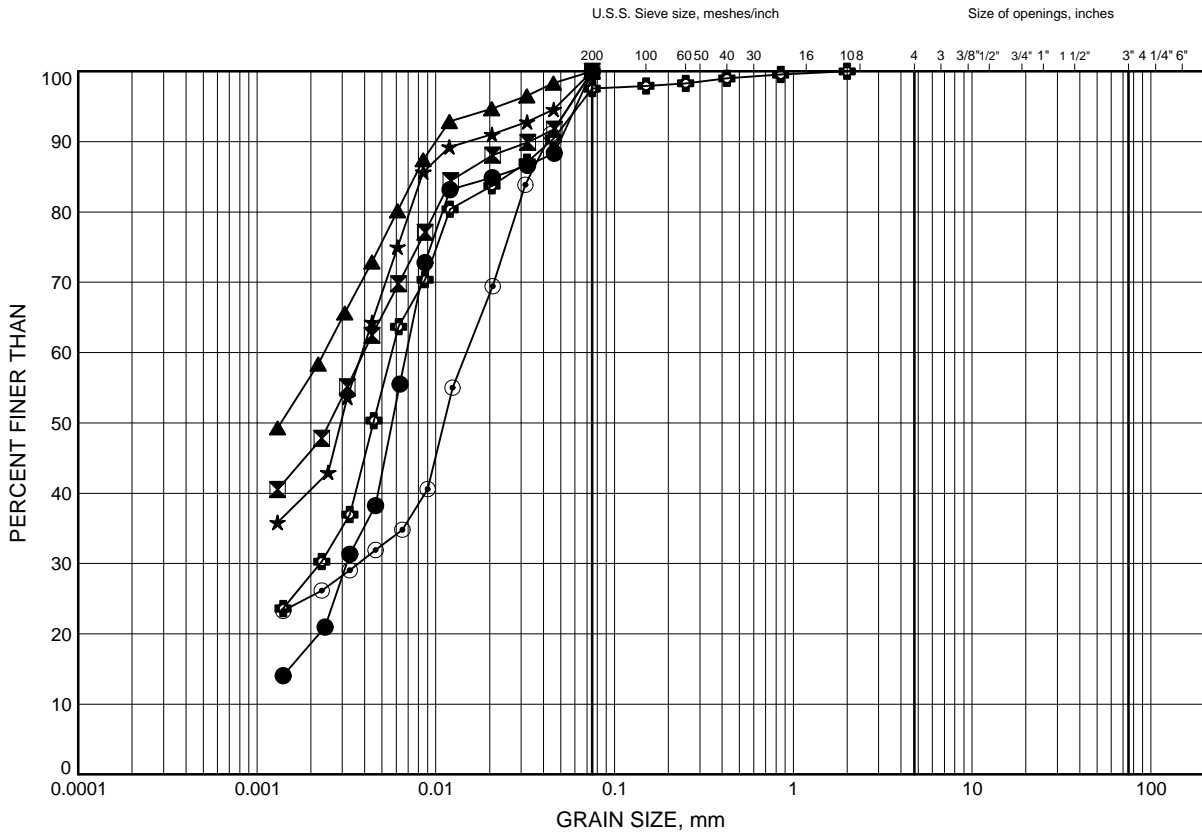


Prep'd AN  
Chkd. AMP

# Blanche River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B3

## Clayey SILT to Silty CLAY



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR-01	6.40	267.20
⊠	BR-01	12.50	261.10
▲	BR-01	17.07	256.53
★	BR-01	23.16	250.44
⊙	BR-01	29.26	244.34
⊕	BR-02	4.82	266.81

Date October 2015

GWP# 5146-13-00



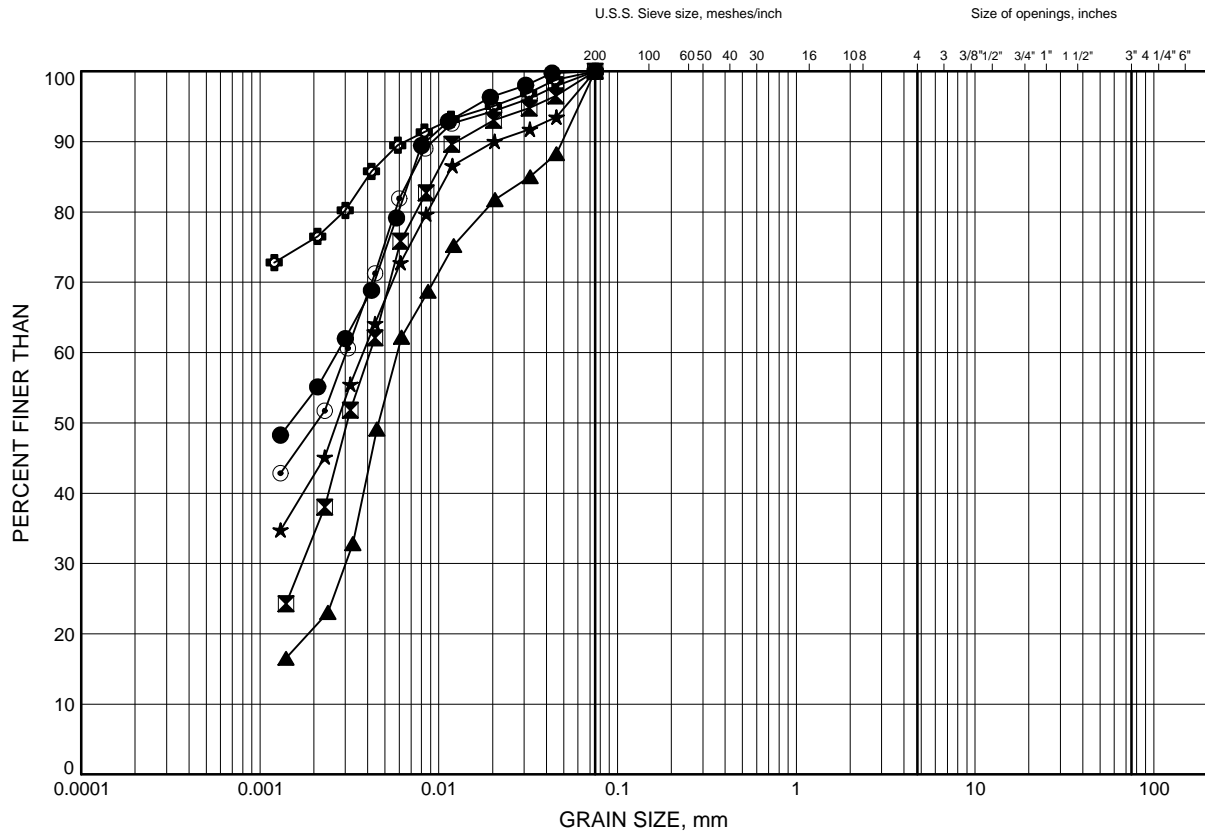
Prep'd AN

Chkd. AMP

# Blanche River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B4

## Clayey SILT to Silty CLAY



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR-02	16.25	255.38
⊠	BR-03	2.87	268.76
▲	BR-03	3.63	268.00
★	BR-03	5.16	266.48
⊙	BR-03	17.35	254.28
⊕	BR-04	1.07	273.53

Date ..October 2015.....

GWP# ..5146-13-00.....



Prep'd .....AN.....

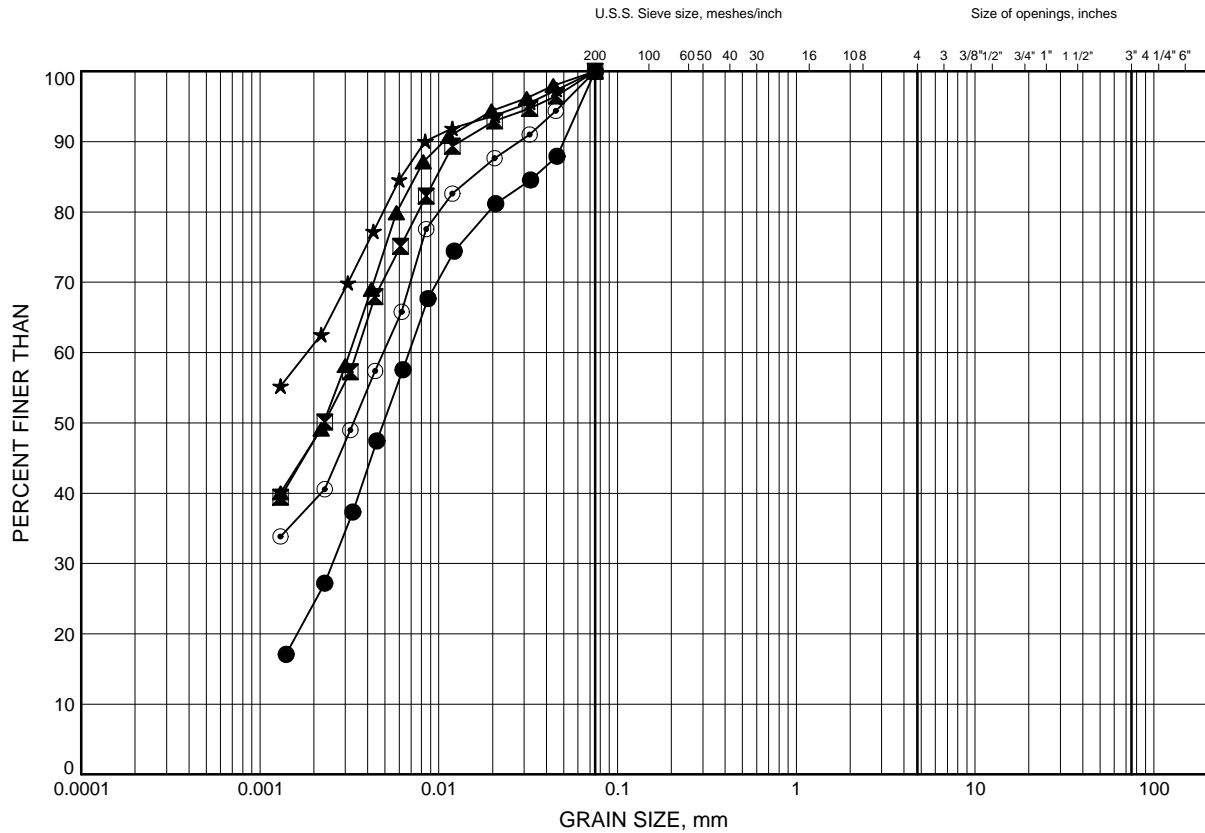
Chkd. ....AMP.....

