

CONTRACT NO. 2017-3003

G.W.P. 3042-11-00

FOUNDATION INVESTIGATION REPORT

UNNAMED TRIBUTARY CULVERT
HWY 23, STATION 19+544.99 (ELMA TOWNSHIP)

(SITE No. 25-340/C)

CONTRACT 4
STRUCTURE REPLACEMENTS
AND REHABILITATIONS



April 2017

FOUNDATION INVESTIGATION REPORT

**Culvert Replacement
Site No. 25-340/C, Highway 23
Contract 4 Structure Replacements and Rehabilitation
GWP 3042-11-00
Ministry of Transportation, West Region**

Submitted to:

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REPORT



Report Number: 12-1132-0163-4000-R05

Geocres No.: 40P11-22

Distribution:

8 Copies - Stantec Consulting Ltd.
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Stantec Consulting Ltd. (Stantec) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations as part of the detailed design work for GWP 3042-11-00. The project involves the detailed design of the replacement and rehabilitation of several structures along multiple highways in southern Ontario. This report addresses the proposed replacement of the culvert at Site 25-340/C at about Station 19+545 on Highway 23, in Perth County, Geographic Township of Elma, Ontario.

The purpose of the foundation investigation is to explore the subsurface conditions at the location of the proposed culvert replacement by drilling boreholes and carrying out in situ and laboratory testing on selected samples. The terms of reference for the scope of work are outlined in the MTO's Request for Proposal, in Golder Associates' proposal P2-1132-0163 dated February 25, 2013, and in the Change Order 12-1132-0163-4000-C03 dated September 13, 2016. The work was carried out in accordance with our Quality Control Plan for Foundation Engineering dated March 26, 2013.

2.0 SITE DESCRIPTION

The subject culvert is located at about Station 19+545 and spans Highway 23 approximately 290 metres southwest of the intersection with Fisher Avenue in Atwood, Ontario. The Town of Atwood is approximately 300 metres northeast of the site. The replacement culvert will be constructed in approximately the same location as the existing culvert. The approximate location of the culvert is shown on the Key Plan, Figure 1.

This section of Highway 23 is currently a two lane, undivided highway with gravel shoulders. It is generally oriented northeast-southwest in the vicinity of the subject site. An unnamed watercourse referred to as 'Hanna Drain' on an original drawing flows through the culvert from east to west beneath Highway 23. The existing culvert has an overall length of about 27.6 metres, including extensions. The date of original construction is circa 1938, the date of construction of the extensions is unknown.

Existing Dimensions (m)	Obvert Elevation (m)		Construction
	Lt ¹	Rt ¹	
4.2 x 1.8 x 27.6	360.53	360.55	Concrete NRFO

NOTE: 1. When facing the direction of increasing chainage, Lt and Rt are defined as Left and Right of centreline, respectively.

The banks of the watercourse have been partially lined with riprap and an embankment along Highway 23 at the culvert outlet is supported with sand bags. All other embankments near the culvert are grass covered or supporting elements are not visible due to tall grasses. The unnamed watercourse flows through fields on both sides of Highway 23. Selected site photographs are provided in Appendix B.



2.1 Site Geology

The project area is located within the physiographic region of southern Ontario known as the Dundalk Till Plain, near its southern extent. This area is comprised of a gently undulating till plain with its flutings running southeasterly. This region is bounded by moraines on the east with some morainic ridges in the northeast portion of the region. Numerous small flat-floored valleys form a network over the plain connecting to the Grand or the Maitland spillways systems; these are frequently swampy. Much of the till plain is characterized by swamps or bogs, and by poorly drained depressions.¹ The overburden in the area of the site generally consists of glaciolacustrine deep water deposits of gravel, sand, and silt.²

The geological mapping indicates that the site is on the border of the Lucas Formation, consisting of light tan microcrystalline and microcrystalline dolomite (with anhydrite in the subsurface), and the Amherstburg Formation, which reportedly consists of grey to dark brown crinoidal limestone and dolomite (locally cherty, bituminous, and biostromal).³ The bedrock surface at the site is at about elevation 342 metres⁴, or about 18 metres below the general ground surface⁵.

3.0 INVESTIGATION PROCEDURES

The geotechnical field investigation was carried on September 21 and 22, 2016, during which time three boreholes were drilled at the approximate locations shown on Drawing 1, attached.

The boreholes were drilled using a track-mounted Diedrich D50T rig supplied and operated by a specialist drilling contractor. Samples of the overburden were typically obtained at depth intervals of 0.75 metres to about 6 metres depth and at 1.5 metre intervals thereafter using 50 millimetre outside diameter split spoon sampling equipment in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). The results of the SPT testing, as presented on the Record of Borehole sheets, Drawing 1 and in Section 4.0 of this report, are unmodified (not standardized for hammer efficiency, borehole diameter, rod length, etc.). The samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 40 millimetres. Therefore, particles or objects that may exist within the soils that are larger than this dimension will not be sampled or represented in the grain size distributions. Larger particle sizes, including cobbles and boulders, are known to be present in the glacial tills as discussed in the text of this report.

