

**FOUNDATION INVESTIGATION AND DESIGN REPORT
CULVERT REHABILITATION AT SHIRLEY LAKE
SITE NO. 39E-228
HIGHWAY 652
NORTHEAST OF COCHRANE, ONTARIO
G.W.P. No. 5193-13-00**

GEOCRES Number: 42H-54

Report to

URS Canada Inc.

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

November 13, 2014
File: 19-4406-9

H:\19\4406\9 Highways 11, 583, 652 Culverts 5012-E-0033-
Foundations\Reports & Memos\Shirley Lake\1944069 Hwy
652 Shirley Lake FIDR FINAL nov 14.doc

TABLE OF CONTENTS

SECTION	PAGE
PART 1 FACTUAL INFORMATION	
1 INTRODUCTION.....	1
2 SITE DESCRIPTION.....	1
3 SITE INVESTIGATION AND FIELD TESTING	2
4 LABORATORY TESTING	2
5 DESCRIPTION OF SUBSURFACE CONDITIONS	3
5.1 General.....	3
5.2 Fill.....	3
5.3 Peat	4
5.4 Silty Clay	4
5.5 Groundwater Conditions.....	5
6 MISCELLANEOUS.....	5
PART 2 ENGINEERING DISCUSSION AND RECOMMENDATIONS	
7 GENERAL	7
8 UNWATERING	7
9 SHEETPILE COFFERDAMS.....	8
10 CONSTRUCTION CONCERNS	8
11 CLOSURE.....	8

Appendices

Appendix A	Record of Borehole Sheets
Appendix B	Laboratory Test Results
Appendix C	Borehole Locations and Soil Strata Drawing
Appendix D	Suggested Wording for NSSP
Appendix E	Selected Photograph of Culvert Location

**FOUNDATION INVESTIGATION AND DESIGN REPORT
CULVERT REHABILITATION AT SHIRLEY LAKE
SITE NO. 39E-228
HIGHWAY 652
NORTHEAST OF COCHRANE, ONTARIO
G.W.P. No. 5193-13-00**

GEOCRES Number: 42H-54

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) near the inlet of a culvert on Highway 652 at Shirley Lake, located approximately 88 km north of Highway 579.

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

Thurber was retained by URS Canada Inc. (URS) to carry out this foundation investigation under the MTO Agreement Number 5012-E-0033. The foundation terms of reference indicated that there is no record available of any previous foundation investigation carried out at or near the subject culvert.

2 SITE DESCRIPTION

The culvert site is located on Highway 652 in the Township of Tweed, approximately 88 kilometres North of Highway 579 near Cochrane, Ontario. The culvert allows Shirley Lake to flow northeast under Highway 652 into a swampy area.

The existing culvert, constructed in 1982, consists of a single 3.0 m span by 51 m long SPP frame. It is understood that the culvert is in fair condition with deterioration of several elements. The embankment height above the culvert is approximately 6 m.

The site is located in a rural area with swamps, creeks and other watercourses nearby. The area surrounding the site is heavily forested and of generally low relief with no visible bedrock outcrops. This site is adjacent to a clearing featuring a short access road on the southeast side of the bridge.

Based on published geological information, the general area of the project is covered by glacio-lacustrine sediments of clays and silts laid down by the Glacial Lake Barlow-Ojibway. These deposits are mostly varved clays, but massive clays are also present in some areas. Below the clays are glacial outwash deposits of silts, sands and gravel underlain by Early Precambrian metasedimentary rocks.

3 SITE INVESTIGATION AND FIELD TESTING

This borehole investigation and field testing program was carried out on October 3, 2013. The program consisted of drilling and sampling two boreholes identified as SL13-01 and SL13-02 to depths of 7.0 m and 8.1 m, respectively (Elevations 285.9 m and 284.2 m). Both boreholes were located in the vicinity of the culvert inlet. The Record of Borehole sheets are included in Appendix A.

The borehole locations were staked in the field and utility clearances were obtained prior to commencement of drilling operations. The co-ordinates and elevations of the as-drilled boreholes were subsequently provided by Callon Dietz utilizing Digital Terrain Model (DTM), based on borehole location sketches provided by Thurber. The approximate locations and elevations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing included in Appendix C.

The drilling was carried out using a CME45 track-mounted drill rig using hollow stem auger drilling techniques until the target depth was reached. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). In addition, a Dynamic Cone Penetration Test (DCPT) was conducted below the sampled depth of Borehole SL13-02.

The drilling and sampling operations were supervised on a full time basis by an experienced member of Thurber's technical staff. The recovered soil samples were logged in the field and processed for transportation to Thurber's geotechnical laboratory in Oakville, Ontario, for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. The details of standpipe piezometer installation and borehole completion are summarized in Table 3-1.

Table 3-1
Borehole Completion and Standpipe Piezometer Installation Details

Borehole Number	Standpipe Piezometer Installations				Completion Details
	Tip Depth / Elev. (m)	Screen Depth (m)	Screen Elevation (m)	Sand Filter Stratum	
SL13-01	6.7 / 286.2	2.3 – 6.7	286.3 – 290.6	Silty Clay	Sand and bentonite holeplug to surface
SL13-02		No Installation			Bentonite holeplug to 3.3m and a mixture of cuttings and bentonite holeplug to surface

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.