# Blanche River Bridge

## GRAIN SIZE DISTRIBUTION

FIGURE B5

### Clayey SILT to Silty CLAY



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR-04	4.88	269.72
⊠	BR-04	7.92	266.68
▲	BR-04	10.97	263.63
★	BR-04	15.54	259.06
⊙	BR-04	23.16	251.44

Date ..October 2015.....

GWP# ..5146-13-00.....



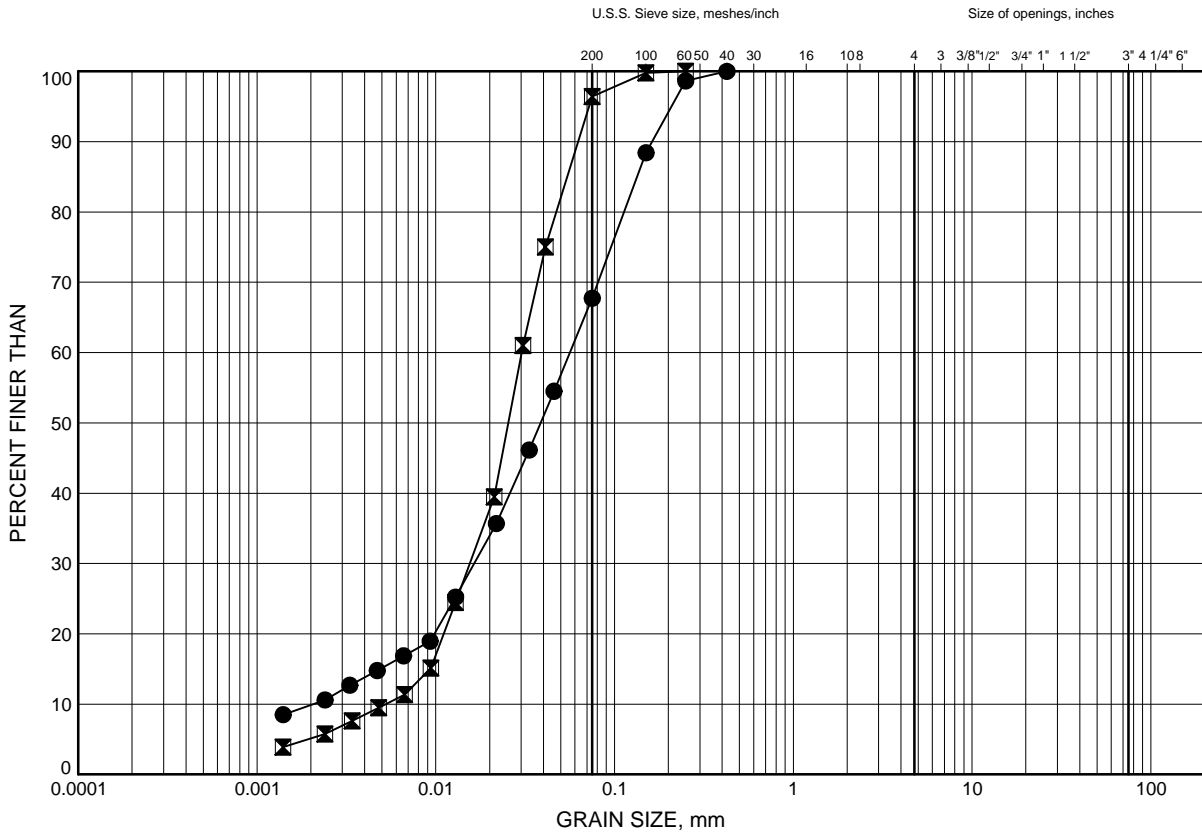
Prep'd .....AN.....

Chkd. ....AMP.....

# Blanche River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B6

## SILT to Sandy SILT



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR-01	35.36	238.24
⊠	BR-03	28.02	243.62

Date ..October 2015.....

GWP# ..5146-13-00.....



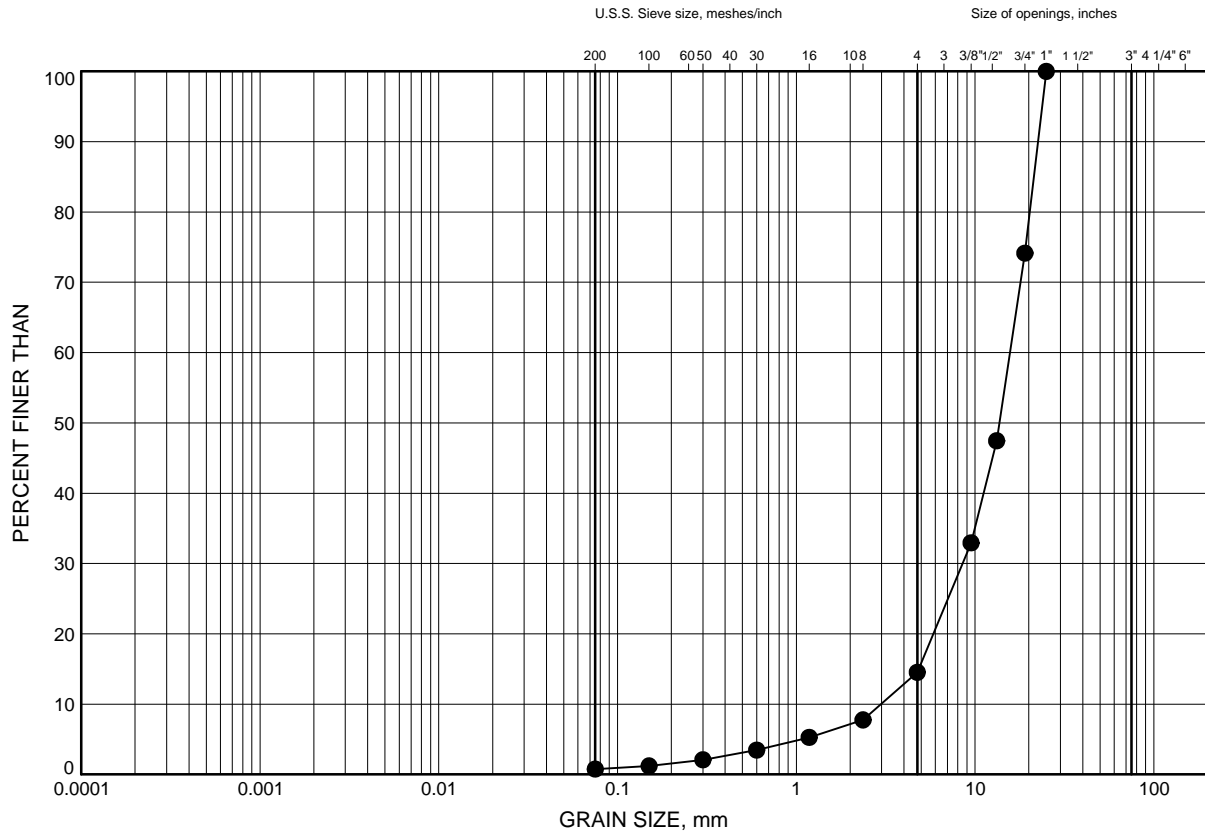
Prep'd .....AN.....

Chkd. ....AMP.....

# Blanche River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B7

## GRAVEL



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR-02	31.55	240.09

Date ..October 2015.....

GWP# ..5146-13-00.....



