

**FOUNDATION INVESTIGATION AND DESIGN REPORT
LATOUR CREEK CULVERT REHABILITATION
HIGHWAY 567
NEW LISKEARD DISTRICT, ONTARIO**

G.W.P. No. 5201-13-00, W.P. No. 5201-13-02, SITE NO. 47-315/C

GEOCRES Number: 31M-115

Report to

MMM Group Limited

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February 25, 2021
File: 19-5161-251

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FIDR\195161251 Latour Creek Culvert FINAL FIDR-rev.doc

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) at the culvert under Highway 567 carrying Latour Creek, located in the Township of Lorrain, New Liskeard District, Ontario.

The purpose of this investigation was to obtain subsurface information at the culvert location and, based on the data obtained, to provide a borehole location plan, stratigraphic profile, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by MMM Group Limited to carry out this foundation investigation under the MTO Assignment Number 5014-E-0019.

2 SITE DESCRIPTION

The culvert site is located on Highway 567, approximately 16.7 km south of old Highway 11B (Rorke Avenue) in the Township of Lorrain, New Liskeard District, Ontario. This culvert allows Latour Creek to flow, from west to east, under Highway 567. Highway 567 generally runs in a northwest-southeast direction at the culvert site.

An Ontario Structure Inspection Manual (OSIM) report prepared in 2011 reports the existing structure to be a 41 m long, 4.6 m span by 4.3 m high, corrugated steel pipe arch culvert, with approximately 3.5 m of fill above the culvert. It is understood that the structure is in good condition with minor deterioration of several elements with more significant deterioration of the structural steel coatings. The culvert is proposed for rehabilitation.

The grade level of Highway 567 at the existing culvert is at approximate Elevation 197.6 m.

The site is located approximately 15 km southeast of Cobalt. Naturally low-lying areas are present near the inlet and outlet of the culvert, with vegetation consisting of grass, shrubs, and frequent trees. The area in the immediate vicinity of the culvert is undulating and generally sloping downwards from the highway grade to the creek.

Based on published geological information, the general area of the project is covered by glaciolacustrine fine-textured deposits of clays and silts deposited during the Pleistocene period. These deposits are often rhythmically laminated or varved and are overlain by thin layer of swamp and alluvium deposits composed of silt, sand, possible gravel and organics. The soils in the immediate vicinity of the creek valley consist of recent alluvium deposits including sand, silt, gravel and organic material. The bedrock in the area consists of Precambrian quartzite, arkose, siltstone, and conglomerate of the Lorrain Formation (Cobalt Group).

3 SITE INVESTIGATION AND FIELD TESTING

The borehole investigation and field testing program was carried out from June 9 to 10, 2015. The program consisted of drilling and sampling 2 boreholes, numbered LC-01 and LC-02, to depths of 4.0 and 2.7 m respectively. Of these boreholes, one was located near the culvert inlet (LC-01) and one was located near the culvert outlet (LC-02). Both boreholes were drilled near the base of the highway embankment.

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 coordinate system MTM NAD 83, Zone 12 was used for the boreholes. The approximate borehole locations are shown on the Borehole Locations and Soil Strata drawing included in Appendix C.

Access to the culvert inlet and outlet was only possible for a portable tripod drill rig, which was used to advance the boreholes to the target depth using NW casing and wash boring techniques. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). Groundwater conditions in the open boreholes were observed throughout the drilling operations. The details regarding borehole completion are summarized in Table 3.1.

Table 3.1 - Borehole Completion and Backfilling Details

Borehole	Borehole Depth/ Elevation (m)	Borehole Backfilling Details
LC-01	4.0 / 189.5	Bentonite holeplug from 4.0 m to ground surface.
LC-02	2.7 / 191.7	Bentonite holeplug from 2.7 m to ground surface.

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

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, secured the recovered soil samples in labelled containers, and transported the samples to Thurber's laboratory for further examination and testing.

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected soil samples were subjected to grain size distribution analyses (sieve and hydrometer) and plasticity testing (Atterberg Limits). The results of this laboratory testing program are shown on the Record of Borehole sheets in Appendix A and on the figures 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 the surface water from the creek upstream of the existing culvert were collected. The samples were submitted to AGAT Laboratories in Mississauga, Ontario for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 below and are presented in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix A for details of the soil stratigraphy encountered in the boreholes. A stratigraphic section for this culvert site are presented on the Borehole Locations and Soil Strata Drawing in Appendix C for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the record of boreholes governs any interpretation of the site conditions.

A 1956 report by the Department of Highways Ontario, Materials and Research Branch, describes a foundation investigation that was conducted prior to construction of the existing culvert. The locations of the boreholes from the 1956 report (Geocres No. 31M-02) could not be determined with sufficient accuracy to reference in the subsurface stratigraphy described in the current report, however the 1956 factual information is presented in Appendix C for information purposes. The subsurface conditions encountered during the 1956 investigation generally consisted of silty clay with some boulders and sand and gravel deposits, underlain by bedrock at depths below the ground surface ranging from 2.7 m on the south side of the creek and 4.1 to 12.3 m on the north side of the creek.

In general, the subsurface conditions encountered in the boreholes from the current investigation consist of a silty clay, which is overlain by sand and gravel fill in Borehole

LC-02 with a thin veneer of silt. The boreholes were terminated on casing refusal at 2.7 and 4.0 m depths on probable boulders or bedrock. Groundwater levels are generally in the order of 1.2 m below original ground surface. More detailed descriptions of the individual stratum are presented below.

5.2 Silt

A 50 mm thick layer of silt with some clay, some sand and roots was encountered at the ground surface in Borehole LC-02 located near the culvert outlet area. The silt layer overlies sand and gravel embankment fill. The measured moisture content of a sample of the silt was 23%.

5.3 Sand and Gravel Fill

A layer of sand and gravel embankment fill was encountered underlying the silt in Borehole LC-02. This layer typically consists of brown sand and gravel with trace silt. The thickness of the sand in gravel in Borehole LC-02 was 0.7 m with a lower boundary depth of 0.8 m (base Elevation 193.6 m).

An SPT N-value measured in the sand and gravel fill was 23 blows per 0.3 m penetration indicating a compact density. The measured moisture content of the recovered sample was 10%. A grain size analysis conducted on a sample of the sand and gravel fill is presented in Figure B1 in Appendix B. The result is summarized in the following table.

Soil Particles	%
Gravel	47
Sand	46
Silt and Clay	7

5.4 Silty Clay

Silty clay was encountered at the ground surface in Borehole LC-01 and below the sand and gravel fill in Borehole LC-02 at a depth of 0.8 m. The boreholes were terminated within the silty clay at depths of 4.0 and 2.7 m (base Elevations 189.5 and 191.7 m respectively) due to casing refusal on suspected boulders or bedrock at the base of the clay.

The silty clay was brown to grey in colour and contained clayey silt layers, trace to some sand, trace gravel and occasional cobbles. Near the ground surface in Borehole LC-01, the upper 0.6 m of the silty clay deposit was dark brown and also contained some organics in the form of roots.