A sample of creek water from Shirley Lake was submitted to AGAT Laboratories in Mississauga, a qualified analytical laboratory, for testing against selected corrosivity parameters.

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 profile at the culvert inlet is 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.

In general, the subsurface stratigraphy encountered in the boreholes located in the vicinity of the culvert inlet consists of layers of granular and cohesive fill overlying a deposit of native silty clay containing some sand. A sand deposit was encountered below the silty clay in Borehole SL13-02. More detailed descriptions of the individual stratum are presented below.

5.2 Fill

Fill was encountered at the surface in both boreholes. The fill was brown in colour and varied in composition, consisting of silty clay with sand, sand, and sand and gravel. The fill layer was fully penetrated in both boreholes and was found to be 1.6 m thick in Borehole SL13-01 and 5.6 m thick in Borehole SL13-02 (Elevations 291.3 and 286.7 m).

SPT N-values measured in the cohesionless fill typically ranged from 1 to 7 blows per 0.3 m penetration indicating a very loose to loose state; SPT N-values measured in the cohesive fill ranged from 5 to 10 blows per 0.3 m penetration, indicating a firm to stiff consistency. Measured moisture contents of the recovered fill samples ranged between 7% and 22%. Results of grain size analyses conducted on samples of the fill are presented on Figures B1 to B3 in Appendix B and are summarized in the following table.

Cobbles and boulders were inferred in the fill during auger advance.

Soil Particles	%
<u>Silty Clay Fill</u>	
Sand	24
Silt	43
Clay	33
<u>Sand Fill</u>	
Gravel	1
Sand	92
Silt and Clay	7
<u>Sand and Gravel Fill</u>	
Gravel	36
Sand	55
Silt and Clay	9

5.3 Peat

A layer of peat 50 mm in thickness was encountered beneath the fill in Borehole SL13-01 at a depth of 1.6 m. The peat was amorphous and black in colour.

The measured SPT N-value in the peat was 3 blows per 0.3 m penetration indicating a very loose state. The measured water content of a peat sample was 102%.

5.4 Silty Clay

Silty clay was encountered beneath the fill in both boreholes. The silty clay typically contained some sand and little to no gravel and was grey in colour. A layer of compact sand was encountered below the silty clay layer in Borehole SL13-02 at a depth of 7.2 m (Elevation 285.1 m).

The silty clay layer was not fully penetrated in Borehole SL13-01 which was terminated at a depth of 7.0 m (Elevation 285.9 m). SPT N-values measured within the clay layer ranged between 3 and 5 blows per 0.3 m penetration, and in conjunction with field vane shear strengths ranging from 38 to 47 kPa, indicate typically firm consistency with occasional soft zones. Measured water contents of clay samples typically ranged from 22% to 24%.

Two samples of silty clay were subjected to gradation analysis, and two were also subjected to Atterberg Limits testing. The results of these tests are summarized in the tables below and on the Record of Borehole sheets included in Appendix A. Figure B4 presents the grain size distribution curves and Figure B5 presents the Atterberg Limits results on a plasticity chart.

Soil Particles	%
Gravel	0
Sand	16 to 19
Silt	36 to 41
Clay	43 to 45
Soil Particles	%
Liquid Limit	35
Plasticity Index	17 to 18

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

5.5 Groundwater Conditions

Free water was observed in Borehole SL13-02 at 7.0 m depth (Elevation 285.3 m) in the open borehole upon completion of drilling. A standpipe piezometer was installed in Borehole SL13-01. Measured water levels in this standpipe are presented below.

Borehole	Date of Reading	Water Level Depth (mbgs)	Water Level Elevation (m)
SL13-01	November 1, 2013	3.3	289.6
	November 7, 2013	3.1	289.8

Where surface water is present, the groundwater level should be assumed to coincide with the lake water level. Local high water levels and the effects of heavy rainfalls must also be taken into consideration.

6 MISCELLANEOUS

The drilling and sampling operations in the field were supervised on a full time basis by Ms. Katrina Young of Thurber Engineering Ltd. Routine laboratory testing was carried out by the Thurber Engineering Ltd. geotechnical laboratory in Oakville, Ontario. A sample of creek water was submitted to AGAT Laboratories in Mississauga, Ontario, for testing against corrosivity parameters.

Borehole locations were selected by Thurber. Callon Dietz provided the northing and easting coordinates and ground surface elevations utilizing their DTM based on a borehole location sketch provided by Thurber.

Eastern Ontario Diamond Drilling of Hawkesbury, Ontario, supplied and operated the track-mounted drill rig to carry out the drilling, sampling, in-situ testing operations and standpipe installation.

Overall project management was provided by Mr. Alastair Gorman, P.Eng. Direction of the field program was provided by Dr. Sydney Pang, P.Eng. Interpretation of the field data and preparation of this report was completed by Ms. Katrina Young, E.I.T. and Dr. Pang. The report was reviewed by Mr. Gorman and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.

Sydney Pang, P.Eng.,
Senior Foundations Engineer



Alastair Gorman, P.Eng.
Project Manager, Senior Foundations Engineer



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



**FOUNDATION INVESTIGATION AND DESIGN REPORT
CULVERT REHABILITATION AT SHIRLEY LAKE
SITE NO. 39E-228
HIGHWAY 652
NORTHEAST OF COCHRANE, ONTARIO
G.W.P. No. 5193-13-00**

GEOCRES Number: 42H-54

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides foundation recommendations for the rehabilitation of the existing culvert at Shirley Lake on Highway 652, located approximately 88 km north of Highway 579 near Cochrane, Ontario.

