

**FOUNDATION INVESTIGATION REPORT
BUG RIVER BRIDGE REPLACEMENT
HIGHWAY 105, RED LAKE DISTRICT, ONTARIO
G.W.P. 6942-10-00, SITE 41N-2**

Geocres Number: 52K-8

Report to

GENIVAR

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

October 16, 2012
File: 19-5308-40

H:\19\5308\40 NWR 11 Bridge 3 Culvert Rehabs\Reports &
Memos\Bug River Bridge\Bug River Bridge FIR - FINAL.doc

TABLE OF CONTENTS

PART 1 FACTUAL INFORMATION

1	INTRODUCTION	1
2	SITE DESCRIPTION	1
3	SITE INVESTIGATION AND FIELD TESTING	2
4	LABORATORY TESTING	4
5	DESCRIPTION OF SUBSURFACE CONDITIONS	4
5.1	Pavement structure.....	5
5.2	Sand and Gravel Fill	5
5.3	Silty Clay	6
5.4	Sand	6
5.5	Layer of Organic clayey silt/silty clay	7
5.6	Sandy Silt.....	8
5.7	Silty Sand	8
5.8	Bedrock.....	9
5.9	Water Levels	10
6	MISCELLANEOUS.....	11

Appendices

Appendix A	Record of Borehole Sheets (current investigation)
Appendix B	Laboratory Test Results
Appendix C	Report from previous investigation (1956)
Appendix D	Site Photographs
Appendix E	Foundation ComparisonBorehole Locations and Soil Strata Drawings

**FOUNDATION INVESTIGATION REPORT
BUG RIVER BRIDGE REPLACEMENT
HIGHWAY 105, RED LAKE DISTRICT, ONTARIO
G.W.P. 6942-10-00, SITE 41N-2**

Geocres Number: 52K-8

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the location of a proposed bridge replacement carrying Highway 105 over Bug River. The existing Bug River bridge is approximately 9.8 km south of Highway 125 in the Red Lake 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 and sections, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

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

- Report on a Foundation Investigation for The Bug River Bridge, Highway No. 105, Red Lake District, Ontario, dated June 6, 1956 by Racey, MacCallum & Associates Ltd. (Reference 1).

The previous report is included in Appendix C for reference.

Thurber carried out the investigation as a sub-consultant to GENIVAR, under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0027.

2 SITE DESCRIPTION

The Bug River Bridge is located on Highway 105, approximately 9.8 km south of Highway 125 and 25 km north of Snake Falls, in the Red Lake District, Ontario.

Highway 105 is a two-lane paved road. The existing structure consists of a six-span bridge with a concrete and timber deck which was built in 1958. Each span is approximately 6 m long, for a total bridge length of 37 m. The width of the existing bridge is 9.8 m. The concrete wing walls, deck, curbs, approach slabs, and barrier walls were replaced in 1989.



At this location, Bug River flows from south to north into Gullrock Lake. As noted on the preliminary General Arrangement drawing (GA) provided by GENIVAR, the water level in the Bug River was measured at elevation 355.7 m in May 2011.

The lands immediately surrounding the bridge site consist primarily of forested areas. Immediately to the northwest of the bridge, the land consists of a low lying area with swamp vegetation.

Selected photographs in Appendix D show the general nature of the surrounding land and the existing bridge structure. Photos of the site indicate presence of rock fill on the forward and side slopes below the existing abutments. It is not confirmed if this rockfill is for erosion control purposes or whether the embankments contain rockfill.

The site is located within the Red Lake District, which is underlain by Archean rocks of the Superior Province of the Canadian Shield. Based on bedrock geology maps published by the Ontario Geological Survey, the site is located in an area that is underlain by felsic to intermediate metavolcanic rocks. Locally, the overburden consists primarily of silt and sand deposits.

3 SITE INVESTIGATION AND FIELD TESTING

The approximate locations of the boreholes drilled for the current investigation are shown on the attached Borehole Locations and Soil Strata Drawing included in Appendix E. The boreholes were drilled behind the existing abutment locations. The latest General Arrangement (GA) drawing shows that the proposed abutments are located about 3.0 m to 4.0 m in front of the existing abutments. The borehole locations were marked in the field and utility clearances were obtained prior to drilling.

The site investigation and field testing for this project were carried out from August 7 to 9, 2011 and consisted of drilling and sampling six boreholes (identified as BUG-01 to BUG-06) and performing one Dynamic Cone Penetration Test (DCPT). All boreholes, as well as the DCPT, were advanced through the highway embankments at the existing bridge site. Boreholes BUG-01 and BUG-06 were drilled at the north and south approaches, respectively and were terminated at depths of 10.8 m and 11.3 m (elevations 347.9 and 347.6). Boreholes BUG-02 and BUG-03 were drilled near the north abutment while Boreholes BUG-04 and BUG-05 were drilled near the south abutment. Boreholes BUG-02 to BUG-05 were advanced within the overburden to depths ranging from 12.9 m to 14.0 m (elevations 345.9 to 344.8). Bedrock was proved in Boreholes BUG-02 and BUG-05 by NQ size diamond coring. Borehole BUG-02 was advanced 2.7 m into bedrock and terminated at a depth of 16.4 m (elevation 342.2). Borehole BUG-05 was advanced 3.7 m into bedrock and terminated at a depth of 17.7 m (elevation 341.2). Boreholes BUG-03 and BUG-04 were terminated upon auger refusal on probable bedrock or boulders at 13.4 m and 12.9 m depth, (elevations 345.3 and 345.9), respectively.

Borehole BUG-03 was supplemented by a DCPT conducted adjacent to the borehole. The DCPT was conducted from 1.5 m to 13.3 m depth (elevations 357.2 to 345.4). The DCPT was terminated upon refusal.

Three boreholes (BH 1, BH 2, and BH 3) were advanced at this site for the 1956 foundation investigation (Reference 1). The borehole logs of the previous investigation are included in Appendix C. These boreholes were advanced to depths of approximately 13.7 m to 16.3 m. Boreholes BH 1 and BH 2 were drilled on the north and south sides of the river and BH 3 was drilled through the bridge deck in the middle of the river. There is insufficient data in the 1956 foundation report to determine the exact locations and ground elevations of these boreholes. However, the subsurface conditions encountered in these 3 boreholes appear to correlate well with the subsurface conditions encountered in the 6 boreholes drilled for the current investigation.

The drilling was carried out from the highway grade using a CME 75 truck-mounted drill rig. A combination of hollow-stem augers, NW casing and NQ coring methods were used to advance the boreholes. Overburden samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

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.

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

Groundwater conditions were observed in the open boreholes during the drilling operations. One standpipe piezometer, consisting of 19 mm diameter PVC pipe with a slotted screen, was installed at each abutment and enclosed in filter sand to permit longer term groundwater level monitoring. The boreholes were backfilled with bentonite holeplug in general accordance with O.Reg. 903 upon completion. The locations and completion details of the boreholes and piezometers are presented in Table 3.1.

Table 3.1 – Borehole Abandonment Details

Location	Borehole	Piezometer Tip Depth/ Elevation (m)	Abandonment Details
North approach	BUG-01	None installed	Backfilled with bentonite holeplug from 10.8 m to 1.9 m, sand from 1.9 m to 0.2 m, then asphalt to surface.
North abutment	BUG-02	None installed	Backfilled with bentonite holeplug from 16.4 m to 1.8 m, auger cuttings from 1.8 m to 0.6 m, sand from 0.6 m to 0.3 m, then asphalt to surface.
	BUG-03	13.4 / 345.3	Piezometer with 1.5 m slotted screen installed with sand filter to 11.1 m, bentonite holeplug from 11.1 m to 2.6 m, auger cuttings from 2.6 m to 0.6 m, sand from 0.6 m to 0.3 m, then cement to surface. Flushmount casing protector installed.
South Abutment	BUG-04	12.2 / 346.6	Piezometer with 1.5 m slotted screen installed with sand filter from 12.2 m to 10.0 m, bentonite holeplug from 10.0 m to 2.2 m, auger cuttings from 2.2 m to 0.6 m, sand from 0.6 m to 0.3 m, then cement to surface. Flushmount casing protector installed.
	BUG-05	None installed	Backfilled with bentonite holeplug from 17.7 m to 1.6 m, auger cuttings from 1.6 m to 0.3 m, then cement to surface.
South approach	BUG-06	None installed	Backfilled with bentonite holeplug from 11.3 m to 1.5 m, auger cuttings from 1.5 m to 0.1 m, then concrete to surface.

The piezometers will be decommissioned in accordance with O. Reg. 903 prior to the end of 2012.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to gradation analysis (hydrometer and sieve) and Atterberg Limits tests, where appropriate. The results of these tests are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

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

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil and rock stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing included in Appendix E. 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.

In general terms, the overburden soil stratigraphy encountered at this site consists of sand and gravel fill overlying native layers of sand and sandy silt to silty sand. Silty clay was encountered below the fill and above the sandy silt to silty sand in both approach boreholes. A 0.6 m to 1.4 m thick layer of organic clayey silt/silty clay was encountered at the south abutment. The overburden is underlain by highly to moderately weathered metamorphic bedrock of gneissic structure. More detailed descriptions of the individual strata are presented below.

5.1 Pavement structure

Pavement structure was encountered in all the boreholes drilled at this site. The boreholes were drilled through the existing Highway 105 lanes. The pavement structure consists of approximately 125 mm to 150 mm of asphalt overlying granular fill.

5.2 Sand and Gravel Fill

Granular fill consisting of sand and gravel containing trace silt and clay and occasional cobbles was encountered below the asphalt in all the boreholes. The thickness of the granular fill ranges from 2.8 m to 3.8 m, with the base of the granular fill encountered at depths ranging from 2.9 to 4.0 m (elevations 354.9 to 356.0).

SPT N-values recorded in the sand and gravel fill ranged from 3 to 49 blows for 0.3 m penetration, indicating a loose to dense relative density. Typically, the higher SPT 'N' values were recorded near the ground surface.

The moisture contents of samples of the sand and gravel fill ranged from 2% to 22%. Typically, the moisture content of the granular fill was less than 5%.

Two samples of the granular fill were selected for laboratory gradation analysis, the results of which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and the grain size distribution curves for these samples are plotted on Figure B1 of Appendix B.

Soil Particles	Percentage (%)
Gravel	36
Sand	57 to 59
Silt and Clay	5 to 7

As indicated earlier, rockfill is visible on the forward and side slopes below the existing abutments. It is not confirmed if this rockfill is for erosion protection purposes or whether the embankment below and in front of the abutments were constructed with rockfill. No boreholes were drilled in these areas, where rockfill is visible in the sideslopes below the

abutments. It must be recognized that embankment fills are heterogeneous in nature and may contain obstructions such as boulders or rockfill.

5.3 Silty Clay

Silty clay was encountered below the granular fill in Boreholes BUG-01, BUG-04, and BUG-06. The silty clay contains trace sand and occasional rootlets. The thickness of the silty clay ranges from 0.9 m to 3.1 m, with the base of the silty clay encountered at depths of 4.3 to 6.1 m (elevations 352.6 to 354.5).

SPT N-values recorded in the silty clay ranged from 5 to 7 blows for 0.3 m penetration, indicating a firm consistency.

The moisture contents of samples of the silty clay ranged from 22% to 32%.

Two samples of the silty clay were selected for laboratory gradation analysis, the results of which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and the grain size distribution curves for these samples are plotted on Figure B2 of Appendix B. One sample of the silty clay also underwent Atterberg Limits testing, the results of which are included on the Record of Borehole sheets and plotted on Figure B7 of Appendix B. These results are also presented below.

Soil Particles	Percentage (%)
Gravel	0
Sand	5
Silt	38 to 52
Clay	43 to 57

Index Property	Percentage (%)
Liquid Limit	58
Plastic Limit	22
Plasticity Index	36

Results of the Atterberg Limits tests indicate that the silty clay is of high plasticity with a group symbol of CH.

5.4 Sand

Native brown to grey sand containing trace to some gravel and trace silt and clay was encountered in all of the boreholes, with the exception of Borehole BUG-01, at the depths and elevations indicated in Table 5.1.

Table 5.1 – Depths and Elevations of Native Sand

Foundation Unit	Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
North abutment	BUG-02	3.0 to 5.0	355.7 to 353.7	2.0
		10.0 to 13.7	348.7 to 345.0	3.7
South abutment	BUG-03	3.7 to 5.5	355.0 to 353.2	1.8
		8.5 to 13.4 (borehole termination depth)	350.2 to 345.3	4.9
South abutment	BUG-04	5.5 to 12.9 (borehole termination depth)	353.4 to 345.9	7.4
		3.0 to 5.2	355.9 to 353.7	2.2
South Approach	BUG-05	6.6 to 14.0	352.3 to 344.8	7.4
		6.1 to 11.3 (borehole termination depth)	352.8 to 347.6	5.2

Trace gravel and occasional wood fragments were noted in the upper sand layer.

Occasional cobbles and rock fragments were encountered within the lower sand layer.

SPT ‘N’ values measured in the sand ranged from 1 to 31 blows per 0.3 m of penetration, indicating a very loose to dense relative density. Typically, ‘N’ values recorded in the sand were between 4 and 15 blows for 0.3 m penetration, indicating a loose to compact relative density. A SPT ‘N’ value of 100 blows for 0.1 m penetration was recorded in Borehole BUG-05 at a depth of 13.1 m due to the presence of a probable boulder or bedrock.

The natural moisture contents of samples of the sand ranged from 10% to 21%.

Selected samples of the sand underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and the grain size distribution curves for these samples are plotted on Figure B4, Appendix B.

Soil Particles	Percentage (%)
Gravel	0 to 26
Sand	62 to 95
Silt	19
Clay	2
Silt and Clay	3 to 12

5.5 Layer of Organic clayey silt/silty clay

A dark brown layer of organic clayey silt/silty clay containing wood fragments, and trace rootlets was encountered below the silty clay in Borehole BUG-04 and below the native sand in Borehole BUG-05 at the south abutment.

The thickness of the organic clayey silt/silty clay layer was 0.6 m in Borehole BUG-04 and 1.4 m in Borehole BUG-05. The base of the layer of organic clayey silt/silty clay was at depths of 5.5 m and 6.6 m (elevations 353.4 and 352.3) in Boreholes BUG-04 and BUG-05, respectively.

SPT N-values of 0 to 5 blows for 0.3 m penetration were recorded in the layer of organic clayey silt/silty clay, indicating a very soft to firm consistency.

The moisture content of two samples collected from the layer of organic clayey silt/silty clay were 70% and 74%.

5.6 Sandy Silt

A layer of sandy silt was encountered below the layer of sand in Boreholes BUG-02 and BUG-03. The sandy silt is grey and contains trace to some clay. The sandy silt layer was 1.6 m thick in Borehole BUG-02 and 3.0 m thick in Borehole BUG-03. The base of the sandy silt was at depths of 6.6 m and 8.5 m (elevations 352.2 and 350.2) in Boreholes BUG-02 and BUG-03, respectively.

SPT 'N' values recorded in the sandy silt layer ranged from 2 to 8 blows per 0.3 m of penetration, indicating a very loose to loose relative density.