Groundwater conditions in the boreholes were observed throughout the drilling operations and a piezometer was installed in borehole BH-503 as indicated on the corresponding Record of Borehole sheet. The boreholes were backfilled in accordance with current MTO procedures and Ontario Regulation 903 (as amended).

The field work was monitored on a full-time basis by an experienced member of our staff who located the boreholes in the field, obtained utility locates, monitored the drilling, sampling and in-situ testing operations and logged the boreholes. The samples were identified in the field, placed in uniquely-labelled containers and transported to our

¹ Chapman, L.J., and Putnam, D.F., 1984: Physiography of Southern Ontario; Ontario Geological Survey, Special Volume 2, 270p.

² Cooper, A.J., Fitzgerald, W.D., and Clue, Jack. 1977: Quaternary Geology of the Seaforth Area, Southern Ontario; Ontario Geological Survey Prelim. Map, P.1233. Geol. Serv., scale 1:50,000. Geology 1975, 1976.

³ Sanford B.V., 1969: Geology Toronto-Windsor Area, Ontario; Ontario Geological Survey of Canada Map 1263A, Scale 1:250,000.

⁴ Cooper, A.J., 1978. Bedrock Topography of the Goderich-Seaforth Area, Southern Ontario; Ontario Geological Survey Prelim. Map P.1974, Bedrock Topography Ser., Scale 1:50,000. Compilation 1977, 1978.

⁵ Cooper, A.J. and Nicks, L.P., 1981: Drift Thickness of the Goderich and Seaforth Areas, Southern Ontario; Ontario Geological Survey, Map P.2450, Drift Thickness Series, Scale 1:50,000. Compilation 1979, 1980.



London laboratory for further examination and testing. Index and classification tests, consisting of water content determinations, grain size distribution analyses and Atterberg limits determination, were carried out on selected samples. The results of the laboratory testing are shown on the Record of Borehole sheets and in Appendix A.

The as-drilled borehole locations and ground surface elevations at the borehole locations are shown on the Record of Borehole sheets and on Drawing 1. Table 1, below, summarizes the coordinates, ground surface elevations and depths of the boreholes.

Table 1: Geospatial and borehole exploration summary.

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
BH-501	4 836 805	423 845	362.02	11.13
BH-502	4 836 820	423 847	361.49	9.60
BH-503	4 836 810	423 861	362.10	9.60

4.0 SUBSURFACE CONDITIONS

4.1 Site Stratigraphy

The subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the in-situ and laboratory testing carried out on selected samples, are given on the attached Record of Borehole sheets and in Appendix A. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous samples and observations of drilling resistance and, therefore, may represent transitions between soil types rather than exact planes of geological change. Further, the subsurface conditions will vary between and beyond the borehole locations.

The boreholes drilled at the site generally encountered fill materials associated with the adjacent pavements, embankment fill materials, and native clayey silt till, and silty clay till.

The locations and elevations of the boreholes and an interpreted stratigraphic profile are shown on Drawing 1. A detailed description of the subsurface conditions encountered in the boreholes is provided on the Record of Borehole sheets and is summarized in the following sections.

4.2 Soil Conditions

Fill materials associated with the existing pavements and Highway 23 platform embankment were encountered at the ground surface in all of the boreholes. The fill materials generally consisted of sand and crushed gravel and sand in the upper portion (to about elevation 361.0 to 361.6 metres). Beneath the sand and gravel fill and sand fill, clayey silt and sandy silt embankment fill was encountered. The embankment fill was about 2.1 to 2.4 metres thick at the borehole locations and extended to about elevations 358.6 to 359.2 metres. The fill materials had N values, as determined in the standard penetration testing, of 5 to 20 blows per 0.3 metres. Samples of the fill had water contents of about 10 to 36 per cent. A sample of the fill from BH-501 had plastic and liquid limits of about



22 and 35 per cent, respectively, based on a single Atterberg limits determination. This data is presented on Figure A-4. Grain size distribution curves for samples of the fill materials are provided on Figure A-1.

Below the fill, a 0.3 metre thick layer of sandy silt was encountered in BH-501 at about elevation 359.1 metres. Silty clay till was encountered beneath the sandy silt in BH-501 and the fill in BH-502 at elevation 358.8 and 358.6 metres, respectively. The silty clay till layers were about 2.0 and 2.3 metres thick. The silty clay till had N values of 5 to 26 blows per 0.3 metres with water contents of about 19 to 21 per cent. The silty clay till had average plastic and liquid limits of about 22 and 38 per cent, respectively, based on two Atterberg limits determinations. These data are shown on Figure A-4. Grain Size distribution curves for samples of the silty clay till are provided on Figure A-2. Cobbles and boulders should be expected in the till.

Beneath the silty clay till in BH-501 and BH-502 and the fill in BH-503, clayey silt till was encountered between about elevation 356.3 and 359.2 metres. All of the boreholes were terminated in the clayey silt till after exploring it for about 4.4 to 6.7 metres. The clayey silt till had N values of 4 to greater than 100 blows per 0.3 metres and water contents of about 17 to 33 per cent. The clayey silt till had average plastic and liquid limits of about 16 and 31 per cent, respectively, based on four Atterberg limits determinations. These data are shown on Figure A-4. Grain size distribution curves for samples of the clayey silt till are shown on Figure A-3. Cobbles and boulders should be expected in the clayey silt till.