Based on the terms of reference, the existing culvert, constructed in 1982, consists of a single 3.0 m span by 51 m long SPP frame. It is understood that the culvert is in fair condition with deterioration of several elements. The existing embankment fill height above the culvert is approximately 6 m.

Preliminary information provided by URS indicates that current project requirements involve installation of invert paving comprising cast-in-place concrete reinforced with welded wire fabric within the lower half of the existing culvert barrel. Cobbles of 300 mm nominal size will also be placed on the concrete invert. It is understood that the inlet and outlet inverts are at Elevations 289.710 and 289.591 m, respectively. The culvert will not be exposed by excavation. Accordingly, the discussion and recommendations are limited to the design of a cofferdam at the culvert inlet to facilitate the rehabilitation work.

The discussions and recommendations presented in this report are based on the factual data obtained during the course of the investigation and on our understanding of the rehabilitation strategy.

A selected photograph showing the existing conditions of the culvert area are included in Appendix E for reference.

8 UNWATERING

In order to facilitate the rehabilitation works, unwatering methods including, but not necessarily limited to, temporary diversion of surface water, sandbag and/or sheetpile cofferdams will be required. Beyond the toe of the embankment, the groundwater level may vary but is expected to be governed by the water level in the lake. The Contractor must make provisions to control any water seepage,

surface runoff and ponding by measures including the use of sump pumps to maintain dry excavations during the course of the rehabilitation works.

9 SHEETPILE COFFERDAMS

The design of all cofferdams, if used, is the responsibility of the Contractor. It is anticipated that if sheetpiles are used, they will need to be extended into the silty clay and perhaps the underlying sand at some locations.

An interlocking sheetpiled wall may be designed using the parameters given below:

γ	=	20 kN/m ³
γ_w	=	10 kN/m ³
K_a	=	0.33 (road embankment fill)
K_p	=	2.6 (silty clay)
	=	3.0 (sand)

Full hydrostatic pressure must be considered, assuming a water level at least equal to the design lake water level.

The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall, and these factors must be considered when designing the sheetpiles. Typically, a triangular earth pressure distribution should be used for a cantilevered sheetpiled wall.

The designer of the sheetpile cofferdam must check whether the penetration depth is sufficiently deep to provide base fixity. Suggested wordings of an NSSP alerting the Contractor of potential obstructions such as cobbles and boulders in the fill are included in Appendix D.

The cofferdams must be designed by a Professional Engineer experienced in such designs.

10 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to, issues related to the design of an unwatering system. Design of an unwatering system is the responsibility of the Contractor and the Contract Documents must alert him of the responsibility and the need to engage a dewatering specialist.

11 CLOSURE

Preparation of this foundation design report was carried out by Ms. Katrina Young, E.I.T. and Dr. Sydney Pang, P.Eng. The report was reviewed by Mr. Alastair Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng.

THURBER ENGINEERING LTD.

Sydney Pang, P.Eng.
Senior Foundations Engineer



Alastair Gorman, P.Eng.
Project Manager, Senior Foundations Engineer



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



Appendix A

Record of Borehole Sheets

19-4406-9

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

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

DISCONTINUITY SPACING

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

SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

STRENGTH CLASSIFICATION

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

TERMS

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

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 SL13-01

1 OF 1

METRIC

GWP# 5193-13-00 LOCATION Shirley Lake N 5 483 258.5 E 490 651.3 ORIGINATED BY KMY
HWY 652 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2013.10.03 - 2013.10.03 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								20 40 60 80 100	w _P w w _L					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
292.9	GROUND SURFACE													
0.0	Silty CLAY , some sand, inferred cobbles and boulders Stiff to Firm Brown Moist (FILL)		1	SS	10									
			2	SS	5		292							0 24 43 33
291.3														
291.3	PEAT : (50 mm)		3	SS	3		291							
1.7	Silty CLAY , some sand, occasional rootlets Firm Brown to Grey Moist							3.0 +						
			4	SS	3		290							
							289	2.0 +						
			5	SS	5		288							0 16 41 43
							287	3.0 +						Vane wet
			6	SS	4									
285.9							286	10.0 +						
7.0	END OF BOREHOLE AT 7.0 m. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Nov. 1/13 3.3 289.6 Nov. 7/13 3.1 289.8													

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SL13-02

1 OF 2

METRIC

GWP# 5193-13-00 LOCATION Shirley Lake N 5 483 262.7 E 490 643.3 ORIGINATED BY KMY
HWY 652 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2013.10.03 - 2013.10.03 CHECKED BY SKP

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 × LAB VANE	W _P W W _L				
292.3	GROUND SURFACE														
0.0	Silty SAND with clay, some rootlets, trace silt Loose Brown Moist (FILL)		1	SS	6		292								
			2	SS	5		291								
290.8															
1.5	SAND , trace silt, trace gravel Loose Light Brown Moist (FILL)		3	SS	7		290								
			4	SS	4										
289.3															
3.0	SAND and GRAVEL , trace silt Very Loose Brown Saturated (FILL)		5	SS	5		289								36 55 9 (SI+CL)
			6	SS	4		288								
			7	SS	1		287								Split spoon wet
286.7															
5.6	Silty CLAY , some sand Firm Grey Moist		8	SS	4		286								0 19 36 45
285.1															
7.2	SAND , trace silt Compact Grey Saturated						285								
			9	SS	14										
284.2															
8.1	END OF SAMPLING AND START OF DCPT AT 8.1 m.						284								
							283								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SL13-02