The moisture content of samples of the sandy silt ranged from 18% to 27%.

One sample of the sandy silt underwent laboratory gradation analysis. The grain size distribution curve for this sample is plotted on Figure B5 of Appendix B. The results of the gradation analysis are summarized as follows and are presented on the Record of Borehole sheets in Appendix A.

Soil Particles	Percentage (%)
Gravel	0
Sand	22
Silt	71
Clay	7

5.7 Silty Sand

Grey silty sand containing trace clay and trace gravel was encountered in Boreholes BUG-01, BUG-02, and BUG-06 at the depths and elevations indicated in Table 5.2.

Table 5.2 – Depths and Elevations of Native Silty Sand

Foundation Unit	Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
North approach	BUG-01	6.1 to 10.8 (borehole termination depth)	352.6 to 347.9	4.7
North abutment	BUG-02	6.6 to 10.0	352.2 to 348.7	3.4
South Approach	BUG-06	4.3 to 6.1	354.5 to 352.8	1.8

SPT ‘N’ values measured in the silty sand ranged from 2 to 17 blows per 0.3 m of penetration, indicating a very loose to compact relative density. The natural moisture contents of samples of the silty sand ranged from 14% to 22%.

Two samples of the silty sand were selected for laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets in Appendix A and the grain size distribution curves for these selected samples are plotted on Figure B3 of Appendix B.

Soil Particles	Percentage (%)
Gravel	0 to 3
Sand	50 to 71
Silt	24 to 47
Clay	2 to 3

5.8 Bedrock

The overburden soils described above are underlain by grey metamorphic bedrock of gneissic structure. Occasional horizontal and sub-vertical joints were noted throughout the bedrock cores. The bedrock is generally described as moderately weathered to fresh.

Bedrock was proved by coring in Boreholes BUG-02 and BUG-05 drilled at the north and south abutment, respectively. Table 5.3 summarizes depths and elevations to the top of bedrock or depth to auger refusal in the boreholes.

Table 5.3 – Depths and Elevations of Top of Bedrock / Auger Refusal

Location	Borehole	Top of Bedrock/Auger Refusal	
		Depth (m)	Elevation (m)
North approach	BUG-01	10.8	347.9
North abutment	BUG-02 ⁽¹⁾	13.7	345.0
	BUG-03	13.4	345.3
South Abutment	BUG-04	12.9	345.9
	BUG-05 ⁽¹⁾	14.0	344.8
Norhtwest side of river	BH-1 ⁽²⁾	14.9	-
River	BH-2 ⁽²⁾	12.8	-
Southeast side of river	BH-3 ⁽²⁾	14.5	-

⁽¹⁾ Bedrock proved by coring

⁽²⁾ Boreholes from previous investigation in 1956. (Reference 1)

Total core recovery (TCR) in the bedrock was 100% in all cores. The RQD values typically ranged from 63% to 82%, indicating poor to fair to good rock quality. An RQD value of 0% was recorded for Run 1 in Borehole BUG-05, which was only 0.5 m long and contained a rubble zone. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was generally 0 to 7. The FI was 15 at the top of Run 2 in Borehole BUG-05.

The estimated unconfined compressive strength of the rock cores generally ranges from 78 MPa to 165 MPa, indicating a strong to very strong rock. A higher estimated unconfined compressive strength of 256 MPa was measured in Borehole BUG-02 Run1, indicating an extremely strong rock. These estimated rock strength values are interpreted from point load tests that were conducted on rock cores recovered from the boreholes. The results of the point load tests are presented on the Record of Borehole sheet in Appendix A, as average estimated unconfined compressive strength per run. A summary of the Point Load Test Results is presented in Appendix B.

5.9 Water Levels

Water levels were observed in the open boreholes during drilling operations. Two standpipe piezometers were installed at this site, in Boreholes BUG-03 and BUG-04 to monitor water levels after completion of drilling. The water levels measured in the open boreholes and piezometers are summarized in Table 5.4.

Table 5.4 – Water Level Measurements

Location	Borehole	Date	Water Level (m)		Comment
			Depth	Elevation	
North approach	BUG-01	Aug. 7, 2011	2.4	356.3	Open borehole
North abutment	BUG-02	Aug. 7, 2011	3.0	355.7	Open borehole
	BUG-03	Sept. 15, 2011	3.3	355.4	Piezometer
South abutment	BUG-04	Sept. 15, 2011	3.6	355.2	Piezometer
	BUG-05	Aug. 8, 2011	3.0	355.9	Open borehole

The piezometric readings reveal that the groundwater level is at an approximate elevation of 355.3, 3.3 m to 3.6 m below ground surface.

The Preliminary GA drawing indicates that the Bug River water level was at elevation 355.7 m in May 2011.

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

6 MISCELLANEOUS

Borehole locations were selected in the field by Thurber Engineering Ltd. Borehole elevations and coordinates were provided by Genivar.

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

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied a truck mounted CME 75 drill rig and conducted the drilling, sampling and in-situ testing operations.

The field program was supervised on a full time basis by Mr. Stephane Loranger of Thurber.

Routine laboratory testing was carried out by Thurber Engineering Ltd.

Overall planning and supervision of the field program was conducted by Mr. Mark Farrant, P. Eng. Interpretation of the data and preparation of this report were carried out by Ms. Lindsey Blaine, E.I.T. and Ms. R. Palomeque Reyna, P.Eng.

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

Thurber Engineering Ltd
Lindsey Blaine, E.I.T.
Project Manager

Rocio Palomeque Reyna, P.Eng.
Geotechnical Engineer



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



Appendix A

Record of Borehole Sheets (current investigation)

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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







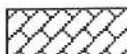
Water Level

C_{pen}

Shear Strength Determination by Pocket Penetrometer

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

EXPLANATION OF ROCK LOGGING TERMS

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

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	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 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.

RECORD OF BOREHOLE No BUG-01

2 OF 2

METRIC

W.P. 6942-10-00 LOCATION N 281 06.6 E 358.7 Bug River Bridge ORIGINATED BY SLL
HWY 105 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2011.08.07 - 2011.08.07 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page													
347.9	Silty SAND, trace clay, trace gravel Loose Grey Wet		9	SS	100/		348							
10.8	END OF BOREHOLE AT 10.8m UPON REFUSAL ON PROBABLE BEDROCK OR BOULDER. WATER OBSERVED AT 2.4m DURING DRILLING. BOREHOLE GROUTED WITH BENTONITE HOLEPLUG TO 1.9m, SAND TO 0.2m, THEN ASPHALT TO SURFACE.				0.150									

RECORD OF BOREHOLE No BUG-02

1 OF 2

METRIC

W.P. 6942-10-00 LOCATION N 280 93.1 E 973.3 Bug River Bridge ORIGINATED BY SLL
 HWY 105 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2011.08.07 - 2011.08.07 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					PLASTIC LIMIT w _p NATURAL MOISTURE CONTENT w LIQUID LIMIT w _L
358.7								20 40 60 80 100					
0.0	ASPHALT: (125mm)												
0.1	SAND and GRAVEL, trace silt and clay Compact to Very Loose Brown Moist (FILL)		1	SS	13		358						
			2	SS	7		357						
			3	SS	3		356						
355.7													
3.0	SAND, trace gravel, occasional wood fragments Compact Brown Wet		4	SS	25		355						
			5	SS	27		354						
353.7													
5.0	Sandy SILT, some clay Loose Grey		6	SS	8		353						
352.2													
6.6	Silty SAND, trace clay Loose to Very Loose Grey Wet		7	SS	7		352						
							351						
			8	SS	2		350						0 50 47 3
348.7							349						

Continued Next Page

+ 3, X 3 Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BUG-02

2 OF 2

METRIC

W.P. 6942-10-00 LOCATION N 280 93.1 E 973.3 Bug River Bridge ORIGINATED BY SLL
 HWY 105 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2011.08.07 - 2011.08.07 CHECKED BY RPR

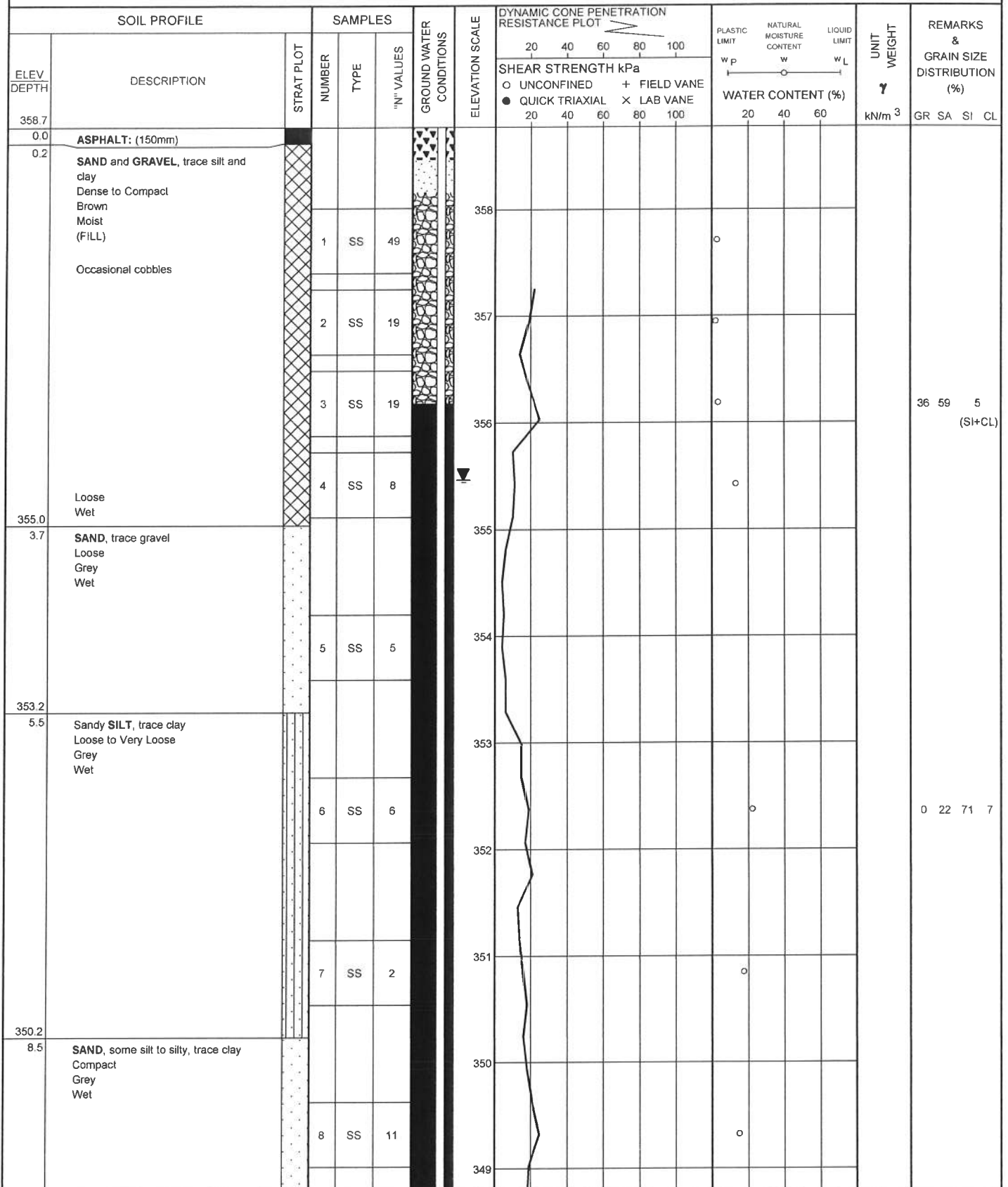
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)					
								20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE			W _P W W _L	20 40 60			
10.0	Continued From Previous Page SAND, trace gravel, trace to some silt and clay Loose Grey Wet		9	SS	4		348									
				10	SS	7		347								
	Compact Some silt, occasional cobbles or bedrock fragments		11	SS	21		346									
345.0																
13.7	BEDROCK, moderately weathered, grey with white bands Coring started at 13.7m Sub-vertical joints at 13.8m, 14.1m, 14.7m, 14.8m, 15.2m, 15.3m, 15.8m and 16.1m		1	RUN			345									
								344								
								343								
342.3																
16.4	END OF BOREHOLE AT 16.4m. WATER OBSERVED AT 3.0m DEPTH DURING DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.8m, AUGER CUTTINGS TO 0.6m, SAND TO 0.3m, THEN ASPHALT TO SURFACE.															

RECORD OF BOREHOLE No BUG-03

1 OF 2

METRIC

W.P. 6942-10-00 LOCATION N 281 02.0 E 972.3 Bug River Bridge ORIGINATED BY SLL
 HWY 105 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2011.08.08 - 2011.08.08 CHECKED BY RPR



Continued Next Page

+ 3, X 3: Numbers refer to
Sensitivity

20
15
10

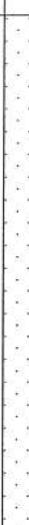

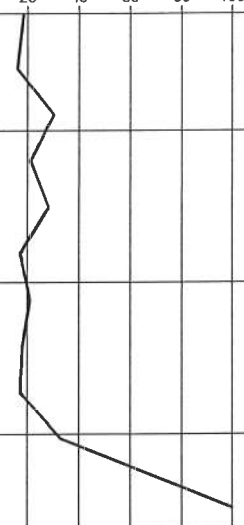
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BUG-03

2 OF 2

METRIC

W.P. 6942-10-00 LOCATION N 281 02.0 E 972.3 Bug River Bridge ORIGINATED BY SLL
HWY 105 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2011.08.08 - 2011.08.08 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	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							
	SAND, some silt, trace clay Loose Grey Wet		9	SS	5		348								
								347							
					10	SS	5		346						
345.3															
13.4	END OF BOREHOLE AT 13.4m UPON AUGER REFUSAL ON PROBABLE BEDROCK OR BOULDER. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Sep.15/11 3.3 355.4														

METRIC

[illegible]

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BUG-04

2 OF 2

METRIC

W.P. 6974-10-00 LOCATION N 280 62.1 E 100 4.2 Bug River Bridge ORIGINATED BY SLL
HWY 105 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2011.08.09 - 2011.08.09 CHECKED BY RPR

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
						20 40 60 80 100	20 40 60 80 100	20 40 60					
	Continued From Previous Page												
	SAND, trace to some silt and clay Loose Grey Wet		9	SS	6	348							
						347							
345.9	Compact Some gravel to gravelly		10	SS	31							26 62 12 (SI+CL)	
12.9	END OF BOREHOLE AT 12.9m UPON AUGER REFUSAL ON PROBABLE BEDROCK OR BOULDER. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Sep.15/11 3.6 355.2												

RECORD OF BOREHOLE No BUG-05

1 OF 2

METRIC

W.P. 6974-10-00 LOCATION N 280 59.0 E 100 0.3 Bug River Bridge ORIGINATED BY SLL
 HWY 105 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2011.08.08 - 2011.08.09 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
358.9 0.0	ASPHALT: (150mm)											
0.2	SAND and GRAVEL, trace silt and clay Dense Brown Moist (FILL)		1	SS	46		358					
	Compact		2	SS	11		357					36 57 7 (SI+CL)
			3	SS	10							
355.9 3.0	SAND, trace gravel, occasional wood fragments Loose to Very Loose Brown Wet		4	SS	9		356					
							355					
			5	SS	4		354					
353.7 5.2	Layer of organic silty CLAY/clayey SILT, with wood fragments, trace rootlets Very Soft Dark Brown Wet		6	SS	0		353					
352.3 6.6	SAND, some gravel, trace silt and clay Loose Brown Wet		7	SS	7		352					11 85 4 (SI+CL)
							351					
			8	SS	5		350					
							349					

Continued Next Page

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

RECORD OF BOREHOLE No BUG-05

2 OF 2

METRIC

W.P. 6974-10-00 LOCATION N 280 59.0 E 100 0.3 Bug River Bridge ORIGINATED BY SLL
HWY 105 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2011.08.08 - 2011.08.09 CHECKED BY RPR

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	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						
	SAND, trace silt and clay, some gravel Compact Grey Wet		9	SS	13												6 91 3 (SI+CL)
	Probable boulder or bedrock at 13.2m		11	SS	100/												
					0.100												
344.8																	
14.0	BEDROCK, moderately weathered to fresh, grey, with white bands		1	RUN													RUN #1 TCR=100% SCR=78% RQD=0% RUN #2 TCR=100% SCR=95% RQD=63% UCS=118MPa (Average)
	Coring started at 14.0m Horizontal joint from 14.2m to 14.5m Rubble zone (150mm thick) at 14.3m																
	Sub-vertical joints at 14.7m, 14.9m, 15.3m, 15.4m, 15.6m, 15.8m, 16.1m, 16.2m and 16.5m to 17.3m																
	Horizontal joints: 100mm at 14.7m 50mm at 15.6m 425mm at 16.1m		2	RUN													
341.2																	
17.7	END OF BOREHOLE AT 17.7m WATER OBSERVED AT 3.0m DURING DRILLING. BOREHOLE GROUTED WITH BENTONITE HOLEPLUG TO 1.6m, CUTTINGS TO 0.3m, THEN CEMENT TO SURFACE.																