4.3 Groundwater Conditions

Groundwater conditions were observed during drilling and a groundwater observation piezometer was installed in BH-503. The installation details are provided on the corresponding Record of Borehole sheet. Groundwater was encountered during drilling in BH-503. BH-501 and BH-502 remained dry during drilling on September 21 and 22, 2016, respectively. A summary of the encountered and measured groundwater levels is provided in the table below.

Table 2: Encountered and measured groundwater levels.

Borehole	Ground Surface Elevation (m)	Encountered Groundwater Elevation (m)	Measured Groundwater Elevation (m)	
			September 22, 2016	October 25, 2016
BH-501	362.02	Dry	-	-
BH-502	361.49	Dry	-	-
BH-503	362.10	354.5	Piezometer dry to 354.2	358.82


The above-noted encountered water levels are not considered to be representative of the long-term, stabilized groundwater conditions. Based on the change in soil colour from brown to grey and the surrounding topography, the long-term groundwater level is inferred to typically be at about elevation 358.4 metres. Groundwater levels are expected to fluctuate seasonally and are expected to be higher during periods of sustained precipitation or during spring snow melt conditions.

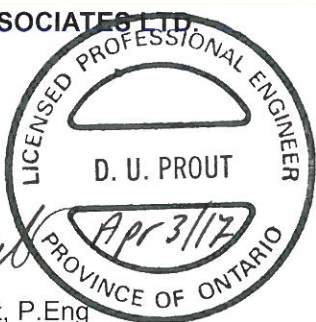



5.0 MISCELLANEOUS


The investigation was carried out using equipment supplied and operated by London Soil Test Limited, an Ontario Ministry of Environment and Climate Change licensed well contractor. The field operations were supervised by Mr. Daniel Hyland, E.I.T. under the direction of the Field Investigation Manager, Mr. Brett Thorner, P.Eng. The laboratory testing was carried out at Golder's London laboratory under the direction of Mr. Michael Arthur. The laboratory is an accredited participant in the MTO Soil and Aggregate Proficiency Program and is certified by the Canadian Council of Independent Laboratories for testing Types C and D aggregates. This report was prepared by Ms. Cara Kennedy, E.I.T. under the direction of the Project Engineer Ms. Dirka U. Prout, P.Eng.. The report was reviewed by Mr. Michael E. Beadle, P.Eng., an Associate with Golder Associates. Mr. Fintan J. Heffernan, P.Eng., the Designated MTO Contact and Quality Control Auditor for this assignment, conducted an independent quality review of the report.

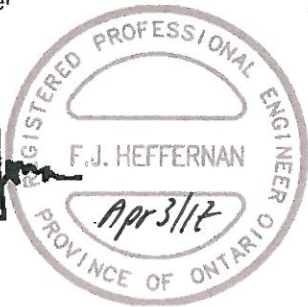
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(final) part a replaceclvrt-25-340-c.docx



LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a)	Index Properties
$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	c_u, s_u	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w _p	plastic limit
w _l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D _R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

RECORD OF BOREHOLE No BH-501

1 OF 1

METRIC

PROJECT 12-1132-0163
W.P. 3042-11-00 LOCATION N 4836804.6 , E 423845.1 ORIGINATED BY DH
DIST HWY 23 BOREHOLE TYPE POWER AUGER, HOLLOW STEM COMPILED BY ZJB/LMK
DATUM GEODETIC DATE September 21, 2016 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE								
362.02	GROUND SURFACE						362	20	40	60	80	100							
0.00	FILL, sand and crushed gravel																		
361.62	Brown																		
0.40	FILL, sand, some silt, some gravel,																		
361.26	with cobbles																		
0.76	Brown		1	SS	20		361												
	FILL, clayey silt, some sand, trace																		
360.50	gravel with topsoil layers																		
1.52	Very stiff																		
	Brown		2	SS	15		360												
	FILL, clayey silt, some sand to																		
	sandy, trace gravel, with topsoil																		
	layers																		
	Firm to stiff																		
	Brown and grey		3	SS	5														
359.12																			
2.90	SANDY SILT, trace gravel, trace						359												
3.20	clay		4	SS	5														
	Loose																		
	Brown																		
	SILTY CLAY TILL, some sand, trace																		
	gravel		5	SS	19		358												
	Firm to very stiff																		
	Brown to grey at about																		
	elev. 358.4m		6	SS	23		357												
356.84																			
5.18	CLAYEY SILT TILL, some sand,																		
	trace gravel		7	SS	20		356												
	Very stiff																		
	Grey		8	SS	18														
							355												
			9	SS	19		354												
							353												
			10	SS	22														
							352												
350.89			11	SS	21		351												
11.13	END OF BOREHOLE																		
	Borehole dry during drilling on September 21, 2016																		

