



**THURBER** ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT  
REPLACEMENT OF STRUCTURAL CULVERT No 3-446C  
800 m WEST OF DEVINE ROAD  
HWY 417 FROM EIGHTH LINE TO LIMOGES  
OTTAWA, ONTARIO  
G.W.P. 4064-06-00**

**GEOCRES Number: 31G-250**

Submitted  
To  
**URS Canada Inc.**

September 29, 2014

File: 19-4406-6

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**FOUNDATION INVESTIGATION AND DESIGN REPORT  
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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 a culvert replacement site on Highway 417 near Ottawa, Ontario.

The foundations terms of reference indicate that there is no record of any previous foundation investigation carried out at or near the subject culvert.

A foundation investigation has been carried out by Thurber Engineering Ltd. (Thurber) for the design of the replacement of Structural Culvert #3-446C on Highway 417 approximately 800 m west of Devine Road (County Road 8), near Ottawa, Ontario. The existing culvert is located at approximate chainage 14+215 EB and 14+266 WB in Cumberland Township. Thurber carried out the investigation as a sub-consultant to URS Canada Inc. (URS) under Agreement No. 4012-E-0001, Part B.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on this data, to provide a borehole location plan, record of boreholes, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions.

**2 SITE DESCRIPTION**

The site is located within a Physiographic Region known as the Russell and Prescott Sand Plains which are characterized by a sand deposit ranging from 3 to 9 m thick underlain by deep marine clay deposits.

In the vicinity of the culvert site, Highway 417 has a rural freeway configuration with two lanes in each direction, separated by a vegetated median which is approximately 24 m wide. The existing

roadway platform for both the eastbound and westbound direction includes two 3.75 m wide lanes, a median shoulder 1.6 m wide and an outside shoulder of 2.9 m. The culvert site is located within a tangent section. The topography is flat with agricultural fields on the south side and light brush on the north side.

Drainage is currently provided through a 3.9 m span, 2.6 m high, multi-plate pipe arch culvert located 10 m to 40 m west of the proposed crossing. Flanking the pipe arch culvert are twin 1.5 m diameter CSP culverts. It is understood that the condition of these existing pipes has deteriorated to the point where replacement is warranted. The embankment side slopes near the existing culverts are vegetated and in good condition, as shown in the photographs provided in Appendix D. The roadway is in fair condition at this location with no dips or bumps present above the existing culverts. The roadway embankment is less than 3.5 m in height.

### 3 SITE INVESTIGATION AND FIELD TESTING

No historical geotechnical data was available from the MTO GEOCREC library for this site.

The field investigation for this site included three boreholes drilled on July 23<sup>rd</sup> and 24<sup>th</sup>, 2014 for the proposed alignment to the east of the existing culvert.

The locations of the boreholes are shown on the Borehole Location and Soil Strata drawing in Appendix A and summarized in the table below.

Location	Borehole	Depth (m)
Near Proposed Inlet	14-1a	10.1
Median ditch	14-2a	12.2
Near Proposed Outlet	14-3a	10.2

The borehole drilling was carried out using a track-mounted drill rig supplied and operated by a specialist drilling contractor. Soil drilling was carried out using hollow stem augers. Soil samples were obtained using a 50 mm outside diameter split spoon sampler advanced in accordance with the Standard Penetration Test (SPT). In-situ shear vane testing was carried out using an MTO N-vane within soft to firm cohesive deposits.

The field work was supervised on a full-time basis by a member of our field staff who located the boreholes in the field, cleared borehole locations of underground utilities, supervised the drilling, sampling and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in appropriately labelled containers and transported back to Thurber's laboratory for further examination and testing.

The locations of the boreholes and ground surface elevations at the borehole locations were surveyed by Thurber.

#### **4 LABORATORY TESTING**

Geotechnical laboratory testing was carried out in the Stantec laboratory in Ottawa, Ontario, and consisted of natural moisture content determination and visual identification of all soil samples in accordance with the current MTO standards. Grain size distribution analysis and Atterberg limit testing were also carried out to MTO and ASTM standards.

It is noted that this is a culvert replacement project with no permanent grade raise proposed. Consolidation testing was therefore not warranted since induced stresses are not increased.

The laboratory test results are presented on the records of boreholes in Appendix B and the figures in Appendix C.

#### **5 DESCRIPTION OF SUBSURFACE CONDITIONS**

##### **5.1 General**

Reference is made to the Record of Borehole sheets in Appendix B for details of the soil stratigraphy encountered in the boreholes. A stratigraphic profile for the culvert replacement alignment is presented on the Borehole Locations and Soil Strata Drawing in Appendix A 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.

The results indicate that the soil stratigraphy consists of a layer of fill over a deposit of clay to silty clay over a silty sand with gravel deposit. A thin layer of peat was found at the proposed inlet borehole. Two of the boreholes were terminated within the clay/ silty clay deposit. The median borehole was terminated within the underlying silty sand with gravel deposit.

##### **5.2 Fill**

The surficial materials in all boreholes consisted of a 50mm to 100mm thick layer of rootmat over a loose to compact fill deposit. The fill ranged from silty sand with gravel to silty clay with sand. The thickness of this deposit ranged from 0.9 to 1.4 m. The base of the fill deposit was encountered at elevations ranging from 73.2 to 74.3 m.

SPT N-values ranged from 7 to 21 blows per 0.3 m penetration indicating a loose to compact deposit. The water content of the samples tested ranged from 7 % to 24 %. Grain size analyses were conducted on two samples of this material and the results are presented on Figure 1 in Appendix C and summarized in the following table.

Soil Particles	%
Gravel	0 to 23
Sand	13 to 45
Silt	19 to 41
Clay	13 to 46

Two samples were tested to determine the Atterberg limits. The results are presented on Figure 5 in Appendix C and summarized in the table below. The samples tested are of low to intermediate plasticity.

Plastic Limit	13 to 20
Liquid Limit	21 to 37
Plasticity Index	8 to 17

### 5.3 Peat / Silty Sand

The surficial layer of fill was underlain by a thin layer of peat in the borehole located near the proposed inlet, 14-1a. The layer was 60mm thick and terminated at an elevation of 73.9 m.

In the borehole located near the proposed outlet, 14-3a, a 75mm thick layer of silty sand with trace organic material was found below the fill layer. The layer terminated at an elevation of 74.2 m.

### 5.4 Silty Clay

The peat/ silty sand deposits in Boreholes 14-1a and 14-3a, were underlain by a layer of brown, oxidized silty clay. The surficial fill in Borehole 14-2a, was underlain by the same layer. The thickness of this deposit ranged from 1.1 to 2.2 m. The base of the deposit was at elevations ranging from 71.7 to 72.8 m.