Measured SPT N-values in the silty clay ranged between 19 and 62 blows per 0.3 m penetration indicating a typically very stiff to hard consistency, with the very stiff material in

the upper 0.6 m, and becoming hard with depth. SPT N-values of 100 blows or greater for less than 0.3 m penetration were also recorded, which are likely indicative of cobbles and boulders or probably bedrock.

The measured water contents of samples recovered from the silty clay typically ranged from 21% to 31%. The results of grain size analyses and an Atterberg Limits test conducted on samples of the silty clay are presented in Figures B2 and B3 in Appendix B. The results are summarized in the following table.

Soil Particles	%
Gravel	0 to 7
Sand	4 to 18
Silt	27 to 73
Clay	23 to 48
Soil Property	%
Liquid Limit	17
Plastic Limit	12

The results of the Atterberg Limits test indicates that the silty clay is typically of low plasticity, with a group symbol of CL-ML.

5.5 Groundwater Conditions

Free water was observed in the boreholes upon completion of drilling and the water level measurements are presented in Table 5.1 below. Wash boring methods were used to advance both boreholes and therefore the water level recorded during or upon completion of drilling may not reflect natural groundwater levels.

Table 5.1 – Water Level Measurements in Open Boreholes

Borehole	Date of Reading	Water Level	
		Depth (m)	Elevation (m)
LC-01	June 9, 2015	1.2	192.3
LC-02	June 10, 2015	-	-

The observed water level in the creek was measured during the drilling investigation at approximately 1.6 to 1.4 m above the base of the culvert at the inlet and outlet respectively (approximate Elevation 190.8 to 190.6 m). A water level was also measured in the creek by MMM Group Limited at Elevation 190.6 on June 16, 2015. The groundwater level should be

assumed to reflect the local creek water level. The groundwater levels are expected to vary seasonally and are subject to severe weather events such as rainstorms.

6 HYDRAULIC CONDUCTIVITY OF SUBSURFACE SOILS

The estimated hydraulic conductivity values for the subsurface soils encountered within the depth of exploration are provided in Table 6.1. The sand and gravel value is estimated from an empirical relationship with grain size distribution, and the silty clay value is based on the typical range of hydraulic conductivity.

Table 6.1 – Hydraulic Conductivity Values for Subsurface Soils

Material	Hydraulic Conductivity (m/s)
Sand and Gravel	1×10^{-4} to 1×10^{-3}
Silty Clay	1×10^{-10} to 1×10^{-8}

7 CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the surface water from the creek was submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 7.1. The laboratory certificates of analysis are presented in Appendix B.

Table 7.1 – Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results	
			LC-01, SS#3, 5'-7'	Latour Creek Culvert
			(Silty Clay)	(Creek Water)
Sulphide	%	mg/L	0.01	<0.05
Chloride	µg/g	mg/L	83	1.53
Sulphate	µg/g	mg/L	5	4.14
pH	pH Units	pH Units	8.32	7.94
Electrical Conductivity	mS/cm	µS/cm	0.241	265
Resistivity	ohm.cm	ohm.cm	4150	3770
Redox Potential	mV	mV	223	290
Langlier Index	-	-	-	0.46
Total Hardness (as CaCO ₃)	-	mg/L	-	145
Total Dissolved Solids	-	mg/L	-	140
Alkalinity (as CaCO ₃)	-	mg/L	-	134
Calcium	-	mg/L	-	42.5
Magnesium	-	mg/L	-	9.40

8 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 relative to the topographic plans provided by MMM Group Limited.

Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied and operated a portable tripod drill rig to carry out the drilling, sampling and in-situ testing operations. The drilling and sampling operations in the field were supervised on a full time basis by Ms. Eckie Siu of Thurber. Geotechnical laboratory testing was carried out by Thurber in its MTO-approved laboratory.

A sample of creek water was submitted to AGAT Laboratories in Mississauga, Ontario for testing of selected corrosivity parameters.

Overall supervision of the field program, interpretation of the data, and preparation of the report were carried out by Mr. Stephane Loranger, CET, Ms. Deanna Pizycki, EIT, and Mr. Mark Farrant 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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GEOCRES Number: 31M-115

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

9 GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides foundation recommendations for the proposed rehabilitation of the existing Latour Creek Culvert on Highway 567, in the Township of Lorrain, New Liskeard District, Ontario.

The existing structure is a 4.6 m span by 4.3 m high corrugated steel pipe arch culvert. Based on the terms of reference, it is understood that the culvert is in good condition with minor deterioration of several elements, and more significant deterioration of the structural steel coatings. Therefore, the culvert is proposed for structural rehabilitation, which may include placement of a liner system, shotcrete treatment, or both. The purpose of the foundation investigation is to provide dewatering recommendations to enable rehabilitation of the culvert in the dry.

The discussions and recommendations presented in this report are based on information provided by MMM Group Limited (MMM) and on the factual data obtained during the course of this investigation.

Selected photographs of the culvert area are included in Appendix E for reference.

10 EXCAVATIONS AND DEWATERING

10.1 Excavations

Where excavations are required in order to rehabilitate the culvert they must be conducted in accordance with the requirements of the Occupational Health and Safety Act and Regulations (OHSA) for Construction Projects. The soil types at this site should be classified as follows:

- | | |
|--|--------|
| • Sand and Gravel Fill / Embankment Fill | Type 3 |
| • Silty Clay (very stiff to hard) | Type 2 |

The Contract Documents should alert the Contractor to the risks associated with excavations near the creek and below the groundwater level and specify that an appropriate dewatering system must be provided to maintain a stable and dry work area.

The Contractor shall be alerted to the presence of shallow bedrock. The presence of shallow bedrock must be considered in the selection of the Temporary Flow Passage System and design of any cofferdam. In light of the shallow bedrock, sheetpile cofferdam is not practical at this site.

Any temporary excavation must not undermine or destabilize existing culvert footings.

10.2 Dewatering

The Contractor must be prepared to control the groundwater and surface water flow at the site to permit the culvert rehabilitation works to be conducted in a dry and stable excavation. The groundwater level for the site at the time of the proposed works should be taken as the water level in the creek. It is recommended that the rehabilitation works be conducted during a drier season when the creek level is likely to be low.

Temporary water course diversion may be required to rehabilitate the culvert in the dry. Water from either surface flow and/or groundwater must be diverted away from the excavation at all times. Groundwater perched within the embankment fill, surface water runoff, and/or the water from the creek will tend to seep into and accumulate in proposed excavations.

If excavations below the groundwater level are anticipated, a cofferdam may be required to control the inflow of water into the excavation.

Dewatering and surface water diversion must remain operational and effective until the culvert is repaired and excavations are backfilled. Decisions regarding dewatering must be taken by the Contractor.

It is recommended that the Contract Documents identify a water level in Latour Creek against which the cofferdam must provide protection and prevent flooding of the work area. The appropriate water level must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field. At a minimum the expected spring thaw level or the level reached by a storm of appropriate return period should be used as the design water level.