RECORD OF BOREHOLE No BH-503

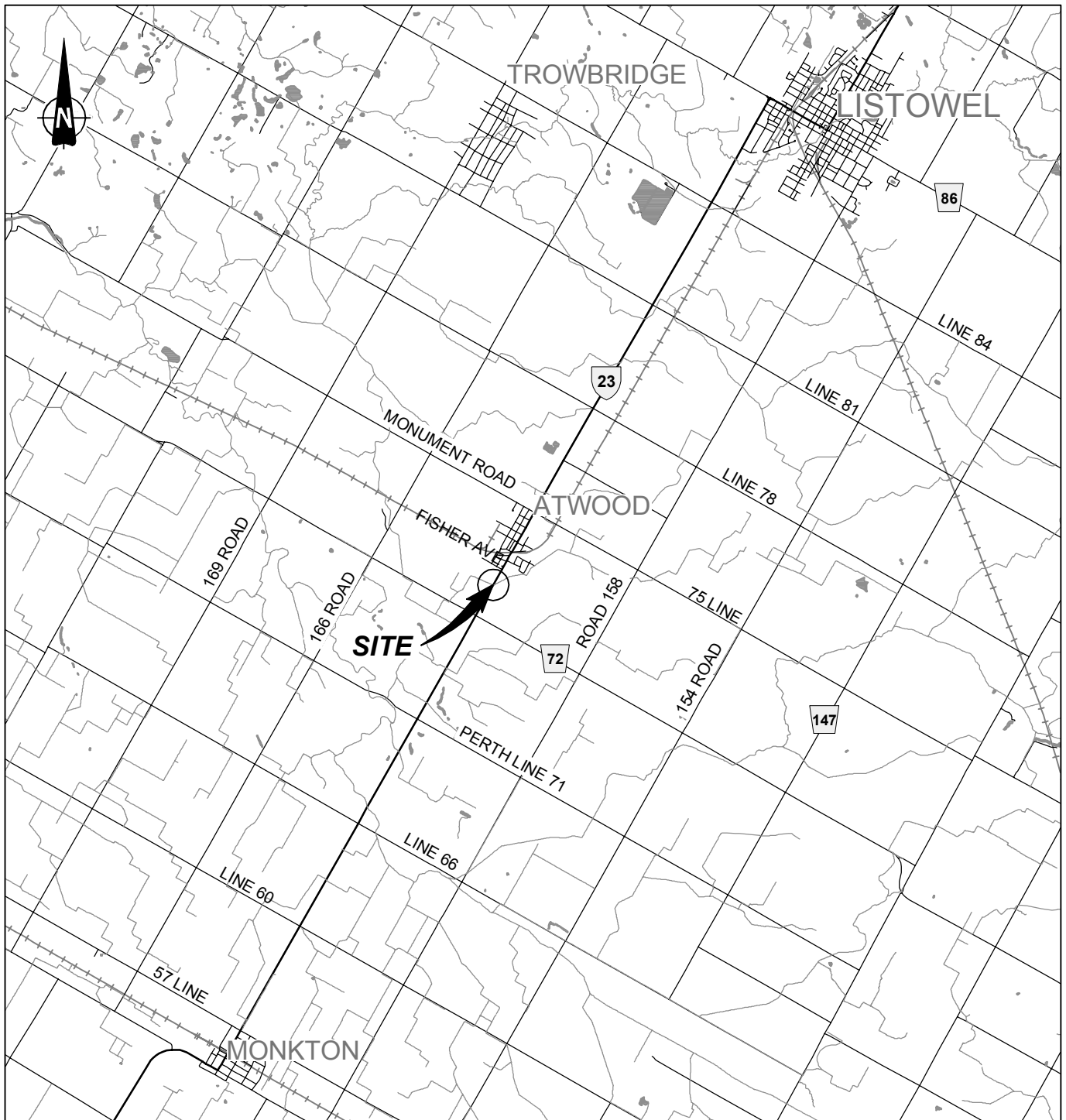
1 OF 1

METRIC

PROJECT 12-1132-0163
W.P. 3042-11-00 LOCATION N 4836810.1, E 423860.8 ORIGINATED BY DH
DIST HWY 23 BOREHOLE TYPE POWER AUGER, HOLLOW STEM COMPILED BY ZJB/LMK
DATUM GEODETIC DATE September 22, 2016 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
362.10	GROUND SURFACE							20 40 60 80 100						
0.08	FILL, sand and crushed gravel Brown													
361.59	APSHALT													
0.51	FILL, sand and crushed gravel Brown													
	FILL, sandy silt, some clay, trace gravel, with topsoil layers Loose to compact		1	SS	20									
			2	SS	11									
			3	SS	8									
359.20														
2.90	CLAYEY SILT TILL, some sand, trace gravel Firm to hard Brown to grey at about elev. 358.4m		4	SS	4									
			5	SS	14									
			6	SS	18									
			7	SS	21									
			8	SS	28									
			9	SS	60/ 254mm									
352.50	END OF BOREHOLE		10	SS	26									
9.60	Groundwater encountered at about elev. 354.5m during drilling on September 22, 2016. Piezometer dry after installation on September 22, 2016. Water level measured in piezometer at elev. 358.82m on October 25, 2016.													

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



SCALE
0 2000 4000m
1:100,000

REFERENCE

PLAN BASED ON CANMAP STREETFILES V.2008.5.

NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING TEXT.

