



January 21, 2013

## FOUNDATION INVESTIGATION REPORT

**ROADWAY PROTECTION  
REHABILITATION OF AIDIE CREEK BRIDGE  
SITE 47-023 ON HIGHWAY 573  
TOWNSHIP OF SAVARD, ONTARIO  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5302-05-00**

**Submitted to:**

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**GEOCRES NO.: 41P-51**

REPORT



**Report Number:** 11-1191-0032-AC

**Distribution:**

- 1 e-copy Ministry of Transportation, Ontario, North Bay, Ontario (Northeastern Region)
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## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the temporary roadway protection associated with the rehabilitation of the Highway 573 bridge crossing Aidie Creek in the Township of Savard, north of Charlton, Ontario.

The Terms of Reference and the Scope of Work for the foundation investigation are outlined in MTO's Request for Proposal (RFP), dated October 2011, and Request for Clarification Letter, dated December 12, 2011. Golder's proposal P1-1191-0032, dated December 2011, for foundation engineering services associated with this project is contained in Section 6.8 of MH's Technical Proposal that forms part of the Consultant's Agreement Number 5011-E-0009 for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Quality Control Plan for foundation engineering services for this project, dated March 22, 2012. The General Arrangement (GA) drawing for the bridge was provided to Golder by MH.

The purpose of this investigation is to establish the subsurface conditions within the vicinity of the proposed roadway protection for the Aidie Creek Bridge by methods of borehole drilling, in situ testing and laboratory testing on selected soil samples. The boreholes were located in the field by Golder relative to stakes installed by MH. The approximate location of the Highway 573 Bridge over Aidie Creek is shown on the Key Plan on Drawing 1.

## **2.0 SITE DESCRIPTION**

The site is situated in the Township of Savard on Highway 573 crossing Aidie Creek, approximately 10 km south of the junction with Highway 11. The bridge was constructed around 1944 and last rehabilitated in 2008. The single-span rigid frame structure is 20 m long and 7 m wide, constructed of reinforced cast-in-place concrete. Based on the GA drawing provided to us by MH, the bridge abutments are supported on footings founded on bedrock on the south abutment and firm clayey silt on the north abutment.

In general, the topography in the vicinity of the bridge is flat with Aidie Creek located about 4 m below the bridge deck. The banks of the river and the approach embankment side slopes are vegetated with grass. The area in the vicinity of the site is landscaped with trees. The surrounding land is mainly used for recreational activities, with grass and tree cover extending beyond the limits of the site. The surface of the roadway at the bridge is at about Elevation 269 m and at the time of the subsurface investigation the creek water level was at about Elevation 264.8 m.

## **3.0 INVESTIGATION PROCEDURES**

The fieldwork for the investigation associated with the proposed temporary roadway protection for the rehabilitation of the Aidie Creek Bridge was carried out between May 29 and 31, 2012. A total of four (4) boreholes were advanced as part of the investigation, one each at the north and south approach embankments (Boreholes AC-2 and AC-4, respectively) and one each at the north and south abutments (Boreholes AC-3 and AC-1, respectively), at approximately the locations shown on Drawing 1.



## FOUNDATION REPORT - AIDIE CREEK BRIDGE HIGHWAY 573, GWP 5302-05-00

The field investigation was carried out using a track-mounted D-50 drilling rig supplied and operated by Walker Drilling of Utopia, Ontario.

The boreholes were advanced through the overburden using 108 mm inside diameter (I.D.) hollow-stem augers. In general, soil samples were obtained at intervals at depths of about 0.75 m and 1.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler operated by automatic hammers on the drill rig, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Field vane shear tests were carried out in cohesive soils for determination of undrained shear strengths (ASTM D2573) using an MTO Standard 'N' size vane.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets in Appendix A. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903-Wells (as amended).

The fieldwork was observed by members of our engineering and technical staff who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO Laboratory Standards and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples.

Survey stakes offset from the Highway 11 centerline were installed by MH prior to the commencement of drilling. The as-drilled borehole locations, in stations and offsets, were measured in reference to the applicable stakes installed by MH and were subsequently converted into MTM NAD 83 coordinates in AutoCAD®. The ground surface elevation at the borehole locations was surveyed by a member of our technical staff in reference to the ground surface elevations at applicable stakes installed by MH. The borehole locations shown on Drawing 1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are as follows:

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
AC-1	5304839.6	378227.0	268.8	4.0
AC-2	5304886.2	378230.4	268.6	14.3
AC-3	5304873.2	378226.4	268.9	12.8
AC-4	5304826.8	378222.9	268.5	3.4



## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

Published literature<sup>1</sup> indicates that the site is located in the transition zone between the Western Abitibi Subprovince of the Superior Province (to the north) and the Huronian Supergroup (to the south). The bedrock geology follows the river valley and consists of mafic metavolcanic rock (Geology of Ontario, OGS Special Volume 4)<sup>1</sup>.

Terrain mapping by the Ontario Geological Survey<sup>2</sup>, describes the soils in the vicinity of the site as silty colluvial slopewash and debris creep sheet with minor talus.