ONTMT4S 0840.GPJ 5/16/12

RECORD OF BOREHOLE No BUG-06

1 OF 2

METRIC

W.P. 6942-10-00 LOCATION N 280 57.3 E 100 8.0 Bug River Bridge ORIGINATED BY SLL
 HWY 105 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2011.08.08 - 2011.08.08 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
358.9 0.0 0.1	ASPHALT: (125mm) SAND and GRAVEL, trace silt and clay Compact Brown Moist		1	SS	28		358					
			2	SS	11		357					
	Dense		3	SS	42							
356.0 2.9	Silty CLAY, trace sand Firm Grey		4	SS	6		356					0 5 52 43
							355					
354.5 4.3	Silty SAND, trace clay Compact Brown Moist to Wet		5	SS	17		354					
							353					
352.8 6.1	SAND, trace to some silt and clay, trace gravel Very Loose to Compact Grey Wet		6	SS	3		352					
			7	SS	7		351					3 87 10 (SI+CL)
			8	SS	10		350					
							349					

Continued Next Page

+ 3, x 3

Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BUG-06

2 OF 2

METRIC

W.P. 6942-10-00 LOCATION N 280 57.3 E 100 8.0 Bug River Bridge ORIGINATED BY SLL
HWY 105 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2011.08.08 - 2011.08.08 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
347.6	SAND, trace to some silt and clay, trace gravel Compact Grey Wet		9	SS	25		348										
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE BACKFILLED WITH HOLEPLUG BENTONITE TO 1.5m, CUTTINGS TO 0.1m, THEN CONCRETE TO SURFACE.																

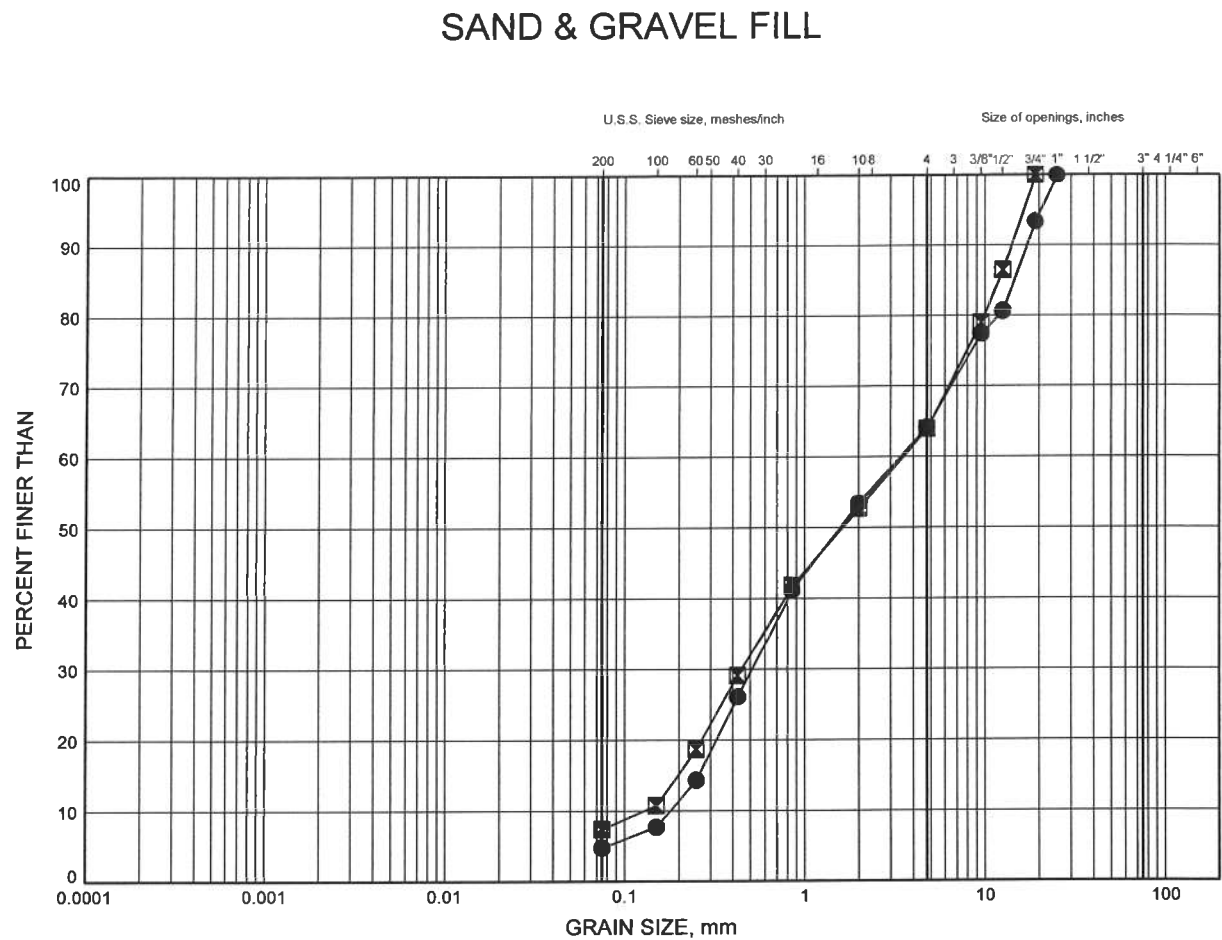
Appendix B

Laboratory Test Results

NWR HWY 11 Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BUG-03	2.59	356.09
⊠	BUG-05	1.83	357.03

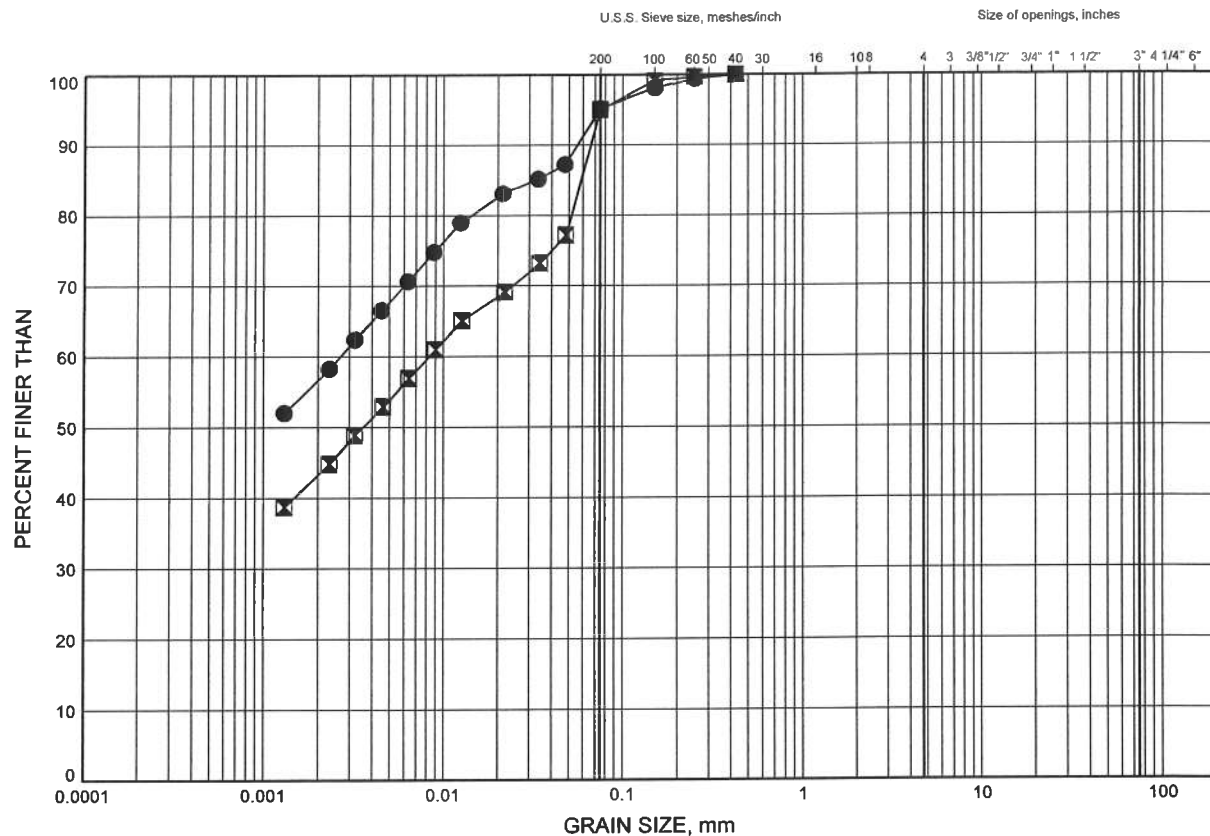


W.P.# 6942-10-00
Prepared By AN
Checked By RPR

NWR HWY 11 Bridge GRAIN SIZE DISTRIBUTION

FIGURE B2

SILTY CLAY



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

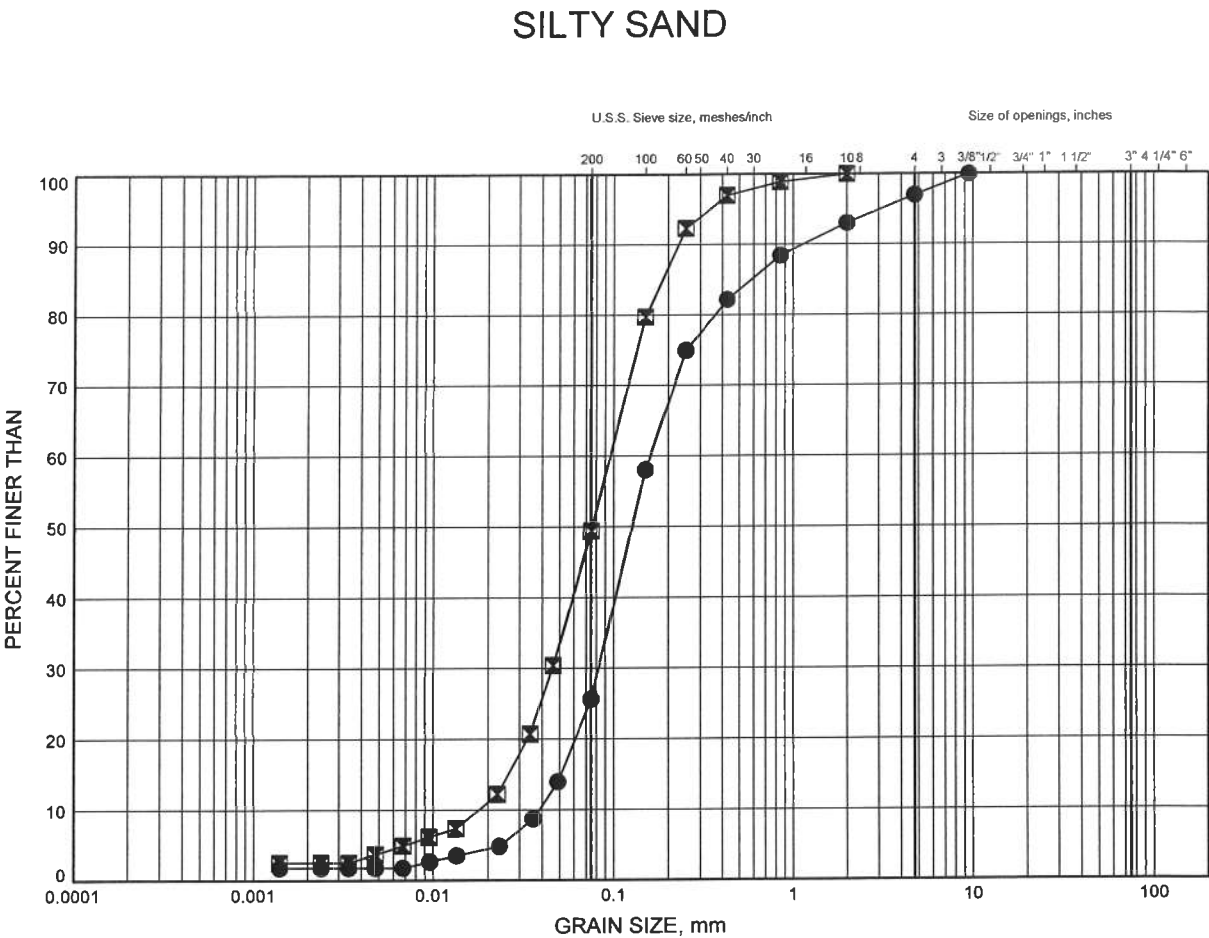
LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BUG-01	3.35	355.34
■	BUG-06	3.35	355.53

NWR HWY 11 Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B3



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BUG-01	7.92	350.77
■	BUG-02	8.84	349.87