PROJECT

HANNA DRAIN CULVERT REPLACEMENT, SITE 25-340/C
HIGHWAY 23
GWP 3042-11-00

TITLE

KEY PLAN



PROJECT No. 12-1132-0163			FILE No. 1211320163-4000-F05001	
CADD	LMK	Jan. 12/17	SCALE	AS SHOWN
CHECK			REV.	0
FIGURE 1				

METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 3042-11-00



CULVERT REPLACEMENT

SHEET

HIGHWAY 23 SITE No. 25-340/C
BOREHOLE LOCATIONS AND SOIL STRATA



Golder Associates Ltd.
LONDON, ONTARIO, CANADA



KEY PLAN

SCALE IN KILOMETRES
0 1 2

LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- Standard Penetration Test Value
- Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL encountered during drilling
- WL measured on October 25, 2016
- Borehole dry during drilling

No.	ELEVATION	CO-ORDINATES (MTM ZONE 11)	
		NORTHING	EASTING
BH-501	362.02	4 836 804.6	423 845.1
BH-502	361.49	4 836 820.3	423 846.6
BH-503	362.10	4 836 810.1	423 860.8

NOTES

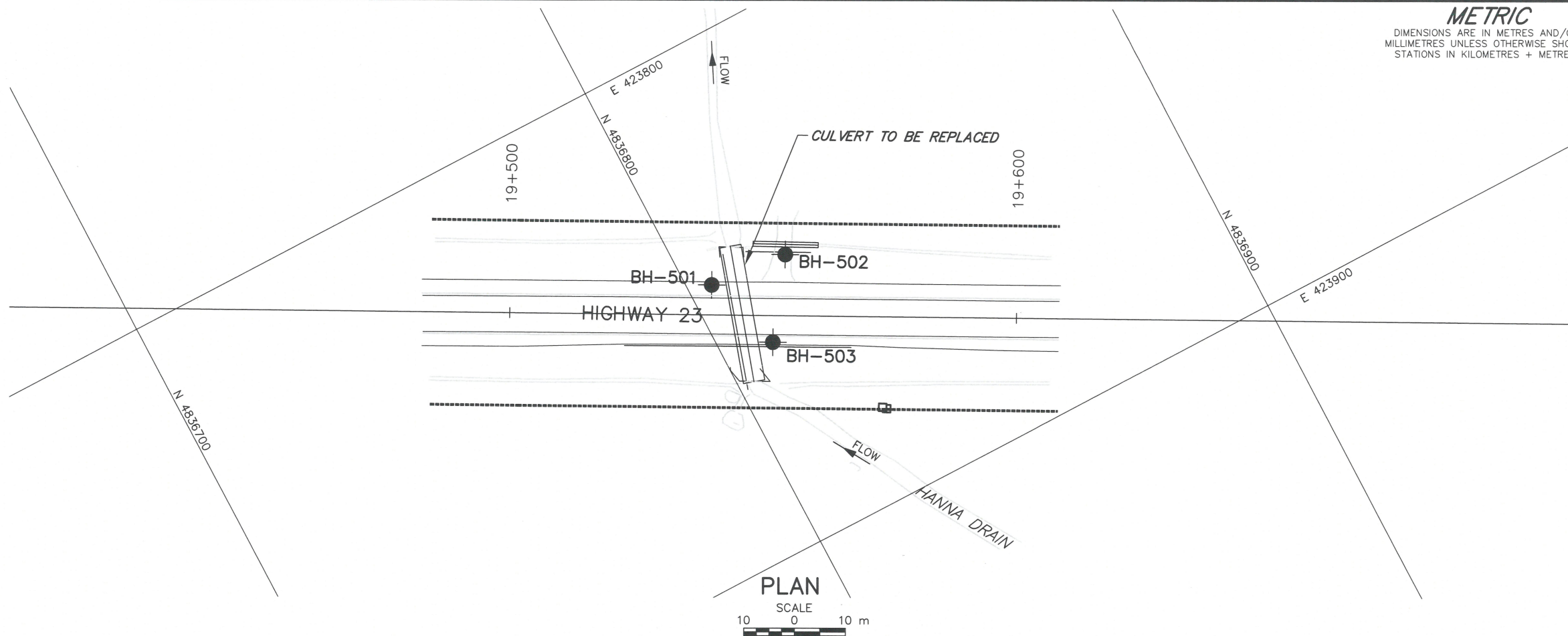
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