### 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions, as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the Record of Borehole sheets in Appendix A. The results of the laboratory tests are also presented in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and in situ testing. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy, as encountered in the boreholes, is shown in profile on Drawing 1.

In general, the subsurface stratigraphy encountered at the site consists of pavement structure (asphalt underlain by embankment fill comprised of gravelly sand and clayey silt) underlain by alternating layers of clayey silt, sand and silt, and silt. Refusal to further auger and split-spoon sampling was recorded at a depth of 4 m or less in the two boreholes advanced at the south abutment/approach embankment.

#### 4.2.1 Asphalt

Approximately 30 mm of asphalt was encountered at ground surface in all boreholes. In Boreholes AC-2 to AC-4 between approximately 100 mm and 240 mm of gravelly sand fill was encountered underlying the surficial asphalt, in turn underlain by a 100 mm thick layer of asphalt. The ground surface at these boreholes ranges from Elevation 268.9 m to 268.5 m.

#### 4.2.2 Fill

A layer of fill comprised of brown, gravelly sand to sand and gravel containing trace silt, between 0.4 m and 3.0 m thick was encountered underlying the asphalt in all of the boreholes. The top of the fill was encountered between Elevation 268.7 m and 268.2 m. In the approach embankment Boreholes AC-2 and AC-4, between 1.5 m and 1.1 m, respectively, of brown to grey clayey silt fill containing trace sand was encountered underlying the gravelly

<sup>1</sup> Geology of Ontario, 1991. Ontario Geological Society Special Volume 4, Part 1. Ministry of Northern Development and Mines, Ontario.

<sup>2</sup> Northern Ontario Engineering Geology Terrain Study, Ontario Geological Society, Map 5020 and 5021.



sand to sand and gravel fill. The top of the clayey silt fill was encountered at Elevation 267.8 m and 267.6 m at the respective boreholes.

SPT 'N'-values measured within the gravelly sand to sand and gravel fill range from 5 blows to 29 blows per 0.3 m of penetration, indicating a loose to compact relative density. SPT 'N'-values measured within the clayey silt fill range from 4 blows to 9 blows per 0.3 m of penetration, indicating a firm to stiff consistency.

The grain size distribution for one sample of the sand and gravel fill is shown on Figure B-1 in Appendix B.

An Atterberg limits test carried out on a sample of the clayey silt fill yielded a liquid limit of about 34 per cent, a plastic limit of about 18 per cent and a plasticity index of about 16 per cent. The result of the Atterberg limits testing is shown on the plasticity chart on Figure B-2 in Appendix B and indicates that the fill consists of clayey silt of low plasticity.

The natural water content measured on two samples of the gravelly sand to sand and gravel fill is about 2 per cent. The natural water content measured on two samples of the clayey silt fill is about 25 per cent and 28 per cent.

#### **4.2.3 Peat**

A 0.4 m and 0.1 m thick layer of black amorphous peat was encountered underlying the fill in Boreholes AC-1 and AC-4, respectively. The top of the peat was encountered at Elevation 266.0 m and 266.5 m at the respective boreholes.

The natural water content measured on a sample of the peat is about 40 per cent.

#### **4.2.4 Clayey Silt**

A deposit comprised of individual or alternating layers of clayey silt and sand and silt were encountered below the fill in Boreholes AC-2 and AC-3 and underlying the peat in Boreholes AC-1 and AC-4. The clayey silt layers are brown to grey and contain trace sand. The layers are between 0.2 m and 4.0 m thick and the uppermost layer was encountered between Elevation 265.6 m and 266.4 m. In Borehole AC-2 the top layer of clayey silt contained trace organics.

SPT 'N'-values measured within the clayey silt portion of the deposit ranges from 0 blows (weight of hammer) to 11 blows per 0.3 m of penetration. In situ field vane testing carried out within this stratum measured undrained shear strengths ranging from about 22 kPa to 47 kPa. The SPT 'N'-values together with the field vane test results suggest that the deposit has a soft to firm consistency.

Atterberg limits testing carried out on four (4) samples of the clayey silt deposit yielded liquid limits ranging from about 23 per cent to 32 per cent, plastic limits ranging from about 15 per cent to 19 per cent and plasticity indices ranging from about 8 per cent to 14 per cent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B-3 in Appendix B and indicate that the deposit consists of clayey silt of low plasticity.

The grain size distributions for two (2) samples of the clayey silt are shown on Figure B-4 in Appendix B.



The natural water content measured on five (5) samples of the clayey silt ranges between about 23 per cent and 34 per cent.

#### **4.2.5 Sand and Silt**

Sand and silt layers were encountered interlayered below the uppermost clayey silt layer in Boreholes AC-2 to AC-4. The sand and silt layers are brown to grey and contain trace to some clay. The layers are between 0.2 m and 2.5 m thick and the uppermost layer was encountered at Elevation 264.0 m in Boreholes AC-2 and AC-3 and at Elevation 266.1 m in Borehole AC-4. In Borehole AC-4, the bottom of this deposit was defined by refusal to split-spoon and auger penetration.