Further discussion with regards to dewatering at this site is provided in the Non-Standard Special Provision (NSSP) in Appendix F.

11 CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the native soil and the creek water indicate the following:

- The potential for corrosion or sulphate attack on concrete treatment systems 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 surface water corrosion on metal is considered to be mild to moderate.
- Appropriate protection measures are recommended to address the mild to moderate potential for corrosion on metal structural rehabilitation elements.

12 CONSTRUCTION CONCERNS

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

- Seasonal fluctuations of the groundwater and creek level 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.

13 CLOSURE

Preparation of this foundation design report was carried out by Mr. Mark Farrant, P.Eng. The report was reviewed by Mr. Alastair Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng.

THURBER ENGINEERING LTD.

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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


4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level
 Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION

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

RECORD OF BOREHOLE No LC-01

1 OF 1

METRIC

GWP# 5201-13-00 LOCATION Latour Creek Culvert N 5 242 521.5 E 415 975.3 ORIGINATED BY ES
 HWY 567 BOREHOLE TYPE Tripod COMPILED BY MFA
 DATUM Geodetic DATE 2015.06.09 - 2015.06.09 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20	40	60	80	100		
193.5	GROUND SURFACE													
0.0	Silty CLAY , with clayey silt layers, trace sand, trace gravel, some organics (roots and rootlets) in upper 0.6m Very Stiff Dark Brown Moist With occasional oxide staining Becoming Hard Brown to Grey		1	SS	21									
192.9														
0.6														
				2	SS	62								
				3	SS	49								
			4	SS	50									
			5	SS	45									
189.5			6	SS	100/ 0.000									
4.0	END OF BOREHOLE AT 4.0m UPON CASING REFUSAL ON PROBABLE BEDROCK OR BOULDERS. WATER LEVEL AT 1.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

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

RECORD OF BOREHOLE No LC-02

1 OF 1

METRIC

GWP# 5201-13-00 LOCATION Latour Creek Culvert N 5 242 523.3 E 416 013.6 ORIGINATED BY ES
 HWY 567 BOREHOLE TYPE Tripod COMPILED BY MFA
 DATUM Geodetic DATE 2015.06.10 - 2015.06.10 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
194.4	GROUND SURFACE							20	40	60	80	100			
0.0	<div><div>SILT, some clay, some sand, some organics (roots) (FILL)</div><div>SAND and GRAVEL, trace silt Compact Brown Wet (FILL)</div><div>Silty CLAY, with clayey silt layers, some sand, trace gravel, occasional cobbles Very Stiff to Hard Brown Moist</div></div>		1	SS	23		194								47 46 7 (SI+CL)
0.1															
193.6				2	SS	19		193							
0.8				3	SS	108/ 0.275									7 18 27 48
191.7			4	SS	100/ 0.225		192								
2.7	END OF BOREHOLE AT 2.7m UPON CASING REFUSAL ON PROBABLE BEDROCK OR BOULDERS. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE. UNSAMPLED PROBEHOLE LOCATED 2.0m NORTH, ENCOUNTERED REFUSAL AT 2.5m DEPTH.														

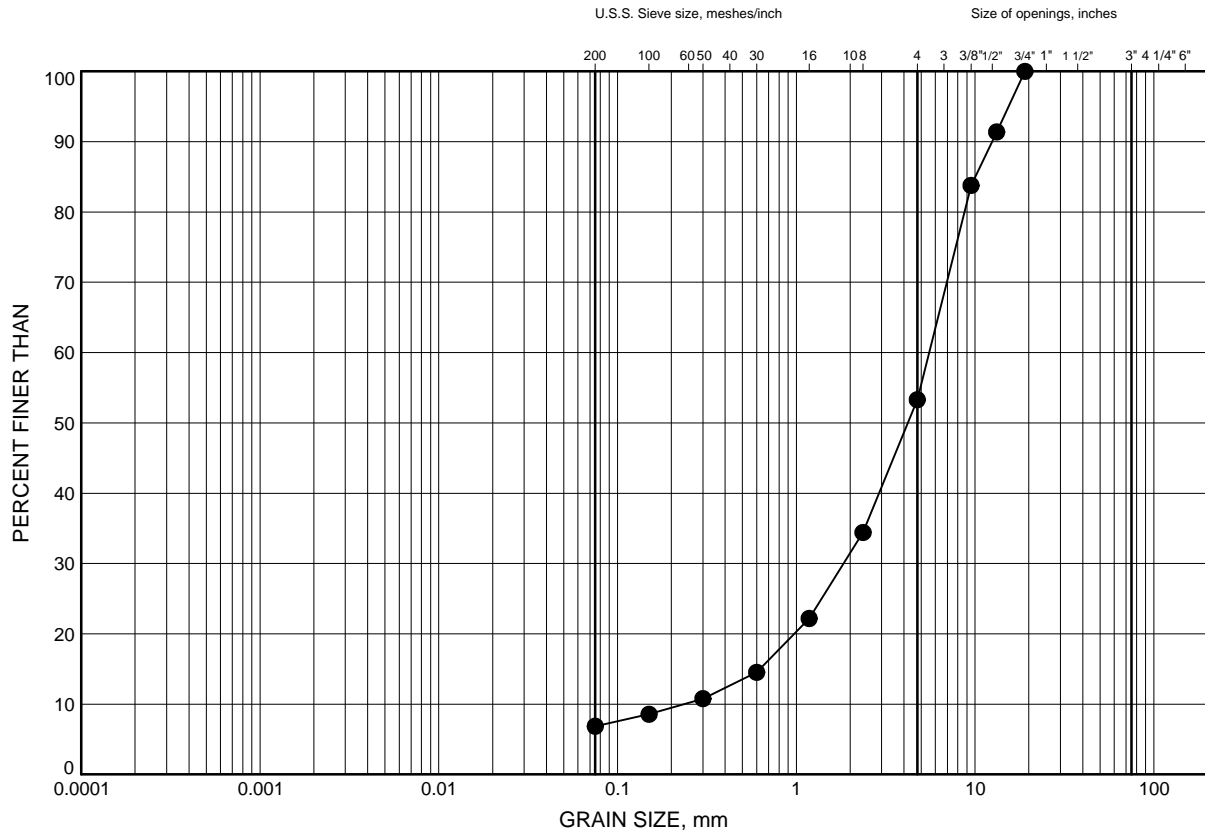
Appendix B

Laboratory Test Results

Latour Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND & GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	LC-02	0.36	194.04