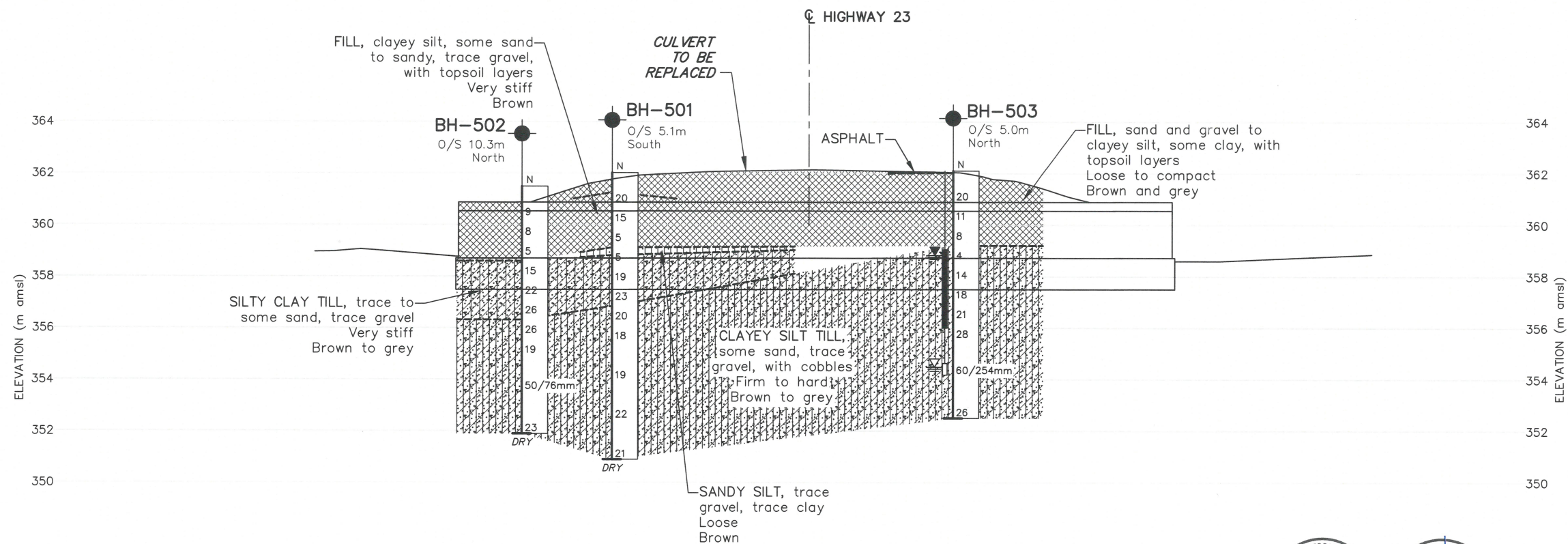
Base plans provided in digital format by Stantec.

NO.	DATE	BY	REVISION
Geocres No. 40P11-22			
HWY.	23	PROJECT NO. 12-1132-0163	DIST.
SUBM'D.	BT	CHKD. DH	DATE: Mar. 16/17
DRAWN:	LMK	CHKD. DUP	APPD. FJH
SITE: 25-340/C			DWG. 1



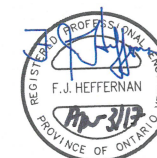
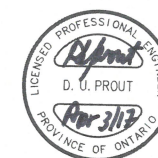
PLAN

SCALE
10 0 10 m



PROFILE ALONG C OF HANNA DRAIN

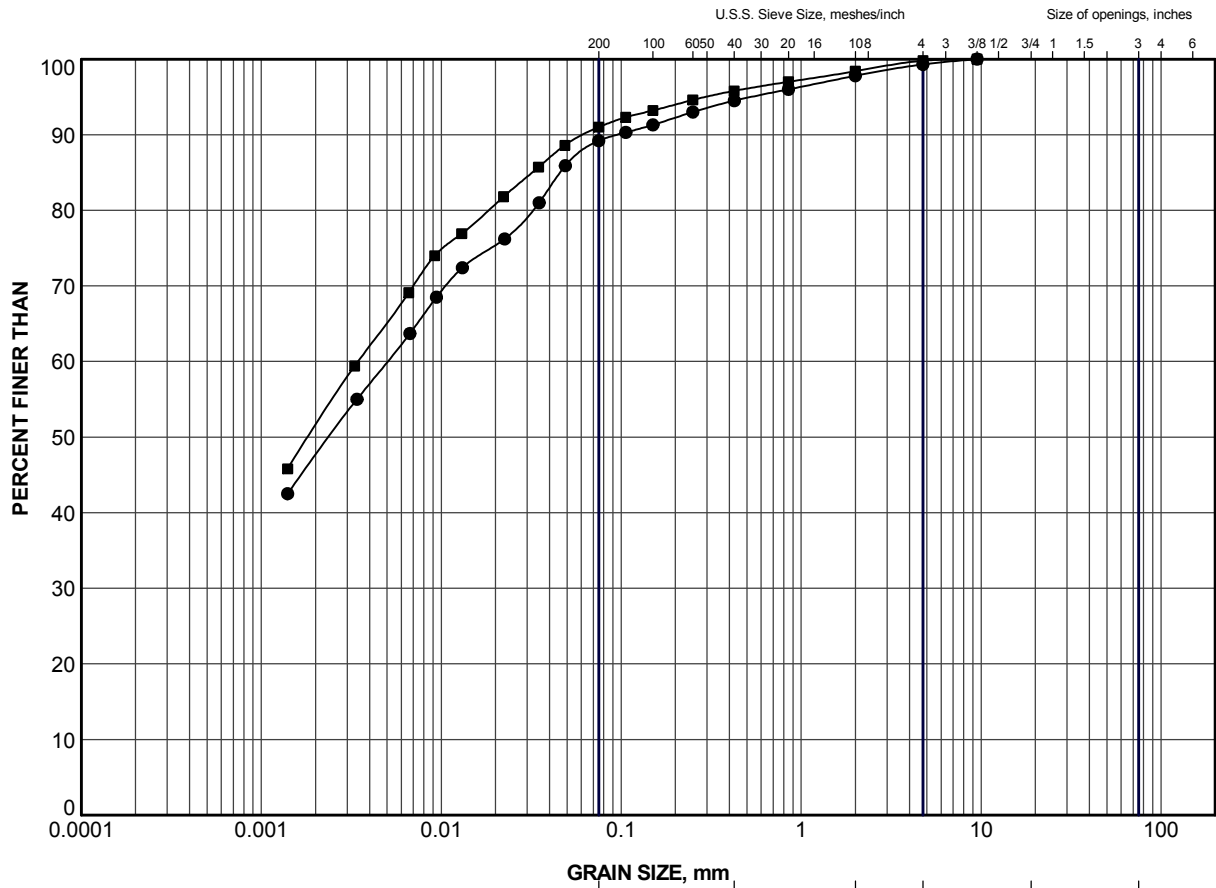
HORIZONTAL SCALE
2 0 2 m
VERTICAL SCALE
2 0 2 m