SPT 'N'-values measured within the sand and silt deposit range from 0 blows (weight of hammer) to 12 blows per 0.3 m of penetration and a SPT 'N'-value of 14 blows per 0.15 m of penetration, indicating a very loose to compact relative density.

The grain size distributions of two (2) samples of the sand to silt layers are shown on Figure B-5 in Appendix B.

The natural water content measured on samples of the sand to silt ranges between about 13 per cent and 24 per cent.

#### **4.2.6 Silt**

A deposit of grey silt containing some clay and trace to some sand was encountered underlying the clayey silt deposit in Boreholes AC-2 and AC-3. The top of the silt deposit was encountered at Elevation 257.2 m and Elevation 255.5 m and the thickness of the deposit is 1.1 m and 1.2 m thick at the respective boreholes. This silt deposit was not fully penetrated in either of these boreholes.

SPT 'N'-values measured within the silt deposit range from 4 blows to 8 blows per 0.3 m of penetration, indicating a loose relative density.

The grain size distribution of a sample of the silt is shown on Figure B-6 in Appendix B.

The natural water content measured on a sample of the silt is about 26 per cent.

#### **4.2.7 Gravel**

A 0.2 m thick layer of pink gravel was encountered underlying the clayey silt deposit in Borehole AC-1. The top of the gravel deposit was encountered at Elevation 265.0 m and the thickness of the deposit is 0.2 m. Refusal to split-spoon and auger advancement was encountered within this layer at a depth of 4.0 m below ground surface.

An SPT 'N'-value of 22 blows per 0.15 m of penetration was measured in this layer although some of the blows did not achieve any penetration, in this case suggesting a compact relative density.



#### **4.2.8 Refusal**

In Boreholes AC-1 and AC-4, refusal to further auger advancement and split-spoon penetration was encountered at depths of 4.0 m and 3.4 m, respectively, below ground surface, corresponding to Elevation 264.8 m and 265.1 m. A DCPT was advanced 1.0 m north of Borehole AC-1. Refusal was encountered at a 4.1 m depth below ground surface, corresponding to Elevation 264.7 m.

#### **4.2.9 Groundwater Conditions**

In general, the soil samples obtained were moist to wet. Groundwater levels were measured in the open boreholes upon completion of drilling and are summarized below.

<b>Borehole</b>	<b>Depth to Groundwater Level Below Ground Surface (m)</b>	<b>Groundwater Elevation (m)</b>
AC-1	3.8	265.0
AC-2	3.7	264.9
AC-3	3.4	265.5
AC-4	3.1	265.4

The water level of the river at the location of the bridge was measured at Elevation 264.8 m in May 2012, and the high water level is Elevation 267.2 m, as provided by MH.

Groundwater levels encountered in the boreholes during and shortly after drilling may not be representative of static levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. Groundwater and river water levels in the area are subject to seasonal fluctuations and to fluctuations after precipitation events and snowmelt.

### **5.0 CLOSURE**

The field personnel supervising the drilling program was Mr. Ed Savard. This report was prepared by Mr. Evan Childerhose, P.Eng. The technical aspects were reviewed by Mr. Jorge M. A. Costa, P.Eng., Principal and Golder's Designated MTO Contact for this project, who also carried out a quality control review of the report.

## Report Signature Page

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EC/JMAC/cl/kp

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[http://capws.golder.com/sites/p111910032mtoblanche3bridges/reports/47-023 ac/final/11-1191-0032-ac fml rpt 13jan21 fidr site 47-023.docx](http://capws.golder.com/sites/p111910032mtoblanche3bridges/reports/47-023%20ac/final/11-1191-0032-ac%20fml%20rpt%2013jan21%20fidr%20site%2047-023.docx)



# APPENDIX A

## Record of Boreholes



SHEET



	Borehole – Current Investigation
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
R	Refusal
	WL upon completion of drilling
	Temporary Protection System

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
AC-1	268.8	5304839.6	378227.0
AC-2	268.6	5304886.2	378230.4
AC-3	268.9	5304873.2	378226.4
AC-4	268.5	5304826.8	378222.9

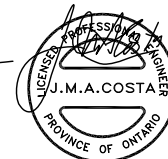
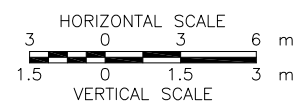
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

Base plans provided in digital format by Morrison Hershfield, drawing file nos. 47023-01.dwg, received July 23, 2012.

NO.	DATE	BY	REVISION
Geocres No. 41P-51			
HWY. 573		PROJECT NO. 11-1191-0032	DIST.
SUBM'D. EC	CHKD.	DATE: DEC 2012	SITE: 47-023
DRAWN: TB	CHKD.	APPD.	DWG. 1





## 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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
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.).