SPT N-values ranged from weight of hammer to 6 blows per 0.3 m penetration and two in-situ vane shear tests indicated shear strength of 17 kPa with a sensitivity of 5. This indicates a firm to soft consistency. The water content of the samples tested ranged from 24 % to 51 %. Grain size analyses were conducted on four samples of this material and the results are presented on Figure 2 in Appendix C and summarized in the following table.

Soil Particles	%
Gravel	0
Sand	1 to 5
Silt	34 to 51
Clay	46 to 65

Four samples were tested to determine the Atterberg limits. The results are presented on Figure 6 in Appendix C and summarized in the table below.

Plastic Limit	17 to 19
Liquid Limit	34 to 53
Plasticity Index	17 to 34

The composition of the deposit is generally described as silty clay with low to high plasticity.

The moisture content, Atterberg Limit and undrained shear strength data are indicative of a clay which is slightly over-consolidated.

## 5.5 Clay

The silty clay layer was underlain by a grey clay deposit in all of the boreholes. Boreholes 14-1a and 14-3a were terminated within the clay deposit at depths of 10.1 and 10.2 m below ground surface (elevation 64.9 to 65.2 m). The clay layer was fully penetrated in Borehole 14-2a where the thickness of the clay was 8.1 m and the base elevation was 63.6 m.

The SPT N-values were consistently weight of hammer with the exception of one sample that straddled the grey clay and the overlying crust where an N-value of 1 blows per 0.3 m penetration was recorded. The results of in-situ vane shear testing indicated undrained shear strengths ranging from 15 to 50 kPa indicating that the grey clay has soft to firm consistency, typically with shear strength increasing with depth. The sensitivity of the clay ranged from 0 to 18, however, it is noted that at some locations the strength of the clay was too low to permit remolded vane tests to be carried out. The moisture content of the grey clay ranged from 57 % to 95 %.

Four samples of this deposit were subjected to gradation analysis. The results are summarized in the table below and presented on Figure 3 in Appendix C.

Soil Particles	%
Gravel	0
Sand	1 to 2
Silt	16 to 32
Clay	66 to 83

Four samples were tested to determine the Atterberg limits. The results are presented on Figure 7 in Appendix C and summarized in the table below.

<b>Plastic Limit</b>	19 to 23
<b>Liquid Limit</b>	46 to 67
<b>Plasticity Index</b>	27 to 44

The sample taken from Borehole 14-3a at a depth of 9.45 m can be classified as having intermediate plasticity (CI) while all other samples can be classified as having high plasticity (CH).

The moisture content, Atterberg Limit and undrained shear strength data are indicative of a clay which is marginally over-consolidated.

#### **5.6 Silty Sand with Gravel (SM)**

The grey clay layer in Borehole 14-2a was underlain by a layer of grey silty sand with gravel (SM). The borehole was terminated within this layer at a depth of 12.2 m below ground surface (elevation of 62.4 m).

SPT N-values were 66 and 21 blows per 0.3 m penetration indicating a very dense to compact deposit. The water content of the samples tested were 8 % and 9 %. Grain size analysis was conducted on a sample of this material and the results are presented on Figure 4 in Appendix C and summarized in the following table.

Soil Particles	%
Gravel	37
Sand	40
Silt	18
Clay	5



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### **5.7 Groundwater Conditions**

Free water was observed in Borehole 14-3a at a depth of 2.6 m below ground surface (elevation of 72.6 m) at the time of drilling.

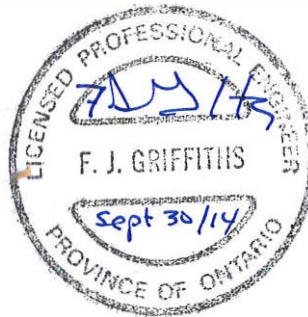
The values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level will be influenced by the water level in the stream and ditches and may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

The general arrangement drawing indicates a water level of 72.64 m and a high water level of 74.13 m in the replacement culvert.

## 6 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber surveyed the borehole locations, and provided the northing and easting coordinates and ground surface elevations. George Downing Estate Drilling Ltd. of Hawkesbury, Ontario supplied and operated a track-mounted CME 75 drill rig to carry out the drilling, sampling, and in-situ testing. The drilling, and sampling operations in the field were supervised on a full time basis by Mr. Nick Weil of Thurber. Laboratory testing was carried out by Stantec in its MTO-approved laboratory in Ottawa.

Overall project management and direction of the field program was provided by Dr. Fred Griffiths, P.Eng. Interpretation of the field data and preparation of this report was completed by Dr. Fred Griffiths, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