2 OF 2

METRIC

GWP# 5193-13-00 LOCATION Shirley Lake N 5 483 262.7 E 490 643.3 ORIGINATED BY KMY
 HWY 652 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2013.10.03 - 2013.10.03 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W P	W	W L	WATER CONTENT (%)		
	Continued From Previous Page							20 40 60 80 100						
281.6							282							
10.7	END OF DCPT AND BOREHOLE AT 10.7 m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 3.3 m, THEN CUTTINGS AND BENTONITE HOLEPLUG TO SURFACE.													

Appendix B

Laboratory Test Results

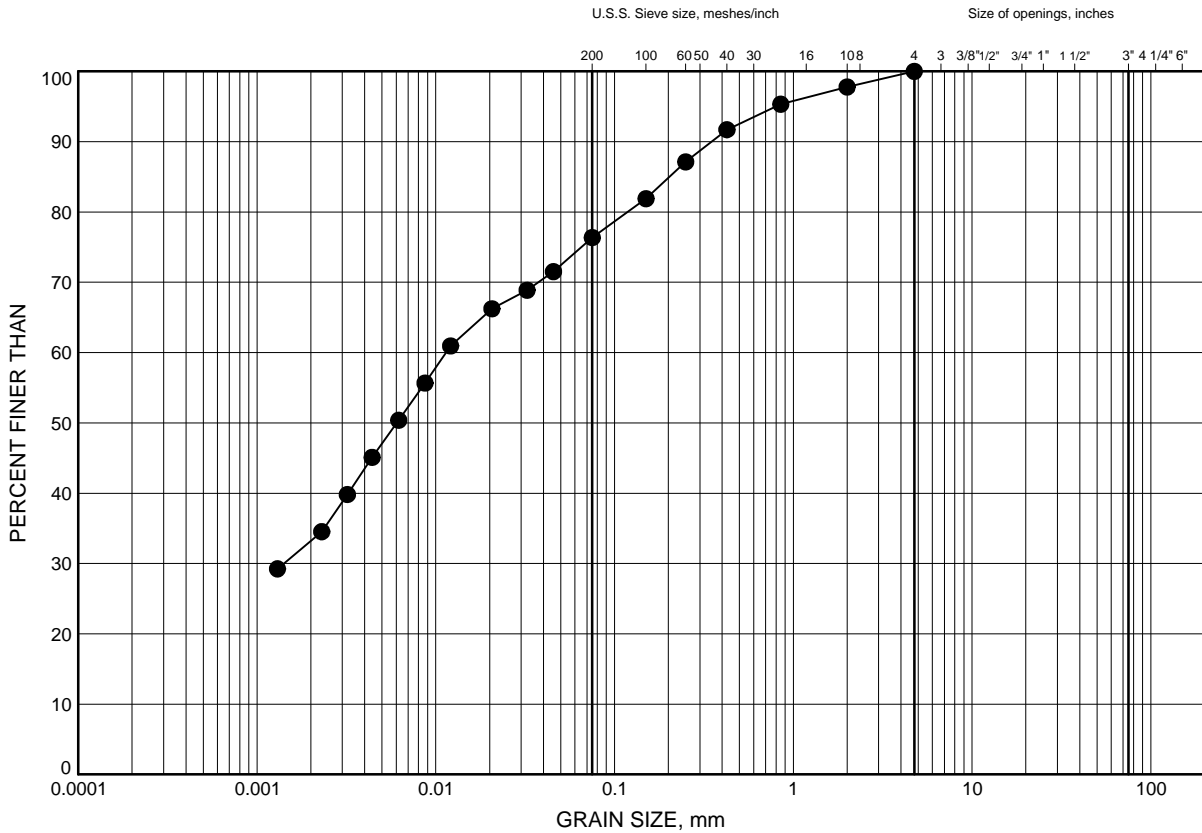
19-4406-9

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B1

SILTY CLAY FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SL13-01	1.07	291.83