<b>PH:</b>	Sampler advanced by hydraulic pressure
<b>PM:</b>	Sampler advanced by manual pressure
<b>WH:</b>	Sampler advanced by static weight of hammer
<b>WR:</b>	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 cm<sup>2</sup> 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) 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

	kPa	$C_u, S_u$	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 <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	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 <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

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

### V. MINOR SOIL CONSTITUENTS

Percent 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 (cohesionless) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



## LIST OF SYMBOLS

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

### I. GENERAL

$\pi$	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

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	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
$\gamma'$	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
$C_\alpha$	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
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	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  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1  
2

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

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



## LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

### WEATHERINGS STATE

**Fresh:** no visible sign of weathering

**Faintly weathered:** weathering limited to the surface of major discontinuities.

**Slightly weathered:** penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

**Moderately weathered:** weathering extends throughout the rock mass but the rock material is not friable.

**Highly weathered:** weathering extends throughout rock mass and the rock material is partly friable.

**Completely weathered:** rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

### BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

### JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

### GRAIN SIZE

<u>Term</u>	<u>Size*</u>
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: \* Grains greater than 60 microns diameter are visible to the naked eye.

### CORE CONDITION

#### Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

#### Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

#### Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

### DISCONTINUITY DATA

#### Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

#### Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

#### Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

#### Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

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

SUD-MTO 001 11-1191-0032+BH09.GPJ GAL-MISS.GDT 26/09/12 DATA INPUT:

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

PROJECT <u>11-1191-0032</u>		<b>RECORD OF BOREHOLE No AC-2</b>				2 OF 2 <b>METRIC</b>	
W.P. <u>5302-05-00</u>		LOCATION <u>N 5304886.2; E 378230.4</u>				ORIGINATED BY <u>EHS</u>	
DIST <u>          </u> HWY <u>573</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring</u>				COMPILED BY <u>AC</u>	
DATUM <u>GEODETIC</u>		DATE <u>May 30, 2012</u>				CHECKED BY <u>EC</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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 <sub>p</sub>	W			W <sub>L</sub>						
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED</span> <span>+ FIELD VANE</span> </div> <div style="display: flex; justify-content: space-between;"> <span>● QUICK TRIAXIAL</span> <span>× REMOULDED</span> </div>																
	END OF BOREHOLE  Note:  1. Water level at a depth of 3.7 m below ground surface (Elev. 264.9 m) upon completion of drilling.																						

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PROJECT 11-1191-0032				RECORD OF BOREHOLE No AC-3				1 OF 1 METRIC						
W.P. 5302-05-00				LOCATION N 5304873.2; E 378226.4				ORIGINATED BY EHS						
DIST _____ HWY 573				BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY AC						
DATUM GEODETIC				DATE May 31, 2012				CHECKED BY EC						
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						
268.9	GROUND SURFACE													
0.0	ASPHALT (30 mm)		1	SS	29									
0.2	Gravelly sand, trace silt (FILL) Compact Brown Moist		2	SS	22									
	ASPHALT (100 mm)		3	SS	14									
	Gravelly sand to sand and gravel, trace silt (FILL) Compact Brown Moist		4	SS	10									
265.7	CLAYEY SILT, trace sand Firm to stiff Brown to grey Moist to wet		5	SS	9									
3.2			6	SS	5									
264.0	SAND and SILT Brown to grey Wet		7	TO	PH									
263.6			8 a	SS	8									
5.5	CLAYEY SILT, trace sand Brown to grey Wet		8 b											
262.8	SAND and SILT Loose Brown to grey Wet		9	SS	3									
6.1														
261.6	CLAYEY SILT, trace sand Firm Brown to grey Wet													
7.3	SAND and SILT Very loose Brown to grey Wet		10	SS	WH									
259.6	CLAYEY SILT, trace sand Very soft to soft Brown to grey Wet		11	SS	2									
9.3	1.2 m of heave encountered at 9.7 m depth.		12	SS	WH									
257.2	SILT, some clay, trace sand Loose Grey Wet		13	SS	6									
11.7														
256.1	END OF BOREHOLE													
12.8	Note:  1. Water level at a depth of 3.4 m below ground surface (Elev. 265.5 m) upon completion of drilling.													

SUD-MTO 001 11-1191-0032-BH09.GPJ GAL-MISS.GDT 26/09/12 DATA INPUT:

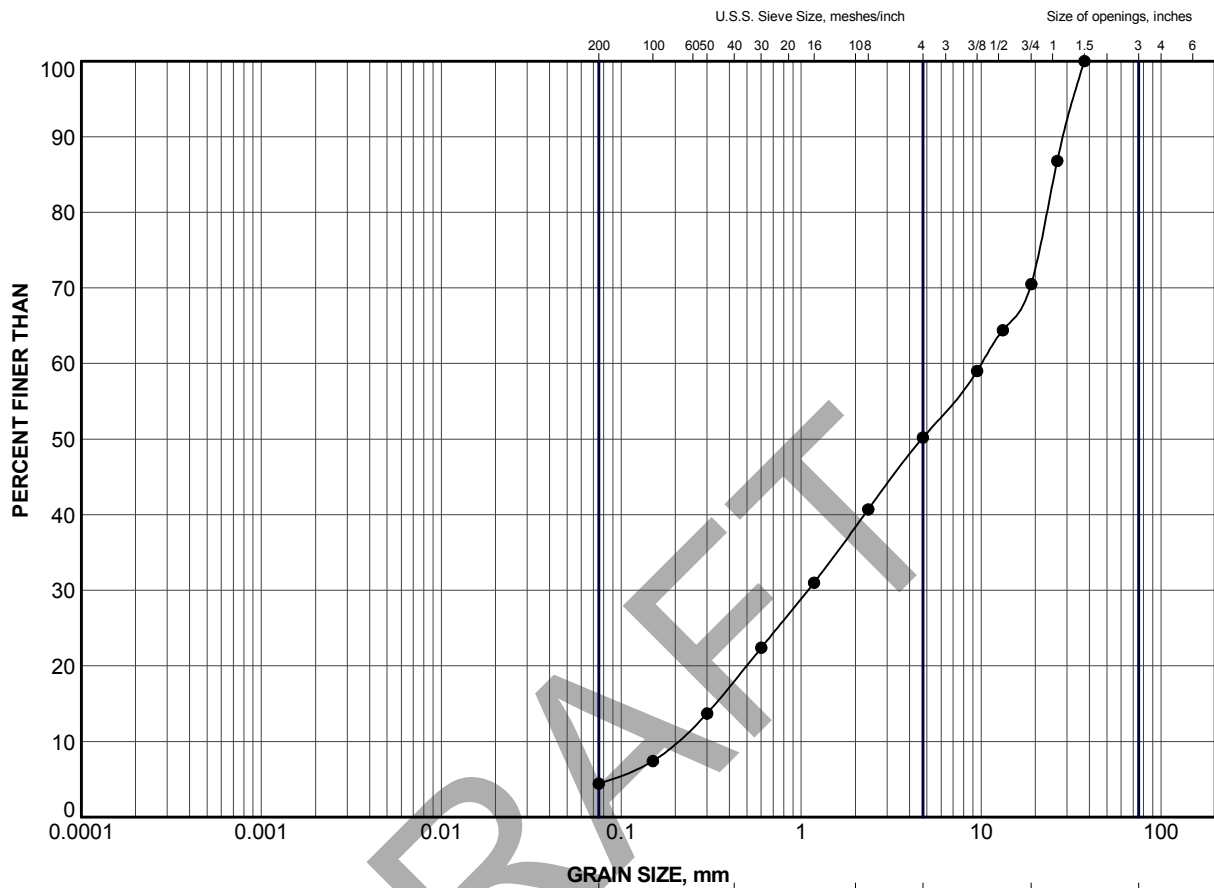
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

PROJECT 11-1191-0032		<b>RECORD OF BOREHOLE No AC-4</b>				1 OF 1 <b>METRIC</b>								
W.P. 5302-05-00		LOCATION N 5304826.8; E 378222.9				ORIGINATED BY EHS								
DIST _____ HWY 573		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY AC								
DATUM GEODETIC		DATE May 31, 2012				CHECKED BY EC								
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						
268.5	GROUND SURFACE													
0.0	ASPHALT (30 mm)		1	SS	19									
0.2	Gravelly sand, trace silt (FILL) Brown Moist													
267.6	ASPHALT (100 mm)		2	SS	4									
0.9	Gravelly sand, trace silt (FILL) Compact Brown Moist to wet													
266.5	Clayey silt, some sand, trace gravel (FILL) Soft to firm Brown to grey Wet		3 a 3 b	SS	7									
266.1	PEAT (Amorphous)		4	SS	12									
2.4	CLAYEY SILT, trace sand Brown Wet													
265.1	SAND and SILT, some gravel Compact Brown Wet		5	SS	14/0.15									12 49 (39)
3.4	END OF BOREHOLE SPLIT SPOON REFUSAL (HAMMER BOUNCING) AND AUGER REFUSAL													
<p>Note:</p> <p>1. Water level at a depth of 3.1 m below ground surface (Elev. 265.4 m) upon completion of drilling.</p>														