Fred J. Griffiths, P.Eng. Ph.D.  
Associate / Senior Geotechnical Engineer



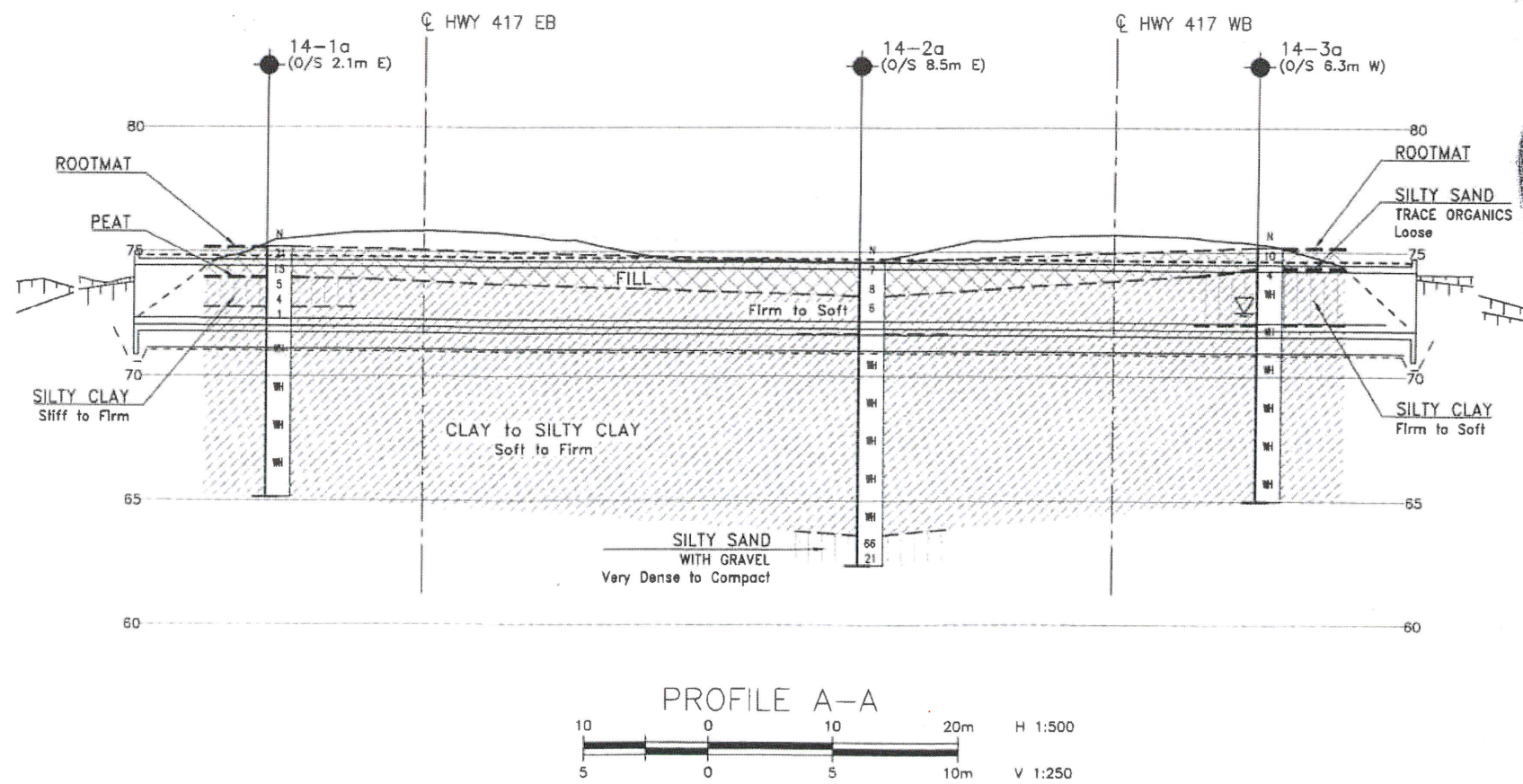
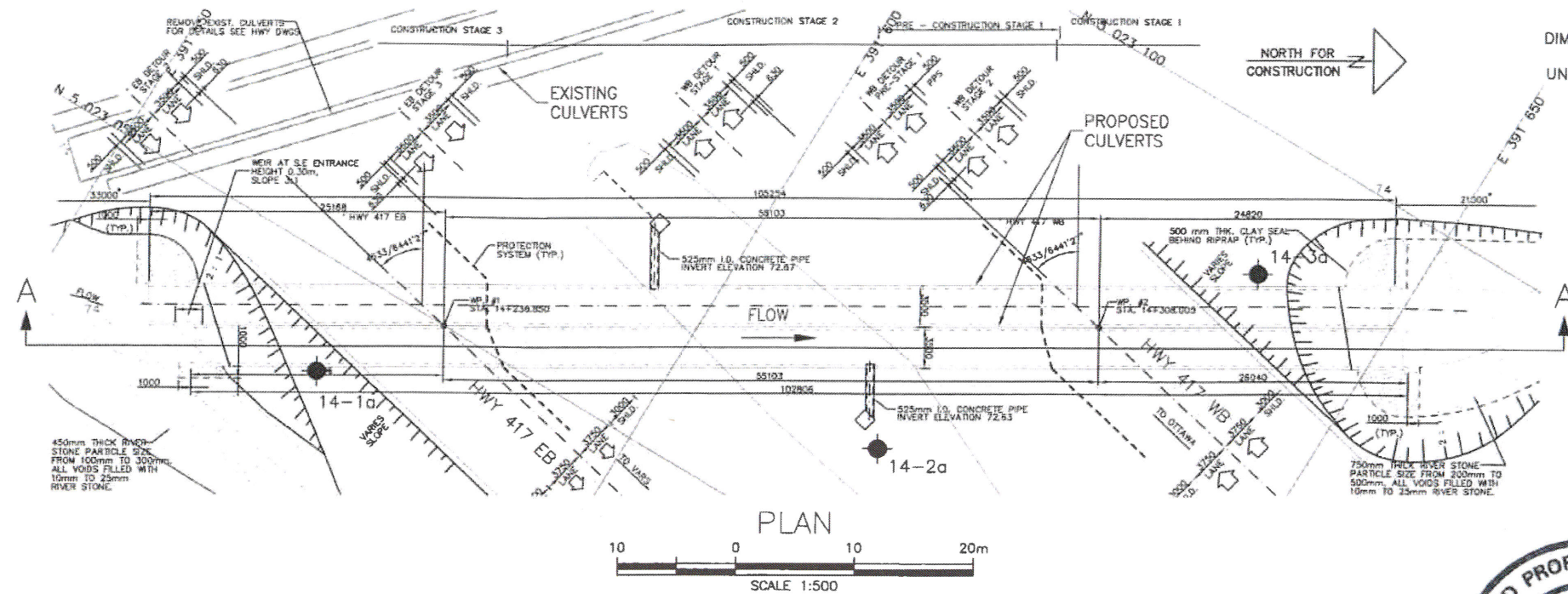
P.K. Chatterji, P.Eng. Ph.D.  
Principal, Designated MTO Contact

**Appendix A**  
**Borehole Locations and Soil Strata Drawings**

19-4406-6



MINISTRY OF TRANSPORTATION, ONTARIO



METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
GWP No 4012-E-0001

HIGHWAY 417  
SHAW CREEK CULVERT  
REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET  
265

URS



THURBER ENGINEERING LTD.



KEYPLAN  
LEGEND

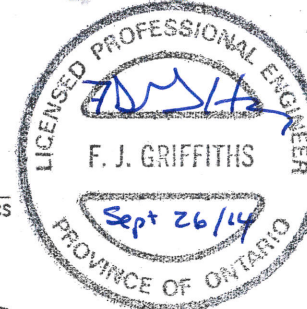
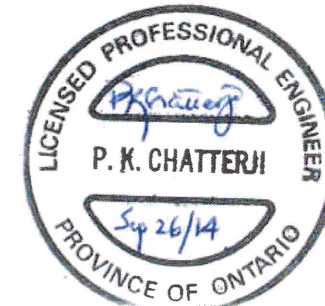
- Borehole
- Borehole and Cone
- Blows /0.3m (Std Pen Test, 475J/blow)
- CONE
- PH
- Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
14-1a	75.2	5 023 041.2	391 574.4
14-2a	74.6	5 023 060.0	391 618.4
14-3a	75.2	5 023 089.0	391 638.0

-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. 31G-250



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	GM	CHK	PC
DRAWN	MFA	CHK	GM
CODE	LOAD	DATE	SEP 2014
SITE	STRUCT	DWG	1