GRAIN SIZE DISTRIBUTION - THURBER 0840.GPJ 1/16/12

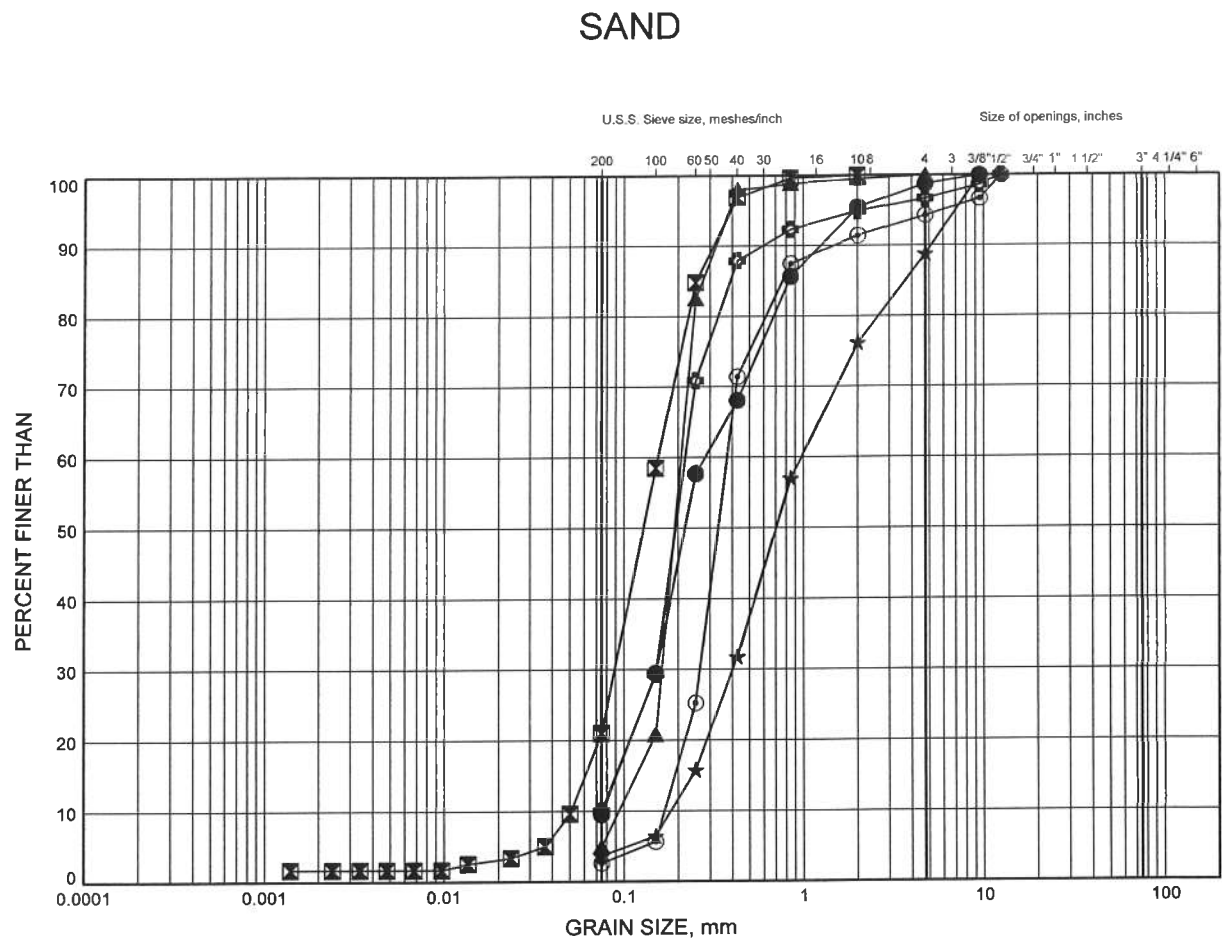
W.P.# 6942-10-00
Prepared By AN
Checked By RPR



NWR HWY 11 Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BUG-02	11.89	346.82
⊠	BUG-03	10.97	347.71
▲	BUG-04	7.92	350.92
★	BUG-05	7.32	351.54
⊙	BUG-05	10.36	348.49
⊕	BUG-06	7.92	350.96

GRAIN SIZE DISTRIBUTION - THURBER 0840.GPJ 1/16/12

W.P.# 6942-10-00
 Prepared By AN
 Checked By RPR



FIGURE B5

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

Size of openings, inches

PERCENT FINER THAN

GRAIN SIZE, mm

Grain Size (mm)	U.S.S. Sieve Size (meshes/inch)	Size of Opening (inches)	Percent Finer (%)
0.075	200	3/8"	5
0.15	100	3/16"	8
0.25	60	1/4"	10
0.35	40	3/8"	12
0.425	35	1/2"	15
0.6	25	3/4"	22
0.85	20	1"	29
1.18	15	1 1/4"	39
1.75	10	1 3/4"	49
2.5	8	2"	58
3.55	6	2 1/2"	78
4.75	4	3"	95
7.5	3	3 3/4"	98
10.0	2	4"	99
20.0	1	4 1/4"	100
40.0	0.5	6"	100

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

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BUG-03	6.40	352.28

GRAIN SIZE DISTRIBUTION - THURBER 0840.GPJ 1/16/12

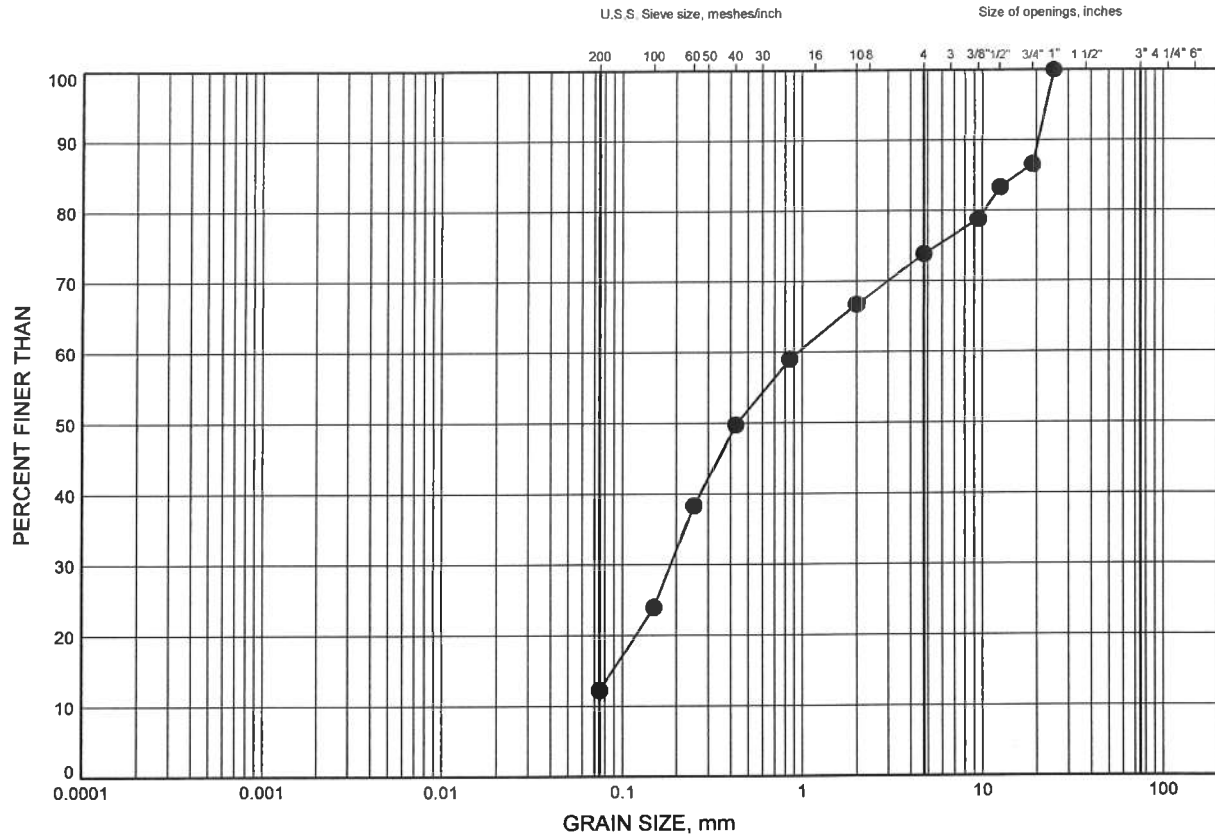
W.P.# 6942-10-00
Prepared By AN
Checked By RPR



NWR HWY 11 Bridge GRAIN SIZE DISTRIBUTION

FIGURE B6

Some GRAVEL to GRAVELLY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BUG-04	12.50	346.35

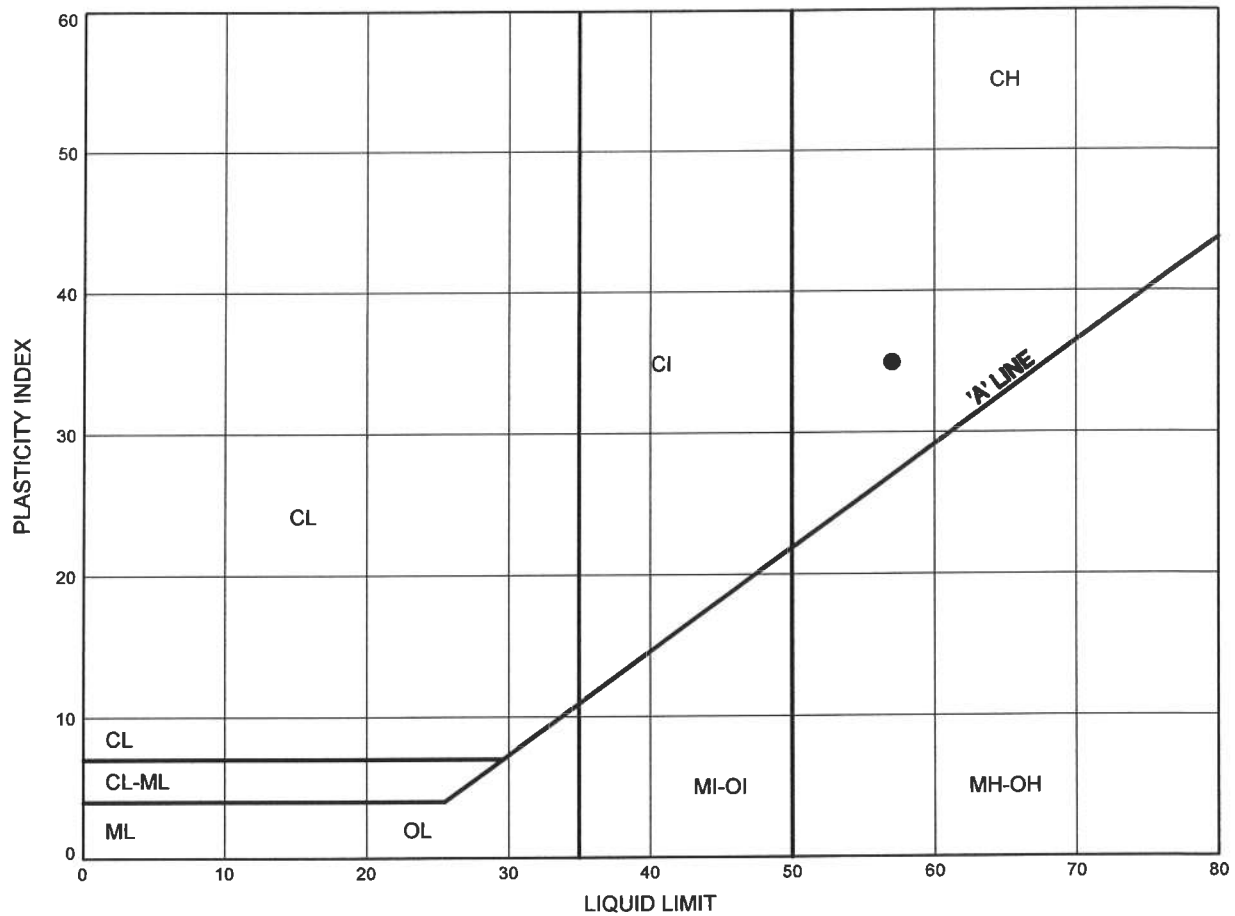


W.P.# 6942-10-00.....
Prepared By AN.....
Checked By RPR.....

NWR HWY 11 Bridge
ATTERBERG LIMITS TEST RESULTS

FIGURE B7

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	BUG-01	3.35	355.34



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

POINT LOAD TEST SHEET

Job No : 19-5308-40 Client : GENIVAR
Date Drilled : August 07/ 2011
Project Name : Bug River Bridge Date Tested : September 06/ 2011
Core Size : NQ BH No : BUG-02 Tester : DB

Test No.	Run No.	Depth (m)	Axial or Diametral	Force (kN)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	1	13.8	D	15.4	46.7	78.5	164.5	Metamorphic	Very Strong
2	1	14.4	D	11.6	47.4	61.0	120.4	Metamorphic	Very Strong
3	1	15.0	A	15.7	47.4	47.2	136.5	Metamorphic	Very Strong
4	1	15.6	A	11.0	47.4	56.1	83.2	Metamorphic	Strong
5	1	16.1	D	24.6	47.5	54.0	255.7	Metamorphic	Extremely Strong
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

POINT LOAD TEST SHEET

Job No : 19-5308-40 Client : GENIVAR
Date Drilled : August 09/ 2011
Project Name : Bug River Bridge Date Tested : September 06/ 2011
Core Size : NQ BH No : BUG-05 Tester : DB

Test No.	Run No.	Depth (m)	Axial or Diametral	Force (kN)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	2	14.7	D	10.6	47.5	61.9	110.1	Metamorphic	Very Strong
2	2	15.2	A	11.1	47.6	61.1	78.3	Metamorphic	Strong
3	2	17.4	A	23.4	48.3	61.0	164.2	Metamorphic	Very Strong
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

Appendix C

Report from previous investigation (1956)

56-F-220C

Hwy. 105

BUG RIVER

B.A. 532

RACEY, MacCALLUM AND ASSOCIATES
LIMITED

A COMPANY OWNED, DIRECTED AND OPERATED BY

Consulting Engineers
AND ASSOCIATED STAFF

MONTREAL  VANCOUVER

TORONTO

DONALD C. MACCALLUM, B.ENG., M.E.I.C., P.ENG.

H. JOHN RACEY, B.SC., M.E.I.C., P.ENG.

GEORGE L. HOUGHTON, A.M.I.MECH.E., M.E.I.C., P.ENG.

TORONTO DIVISION
20 CARLTON STREET

REPORT NO. D-500/T-262

June 5th, 1956.

A.N. Goye, Esq.,
Bridge Engineer,
Department of Highways of Ontario,
Bridge Office, 13th Floor,
East Block, Parliament Building,
Queens Park,
Toronto, Ontario.

Attention: Mr. S. McCombie.

56-F-220C

RE: REPORT ON A FOUNDATION INVESTIGATION
FOR THE BUG RIVER BRIDGE, HIGHWAY
NO. 105, RED LAKE DISTRICT, ONTARIO.

Dear Sirs:

We have completed the foundation investigation at the Bug River Bridge Site in the Red Lake District and prepared the attached report, with details on the presently existing timber trestle bridge and recommendations for the foundation of the new bridge.