# APPENDIX B


## Laboratory Test Results

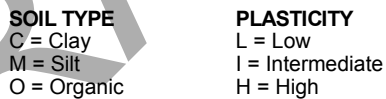


CLAY AND SILT	SAND SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

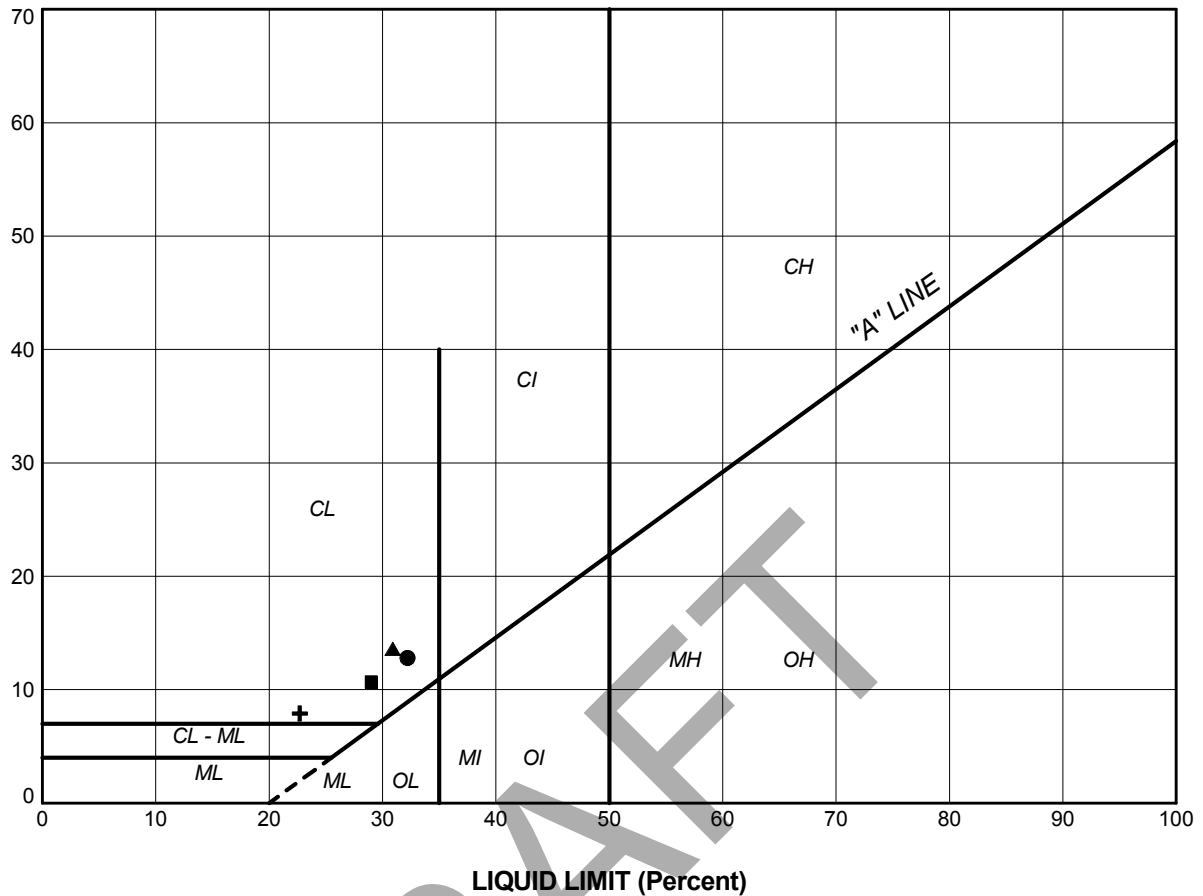
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	AC-1	2	267.7

PROJECT					
HIGHWAY 573 AIDIE CREEK BRIDGE 47-023					
TITLE					
GRAIN SIZE DISTRIBUTION Sand and Gravel (FILL)					
PROJECT No.		11-1191-0032		FILE N41-1191-0032+BH09.GPJ	
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B-1</b>		



SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	AC-4	2	34	18	16

PLASTICITY INDEX (Percent)



LIQUID LIMIT (Percent)

**SOIL TYPE**  
C = Clay  
M = Silt  
O = Organic

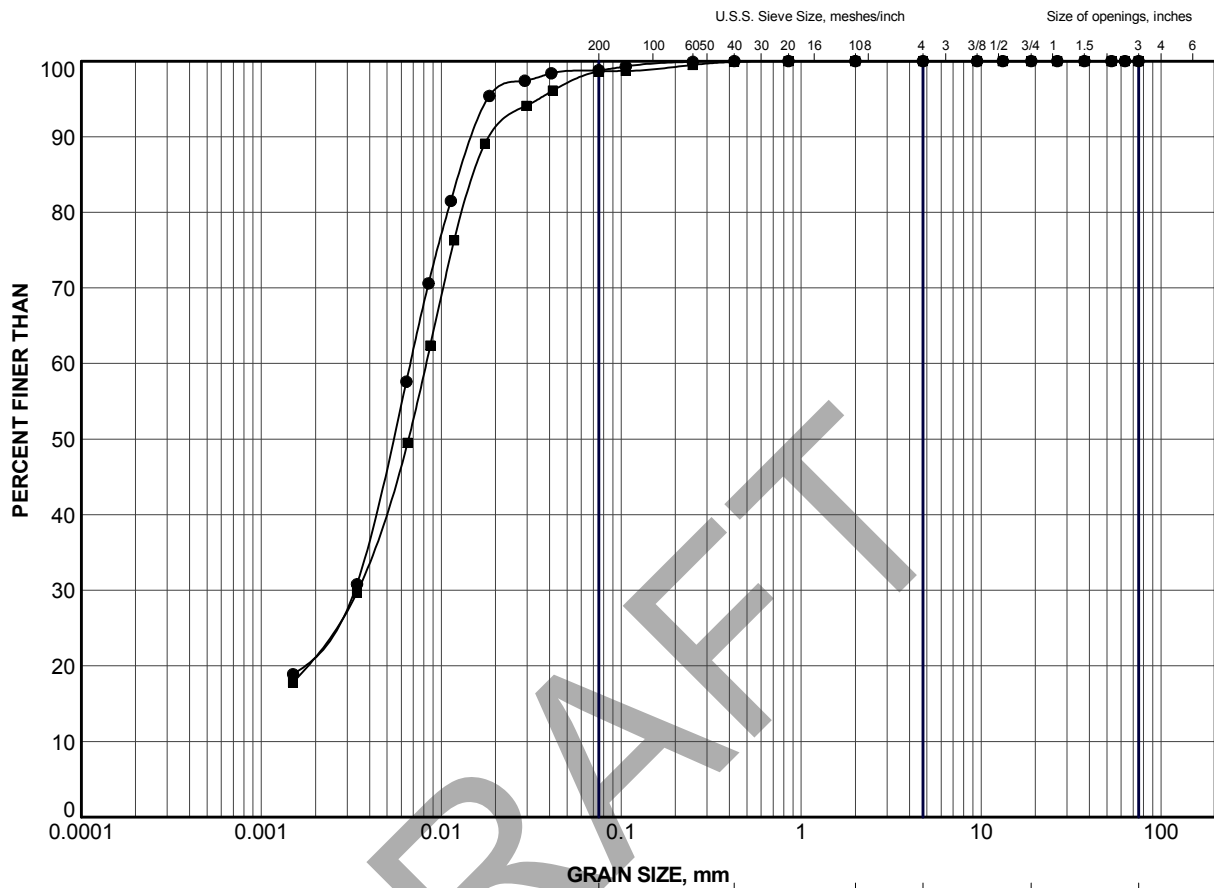
**PLASTICITY**  
L = Low  
I = Intermediate  
H = High