FILENAME: H:\Working\4012-E-0001\4012-E-0001-ShawCreekCulvert.dwg  
PLOTDATE: 9/26/2014 11:15 AM

**Appendix B**  
**Record of Borehole Sheets**

19-4406-6

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

### 1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

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

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

NOTE: Hierarchy of Soil Strength Prediction

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

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

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

### 5. LEGEND FOR RECORDS OF BOREHOLES

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

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



Water Level

C<sub>pen</sub>

Shear Strength Determination by Pocket Penetrometer






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

# UNIFIED SOILS CLASSIFICATION

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



## EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION		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.

TERMS					
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
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.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
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 14-1a

1 OF 2

METRIC

GWP# 4012-E-0001 LOCATION N 5 023 041.2 E 391 574.4 ORIGINATED BY NW  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM  
 DATUM Geodetic DATE 2014.07.23 - 2014.07.23 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								○ UNCONFINED      + FIELD VANE				
								● QUICK TRIAXIAL      × LAB VANE				
						WATER CONTENT (%)						

Continued Next Page

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

# RECORD OF BOREHOLE No 14-1a

2 OF 2

METRIC

GWP# 4012-E-0001 LOCATION N 5 023 041.2 E 391 574.4 ORIGINATED BY NW  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM  
 DATUM Geodetic DATE 2014.07.23 - 2014.07.23 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W P	W	W L	WATER CONTENT (%)		
65.2 10.1	Continued From Previous Page  End of Borehole	///						20 40 60 80 100						

# RECORD OF BOREHOLE No 14-2a

1 OF 2

METRIC

GWP# 4012-E-0001 LOCATION N 5 023 060.0 E 391 618.4 ORIGINATED BY NW  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM  
 DATUM Geodetic DATE 2014.07.24 - 2014.07.24 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
74.6								20	40	60	80	100		
0.0								○ UNCONFINED	+ FIELD VANE					
0.1	100mm ROOTMAT							● QUICK TRIAXIAL	× LAB VANE					
	Silty SAND with gravel to Sandy SILT Loose Grey (FILL)		1	SS	7		74				○			
			2	SS	8						○			
73.2											○			
1.4	CLAY (CH) Firm Brown		3	SS	6		73							0 1 34 65
							72							
71.7														
2.9	CLAY (CH) Firm to Soft Grey		4	AS			71						○	
			5	SS	WH								○	
							70							
			6	SS	WH		69						○	0 1 22 77
							68							
			7	SS	WH		67							
			8	SS	WH		66						○	
							65							

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 14-2a

2 OF 2

METRIC

GWP# 4012-E-0001 LOCATION N 5 023 060.0 E 391 618.4 ORIGINATED BY NW  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM  
 DATUM Geodetic DATE 2014.07.24 - 2014.07.24 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT							UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
								20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
Continued From Previous Page																				
63.6	CLAY (CH) Firm to Soft Grey		9	SS	WH		64													
11.0	Silty SAND with gravel (SM) Very Dense to Compact Grey		10	SS	66		63													
62.4			11	SS	21															
12.2	End of Borehole																			

ONTMT4S 19-4406-6 CULVERT COMBINED.GPJ 2012TEMPLATE(MTO).GDT 29/9/14

# RECORD OF BOREHOLE No 14-3a

1 OF 2

METRIC

GWP# 4012-E-0001 LOCATION N 5 023 089.0 E 391 638.2 ORIGINATED BY NW  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM  
 DATUM Geodetic DATE 2014.07.23 - 2014.07.23 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								20   40   60   80   100						
								○ UNCONFINED   + FIELD VANE						
								● QUICK TRIAXIAL   × LAB VANE						
75.2								20   40   60   80   100						
0.0														
0.1	75mm ROOTMAT													
0.2	SAND with gravel and rootlets Brown Compact (FILL)		1	SS	10		75							
74.3														
74.9	Silty CLAY Brown Stiff (FILL)		2	SS	4		74						0   5   34   61	
0.9	Silty SAND Trace Organics Brown Loose		3	SS	WH								0   3   44   53	
	Silty CLAY (CL) Brown Firm to Soft Moist						73							
72.0														
3.1	CLAY (CH) to Silty CLAY (CI) Grey Soft		4	SS	WH		72							
							71							
			5	SS	WH		70						0   1   20   79	
							69							
			6	SS	WH		68							
							67							
			7	SS	WH		66							
			8	SS	WH								0   2   32   66	

Continued Next Page

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

# RECORD OF BOREHOLE No 14-3a

2 OF 2

METRIC

GWP# 4012-E-0001 LOCATION N 5 023 089.0 E 391 638.2 ORIGINATED BY NW  
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM  
 DATUM Geodetic DATE 2014.07.23 - 2014.07.23 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
						20 40 60 80 100					20 40 60						
64.9	Continued From Previous Page					65	8.0										
10.2	End of Borehole																