For your convenience, we wish to summarize here that one foot diameter piles for the proposed pile foundation are estimated to have a safe bearing capacity between 20 and 26 tons each, at 25 to 35 foot depth below the bridge deck, depending on the pile locations (shown on enclosure h, below). With regard to settlement, an allowable load for piles at 3 foot spacing, of about 15 tons per pile would apply if only 3/4 inch differential settlement is tolerated. By applying the higher safe loads settlement would be proportionately higher.

We trust that the information contained in the report will be of help in the bridge design.

Yours very truly,

RACEY, MacCALLUM AND ASSOCIATES LIMITED.

K. Tubbsing

L. TUBBSING, P.Eng.

RT/EM

Original & 3 copies - Department of Highways of Ontario, Toronto.
Att: Mr. S. McCombie.

1 - R.M.A. Montreal.
2 - Soils Engineers.

REPORT ON A FOUNDATION INVESTIGATION
FOR THE BUC RIVER BRIDGE, HIGHWAY NO. 105,
RED LANS DISTRICT, ONTARIO.

Report No: B-500/T-262

Racey, MacCallum & Associates Ltd.

June 6th, 1956.

CONTENTS

	<u>Page</u>
THE LOCATION OF THE SITE	1
THE PRESENTLY EXISTING BRIDGE	1
THE LOCATION OF THE BORINGS	1
THE FIELD WORK	1
THE SUBSOIL CONDITIONS	2
DISCUSSION OF THE RESULTS	2
CONCLUSIONS	4

ENCLOSURES

	<u>Number</u>
TOPOGRAPHIC SKETCH SHOWING THE LOCATION OF THE SITE.	1 (above)
LAYOUT SKETCH SHOWING THE LOCATION OF THE BORINGS AND OTHER PERTINENT DATA.	1 (below)
PHOTOGRAPHS, FIGS. 1, 2 & 3	2
LONGITUDINAL SECTIONAL SOIL PROFILE	3
DISC - R GIVING AVERAGE PENETRATION RESISTANCE	4 (above)
SECTIONAL PROFILE WITH SAFE BEARING VALUES AT VARIOUS POINT ELEVATIONS	4 (below)
ENGINEERING DATA SHEETS	5, 6 & 7

June 5th, 1956.

**REPORT ON A FOUNDATION INVESTIGATION
FOR THE BUG RIVER BRIDGE, HIGHWAY NO.105,
RED LAKE DISTRICT, ONTARIO.**

This report covers a foundation investigation for the proposed new highway No.105 bridge crossing the Bug River in the Red Lake District, Ontario.

THE LOCATION OF THE SITE:

This bridge site is located on highway No.105 approximately two miles South East of the village of Red Lake, where the highway crosses the Bug River which connects Gullrock Lake with Stone Lake.

THE PRESENTLY EXISTING BRIDGE:

Prior to the field work the bridge was visited in March 1956, and three photographs were taken in order to assist thereby somehow in the design of the new bridge.

The present timber trestle bridge is 120 feet long, 20 feet wide and has bents at 15 foot spacing. The bridge deck was 10 feet above the ice cover of the river. The river embankments slope gradually on either side. The approaches consist of pit run gravel fill. The photographs (figures 1 and 2, encl. 2) show some more details. Figure 3 shows how the bridge was jacked into the required elevation by inserting timbers, 15 feet from the end of the bridge.

THE LOCATION OF THE BOREHOLES:

The location of the three boreholes carried out is as shown on the layout sketch (encl.1, below) one borehole being drilled near either end of the bridge and the third one from the centre of the bridge deck.

THE FIELD WORK:

The drilling equipment was brought to the site on April 9th, 1956, and drilling began immediately on borehole 1, which was completed on April 11th. Borehole 2 was carried out from April 12th to 13th and borehole 3 was started on April 11th and completed on April 16th. The equipment was subsequently loaded and removed from the site.

Drilling was performed with a standard diamond core drill under moderate weather conditions. Sampling was carried out with standard two inch diameter split tube samplers or with Shelby tube samplers, whatever promised to retain the soil sample best.

The penetration of the sampler was recorded for both types of samplers though the correlation to soil density has been established

- 1 -

THE FIELD WORK: (Cont'd).

roughly only for the two inch diameter split tube sampler.

Continuous penetration resistance can be obtained by driving the two inch diameter conical drive point, supplementary to the general drilling, and nearby. This has been done for all three boreholes and a correlation of 75% cone resistance approximately equal to the standard penetration resistance value considered permissible.

In borehole 1 the cone penetration test had to be repeated since it was found that the first cone, driven after the completion of the borehole, found its way into the borehole, thereby indicating lower resistance than was to be expected.

THE SUBSOIL CONDITIONS:

A longitudinal sectional soil profile is presented on enclosure 3.

Under the 12 to 13 feet of pit run gravel fill of the abutments the embankments show a varying sequence of fine to medium sand, silty sand and, particularly in borehole 2, embedded organic matter, possibly flat pockets of very limited size only. In the centre of the river very fine and fine sand occupies the space from the river bottom to about 17 feet below, the deeper material consisting of coarser material, however, no gravel. An increase in grain size and density is found in all holes at the approximate depth of 35 to 40 feet below the bridge deck. Some gravel was noticed in these low beds.

The density of the sand is best characterized by the penetration curves of the two inch conical drive point plotted on the attached Engineering Data Sheets (enclosure 5 to 7). The equivalent penetration of the drive point has been averaged for five foot intervals in a diagram (enclosure 4, above). This diagram will be referred to below for tentative computations of bearing capacities. The scatter of the penetration resistance with depth is comparatively small.

Bedrock, consisting of a very hard dark grey, metamorphic, basic rock and siliceous rock of gneissic structure, occurs in the N.W. below hole 1 at 49 ft. depth, rising gradually to 42 ft. depth in the S.E. below hole 2. Refusal met in hole 3 is in good accordance with this dip of the rock surface.

DISCUSSION OF THE RESULTS:

The sand as a bearing soil is judged from its density. The equivalent number of blows representing the penetration resistance of the sand increases with depth with the exception of a looser zone within 30 to 35 ft. depth (from the bridge deck) below the river bed.

For the determination of approximate bearing capacities the lowest penetration resistance recorded is utilized.

The type of foundation considered here is limited to a

DISCUSSION OF RESULTS: (Cont'd).

pile foundation with 1 foot diameter piles arranged in rows for the bents of the future bridge as it is understood that this is the required pier type.

The bearing capacity of piles has been investigated by G.G. Meyerhof * theoretically, and in a very recent publication ** the immediate utilization of the standard penetration resistance for the determination of approximate bearing capacities has been suggested by the same author.

The ultimate bearing capacity is accordingly determined from:

$$Q_f = k \times A_p + \frac{\bar{N} A_s}{50} \quad (\text{tons})$$

where \bar{N} = average penetration resistance (blows/ft) near pile point,

A_p = sectional area (sq.ft.) of pile point,

\bar{N} = average penetration resistance within embedded length of pile, and

A_s = surface area (sq.ft.) of the embedded length of pile.

This formula applies to saturated sand, no reduction is, therefore, needed for submerged condition.

Safe bearing values, with a factor of safety of three, have been estimated on the basis of the above and the results are entered in a diagram and in a sectional sketch (enclosure 4, above right and below). The latter showing safe bearing values for some selected pile locations and point elevations.

With a factor of safety of three a preferable load of 20 tons per pile of 1 foot diameter would necessitate driving the piles to about El.75 through the present approach fill or to about El.65 in the centre of the river (El.100 being the elevation of the bridge deck). The greater depth in the river is mainly due to the lower density of the sand in the river above El.65.

The given values for safe bearing capacity of single piles are based on the lowest penetration resistances recorded and, therefore,

*) G.G. Meyerhof, The Ult. Bearing Cap. of Found. Geotechnique 1951.

**) G.G. Meyerhof, Penetration Tests and Bearing Capacity of Cohesionless Soils. J.ASCE 1956.

DISCUSSION OF RESULTS (Cont'd).

the actual capacity will be generally higher. Settlement of single piles can be expected to be negligible.

Pile groups in cohesionless soils are considered to be acting as single piles as long as the piles are spaced at more than $2\frac{1}{2}$ to 3 times the pile diameter (Meyerhof). The bearing capacity of a pile group may then be taken as the number of piles times the safe bearing capacity of a single pile. The spacing of the piles of the present bridge is about 5 feet.

A bent with a pile spacing of less than $2\frac{1}{2}$ to 3 pile diameters is considered to be a long footing with width 'B' equal to the pile spacing. Assuming the piles to be at 3 diameters distance on centres the allowable load per pile of a bent would be of the order of 15 tons with differential settlement of $\frac{1}{4}$ inches being tolerated.

The river appears to be relatively slowly flowing and scour may be minimal. With piles founded at EL.65 in the river there is no probability of scour to endanger the pile foundation.

CONCLUSIONS:

The new Big River Bridge is proposed to be founded on one foot diameter piles which will carry safely between 20 and 26 tons, each at 25' to 35' depth below the bridge deck, depending on the pile locations as shown on enclosure 4, 1-10. The allowable load per pile for a spacing of three diameters, at which the foundation acts like a deep long footing, would be of the order of 15 tons for $\frac{1}{4}$ inch of differential settlement tolerated. Utilising the safe bearing values of 20 to 26 tons or more would only increase the settlement proportionately.

Scour is not expected to have effect on the foundation if the piles in the river penetrate to adequate bearing depth (EL.65 or about 35' below the bridge deck).



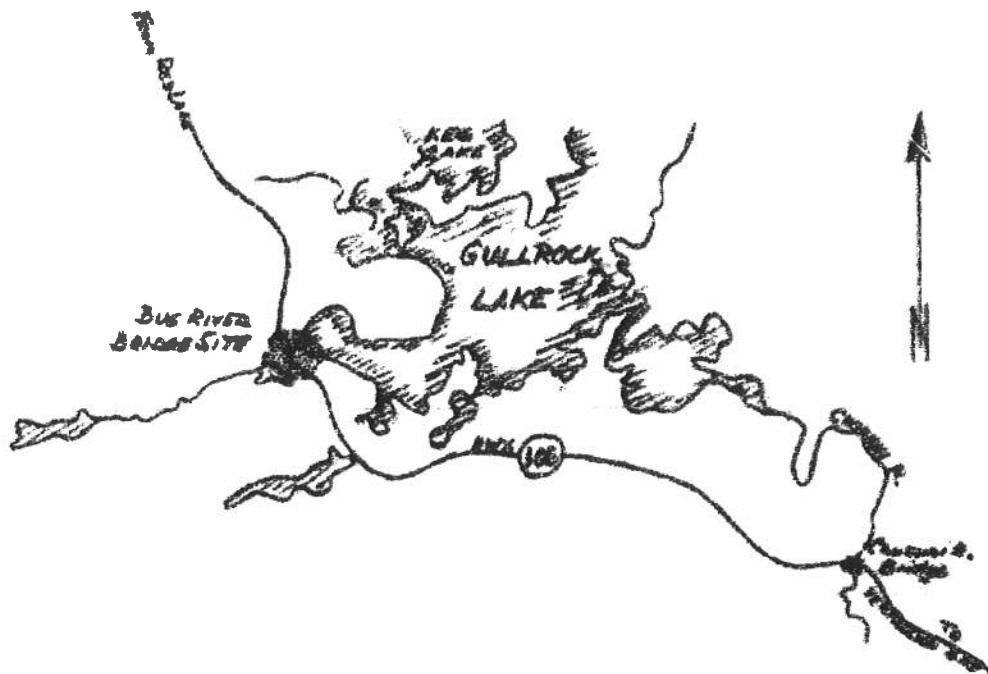
HT/CM

K. Tubbesing

K. TUBBESING, P. Eng.

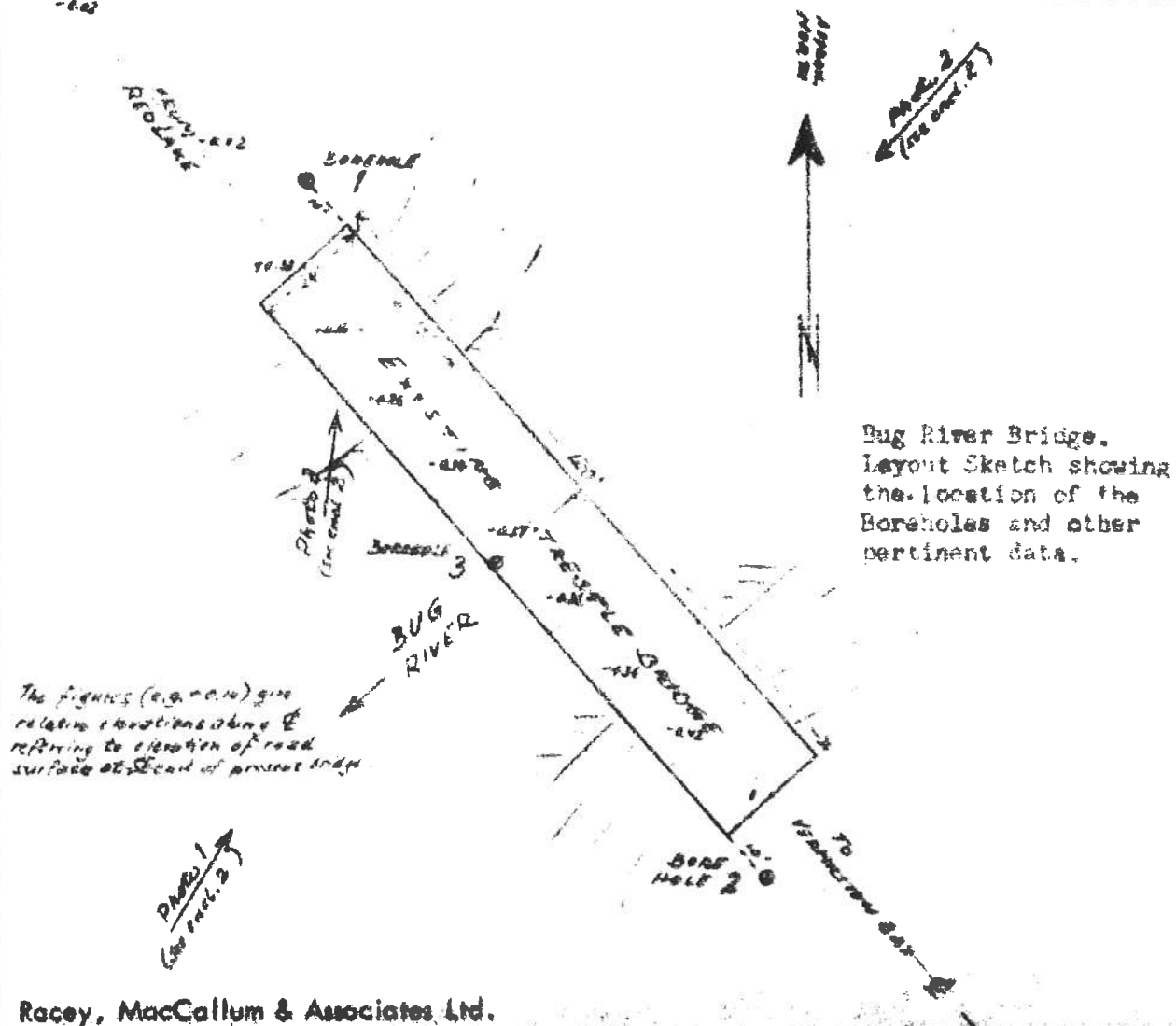
Prop. H₁: ~~False~~

Bug River Bridge.
Topographic Sketch
showing the location
of the site.