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	AC-2	8 b	32	19	13
■	AC-2	10	29	18	11
▲	AC-3	6	31	17	14
+	AC-3	9	23	15	8

PROJECT					
HIGHWAY 573 AIDIE CREEK BRIDGE 47-023					
TITLE					
PLASTICITY CHART Clayey Silt					
PROJECT No.		11-1191-0032		FILE No. 11-1191-0032+BH09.GPJ	
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
			FIGURE B-3		





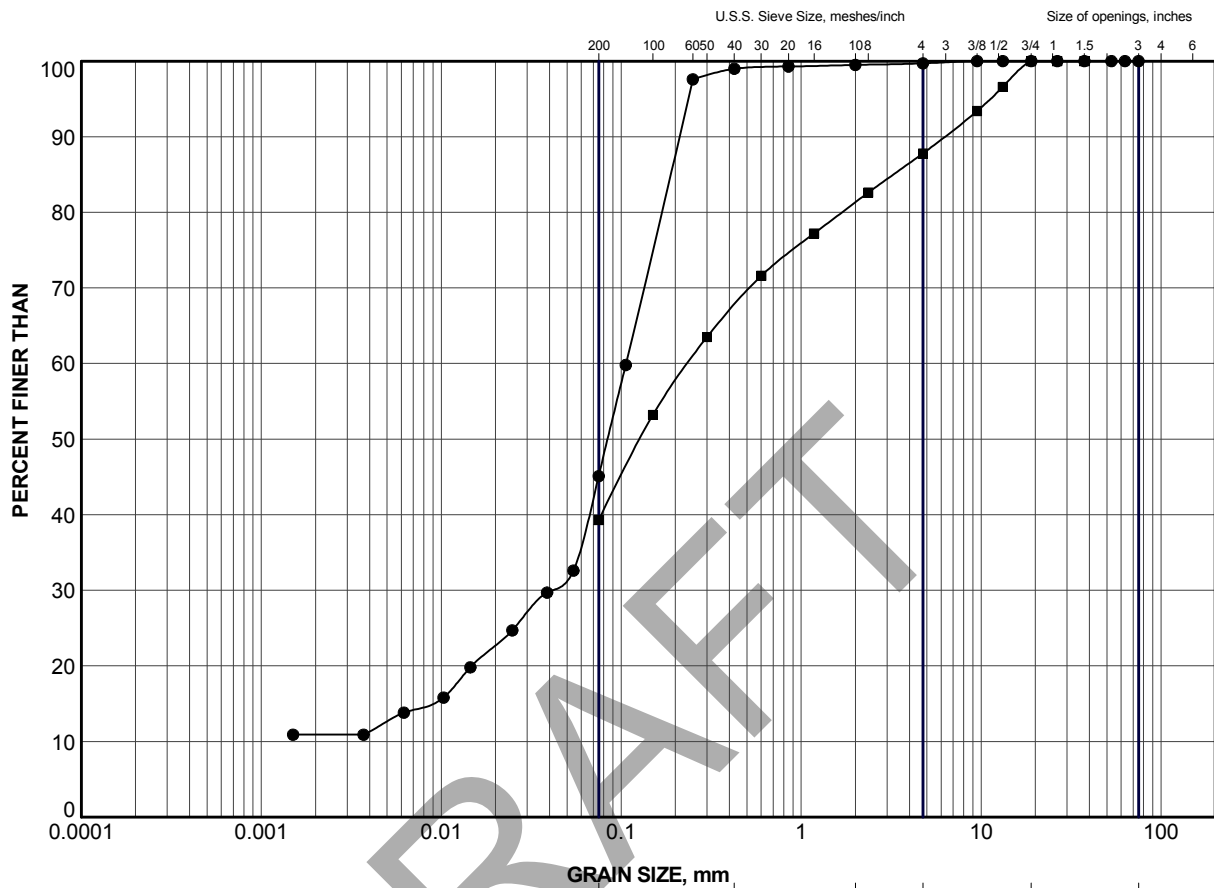
CLAY AND SILT	GRAVEL SIZE, mm						Cobble Size
	fine	medium	coarse	fine	coarse		
	SAND SIZE			GRAVEL SIZE			