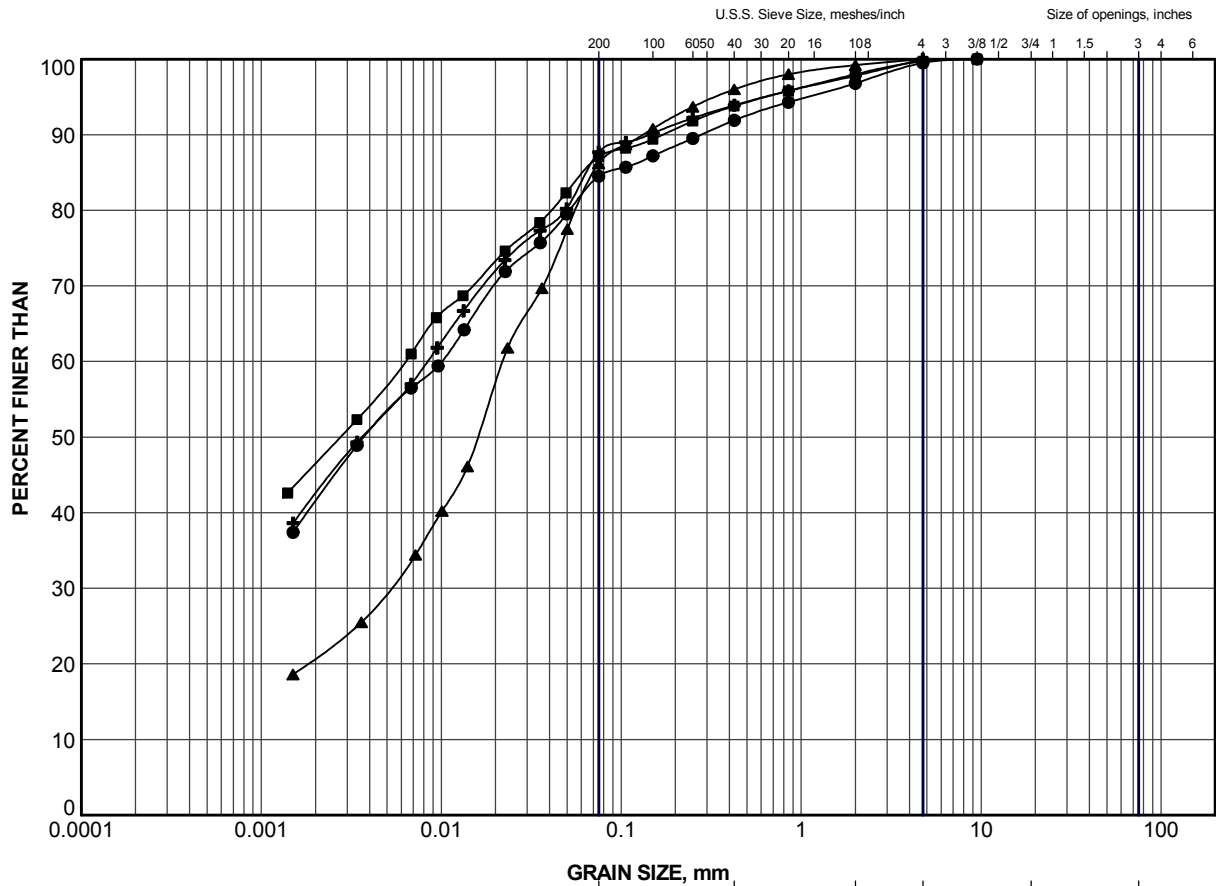




APPENDIX A

Laboratory Test Data




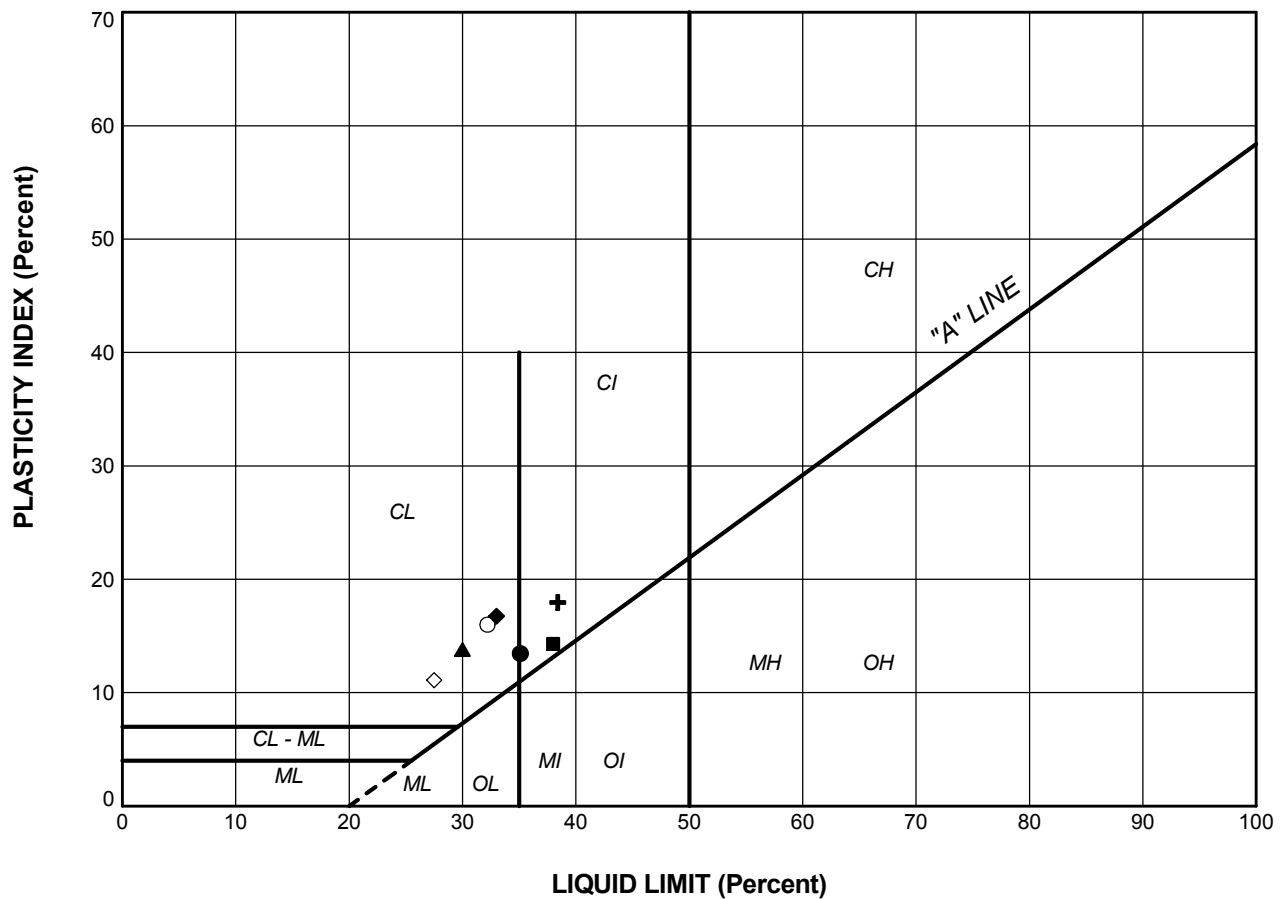


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-501	9	354.2
■	BH-502	8	355.2
▲	BH-503	4a	358.9
+	BH-503	7	356.5

PROJECT			
HANNA DRAIN CULVERT REPLACEMENT, SITE 25-340/C HIGHWAY 23 GWP 3042-11-00			
TITLE			
GRAIN SIZE DISTRIBUTION CLAYEY SILT TILL			
PROJECT No.		12-1132-0163	FILE No. 1211320163-4000-F050A3
DRAWN		ZJB/LMK	Dec 23/16
CHECK			
		SCALE	N/A
		REV.	
		FIGURE A-3	



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
FILL					
●	BH-501	3	35.1	21.7	13.5
SILTY CLAY TILL					
■	BH-501	5	38.0	23.7	14.3
+	BH-502	4	38.4	20.5	18.0
CLAYEY SILT TILL					
▲	BH-501	9	30.0	16.2	13.8
◆	BH-502	8	33.0	16.3	16.8
◇	BH-503	4a	27.5	16.4	11.1
○	BH-503	7	32.2	16.2	16.0

PROJECT			
HANNA DRAIN CULVERT REPLACEMENT, SITE 25-340/C HIGHWAY 23 GWP 3042-11-00			
TITLE			
PLASTICITY CHART			
PROJECT No.		12-1132-0163	FILE No. 1211320163-4000-F050A4
DRAWN	ZJB/LMK	Dec 23/16	SCALE N/A REV.
CHECK			
			FIGURE A-4



APPENDIX B

Site Photographs



APPENDIX B PHOTOGRAPHS



Photograph 1: East elevation (inlet) of Culvert Site 25-340/C.



Photograph 2: West elevation (outlet) of Culvert Site 25-340/C.



APPENDIX B PHOTOGRAPHS



Photograph 3: Looking southwest along Highway 23, east ditch toward inlet of Culvert Site 25-340/C.



Photograph 4: Looking northeast along Highway 23, west ditch toward outlet of Culvert Site 25-340/C.

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