SCALE: 1" = 4 MILES
ARTS, TOP MAP LAC SEUL

- 62 -



Bug River Bridge.
Layout Sketch showing
the location of the
Boreholes and other
pertinent data.

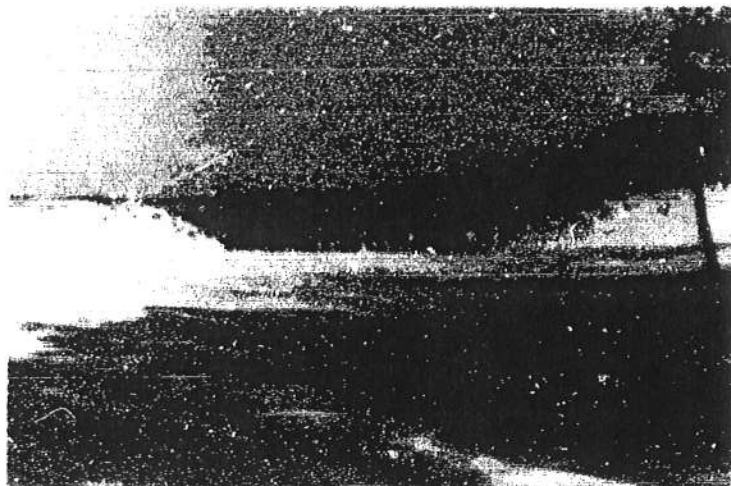


Fig.1. Present Bag
River Bridge
seen from south
west.



Fig.2. Present Bridge
seen from north
east.



Fig.3. Jacked up and
wedged founda-
tion of second
bent from north
west end of
bridge.

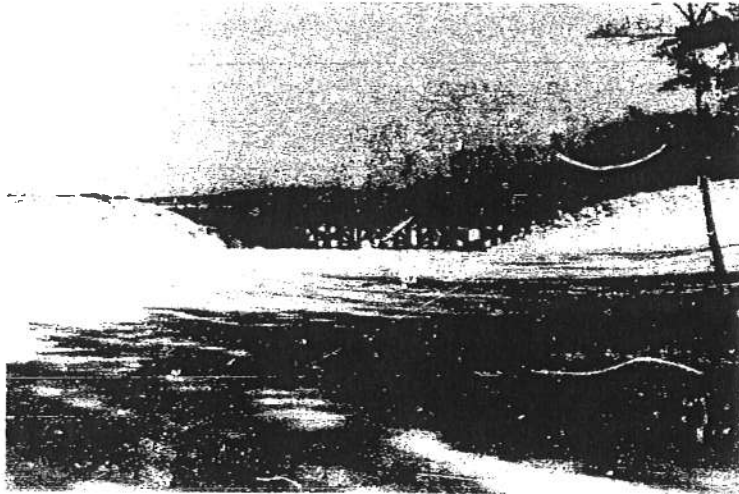


Fig.1. Present Bug
River Bridge
seen from south
west.

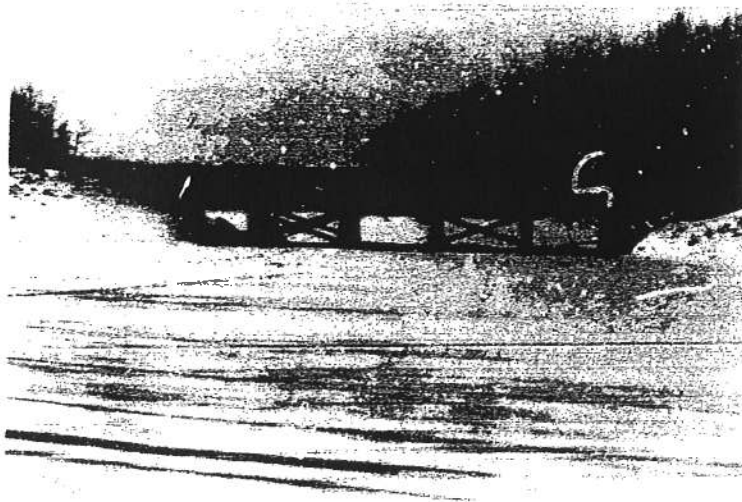


Fig.2. Present Bridge
seen from north
east.

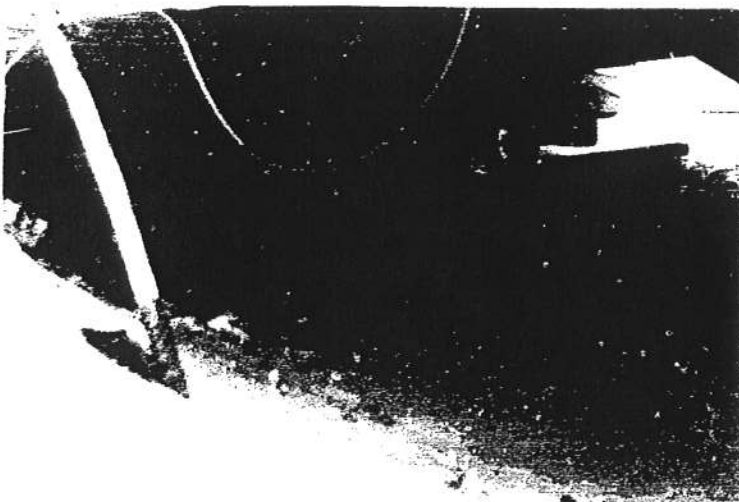


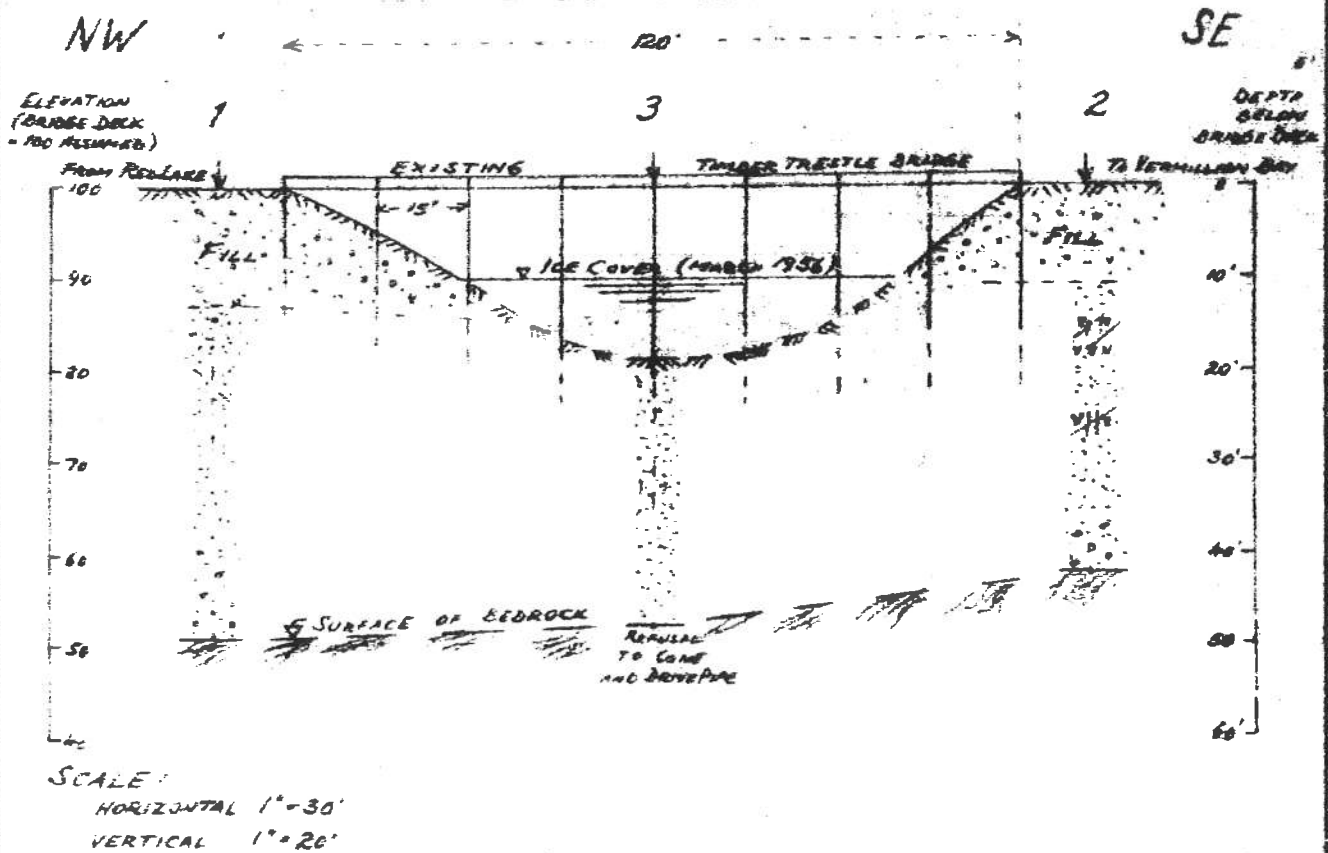
Fig.3. Jacked up and
widened found-
ation of second
bent from north
west end of
bridge.

Order No. S-500/T-262

Enclosure No. 3

Prep. By K. TUBGESING

Longitudinal Sectional Soil Profile
at the
Present Bug River Bridge



Prep. By K. T.

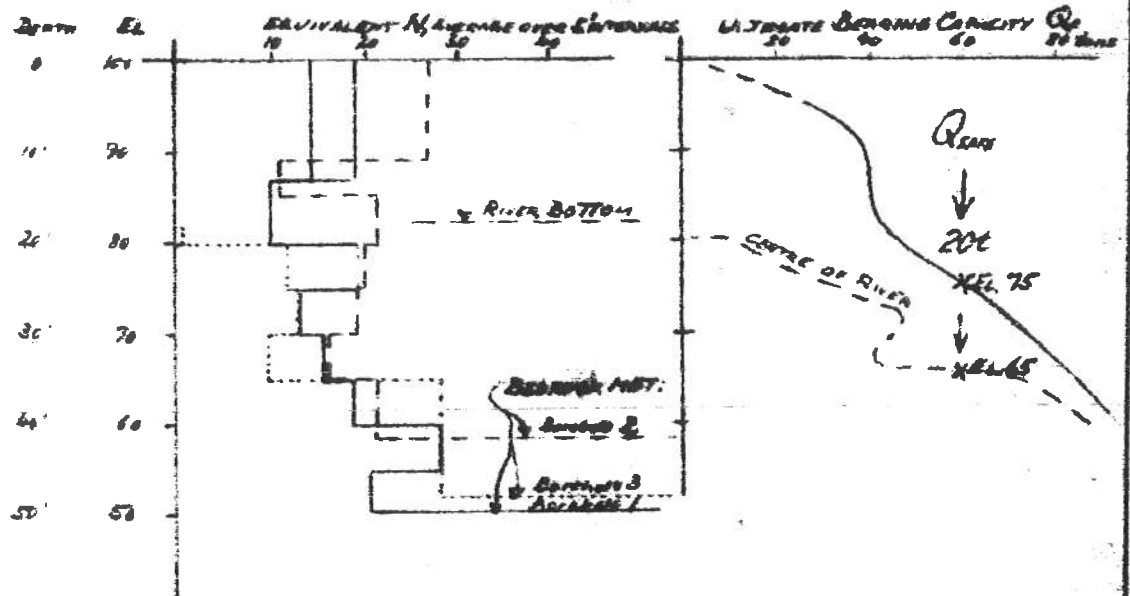
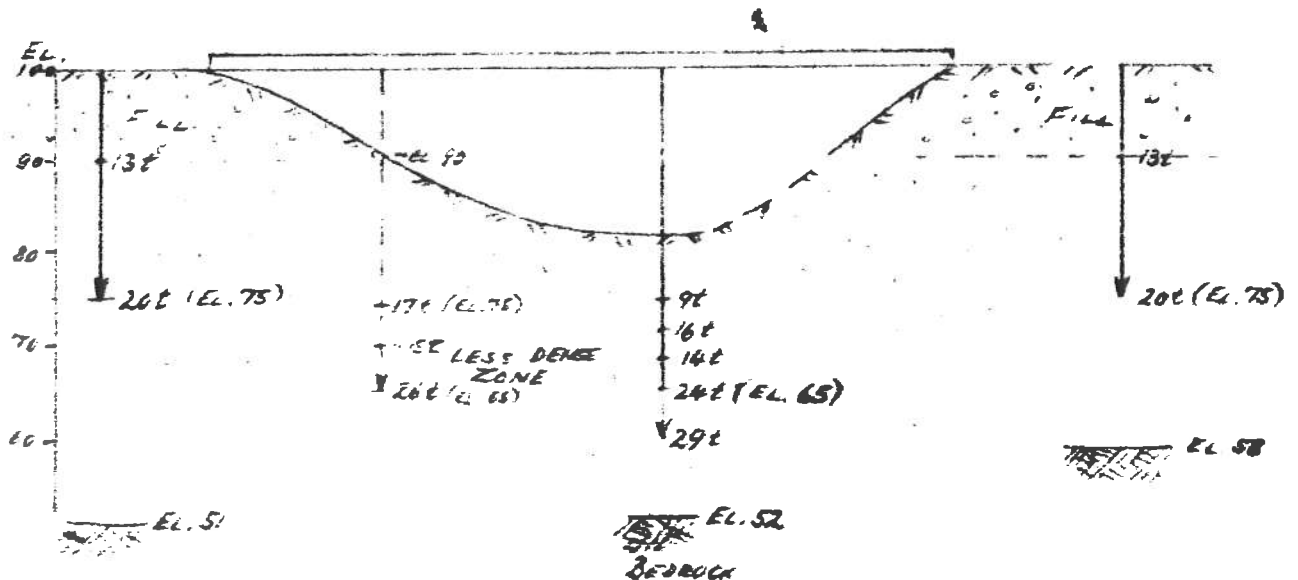


Diagram giving Average Penetration Resistance versus Elevation in the Testholes, and bearing capacities



Sectional Profile with safe bearing values (F.S.=3) at Various Point Elevations for some selected pile locations

Order No. S-500/T-262

Enclosure No. 6

RACEY McCALLUM AND ASSOCIATES LTD.

Foundation Engineering Division

Engineering Data Sheet for Borehole: 2

Project: PROPOSED NEW BOY RIVER BRIDGE

Location: HWY. 105, RED LAKE DISTRICT, ONT.