## **Appendix C**

### **Laboratory Test Results**

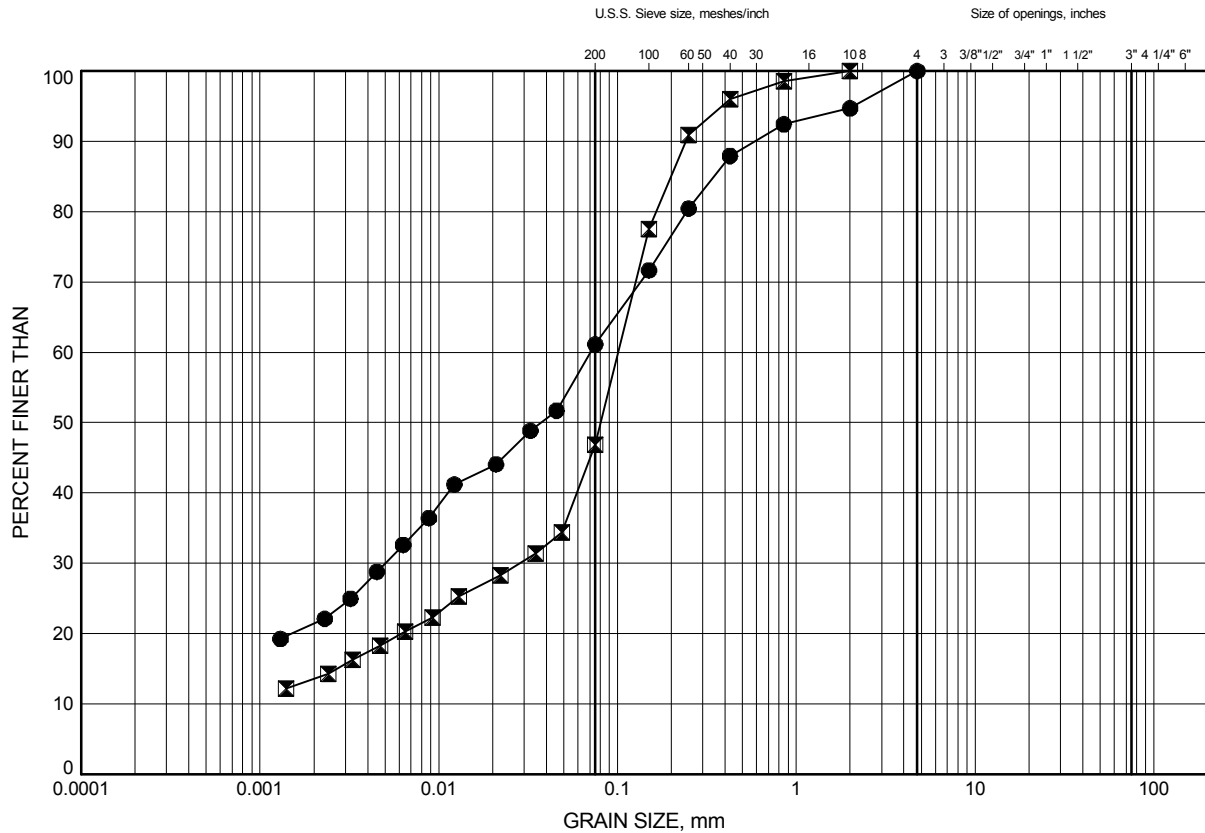
19-4406-6

Part B: Structural Culvert Replacement

# GRAIN SIZE DISTRIBUTION

FIGURE 1

## Silty Sand / Sandy Clay



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	B-1	0.30	74.19
⊠	B-2	0.30	74.59

Date April 2014  
GWP# 4012-E-0001



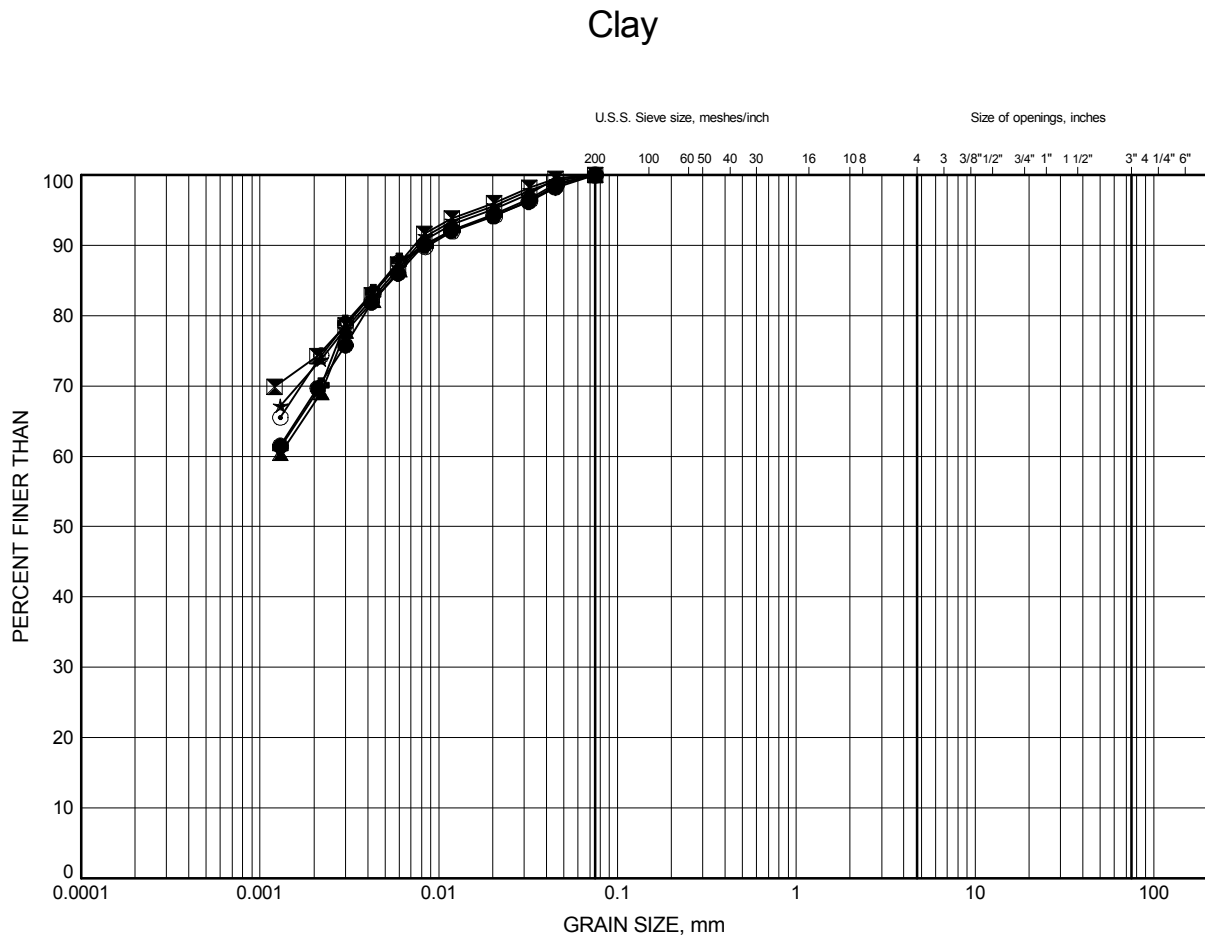
Prep'd CM  
Chkd. PC



# Part B: Structural Culvert Replacement

## GRAIN SIZE DISTRIBUTION

FIGURE 2



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	B-1	1.07	73.43
⊠	B-1	4.11	70.38
▲	B-2	1.83	73.07
★	B-2	3.35	71.55
⊙	B-2	9.45	65.45
⊕	B-3	1.83	72.67