Date February 2016
GWP# 5201-13-00

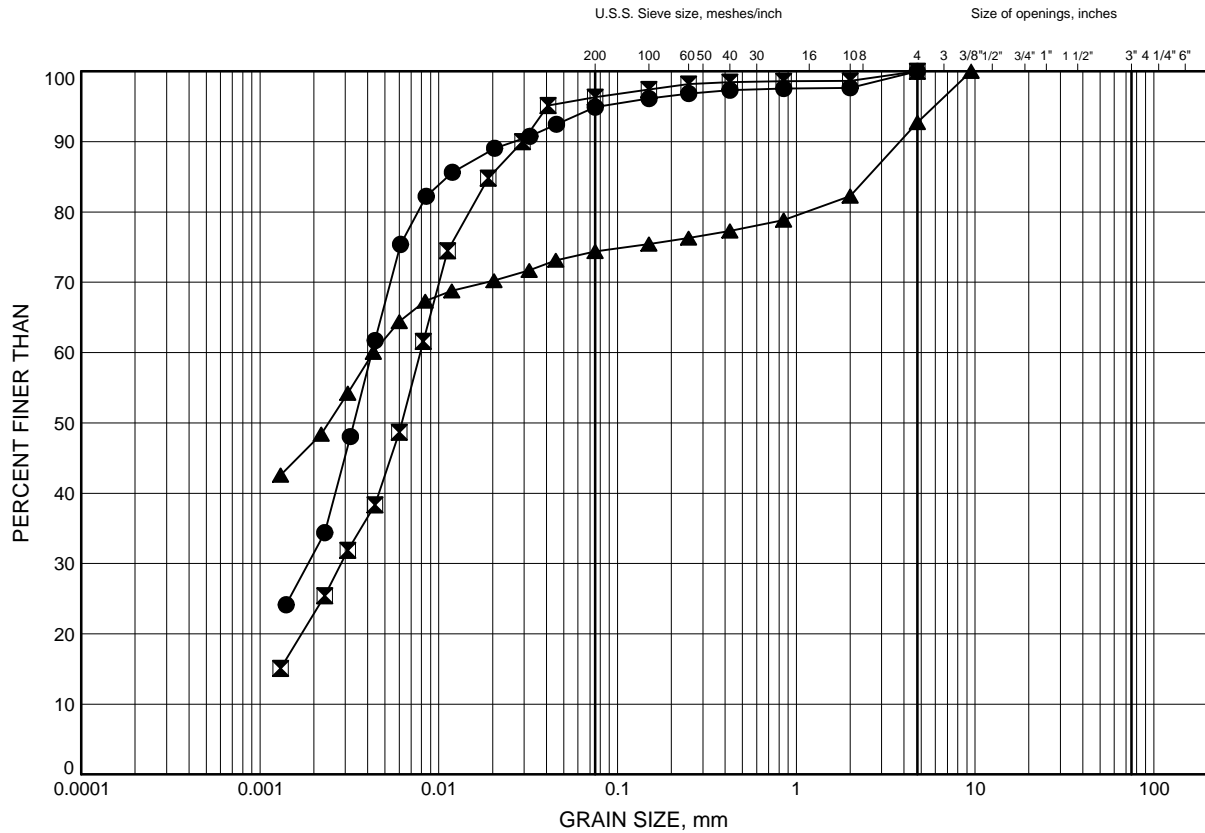


Prep'd AN
Chkd. MEF

Latour Creek Culvert 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)
●	LC-01	1.07	192.43
⊠	LC-01	3.35	190.15
▲	LC-02	1.66	192.74

Date February 2016
GWP# 5201-13-00

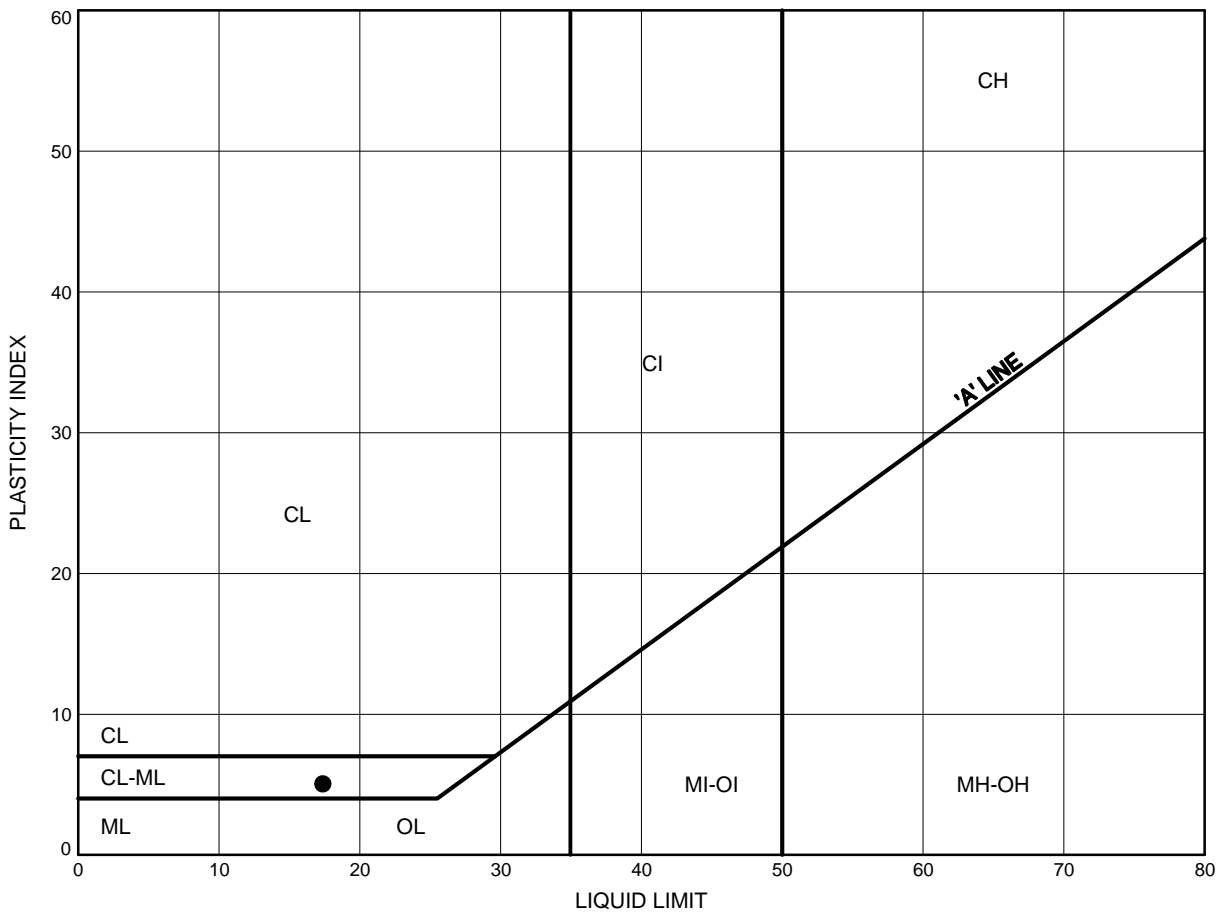


Prep'd AN
Chkd. MEF

Latour Creek Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE B3

Silty CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	LC-01	1.83	191.67

Date February 2016
 GWP# 5201-13-00



Prep'd AN
 Chkd. MEF

Certificate of Analysis

CLIENT NAME: THURBER ENGINEERING LTD

PROJECT: 19-5161-251

SAMPLING SITE:

AGAT WORK ORDER: 16T069627

ATTENTION TO: MARK FARRANT

SAMPLED BY:

Corrosivity Package							
SAMPLE TYPE: Soil		SAMPLE ID: 7394037			DATE RECEIVED: Feb 18, 2016		
DATE SAMPLED: Jun 09, 2015				DATE REPORTED: Feb 23, 2016			
SAMPLE DESCRIPTION: LC-01, SS#3, 5'-7'							
PARAMETER	UNIT	RESULT	G / S	RDL	DATE ANALYZED	INITIAL	DATE PREPARED
Sulfide	%	0.01		0.01	Feb 23, 2016	ME	Feb 23, 2016
Chloride (2:1)	µg/g	83		2	Feb 22, 2016	MM	Feb 22, 2016
Sulphate (2:1)	µg/g	5		2	Feb 22, 2016	MM	Feb 22, 2016
pH (2:1)	pH Units	8.32		NA	Feb 22, 2016	AK	Feb 22, 2016
Electrical Conductivity (2:1)	mS/cm	0.241		0.005	Feb 22, 2016	NG	Feb 22, 2016
Resistivity (2:1)	ohm.cm	4150		1	Feb 22, 2016	SYS	Feb 22, 2016
Redox Potential (2:1)	mV	223		5	Feb 22, 2016	NG	Feb 22, 2016

COMMENTS:

RDL - Reported Detection Limit; G / S - Guideline / Standard
* Sulphide analysis was 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).

Please note that sample was received and analyzed past hold time.

Certified By: _____



Certificate of Analysis

CLIENT NAME: THURBER ENGINEERING LTD

PROJECT: 19-5161-251

SAMPLING SITE:

AGAT WORK ORDER: 15T990315

ATTENTION TO: MARK FARRANT

SAMPLED BY:

Inorganic Chemistry (Water)							
SAMPLE TYPE: Water		SAMPLE ID: 6699742			DATE RECEIVED: Jun 29, 2015		
DATE SAMPLED: Jun 26, 2015				DATE REPORTED: Jul 07, 2015			
SAMPLE DESCRIPTION: Latour Creek Culvert							
PARAMETER	UNIT	RESULT	G / S	RDL	DATE ANALYZED	INITIAL	DATE PREPARED
Electrical Conductivity	uS/cm	265		2	Jul 03, 2015	JC	Jul 03, 2015
pH	pH Units	7.94		NA	Jul 03, 2015	JC	Jul 03, 2015
Langelier Index		0.46			Jul 06, 2015	SYS	Jul 06, 2015
Total Hardness (as CaCO3)	mg/L	145		0.5	Jul 03, 2015	SYS	Jul 03, 2015
Total Dissolved Solids	mg/L	140		20	Jul 06, 2015	AP	Jul 03, 2015
Alkalinity (as CaCO3)	mg/L	134		5	Jul 03, 2015	JC	Jul 03, 2015
Chloride	mg/L	1.53		0.10	Jul 03, 2015	WZ	Jul 03, 2015
Sulphate	mg/L	4.14		0.10	Jul 03, 2015	WZ	Jul 03, 2015
Calcium	mg/L	42.5		0.05	Jul 03, 2015	PB	Jul 03, 2015
Magnesium	mg/L	9.40		0.05	Jul 03, 2015	PB	Jul 03, 2015
Resistivity	ohms.cm	3770			Jul 03, 2015	SYS	Jul 03, 2015
Sulphide	mg/L	<0.05		0.05	Jul 02, 2015	SN	Jul 02, 2015
Redox Potential	mV	290		5	Jul 06, 2015	BG	Jul 06, 2015

COMMENTS:

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

Certified By:

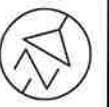


Appendix C

Borehole Locations and Soil Strata Drawings

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

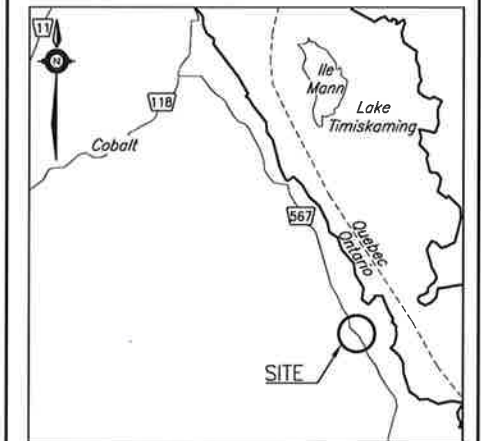
CONT No
GWP No 5201-13-00



HIGHWAY 567
LATOUR CREEK CULVERT
REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA








THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

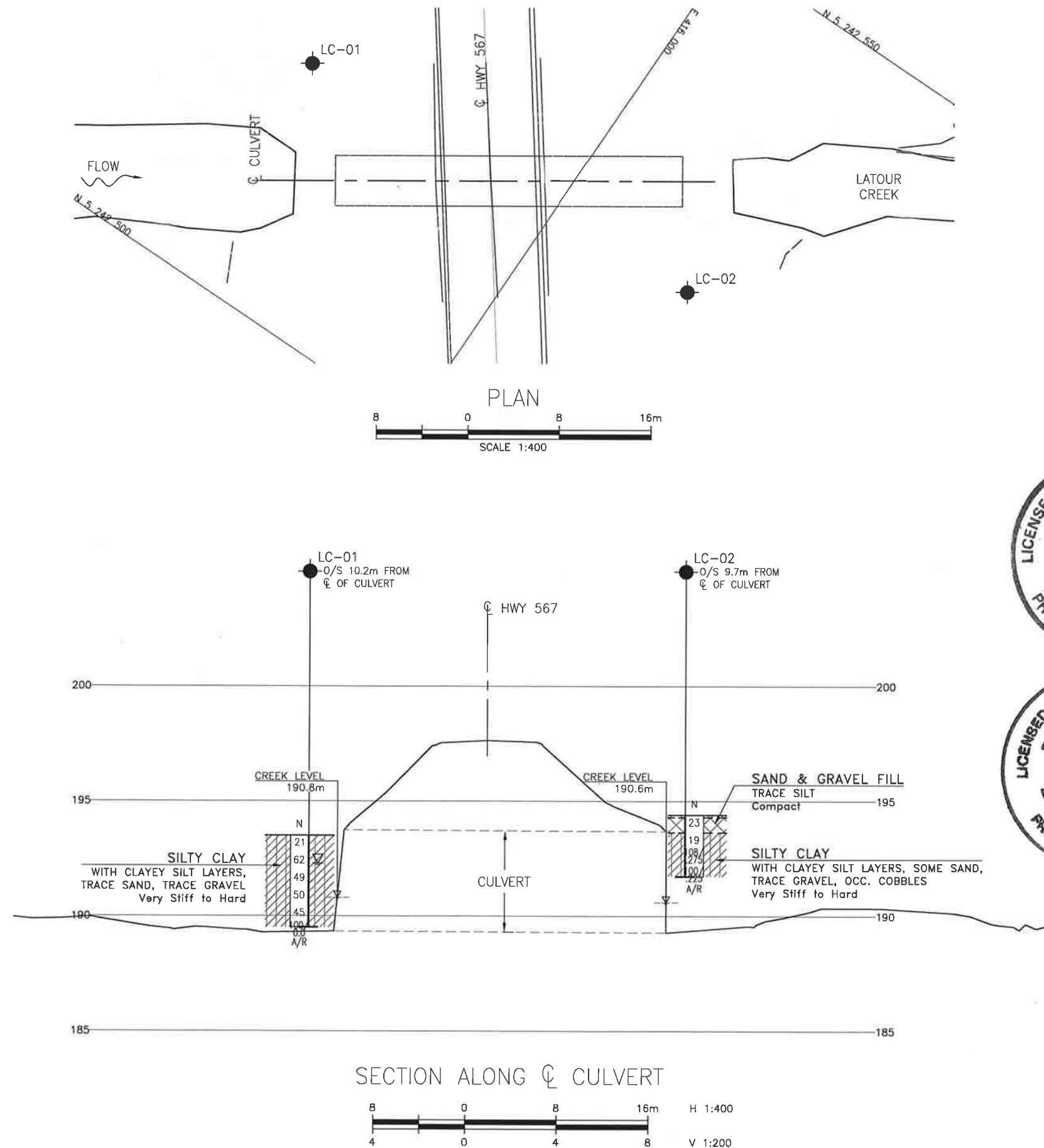
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
LC-01	193.5	5 242 521.5	415 975.3
LC-02	194.4	5 242 523.3	416 013.6