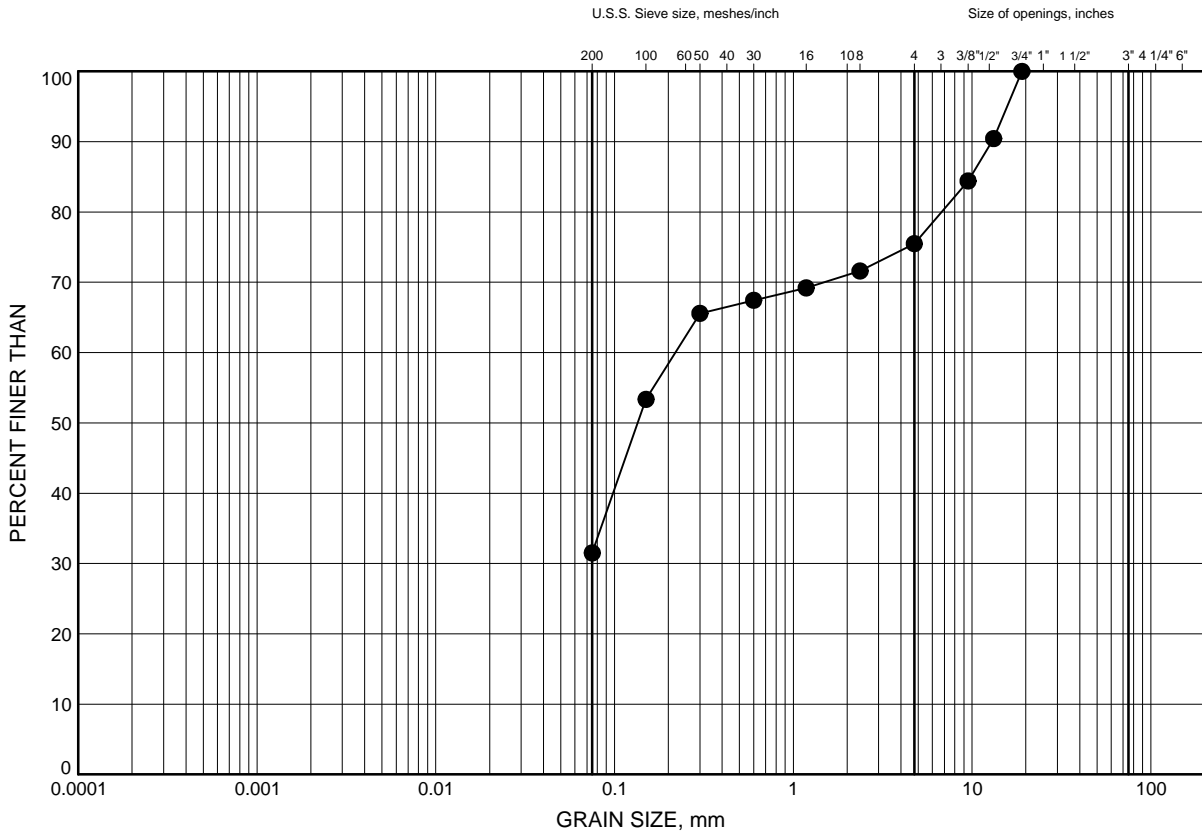
Prep'd .....AN.....

Chkd. ....AMP.....