Date February 2014

GWP# 4012-E-0001



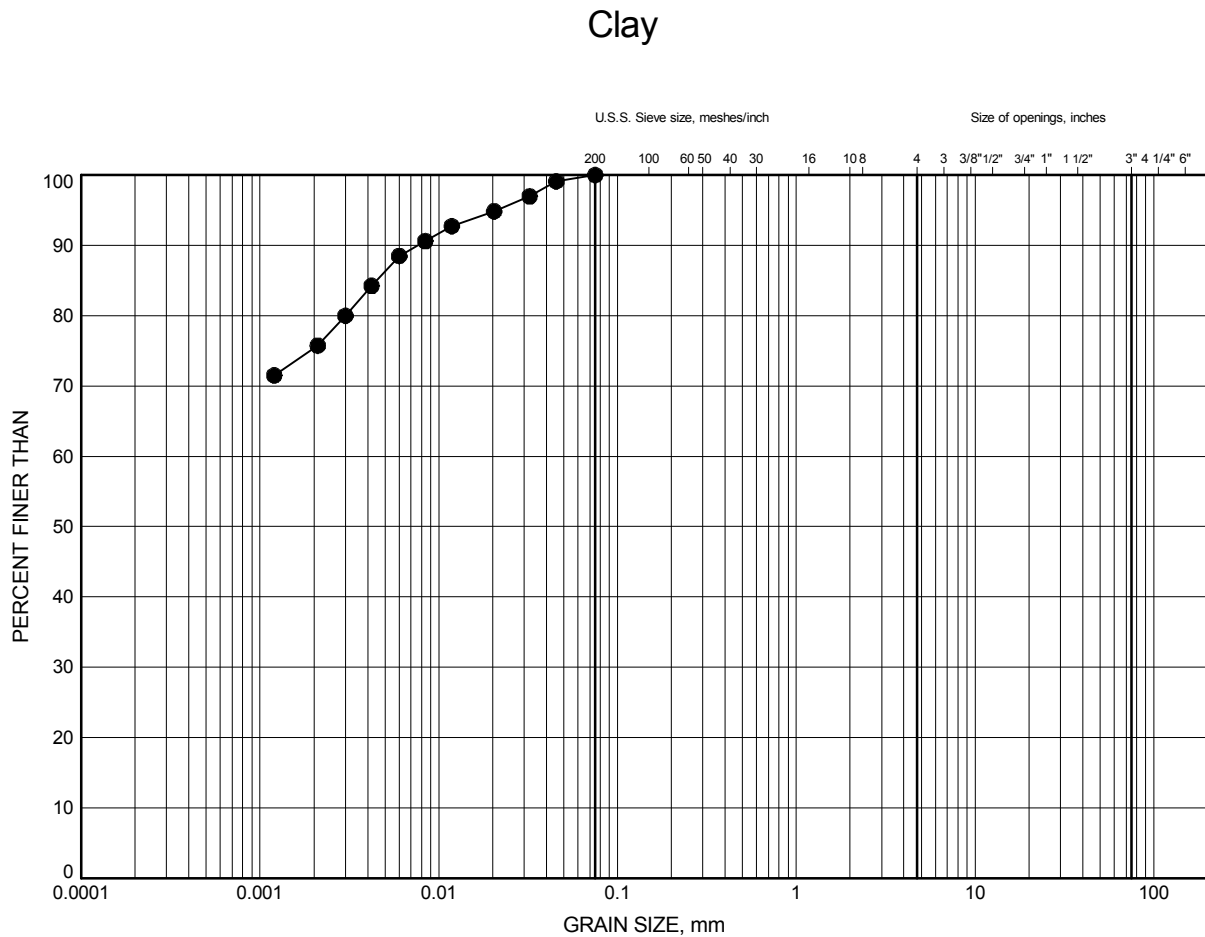
Prep'd CM

Chkd. PC

Part B: Structural Culvert Replacement

# GRAIN SIZE DISTRIBUTION

FIGURE 3



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	B-3	4.88	69.62

Date February 2014  
GWP# 4012-E-0001

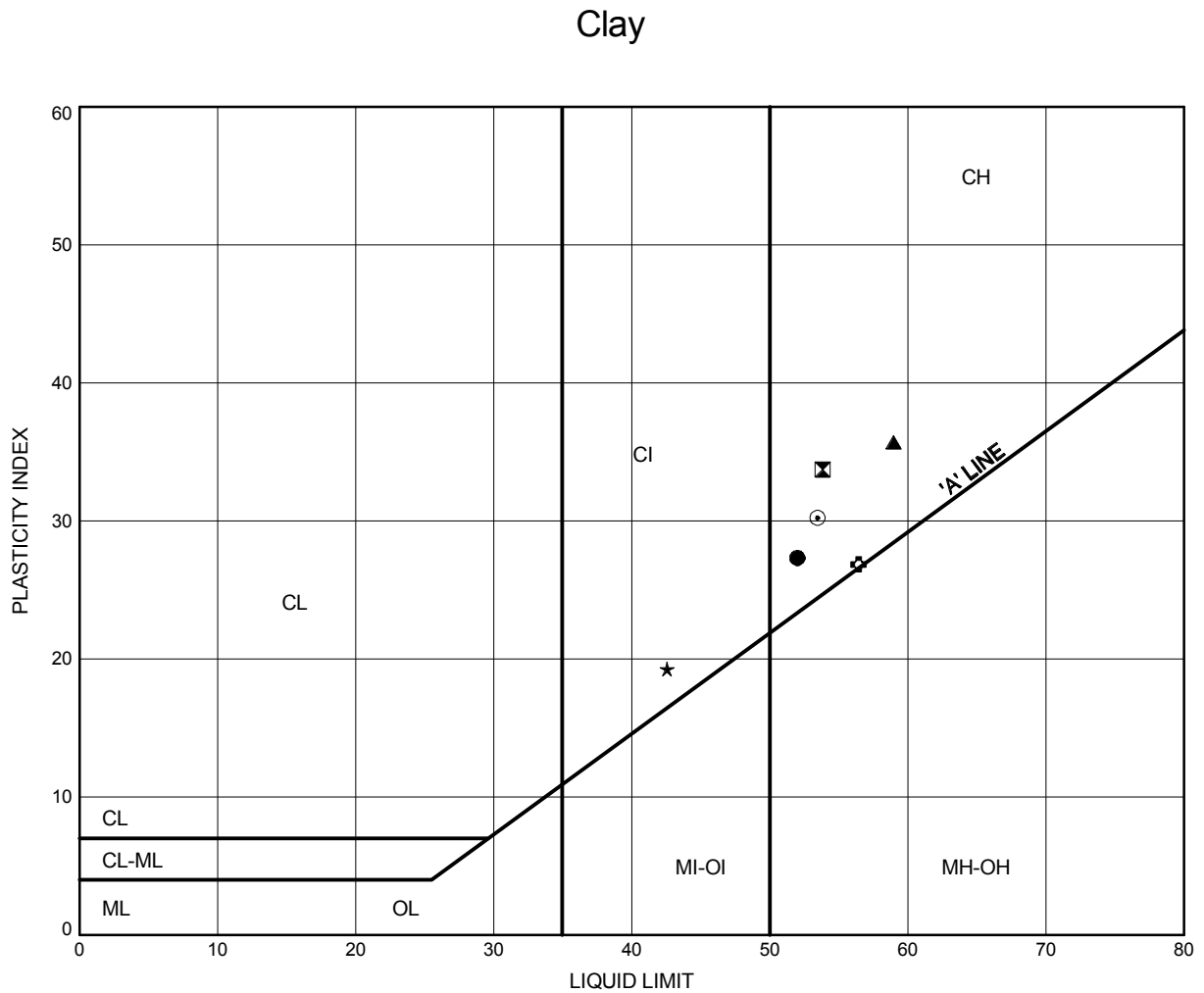


Prep'd CM  
Chkd. PC

Part B: Structural Culvert Replacement

# ATTERBERG LIMITS TEST RESULTS

FIGURE 4



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	B-1	4.11	70.38
⊠	B-2	1.83	73.07
▲	B-2	3.35	71.55
★	B-2	9.45	65.45
⊙	B-3	1.83	72.67
⊕	B-3	4.88	69.62