Hole Location

Hole Elevation and Datum:

Field Work Began APRIL 12th 1958

Ended APRIL 13th 1958

Date: APRIL 19th 1958

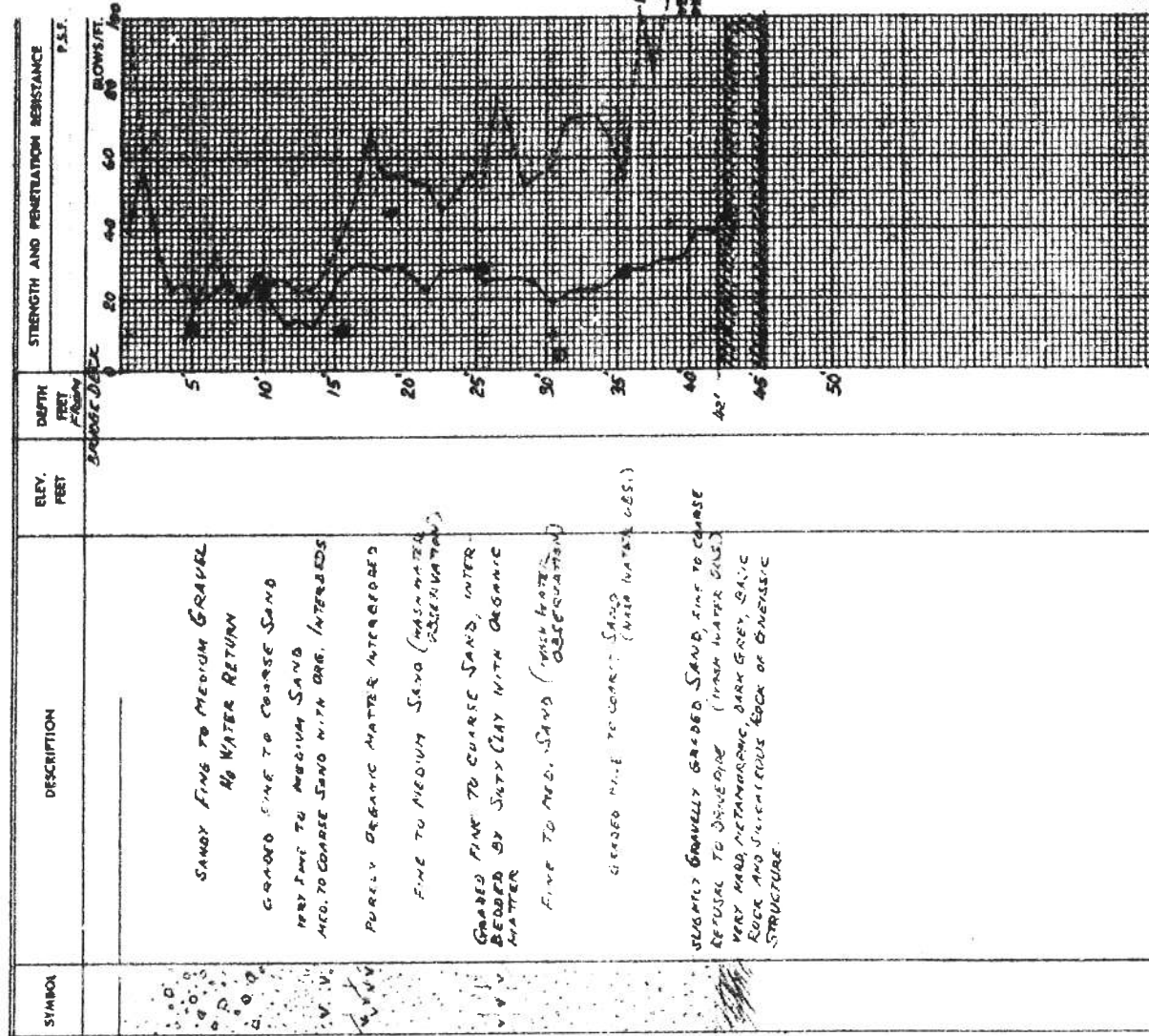
Field Supervisor: R. CASS

Driller: W. LINTON

Prep: G.O.; A.T.

Checked: M. TUDOR

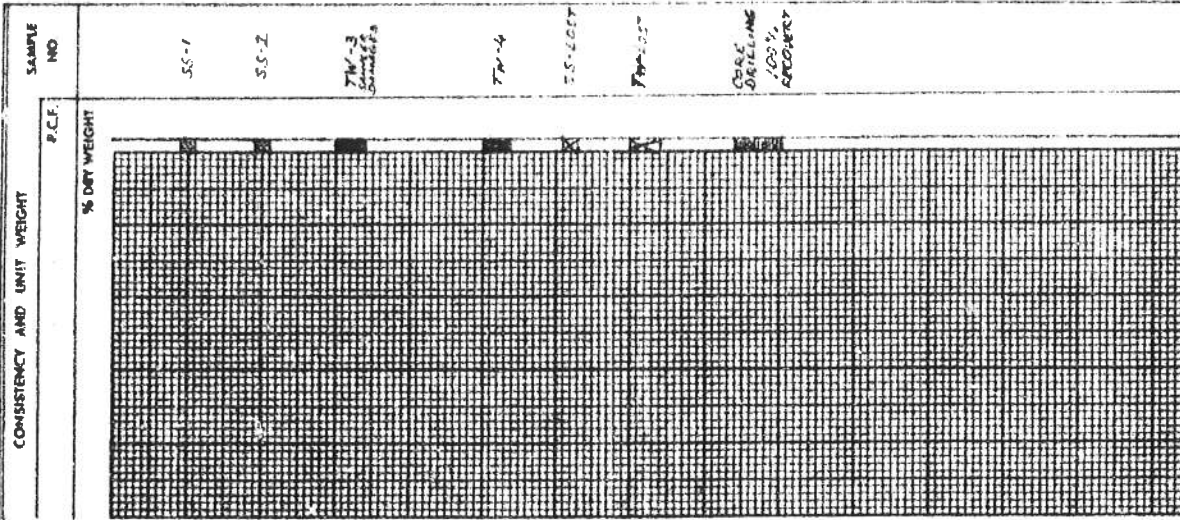
Date: APRIL 19th 1958



LEGEND

- Sampling Method
 - 2" Dia. split tube
 - 2" Shelby tube
- Penetration Resistance
 - 2" Split tube
 - 2" Dia. Cone
 - Coring
- Strength
 - Unconfined compression
 - Vane test and sensitivity
- Consistency
 - Natural moisture
 - Liquid limit
 - Plastic limit
- Natural Unit Weight

(See Figure 1)



Order No. S-500/T-282

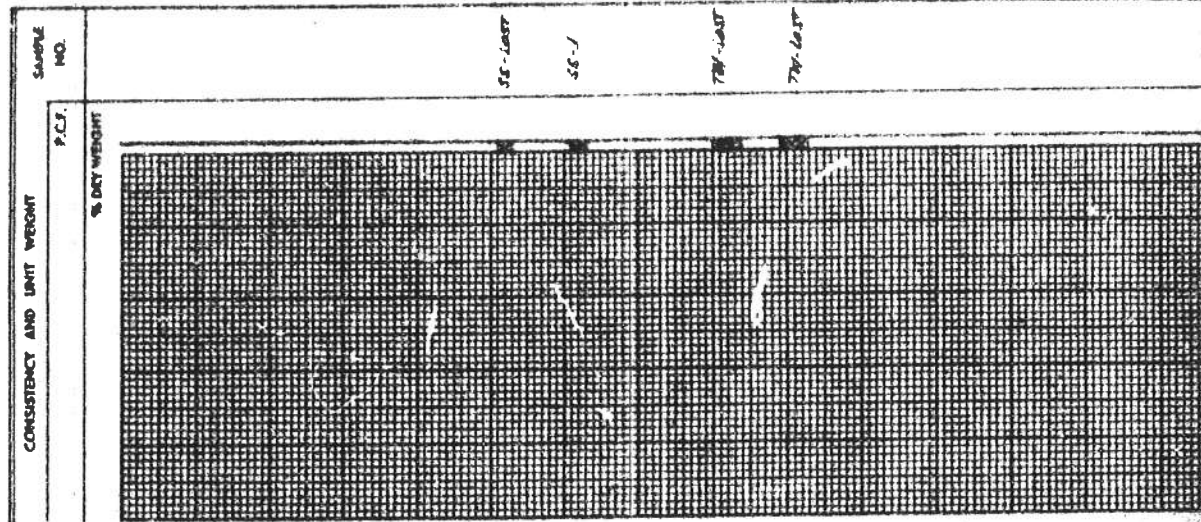
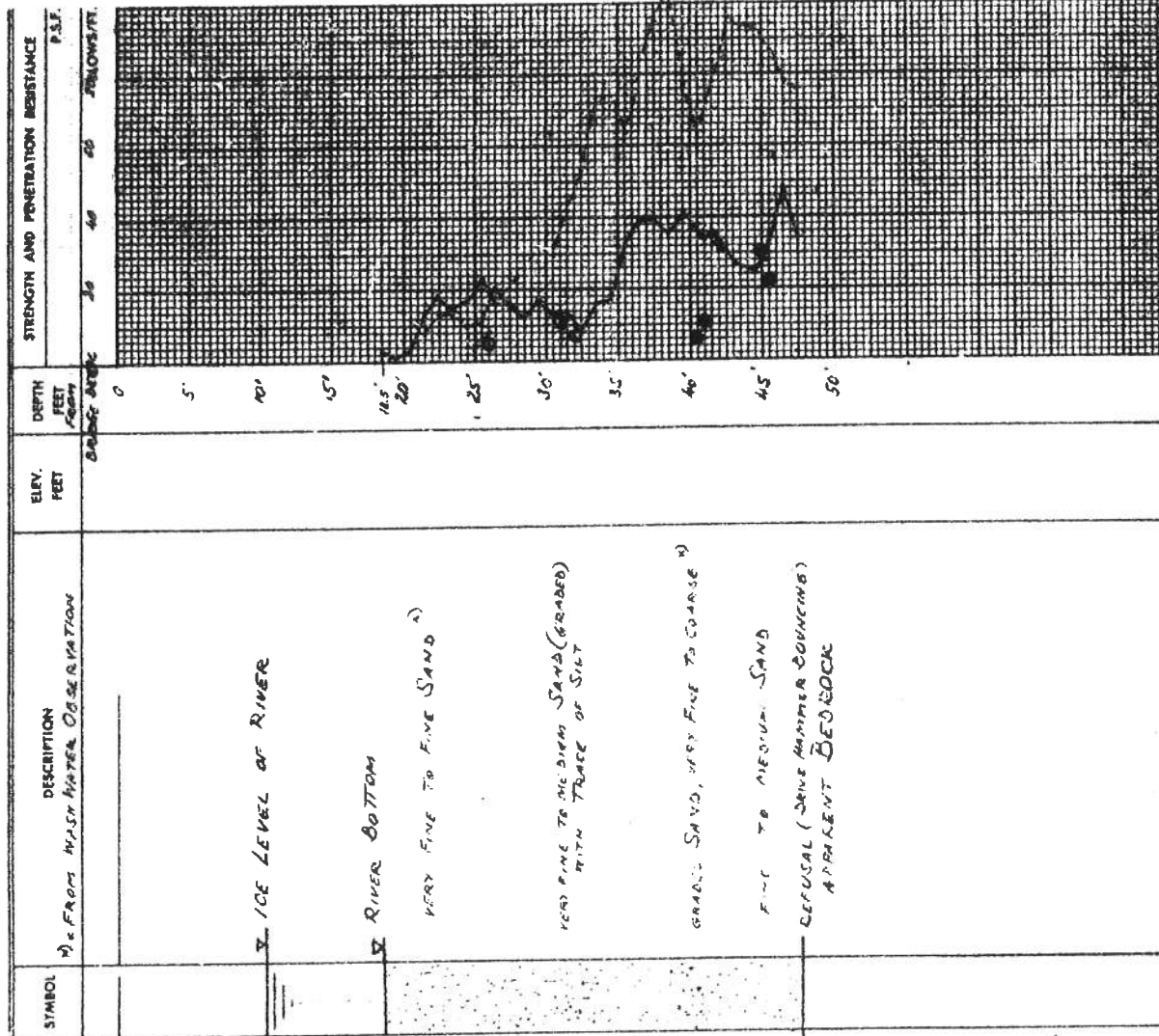
Enclosure No. 7

RACEY McCALLUM AND ASSOCIATES LTD.

Foundation Engineering Division

Engineering Data Sheet for Borehole: 3

Project: PROPOSED NEW BUG RIVER BRIDGE
 Location: HWY. 105, RED LAKE DISTRICT, ONT.
 Hole Location
 Hole Elevation and Datum
 Field Work Begun APRIL 14th, 1958 Ended APRIL 16th, 1958 Date
 Field Supervisor R. CASE
 Driller M. LINTON
 Prep: K. T.
 Checked: K. TURBESING



Symbols:
 1" Dia. Solid Tube
 2" Dia. Solid Tube
 2" Dia. Casing
 2" Dia. Case
 Casing
 Strength
 Unconfined compression
 Vane test and sensitivity
 Consistency
 Natural moisture
 Liquid limit
 Plastic limit
 Natural Unit Weight