Date January 2015
GWP# 5193-13-00



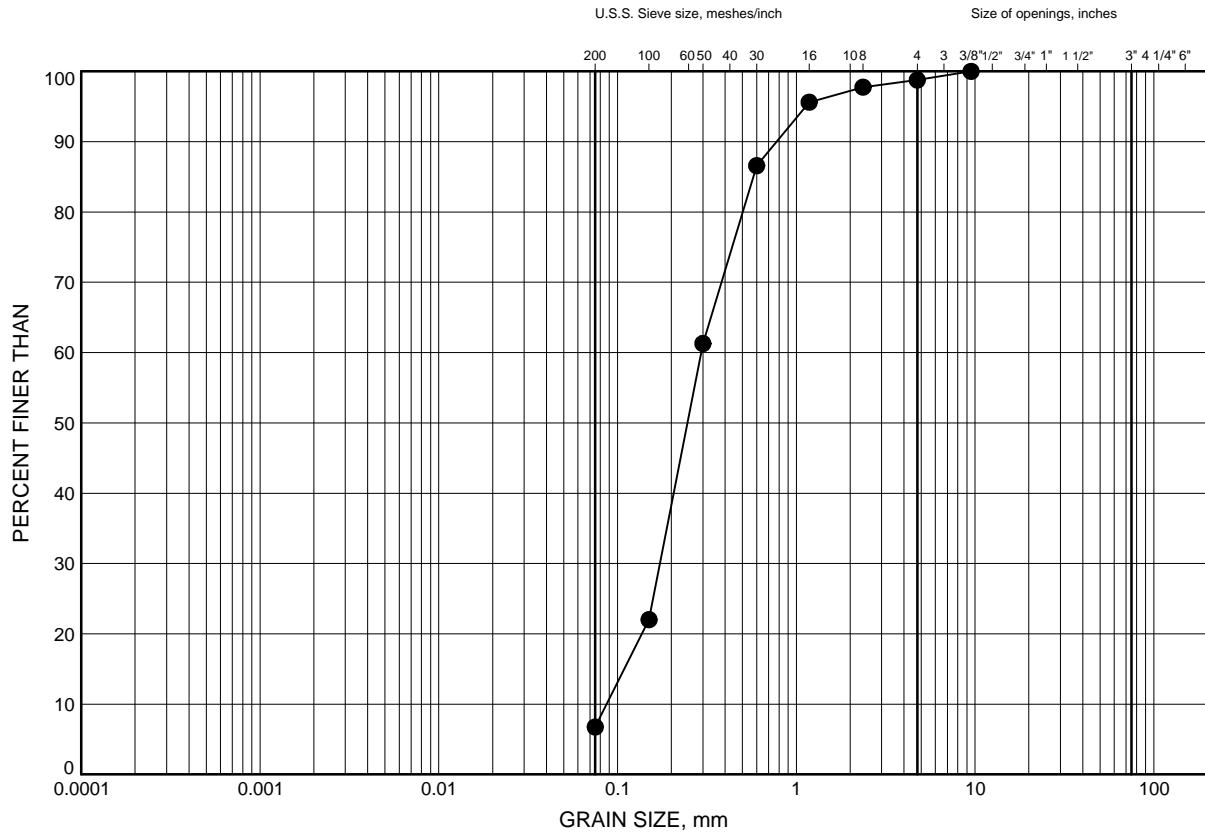
Prep'd AN
Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SL13-02	1.83	290.47

Date January 2015
GWP# 5193-13-00



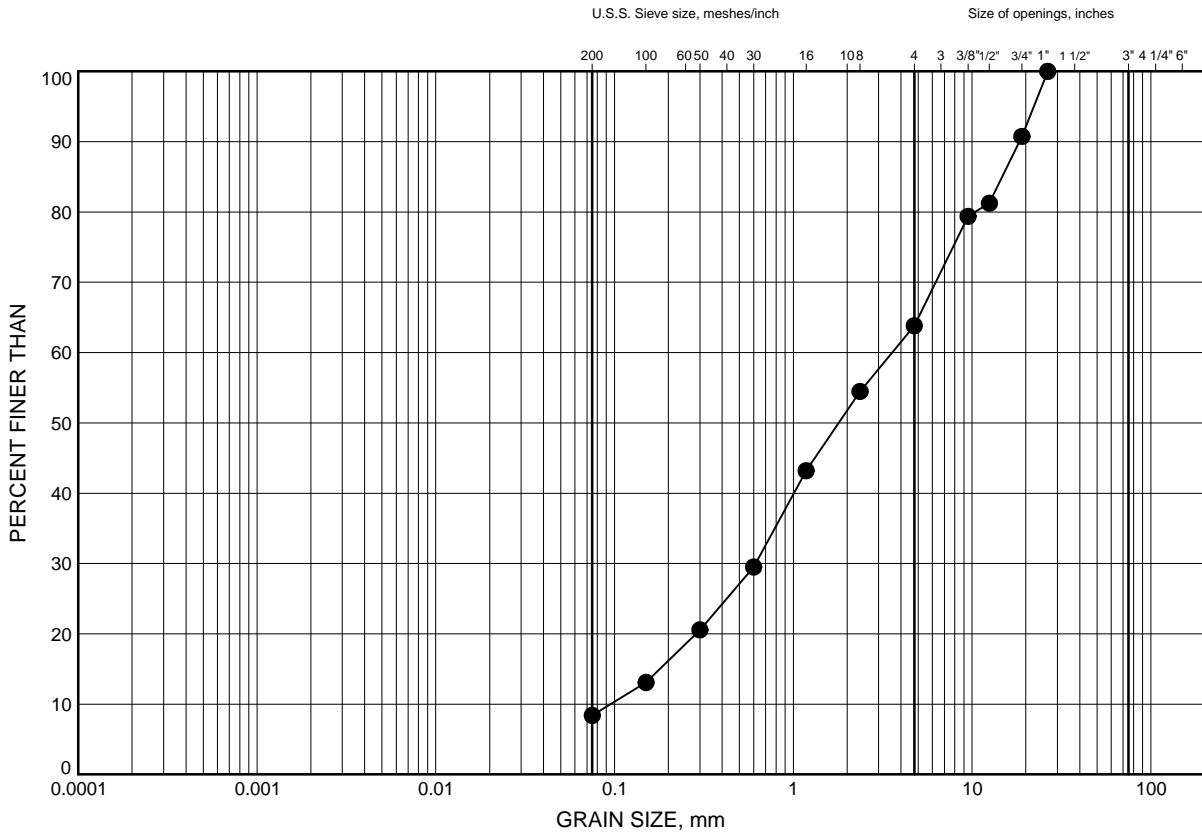
Prep'd AN
Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND AND GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SL13-02	3.35	288.95