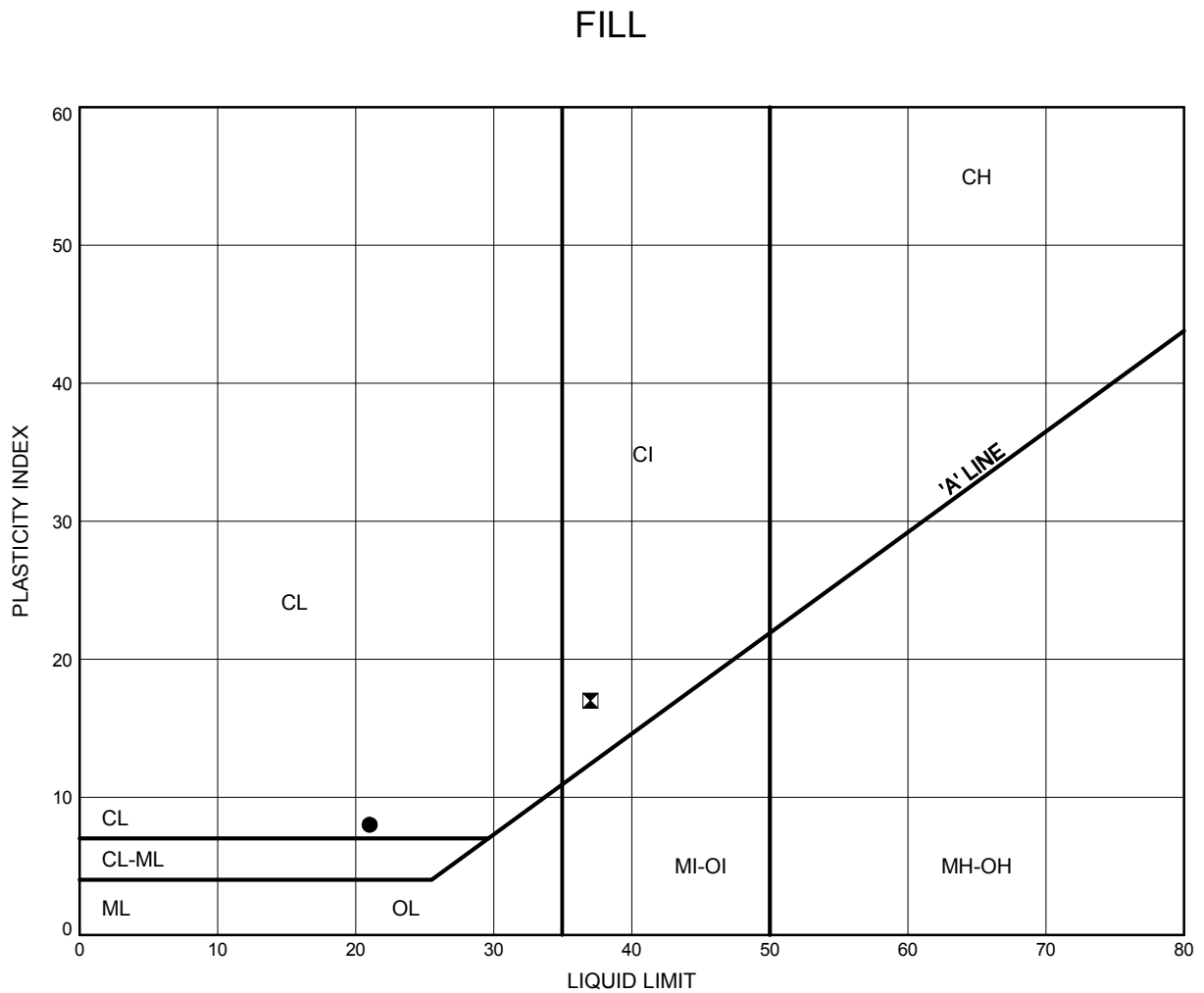
Date February 2014  
GWP# 4012-E-0001



Prep'd CM  
Chkd. PC

# ATTERBERG LIMITS TEST RESULTS

FIGURE 5



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-1a	0.30	74.93
⊠	14-1a	0.91	74.32