-NOTES-

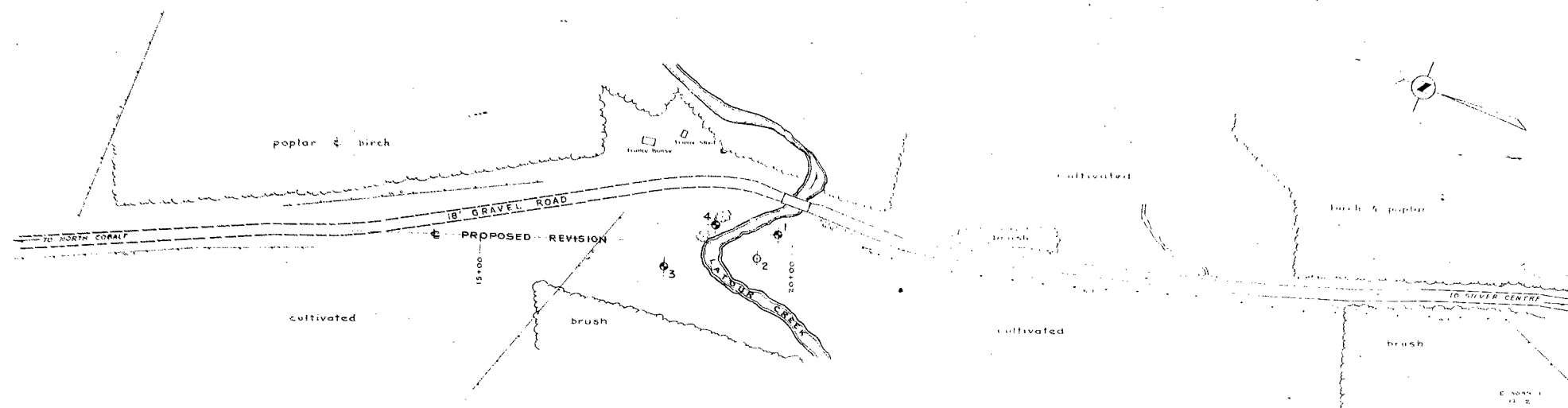
- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31M-115

[illegible]

Appendix D

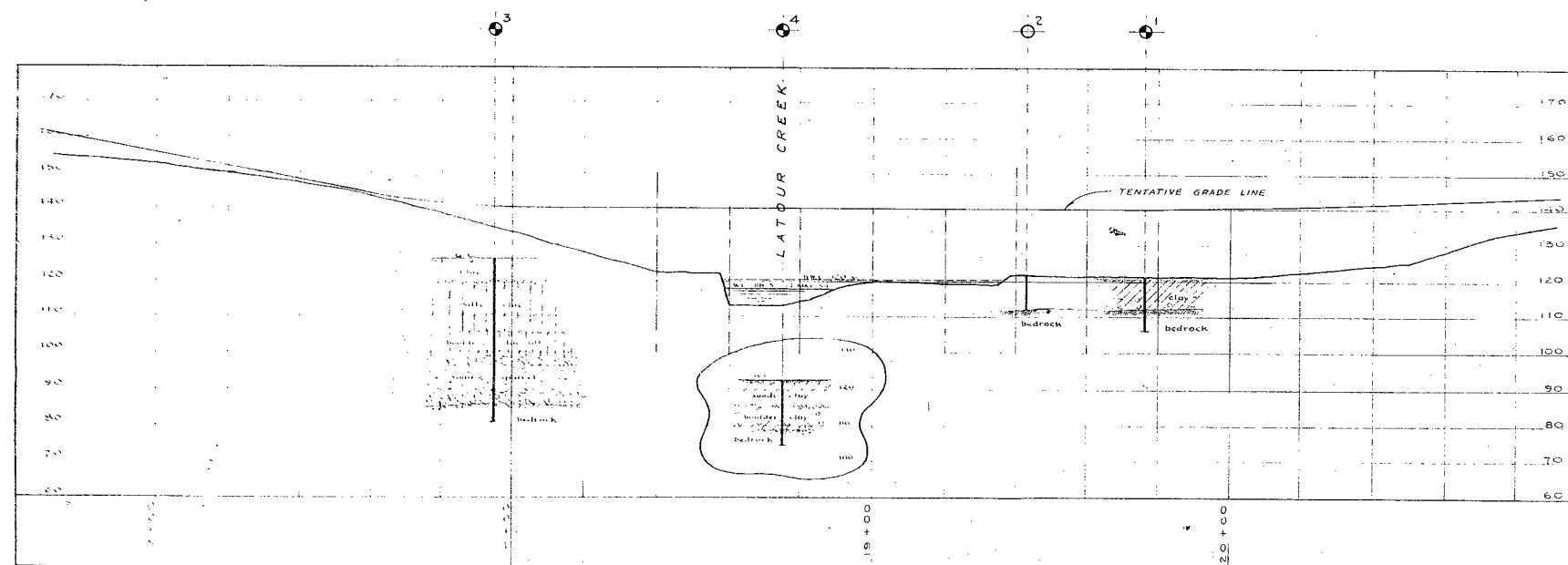
Factual Data from 1956 Foundation Investigation Report



PLAN
Scale - 1 inch = 100 feet

LEGEND			
Bore Holes			
Penetration Hole			
Bore & Penetration Hole			
HOLE NO.	ELEVATION	STATION	DISTANCE FROM CL
1	122.0	19+76	17.5' LT.
2	121.2	19+43	21.5' RT.
3	126.2	17+95	39' RT.
4	122.3	18+75	30' LT.