Date January 2015
GWP# 5193-13-00



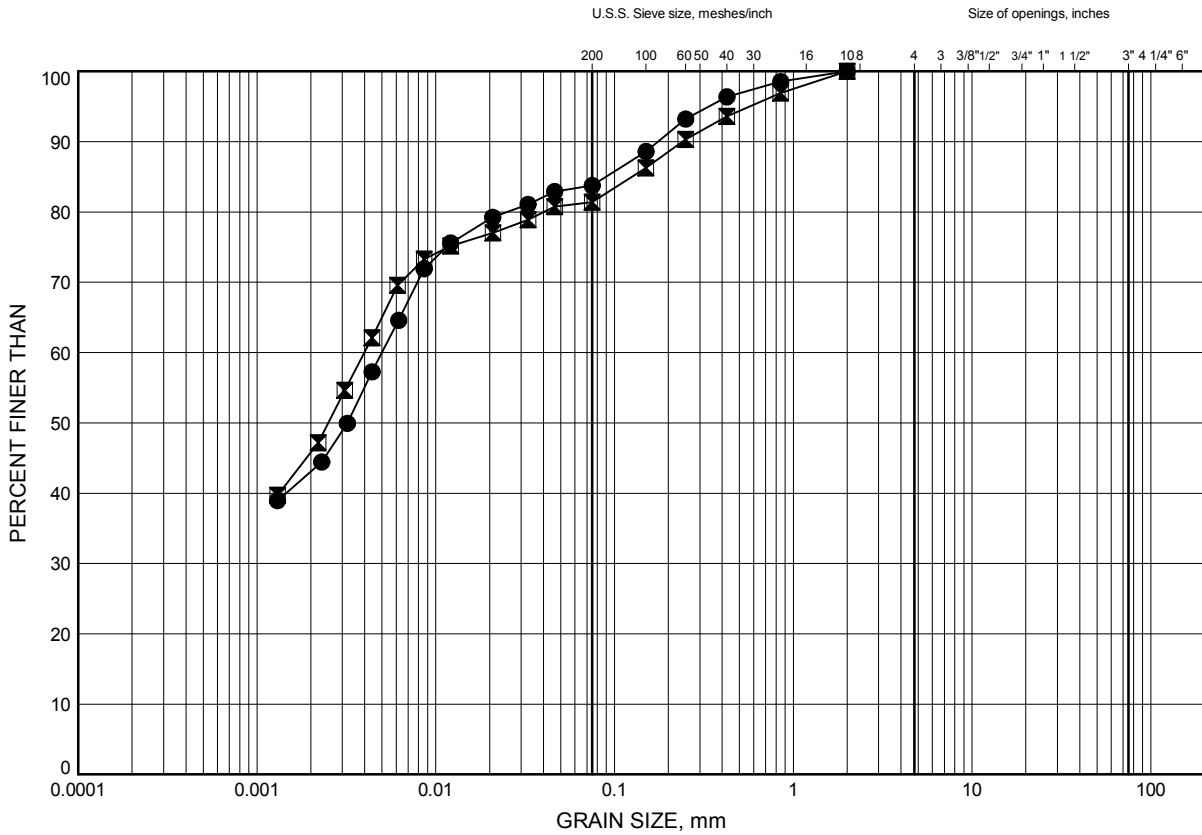
Prep'd AN
Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SL13-01	4.88	288.02
⊠	SL13-02	6.40	285.90