Appendix D

Site Photographs



Photograph 1 – Bug River Bridge



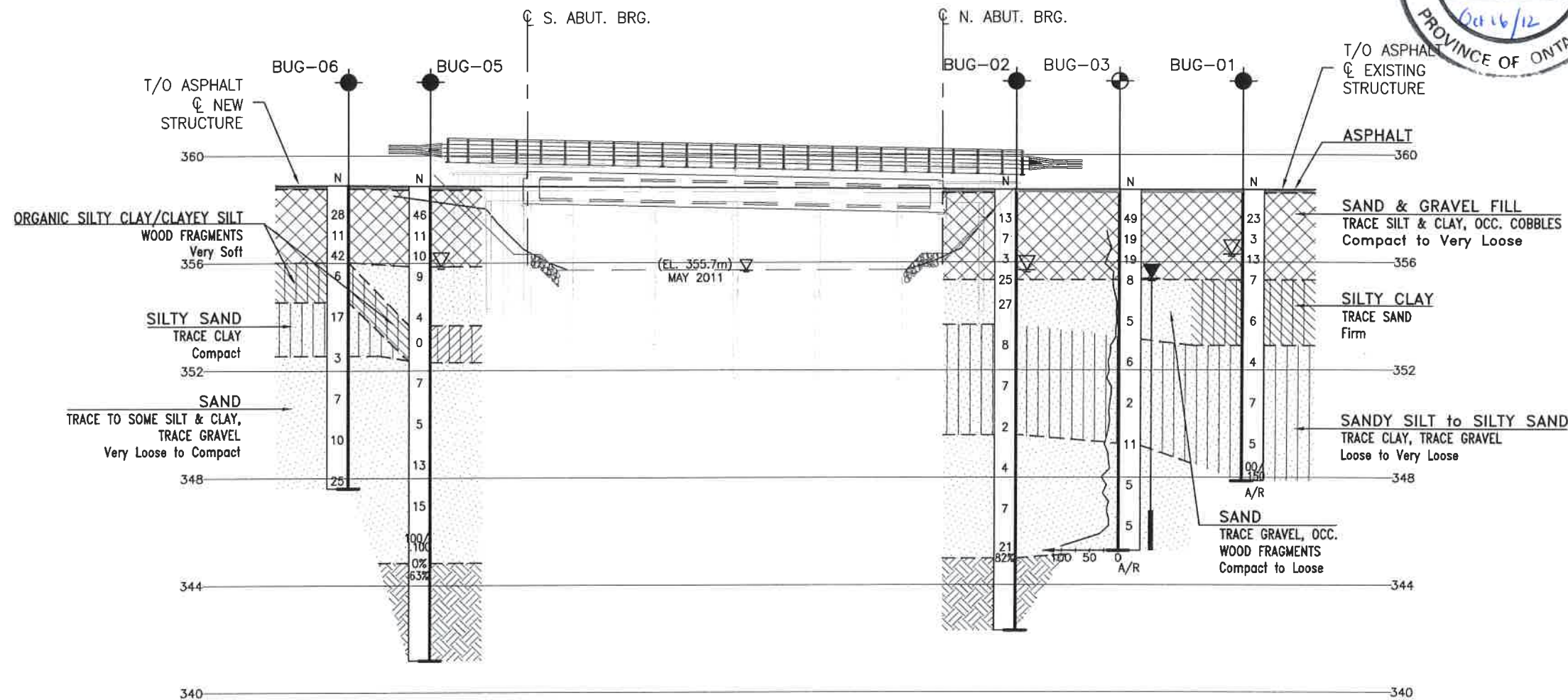
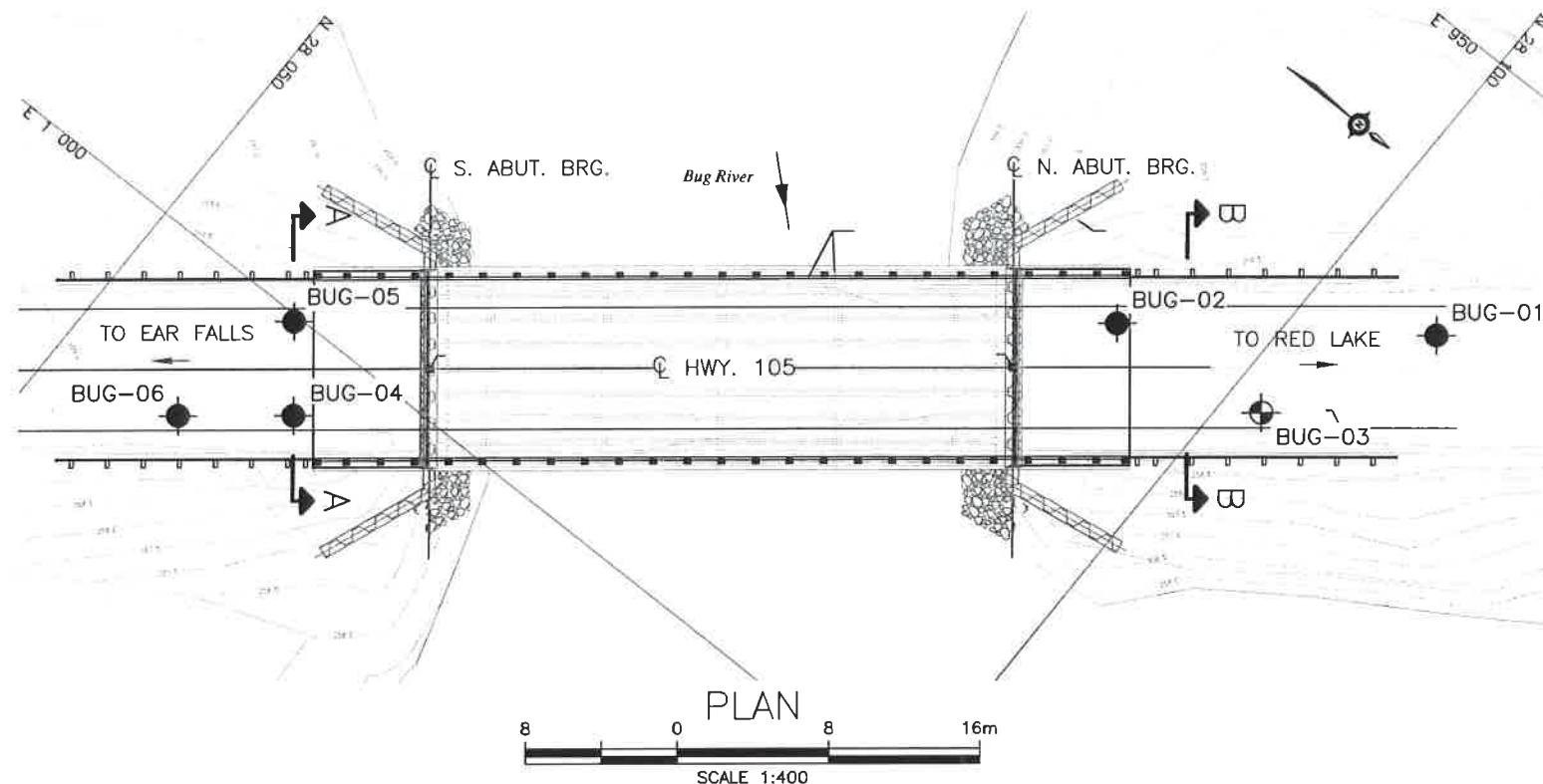
Photograph 2 – Lands north and west the Bug River Bridge



Photograph 3 –Bug River Bridge

Appendix E

Borehole Locations and Soil Strata Drawings



PROFILE ALONG ϕ HWY. 105

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



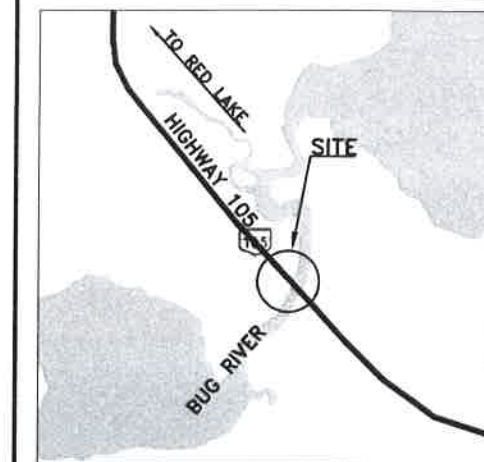
CONT No 2012-6015
WP No 6942-10-01

BUG RIVER BRIDGE
REPLACEMENT
HIGHWAY 105
BOREHOLE LOCATIONS AND SOIL STRATA

GENIVAR



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
	Blows /0.3m (Std Pen Test, 475J/blow)
	Blows /0.3m (60' Cone, 475J/blow)
	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
	Rock Quality Designation (RQD)
	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
BUG-01	358.7	281 06.6	963.4
BUG-02	358.7	280 93.1	973.3
BUG-03	358.7	281 02.0	972.3
BUG-04	358.8	280 62.1	1 004.2
BUG-05	358.9	280 59.0	1 000.3
BUG-06	358.9	280 57.3	1 008.0

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. 52K-8

DATE	BY	DESCRIPTION
DESIGN	LRB	CHK LRB
DRAWN	AN	CHK
DATE	10/17/2012	10/17/2012
DATE	10/17/2012	10/17/2012

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

CONT No 2012-6015
WP No 6942-10-01

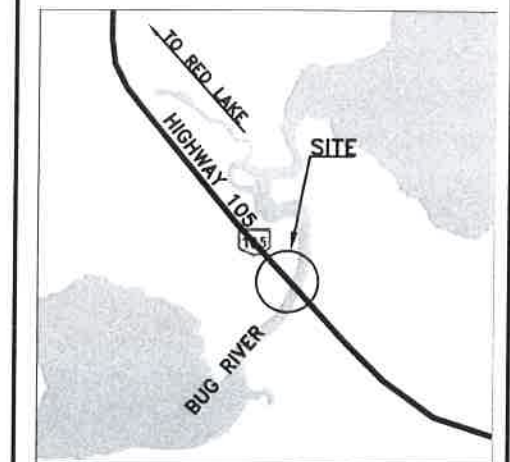
BUG RIVER BRIDGE
REPLACEMENT
HIGHWAY 105
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

GENIVAR



THURBER ENGINEERING LTD.



KEYPLAN LEGEND

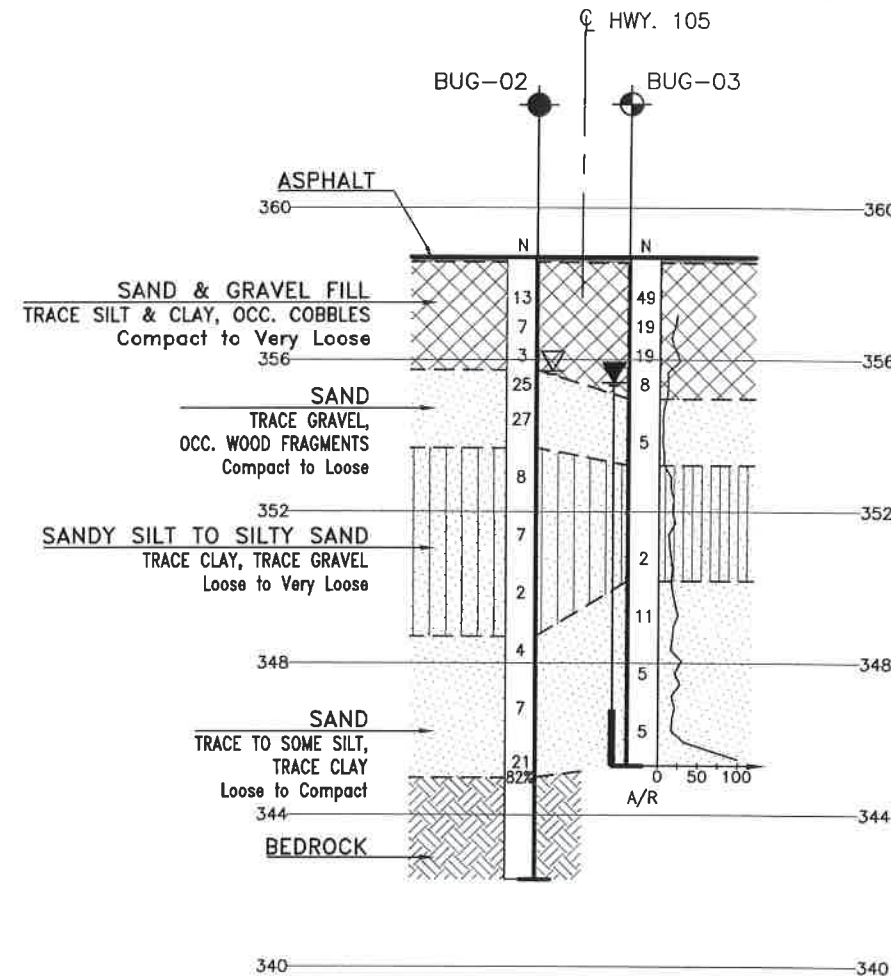
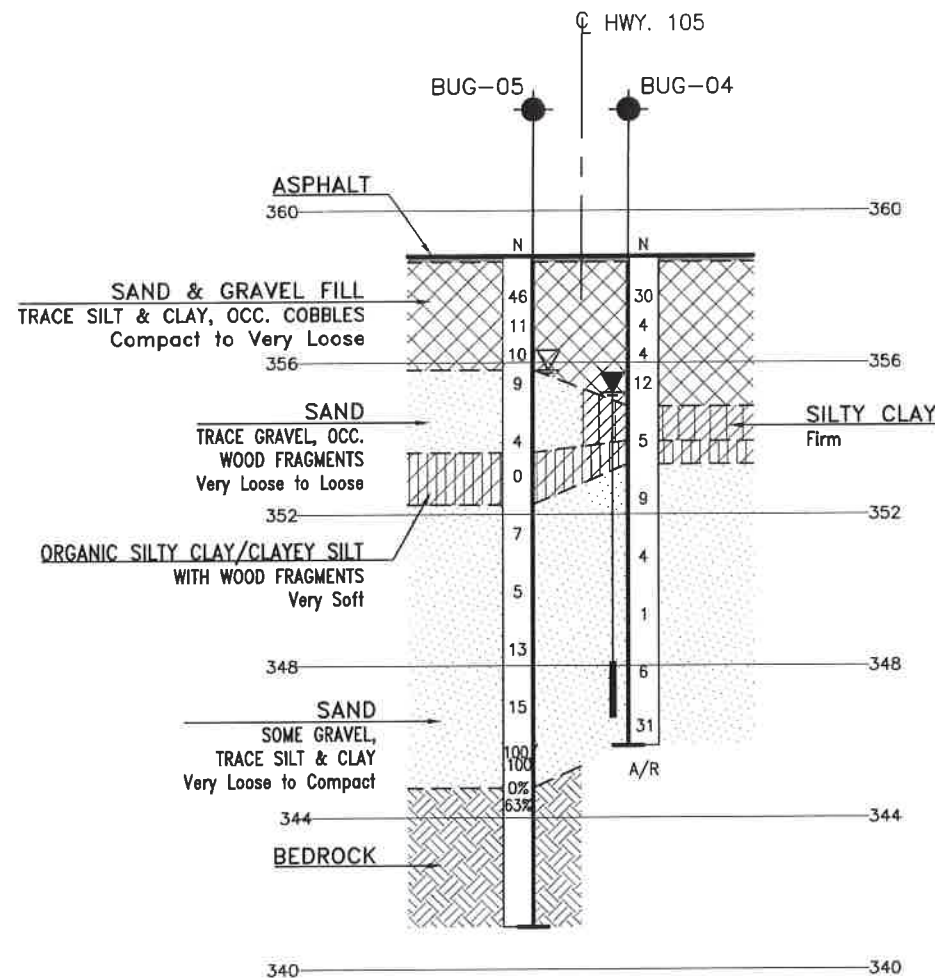
●	Borehole
⊕	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
W	Water Level
HA	Head Artesian Water
P	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
BUG-01	358.7	281 06.6	963.4
BUG-02	358.7	280 93.1	973.3
BUG-03	358.7	281 02.0	972.3
BUG-04	358.8	280 62.1	1 004.2
BUG-05	358.9	280 59.0	1 000.3
BUG-06	358.9	280 57.3	1 008.0

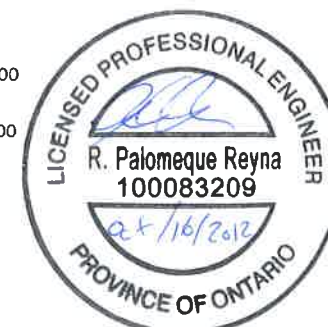
-NOTES-

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

GEOCREs No. 52K-8



H 1:400
V 1:200



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LRB	CHK	LRB
DRAWN	AN	CHK	SITE
			STRUCT
			JDWG 2
			DATE OCT. 2012