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.



PROFILE
Scale - 1 inch = 20 feet

DEPARTMENT OF HIGHWAYS, ONTARIO	
MATERIALS & RESEARCH SECTION - DOWNSVIEW	
LATOUR CREEK PROPOSED CROSSING	
THE KING'S HIGHWAY No. 567	DIV. No. 14
CO. TIMISKAMING	
SUP. LORRAIN	LOT 10 CON. VI
POSITIONS & ELEVATIONS of HOLES	
APPROVED	
ENGINEER	
CHECK ENGINEER	
21 SEPT. 1956	
F-56-9 A	

SOME DEFECTS IN NEGATIVE DUE

TO CONDITION OF ORIGINAL DOCUMENTS

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH BRANCH - FOUNDATIONS SECTION - DOWNSVIEW
OFFICE REPORT ON SOIL EXPLORATION

DRILL RIG 54-1 OPERATION BORE & PENET. JOB F-56-9 WP --- BORING 1 STA. 19+76 175 FT.
CASING BX. --- (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT SEPT. 1956
SAMPLER HAMMER WT. 250 LBS. DROP 23 INCHES COMPILED BY H.S. CHECKED BY --- DATE BORING 17 AUG. 1956

ABBREVIATIONS

V - INSITU VANE SHEAR TEST	Q - TRIAXIAL QUICK	K - PERMEABILITY
M - MECHANICAL ANALYSIS	S - TRIAXIAL SLOW	C - CONSOLIDATION
U - UNCONFINED COMPRESSION	WL - WATER LEVEL IN CASING	CA - CASING
QC - TRIAXIAL CONSOLIDATED QUICK	WT - WATER TABLE IN SOIL	γ - UNIT WEIGHT

SAMPLE TYPES

C.S. - CHUNK	S.S. - SLEEVE SAMPLE
D.O. - DRIVE OPEN	P.S. - PISTON SAMPLE
D.F. - DRIVE FOOT VALVE	W.S. - WASHED SAMPLE
T.O. - THIN WALL	R.C. - ROCK CORE

SAMPLE CONDITION

- DISTURBED
- FAIR
- GOOD
- LOST

SOIL PROFILE

ELEVATION DEPTH		WATER CONDITIONS	DESCRIPTION	STRAT PLOT	ELEVATION SCALE	WATER CONTENT W %			D - NAT.			PW			Δ - LW			CASING BLOW (ACTUAL)	OTHER TESTS	CONDITION	TYPE	NO.	PENETRATION RESISTANCE	ELEV. RECOV					
						PENETRATION TEST RESISTANCE IN LBS PER FOOT AT STANDARD ENERGY (4200) PER BLOW																							
						D. CONE PEN. X-----X-----X																							
						50							100																
2	122-0'		GROUND LEVEL																					122-0'					
	121-0'		TOPSOIL																										
	117-0'	WT.	SOFT LIGHT BROWN CLAY SLIGHTLY SANDY		120																					1.		117-0'	
7	113-0'		LIGHT BROWN BOULDER CLAY		115																								
	107-5'		BEDROCK GRANITE		110																					AxT. R.C.	2.	78 %	
	104-5'		END of BOREHOLE																										
17					105																								

DEPARTMENT OF HIGHWAYS - ONTARIO

**MATERIALS & RESEARCH BRANCH - FOUNDATIONS SECTION - DOWNSVIEW
OFFICE REPORT ON SOIL EXPLORATION**

DRILL RIG 54-1 OPERATION PENETRATION TEST JOB F-56-9 WP BORING 2 STA. 19+43 :21.5 RT
CASING BX (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT SEPT 1956
SAMPLER HAMMER WT. 250 LBS. DROP 33 INCHES COMPILED BY H. S. CHECKED BY DATE BORING AUGUST 21 1956

ABBREVIATIONS





V - INSITU VANE SHEAR TEST
W - MECHANICAL ANALYSIS
U - UNCONFINED COMPRESSION
Q_c - TRIAXIAL CONSOLIDATED QU

K - PERMIABILITY
C - CONSOLIDATION
NG - CASING
Ø - UNIT WEIGHT

CS - CHUNK
DO - DRIVE OPEN
DF - DRIVE FOOT VALVE
TO - THIN WALLED OPEN

TYPES
S.S. - SLE
P.S. - PIST
W.S. - WASI
B.C. - BOCH

E SAMPLE
I SAMPLE
D SAMPLE
CORE

SAMPLE CONDITION	
- DISTURBED	
- FAIR	
- GOOD	
- LOST	

SOIL PROFILE

ELEVATION	DEPTH	WATER CONDITIONS	DESCRIPTION
			STRAT PLOT

GROUND LEVEL

120

511

011

REFUSAL AT ELEV. 1125'
HAMMER BOUNCING

SAMPLES

WATER CONTENT W %		Q - NAT	Q - PW	Δ - LW
PULVERIZATION TEST RESISTANCE BLOWS PER FOOT AT STANDARD ENERGY (4200 IN. LBS PER BLOW)				
D. CONE PEN. X-----X		STAND. PEN. •-----•		
50	100	150	200	250

STRAT PLOT

WATER
CONDITIONS

ELEVATION
DEPTH

ELEV.
RECOV.

MATERIALS & RESEARCH BRANCH - FOUNDATIONS SECTION - DOWNSVIEW
OFFICE REPORT ON SOIL EXPLORATION

DRILL RIG 54-1 OPERATION CORE & PENET.
CASING 3X (standard samplers to fit unless noted)
SAMPLER HAMMER WT. 250 LBS. DROP 23 INCHES

JOB F-50-9 WP
 DATUM GEODETIC
 COMPILED BY H. S. CHECKED BY

BORING 3, STA. 17+95.39 RT
DATE REPORT Sept. 1956
DATE BORING August 24, 1956

ABBREVIATIONS

V = INSITU VANE SHEAR TEST
M = MECHANICAL ANALYSIS
U = UNCONFINED COMPRESSION
Q = TRIAXIAL CONSOLIDATED QUI

Q - TRIAXIAL QUICK
S - TRIAXIAL SLOW
WL - WATER LEVEL
WT - WATER TABLE

K - PERMEABILITY
C - CONSOLIDATION
ING CA - CASING
IL D - UNIT WEIGHT

CS - CHUCK
DO - DRIVE OPEN
DF - DRIVE FOOT VALVE
TO - THIN WALLED OPEN

SS - SLEEVE SAMPLE
PS - PISTON SAMPLE
WS - WASHED SAMPLE
RC - ROCK CORE

- DISTURBED
- FAIR
- GOOD
- LOST

SOIL PROFILE

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH BRANCH - FOUNDATIONS SECTION - DOWNSVIEW
OFFICE REPORT ON SOIL EXPLORATION