# Blanche River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B8

## Gravelly SAND TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR-02	34.52	237.12

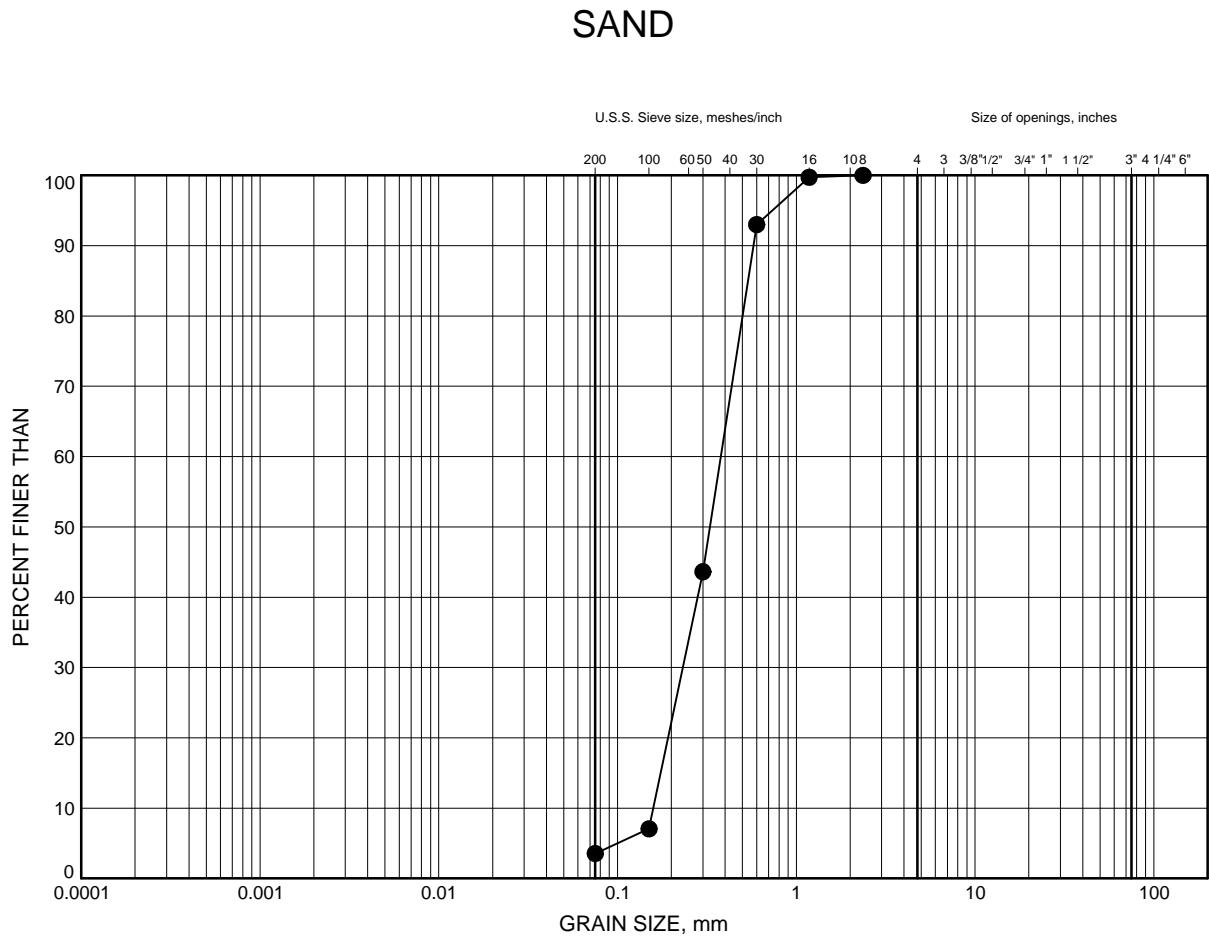
Date October 2015  
GWP# 5146-13-00



Prep'd AN  
Chkd. AMP

# Blanche River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B9



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR-03	34.13	237.51

Date October 2015  
GWP# 5146-13-00

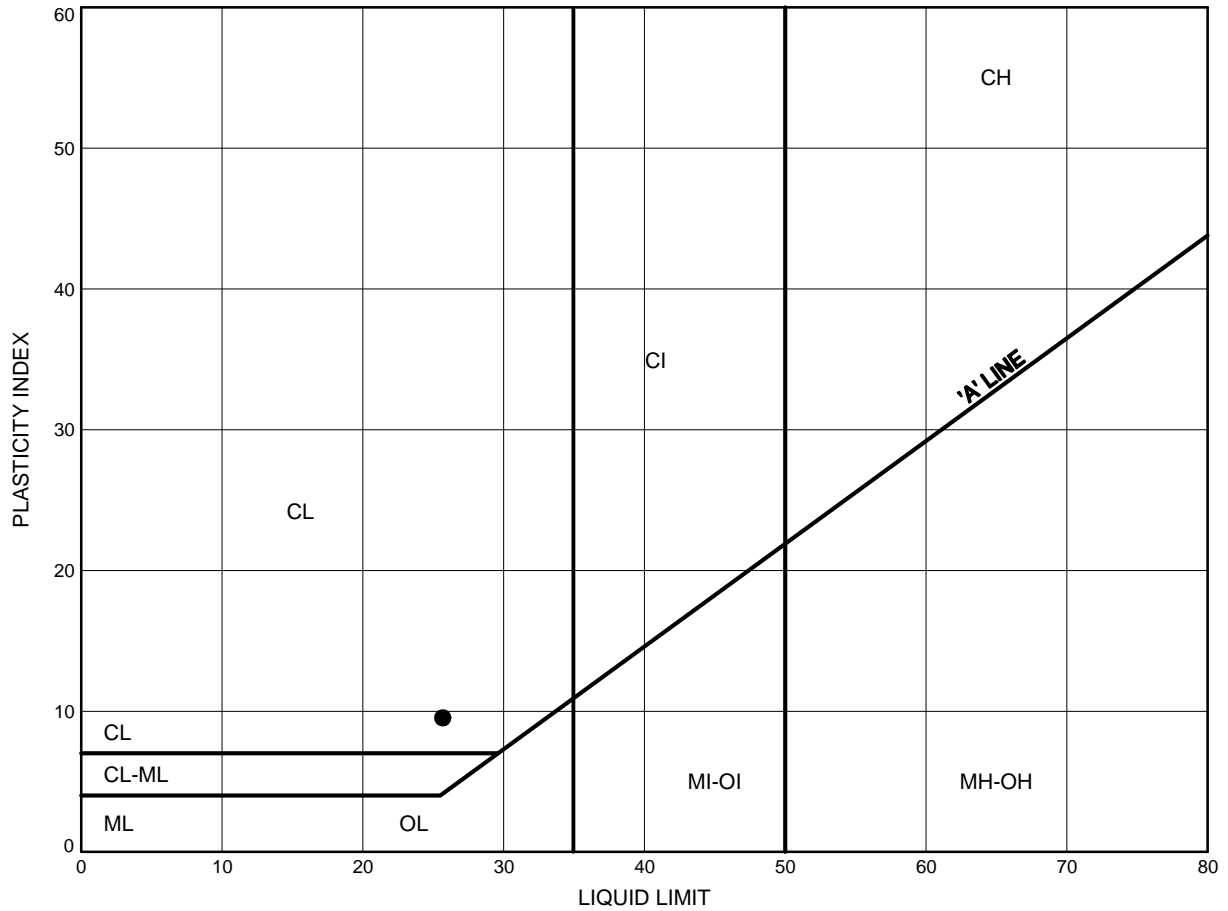


Prep'd AN  
Chkd. AMP

Blanche River Bridge  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B10

Silty CLAY and SAND



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR-01	3.35	270.25

Date October 2015  
 GWP# 5146-13-00

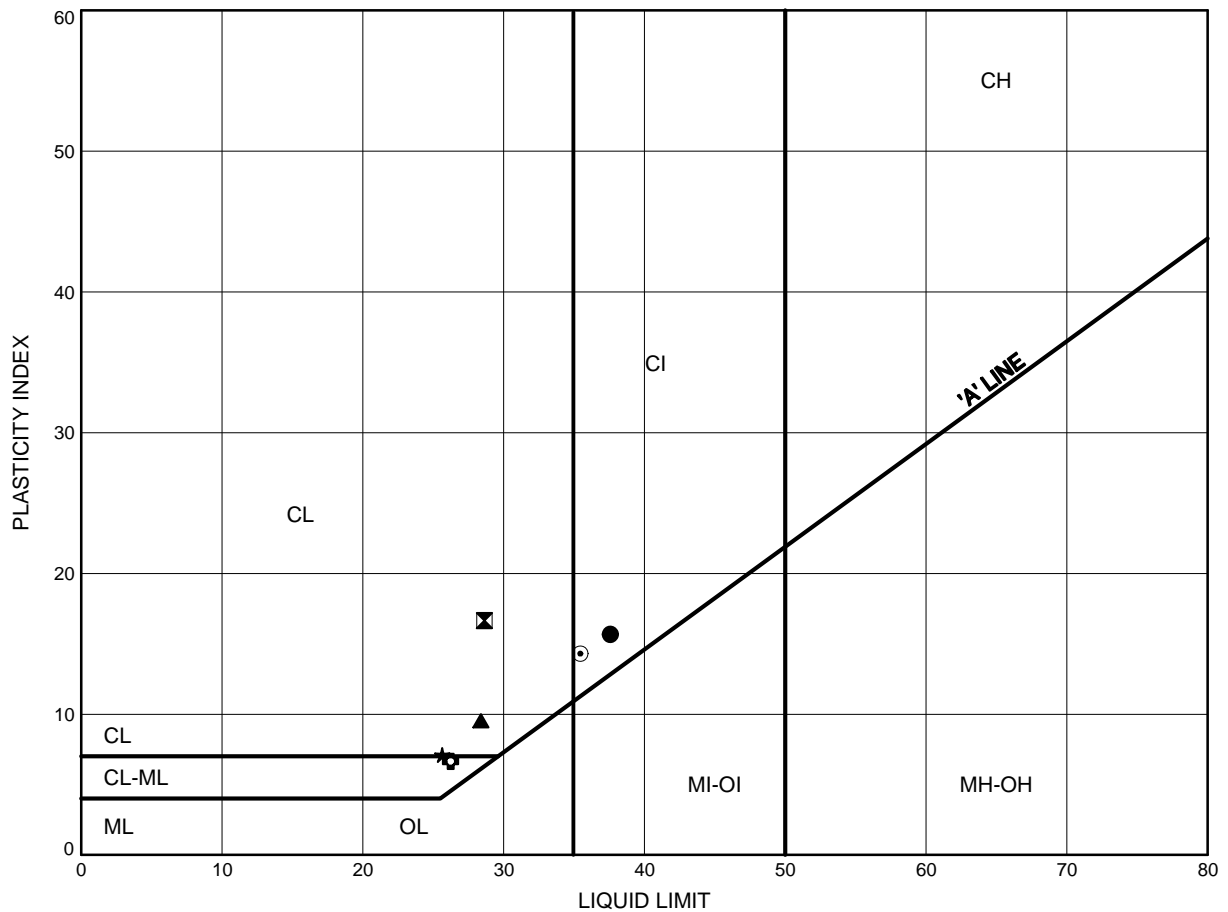


Prep'd AN  
 Chkd. AMP

# Blanche River Bridge ATTERBERG LIMITS TEST RESULTS

FIGURE B11

Clayey SILT to Silty CLAY



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR-01	12.50	261.10
⊠	BR-01	17.07	256.53
▲	BR-01	23.16	250.44
★	BR-02	4.82	266.81
⊙	BR-02	16.25	255.38
⊕	BR-03	2.87	268.76

Date ..October 2015.....

GWP# ..5146-13-00.....



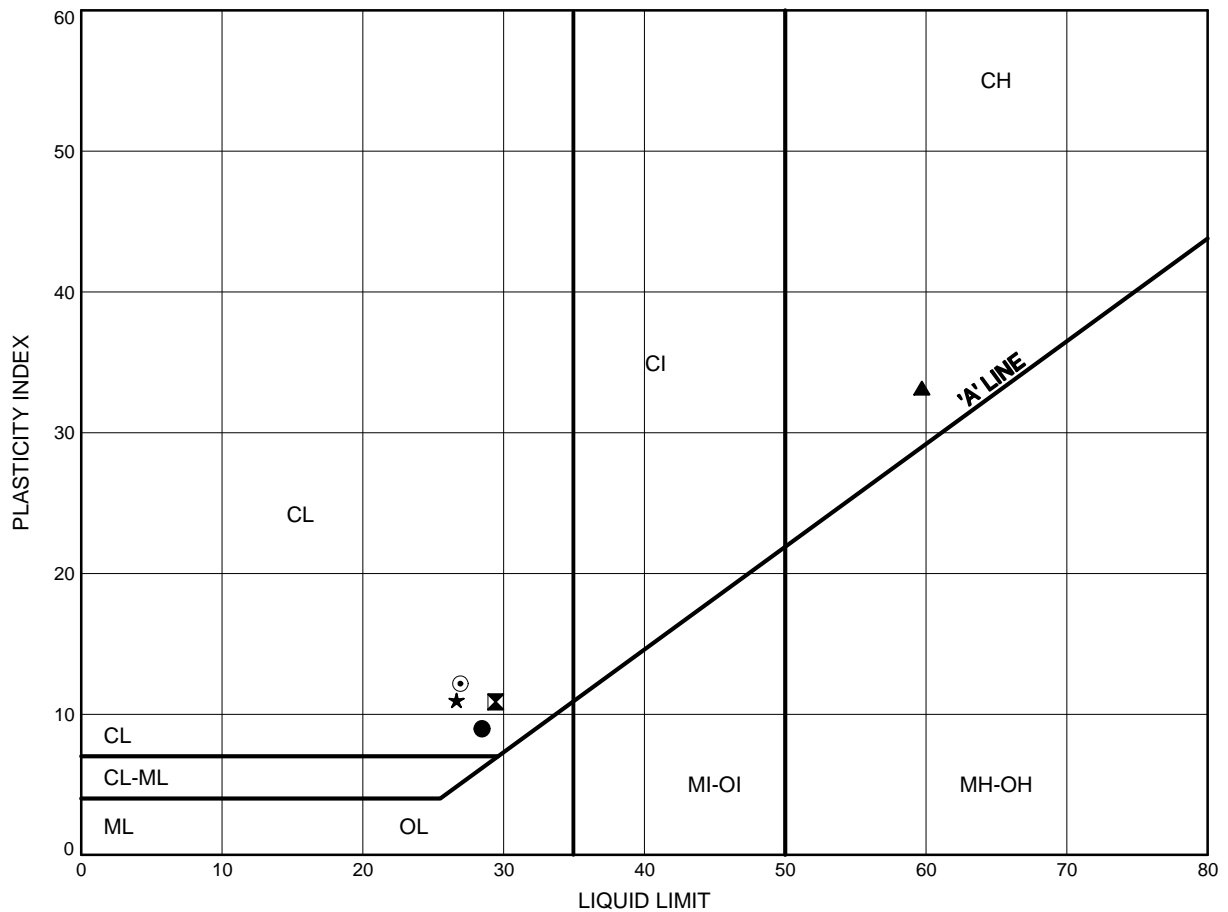
Prep'd .....AN.....