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	AC-2	8 b	262.1
■	AC-3	12	257.9

PROJECT					
HIGHWAY 573 AIDIE CREEK BRIDGE 47-023					
TITLE					
GRAIN SIZE DISTRIBUTION Clayey Silt					
PROJECT No.		11-1191-0032		FILE N41-1191-0032+BH09.GPJ	
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
			FIGURE B-4		





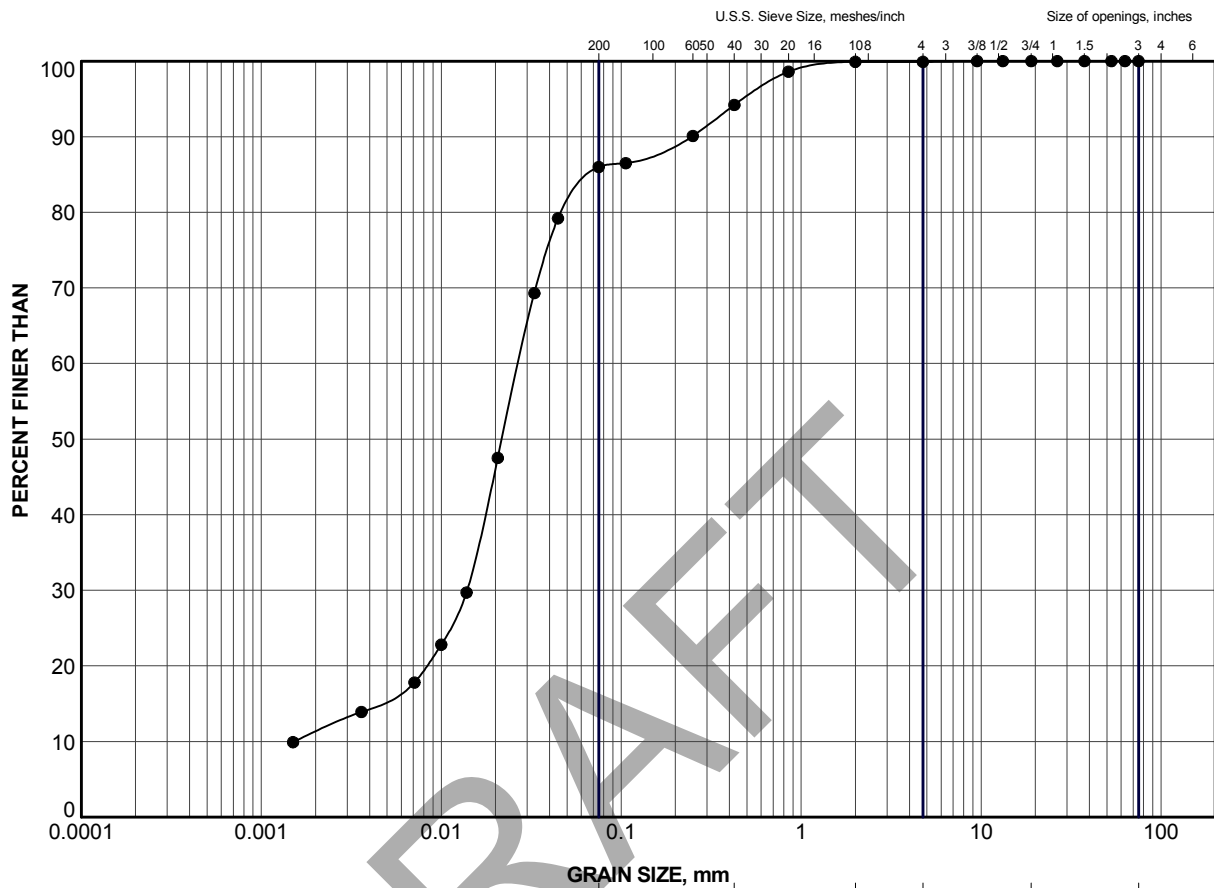
CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	AC-2	8 a	262.3
■	AC-4	5	265.5

PROJECT					
HIGHWAY 573 AIDIE CREEK BRIDGE 47-023					
TITLE					
GRAIN SIZE DISTRIBUTION Sand and Silt					
PROJECT No.		11-1191-0032		FILE N41-1191-0032+BH09.GPJ	
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
			FIGURE B-5		





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

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	AC-2	13	254.6

PROJECT					
HIGHWAY 573 AIDIE CREEK BRIDGE 47-023					
TITLE					
GRAIN SIZE DISTRIBUTION					
Silt					
PROJECT No.		11-1191-0032		FILE N41-1191-0032+BH09.GPJ	
DRAWN	TB	Sep 2012	SCALE	N/A	REV.
CHECK	EC	Sep 2012			
APPR	JMAC	Sep 2012			
			FIGURE B-6		



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