DRILL RIG 54-1 OPERATION SCORE & PENET. JOB F-56-9 WP BORING 4 STA 18+75 30 LT
CASING NX & BX (standard samplers to fit unless noted) DATUM GEODETIC DATE REPORT SEPT 1956
SAMPLER HAMMER WT. 250 LBS. DROP 23 INCHES COMPILED BY H.S. CHECKED BY DATE BORING AUGUST 30 1956

ABBREVIATIONS

V - INSITU VANE SHEAR TEST Q - TRIAXIAL QUICK K - PERMIABILITY
M - MECHANICAL ANALYSIS S - TRIAXIAL SLOW C - CONSOLIDATION
U - UNCONFINED COMPRESSION WL - WATER LEVEL IN CASING CA - CASING
QC - TRIAXIAL CONSOLIDATED QUICK WT - WATER TABLE IN SOIL γ - UNIT WEIGHT

SAMPLE TYPES

C.S. - CHUNK S.S. - SLEEVE SAMPLE
D.O. - DRIVE OPEN PS - PISTON SAMPLE
D.F. - DRIVE FOOT VALVE WS - WASHED SAMPLE
T.O. - THIN WALLED OPEN R.C. - ROCK CORE

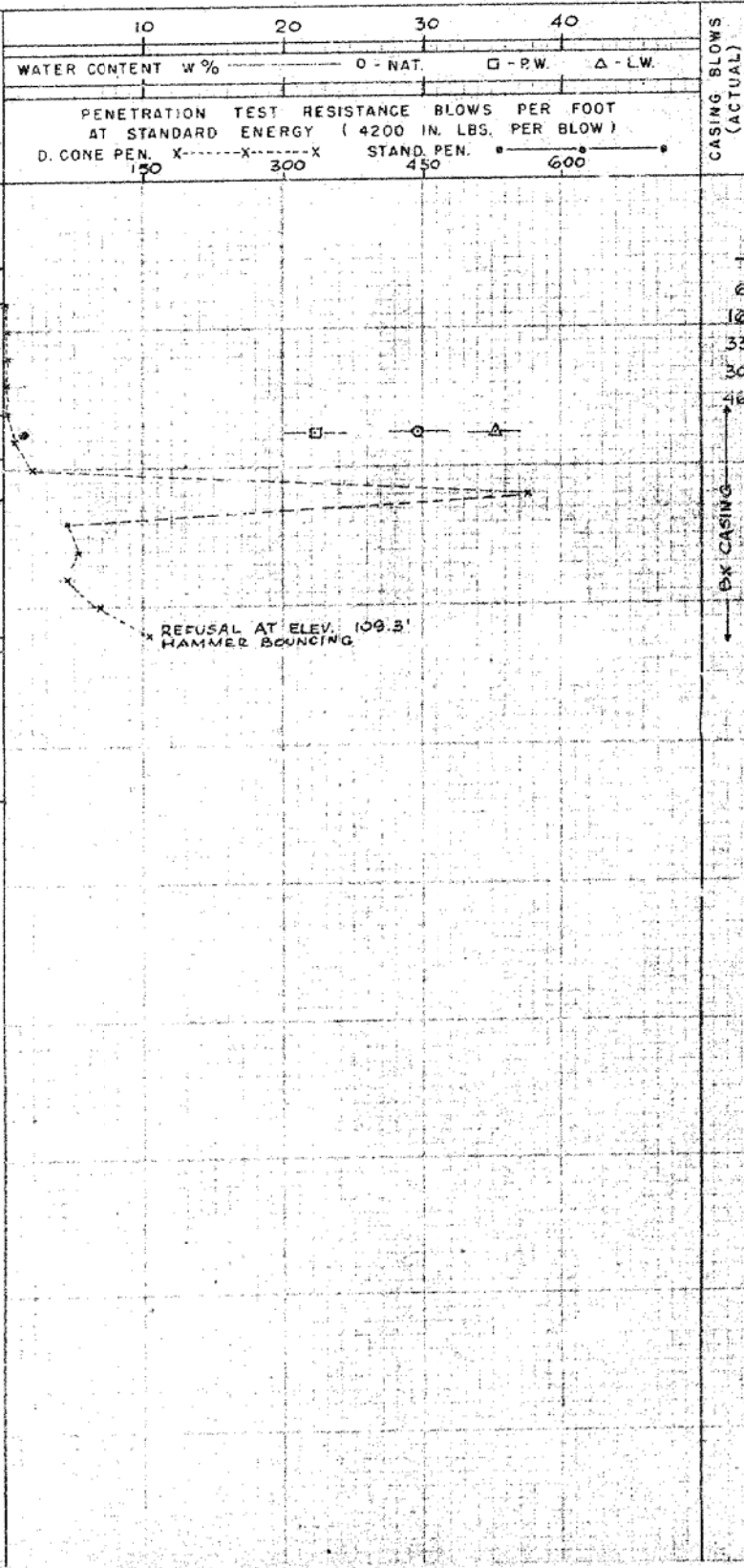
SAMPLE CONDITION



- DISTURBED
- FAIR
- GOOD
- LOST

SOIL PROFILE

ELEVATION DEPTH	WATER CONDITIONS	DESCRIPTION	STRAT PLOT	ELEVATION SCALE
122.3'		GROUND LEVEL		
121.3'		TOPSOIL		
120'		BROWN SANDY CLAY		
117.3'	W.T.	GREY CLAY GRAVELLY		
115.7'		BOULDER		
114.8'		GREY BOULDER CLAY		
113.0'		BOULDER		
113.5'		BEDROCK GRANITE		
103.5'		END OF BOREHOLE		



SAMPLES

OTHER TESTS	CONDITION	TYPE	NO.	PENETRATION RESISTANCE	ELEV. RECOV
				%	
					122.3
					2
					117.3'
		T.O. 3"	1	23	61%
					114.8
					67%
					12
					108.8'
		AXT. R.C.	3		100%
					17
					22

Appendix E

Selected Photographs of Culvert Location

Latour Creek Culvert Rehabilitation
Highway 567, Site No. 47-315/C



Photo 1: Latour Culvert Outlet



Photo 2: Latour Culvert Inlet

Latour Creek Culvert Rehabilitation
Highway 567, Site No. 47-315/C



Photo 3: Road Surface Looking Southeast



Photo 4: Road Surface Looking Northwest

Appendix F

Non-Standard Special Provision

DEWATERING NSSP

The contractor shall implement groundwater control and ground support systems as are required to carry out the construction in a safe, stable, and dry excavation.

The dewatering system shall be designed by a dewatering specialist engaged by the Contractor.

Where a cofferdam is required, the Contractor shall engage an experienced geotechnical engineer licensed to practice in Ontario to carry out the cofferdam design. In light of the shallow bedrock, sheetpile cofferdam is not practical at this site.