Chkd. ....AMP.....

# Blanche River Bridge ATTERBERG LIMITS TEST RESULTS

FIGURE B12

Clayey SILT to Silty CLAY



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR-03	5.16	266.48
⊠	BR-03	17.35	254.28
▲	BR-04	1.07	273.53
★	BR-04	7.92	266.68
⊙	BR-04	10.97	263.63

Date October 2015  
GWP# 5146-13-00



Prep'd AN  
Chkd. AMP

CLIENT NAME: THURBER ENGINEERING LTD  
SUITE 103, 2010 WINSTON PARK DRIVE  
OAKVILLE, ON L6H5R7  
(905) 829-8666

ATTENTION TO: Deanna Pizycki

PROJECT: Temiskaming Structures

AGAT WORK ORDER: 15T015408

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Coordinator

DATE REPORTED: Sep 10, 2015

PAGES (INCLUDING COVER): 5

VERSION\*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

\*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



**AGAT** Laboratories

## Certificate of Analysis

AGAT WORK ORDER: 15T015408

PROJECT: Temiskaming Structures

5835 COOPERS AVENUE  
MISSISSAUGA, ONTARIO  
CANADA L4Z 1Y2  
TEL (905)712-5100  
FAX (905)712-5122  
<http://www.agatlabs.com>

CLIENT NAME: THURBER ENGINEERING LTD

SAMPLING SITE:

ATTENTION TO: Deanna Pizycki

SAMPLED BY:DP

### Corrosivity Package

DATE RECEIVED: 2015-09-04

DATE REPORTED: 2015-09-10

SAMPLE DESCRIPTION: BR-4 SS3 5'-7'

SAMPLE TYPE: Soil

DATE SAMPLED: 9/4/2015

Parameter	Unit	G / S	RDL	6934351
Sulfide	%		0.01	0.02
Chloride (2:1)	µg/g		2	29
Sulphate (2:1)	µg/g		2	47
pH (2:1)	pH Units		NA	7.98
Electrical Conductivity (2:1)	mS/cm		0.005	0.222
Resistivity (2:1)	ohm.cm		1	4500
Redox Potential (2:1)	mV		5	234

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

6934351 \* Sulphide analyses were performed at AGAT Laboratories Vancouver.

EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

Certified By:

*Amanjot Bhela*



## Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD

PROJECT: Temiskaming Structures

SAMPLING SITE:

AGAT WORK ORDER: 15T015408

ATTENTION TO: Deanna Pizycki

SAMPLED BY: DP

### Soil Analysis

RPT Date: Sep 10, 2015			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Corrosivity Package															
Sulfide	6934556		0.13	0.11	16.7%	< 0.01	97%	80%	120%						
Chloride (2:1)	6934351	6934351	29	33	12.9%	< 2	98%	80%	120%	92%	80%	120%	99%	70%	130%
Sulphate (2:1)	6934351	6934351	47	48	2.1%	< 2	99%	80%	120%	103%	80%	120%	94%	70%	130%
pH (2:1)	6934351	6934351	7.98	8.06	1.0%	NA	101%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	6934351	6934351	0.222	0.230	3.5%	< 0.005	93%	90%	110%	NA			NA		
Redox Potential (2:1)	6934351	6934351	234	240	2.5%	< 5	103%	70%	130%	NA			NA		

Comments: NA signifies Not Applicable.

Certified By:

*Amanjot Bhela*

## Method Summary

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 15T015408

PROJECT: Temiskaming Structures

ATTENTION TO: Deanna Pizycki

SAMPLING SITE:

SAMPLED BY:DP

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Sulfide			GRAVIMETRIC
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential (2:1)		McKeague 4.12 & SM 2510 B	REDOX POTENTIAL ELECTRODE



## Certificate of Analysis

CLIENT NAME: THURBER ENGINEERING LTD

PROJECT: 19-5161-252

SAMPLING SITE:

AGAT WORK ORDER: 15T004153

ATTENTION TO: Deanna Pizycki

SAMPLED BY:

Inorganic Chemistry (Water)							
SAMPLE TYPE: Water		SAMPLE ID: 6825041			DATE RECEIVED: Aug 06, 2015		
DATE SAMPLED: Jul 28, 2015				DATE REPORTED: Aug 13, 2015			
SAMPLE DESCRIPTION: Blanche River							
PARAMETER	UNIT	RESULT	G / S	RDL	DATE ANALYZED	INITIAL	DATE PREPARED
pH	pH Units	7.44		NA	Aug 10, 2015	BP	Aug 10, 2015
Langelier Index		-0.85			Aug 11, 2015	SYS	Aug 11, 2015
Total Dissolved Solids	mg/L	76		20		AP	Aug 10, 2015
Alkalinity (as CaCO3)	mg/L	50		5	Aug 10, 2015	BP	Aug 10, 2015
Total Hardness (as CaCO3)	mg/L	59.7		0.5	Aug 11, 2015	SYS	Aug 11, 2015
Chloride	mg/L	13.4		0.10	Aug 07, 2015	JC	Aug 07, 2015
Sulphate	mg/L	11.8		0.10	Aug 07, 2015	JC	Aug 07, 2015
Sulphide	mg/L	<0.05		0.05	Aug 11, 2015	SN	Aug 11, 2015
Resistivity	ohms.cm	5880			Aug 10, 2015	SYS	Aug 10, 2015
Redox Potential	mV	308		5	Aug 12, 2015	BG	Aug 12, 2015

COMMENTS:

RDL - Reported Detection Limit; G / S - Guideline / Standard

Certified By:



## **Appendix C**

### **Site Photographs**



**Photograph 1 – South Elevation, looking southeast**



**Photograph 2 – North Elevation, looking northwest**



**Photograph 3 – East Pier**



**Photograph 4 – West Pier**



**Photograph 5 –West Gabion Basket at West Abutment**

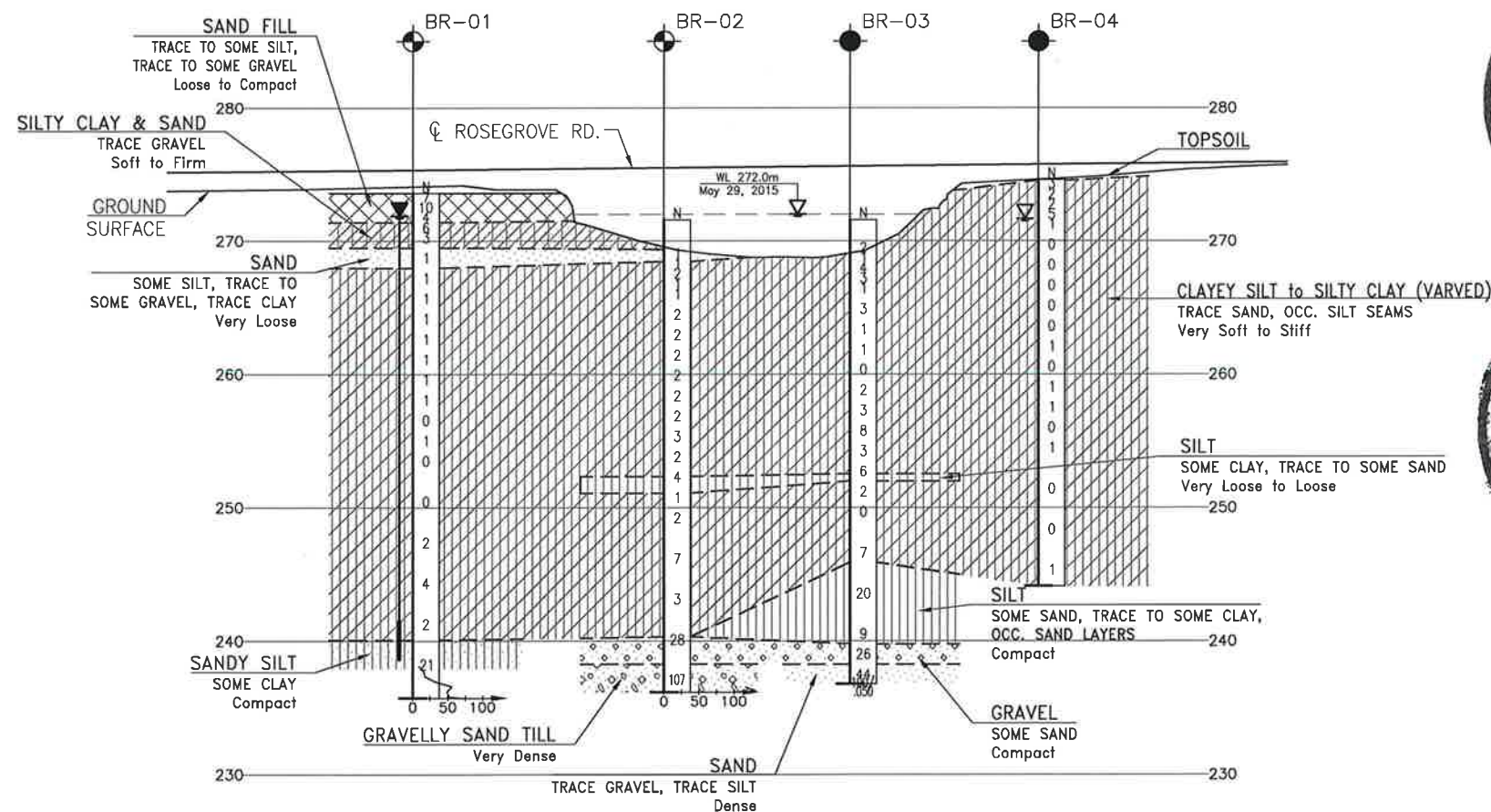
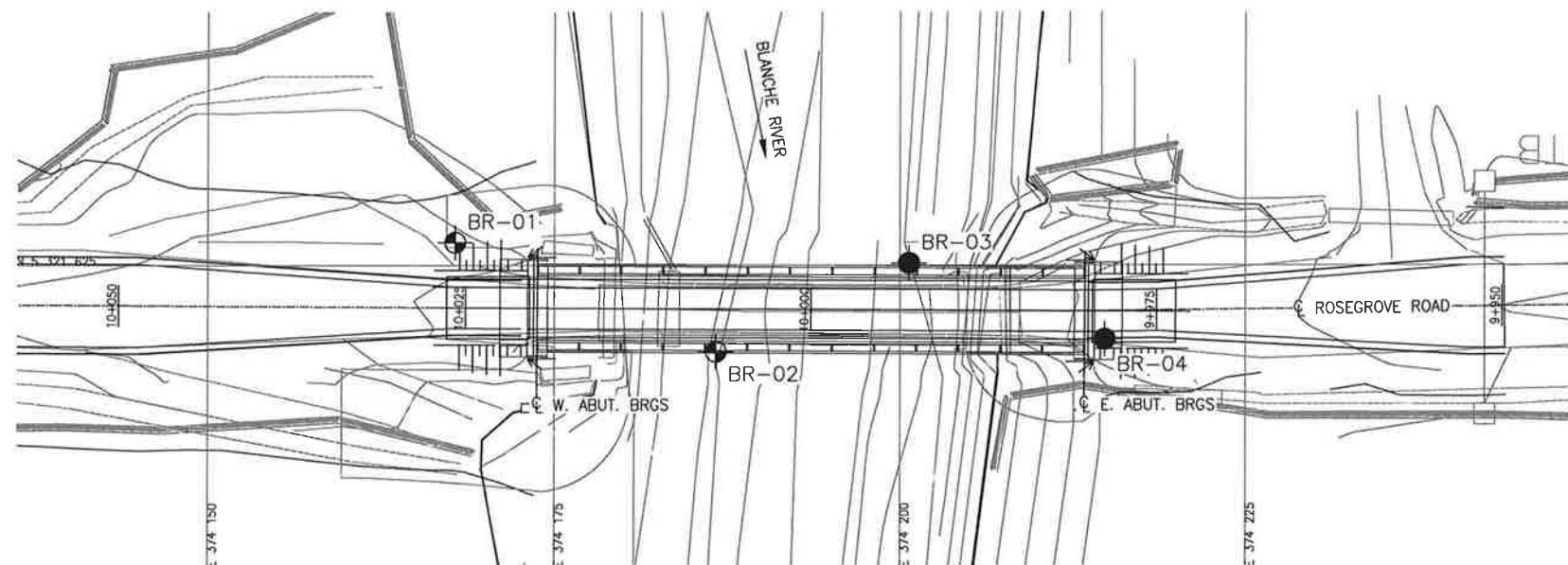


**Photograph 6 – East Abutment/Timber Crib**



**Photograph 7 – West approach looking east**

**Appendix D**  
**Borehole Locations and Soil Strata Drawing**



PROFILE ALONG  $\phi$  ROSEGROVE ROAD



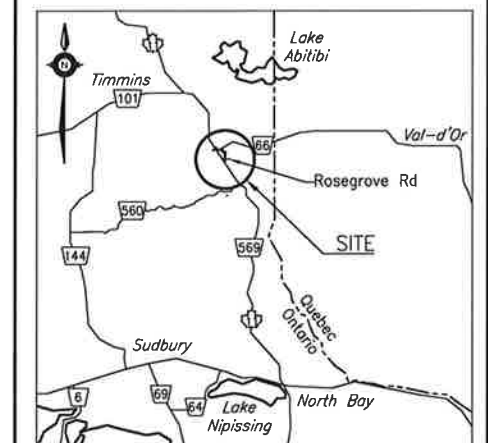
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
GWP No 5146-13-00

BLANCHE RIVER  
BRIDGE  
REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

MMM GROUP

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
BR-01	273.6	5 321 626.6	374 167.8
BR-02	271.6	5 321 618.7	374 186.7
BR-03	270.9	5 321 625.1	374 200.6
BR-04	274.6	5 321 619.6	374 214.8