Date September 2014

GWP# 4012-E-0001



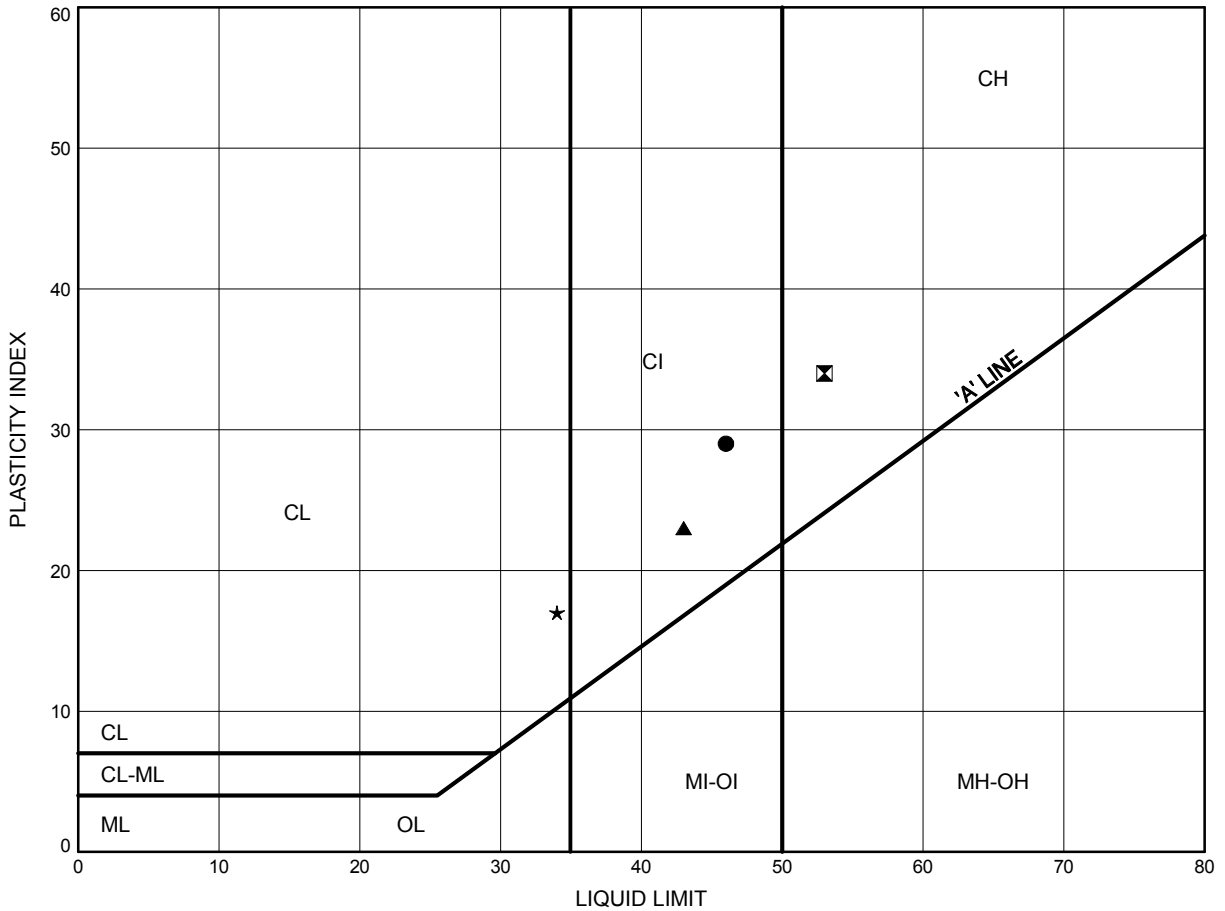
Prep'd GM

Chkd. FJG

# ATTERBERG LIMITS TEST RESULTS

FIGURE 6

Silty CLAY



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-1a	2.13	73.10
⊠	14-2a	1.83	72.77
▲	14-3a	1.07	74.09
★	14-3a	1.83	73.33

Date September 2014

GWP# 4012-E-0001



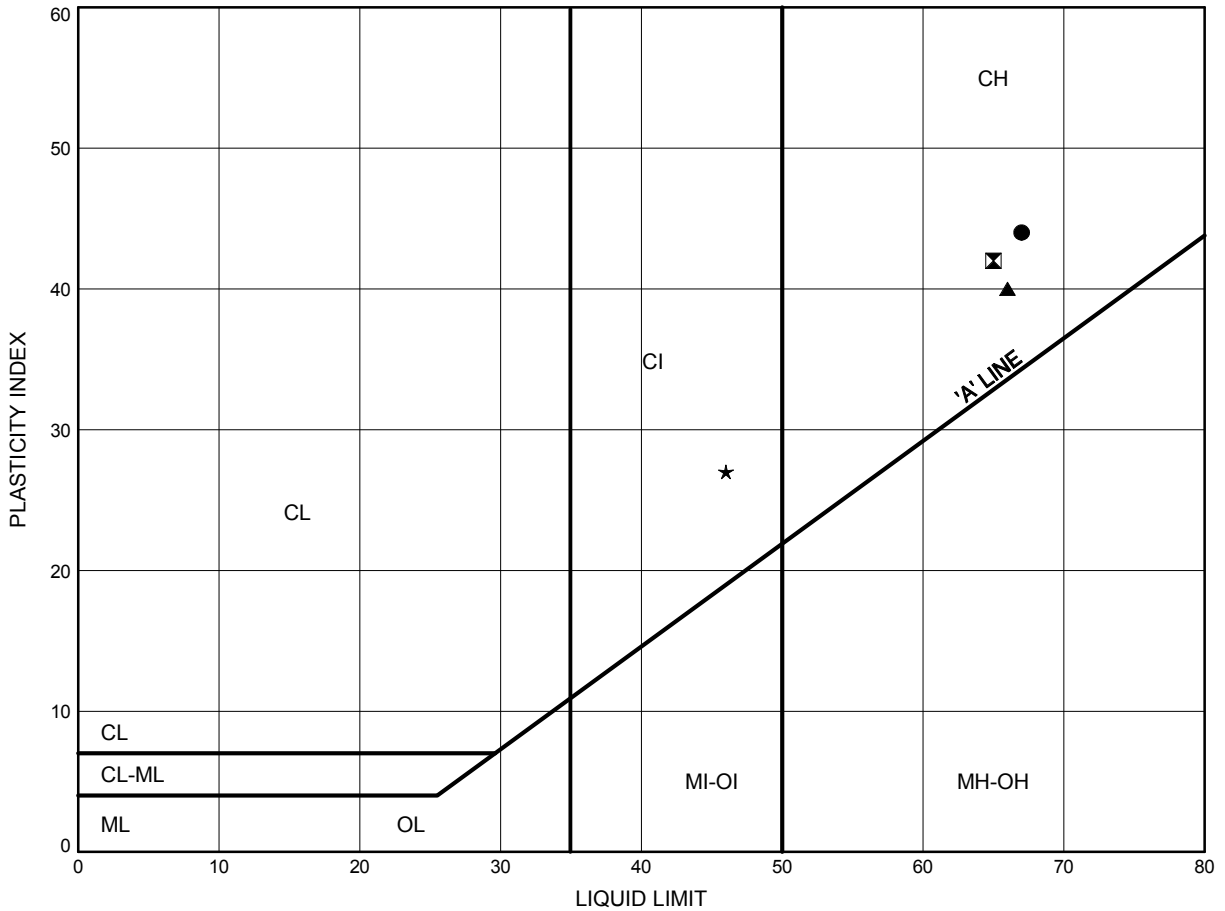
Prep'd GM

Chkd. FJG

# ATTERBERG LIMITS TEST RESULTS

FIGURE 7

## CLAY



### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-1a	5.64	69.59
⊠	14-2a	5.64	68.96
▲	14-3a	4.88	70.28
★	14-3a	9.45	65.71

Date September 2014

GWP# 4012-E-0001



Prep'd GM

Chkd. FJG

## **Appendix D**

### **Selected Photographs of Culvert Locations**

19-4406-6



**Photo 1: South end – existing culvert inlet.**



**Photo 2: North end – existing culvert outlet.**