Date January 2015
GWP# 5193-13-00



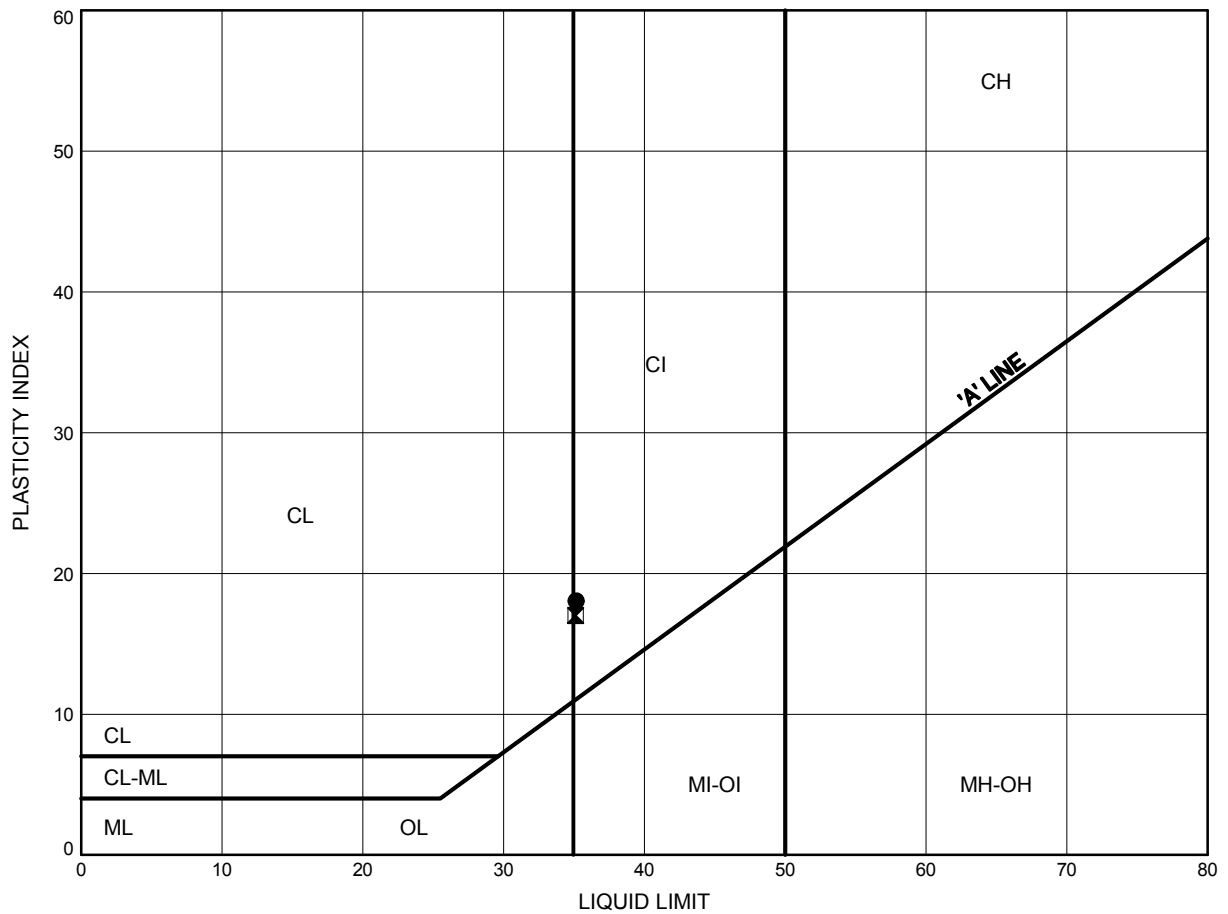
Prep'd AN
Chkd. SKP

Hwys 11, 583, 652 Culverts - Foundations

ATTERBERG LIMITS TEST RESULTS

FIGURE B5

SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SL13-01	4.88	288.02
⊗	SL13-02	6.40	285.90