-NOTES-

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

GEOCREs No. 42A-105

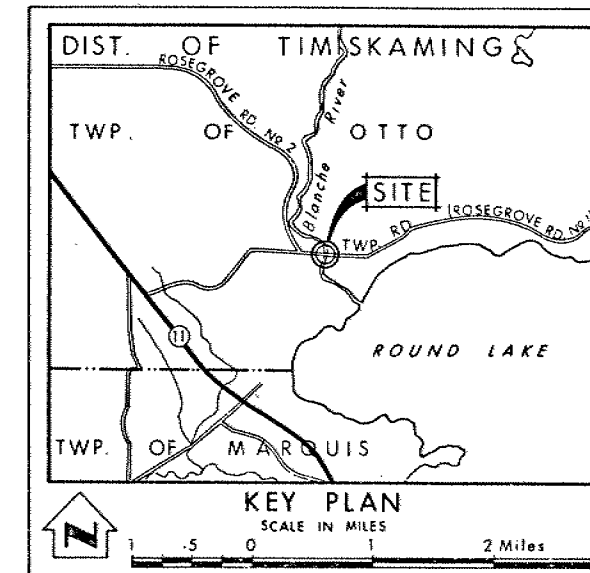
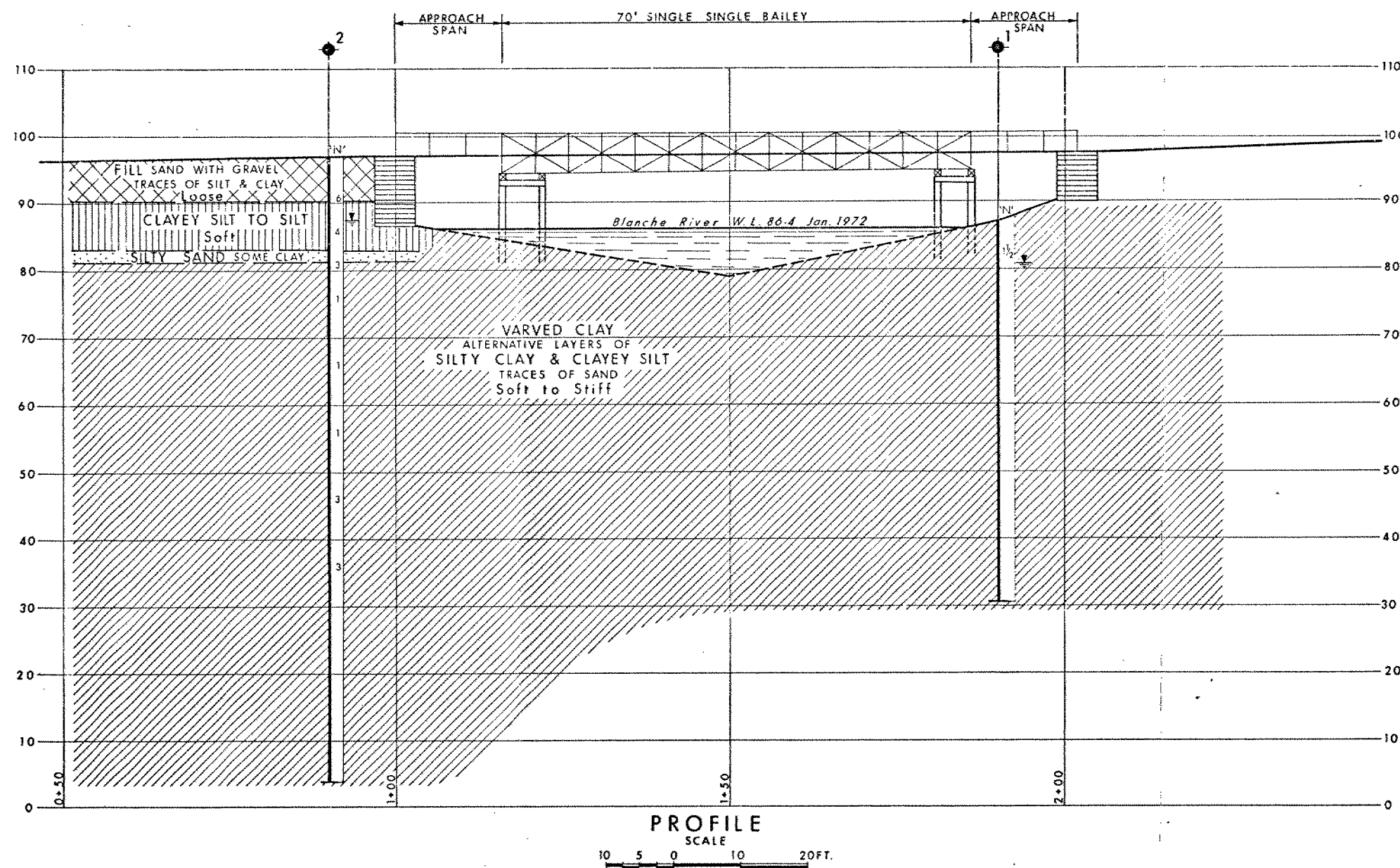
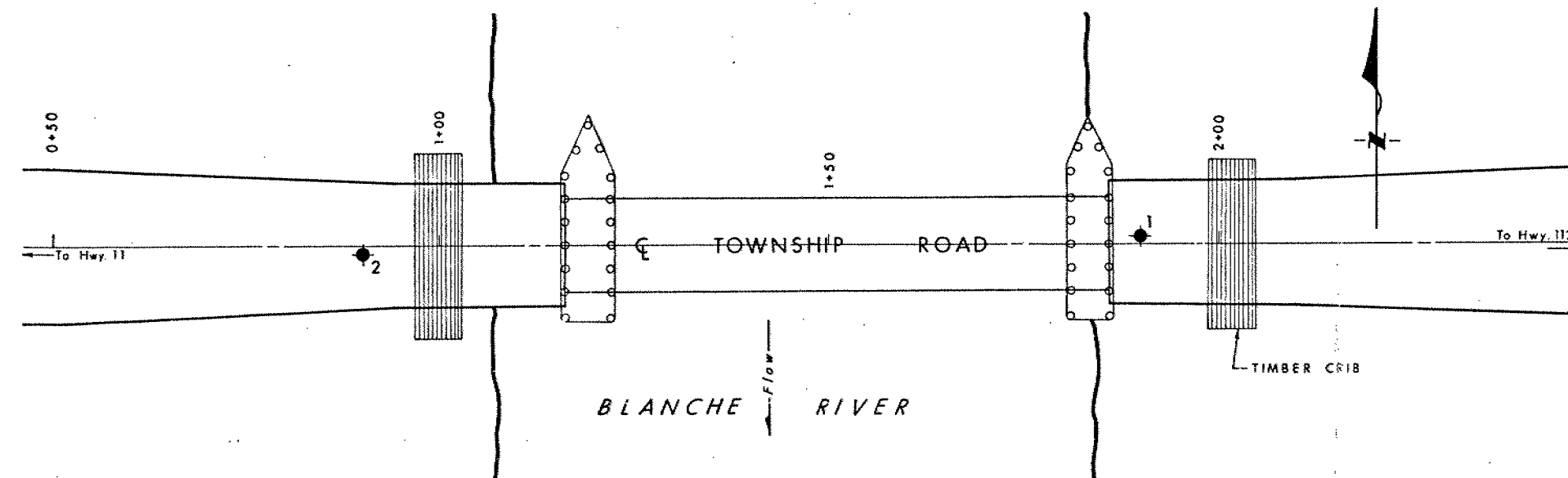
REVISIONS	DATE	BY	DESCRIPTION
DESIGN	DJP	CHK MEF	CODE
DRAWN	MFA	CHK DJP	SITE 47-085
			STRUCT
			DWG 1

FILENAME: H:\Drawing\47\5161\252\4752-Plan&Profile(BlancheRiverBridge).dwg  
PLOTDATE: 4/10/2016 2:20 PM

**Appendix E**

**Factual Data from 1972 Foundation Investigation Report**

**Geocres No.: 42A-23**



LEGEND			
	Bore Hole		
	Cone Penetration Test		
	Bore Hole & Cone Test		
	Water Levels established at time of field investigation, Jan. 1972		
NO.	ELEVATION	STATION	OFFSET
1	87.2	1+90	1' LT.
2	97.1	0+90	1' RT.

— NOTE —  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISIONS	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION & COMMUNICATIONS DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE			
<b>BLANCHE RIVER</b>			
HIGHWAY NO. <u>TOWNSHIP ROAD</u>		DIST. NO. <u>14</u>	
DIST. OF <u>TIMISKAMING</u>			
TWP. <u>OTTO</u>		LOT <u>5</u>	CON. <u>I &amp; II</u>
<b>BORE HOLE LOCATIONS &amp; SOIL STRATA</b>			
SUBMD P. P.	CHECKED	W.P. NO.	DRAWING NO.
DRAWN	CHECKED	JOB NO. <u>72-11008(R)</u>	<b>72-11008A</b>
DATE <u>April 4, 1972</u>	SITE NO.	BRIDGE DRAWING NO.	
APPROVED	CONT. NO.		
PRINCIPAL FOUNDATION ENGINEER			


DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

# RECORD OF BOREHOLE No. 1

FOUNDATION SECTION

JOB 72-11008 (R) LOCATION Sta. 1 + 90 o/s 1' Lt.  
W.P. Nil BORING DATE Jan. 12, 1972  
DATUM Temporary BOREHOLE TYPE Cont. Flight Auger

ORIGINATED BY PP  
COMPILED BY PP  
CHECKED BY *SL*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			BULK DENSITY $\gamma$ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.		WATER CONTENT %					
87.2	Ground Level						1000	2000						
0.0	Varved Clay  alternate layers of  silty clay and  clayey silt   trace of sand    Soft to Firm.		1	SS	1 1/2	80	+5.0							0 1 76 23 807  108  112.5  107.5  107  112  0 1 57 42
			2	TW	PH	70	+ 9.3							
			3	TW	PH	60	+ 9.0							
			4	TW	PH	50	+6.6							
			5	TW	PH	40	+9.0							
30.7			6	TW	PH	30	+ 9.6							
56.5	End of Borehole													

20  
15-5 % STRAIN AT FAILURE  
10

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 72-11008 (R) LOCATION Sta. 0 + 90 o/s 1' Rt.

ORIGINATED BY PP

W.P. Nil BORING DATE Jan. 12, 1972

COMPILED BY PP

DATUM Temporary BOREHOLE TYPE Cont. Flight Auger

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — $w_L$		BULK DENSITY $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT		PLASTIC LIMIT — $w_p$			
							SHEAR STRENGTH P.S.F.		WATER CONTENT — $w$			
97.1	Ground Level					1000	2000					
0.0	Sand with gravel traces of silt & clay.											
90.1	Loose (Fill)		1	SS	6							32 64 ( 4 )
7.0	Clayey silt to silt		2	SS	4							87.4
83.1	Soft											
81.3	Silty sand, some clay		3	SS	3							0 65 25 10
15.8	Silty Clay		4	SS	1							
	and											
	Clayey Silt		5	SS	1							
	Traces of Sand											
	Firm to Stiff		6	SS	1							
	(Varved)											
			7	SS	3							
			8	SS	3							0 2 61 37
11.1												
93.0	End of Borehole											

20  
15-5 % STRAIN AT FAILURE  
10

## **Appendix F**

### **List of SPs and OPSS, and Suggested Text for Selected NSSP**

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

- OPSS.PROV 501
- OPSS 539
- OPSS 804
- OPSS 902
- OPSS 903
- OPSS.PROV 1010

**2. Suggested text for NSSP on “Installation of Roadway Protection System”**

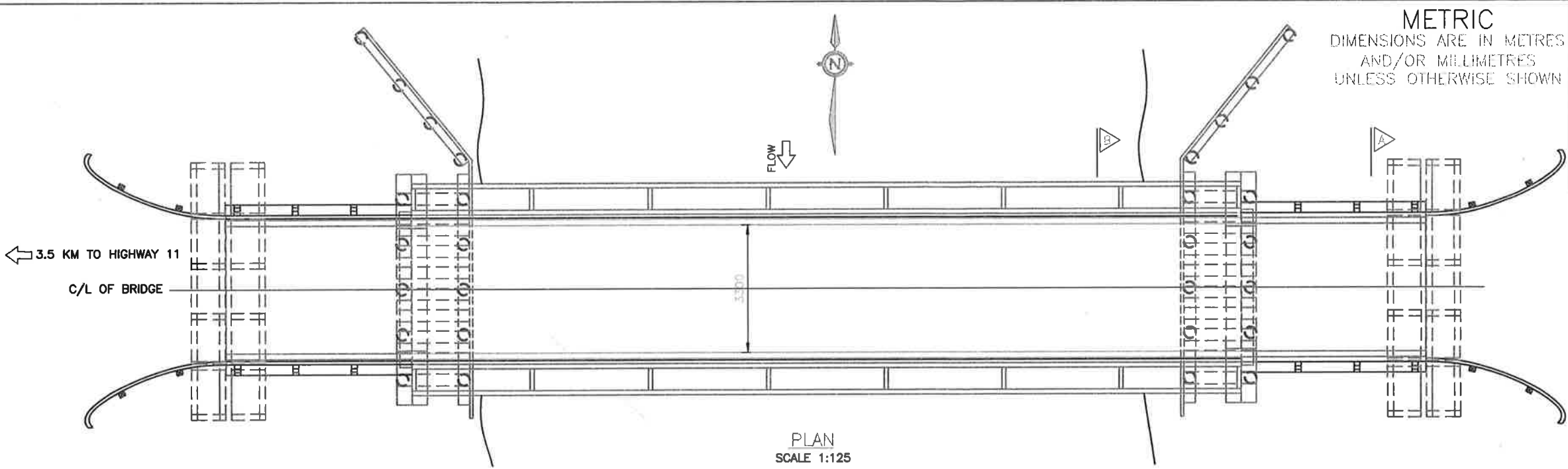
Cobbles and boulders may be present within the existing embankment fill and underlying native soils at this site. These cobbles and boulders may impede the installation of the roadway protection system. At some locations, the installation may not be able to penetrate the obstructions and reach the design depth. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the protection system to the design depth.

## **Appendix G**

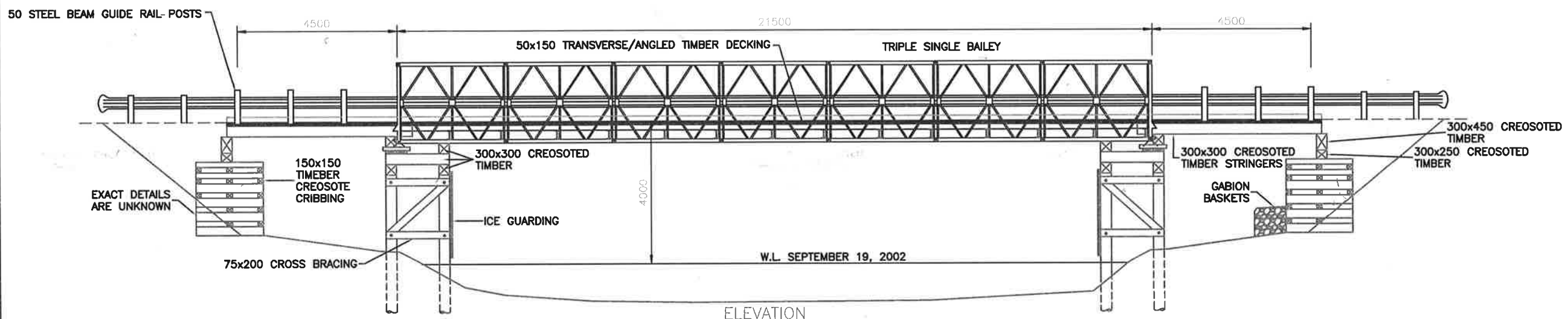
### **Blanche River General Arrangement Drawing, February 2003**

UNIVERSITY OF TRANSWALD, ORANGE  
PA-1-707  
15/01/03

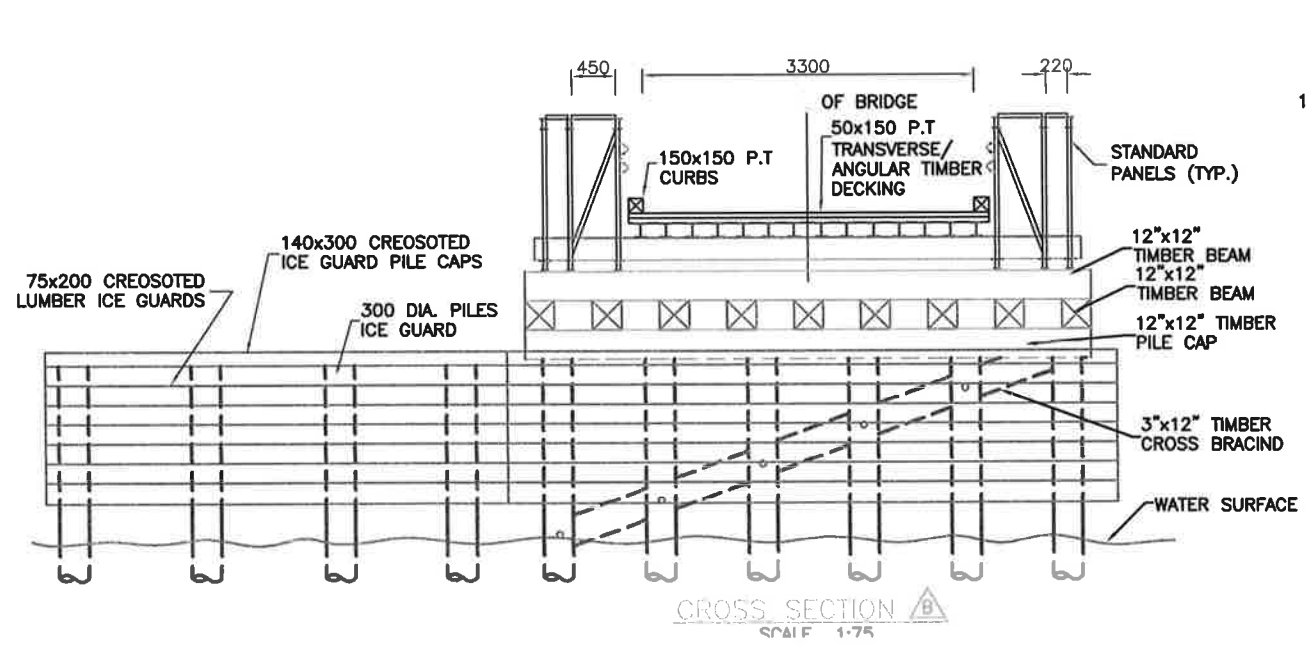
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CREATED:  
1:800/17/20  
20/03/02/05  
15/01/03



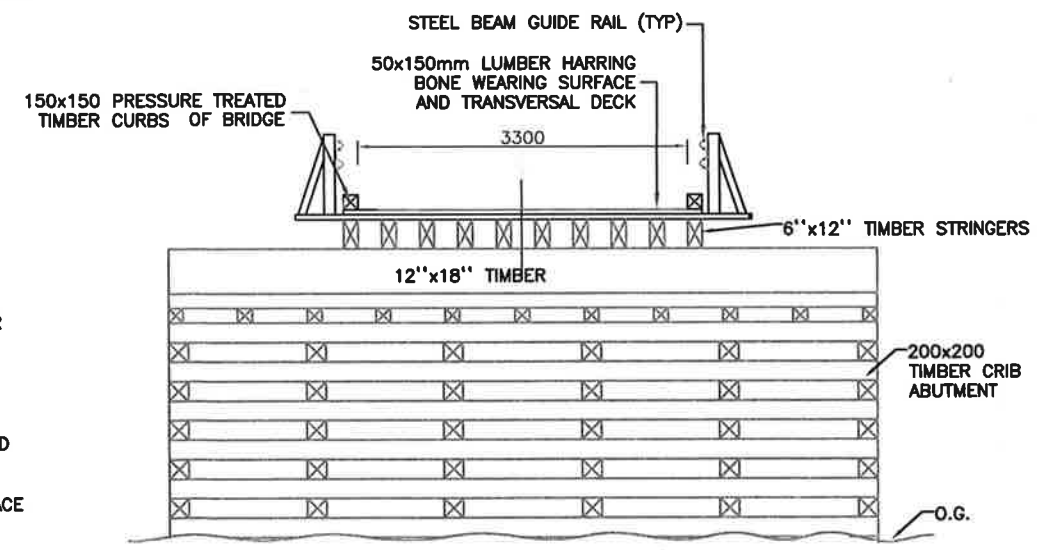
PLAN  
SCALE 1:125



ELEVATION  
SCALE 1:125



CROSS SECTION A  
SCALE 1:75



CROSS SECTION B  
SCALE 1:75

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

DIST 53  
NEW LISKEARD  
BOURKES LOCAL ROADS BOARD

GENERAL ARRANGEMENT  
47-85 BLANCHE RIVER  
3.5KM EAST OF HWY 11  
AND ROSEGROVE RD INT.

SHEET  
1

NOTES:  
1. INFORMATION REGARDING THIS STRUCTURE  
WAS COLLECTED ON SEPTEMBER 19, 2002

REVISIONS		DESCRIPTION			
NO.	DATE	BY	CHK	CODE	LOAD
1	FEB 2003	J.W.	S.D.	SITE 47-85	DWG 1