Date January 2015
GWP# 5193-13-00

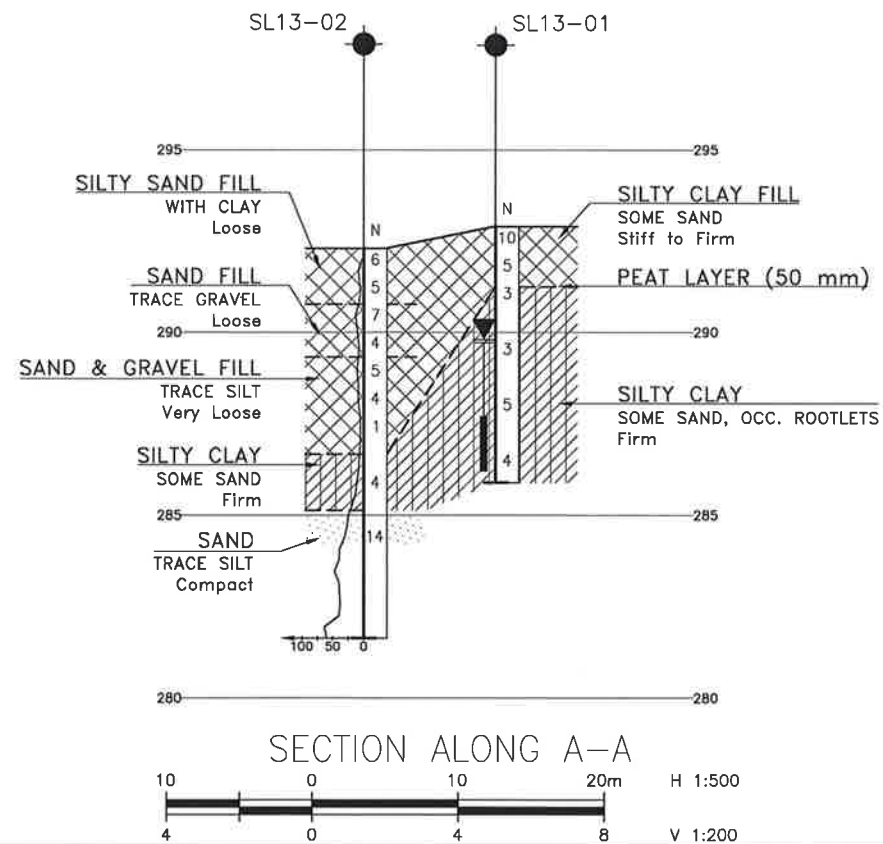
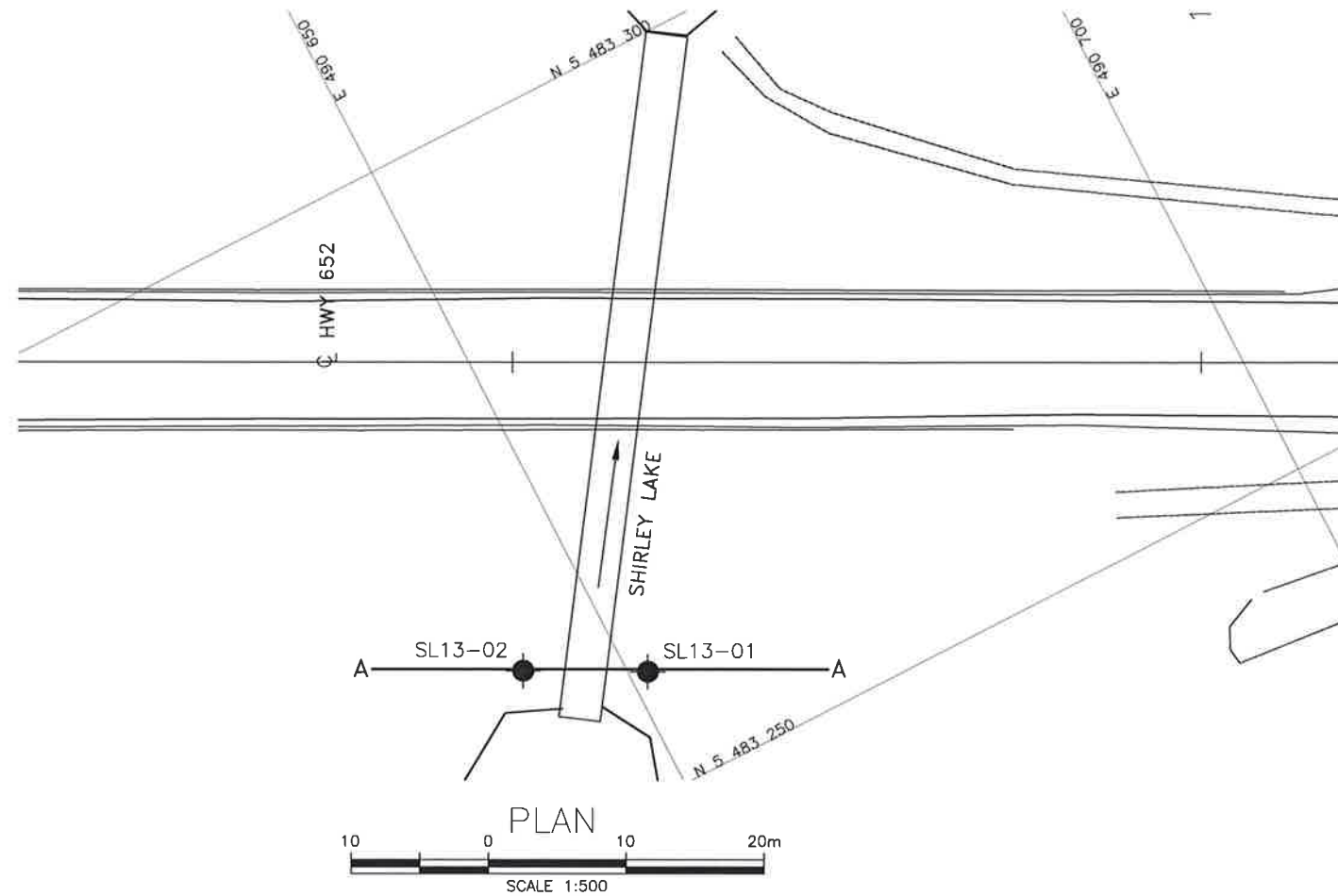


Prep'd AN
Chkd. SKP

Appendix C

Borehole Locations and Soil Strata Drawings

19-4406-9



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

CONT No
GWP No 5193-13-00



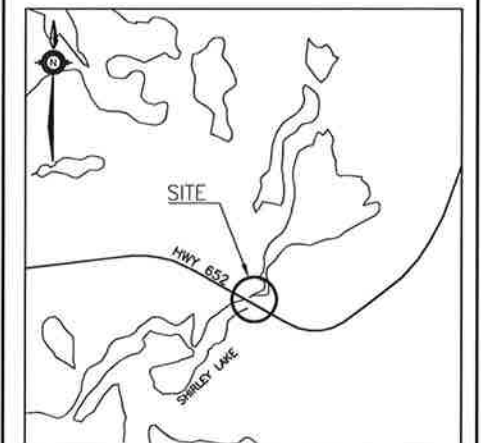
HIGHWAY 652
SHIRLEY LAKE
CULVERT REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

URS



THURBER ENGINEERING LTD.



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

NO	ELEVATION	NORTHING	EASTING
SL13-01	292.9	5 483 258.5	490 651.3
SL13-02	292.3	5 483 262.7	490 643.3

-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. 42H-54



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	SKP	CHK SKP	CODE
DRAWN	AN	CHK PKC	SITE 38E-22BC/STRUCT
			DATE NOV 2014
			DWG 2

Appendix D

Suggested Wording for NSSP

1. Suggested Text for NSSP on “Obstructions”

“Installation of cofferdams could encounter obstructions such as cobbles and boulders embedded in the fill. Such obstructions may impede sheetpile installation and prohibit the sheetpiles from reaching the design depth of installation. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the sheetpiles to the design depth.”

Appendix E

Selected Photograph of Culvert Location



Photo 1: Shirley Lake Culvert – East Side