



November 30, 2009

REPORT



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**Foundation Investigation Report
Oxtongue River Bridge Replacement and Detour
Highway 60, Site No. 40-002
Township of Algonquin Highlands, Ontario
Ministry of Transportation, Ontario
GWP 5550-04-00**

Submitted to:

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the detail design of the Oxtongue River Bridge and Detour on Highway 60 in the Township of Algonquin Highlands, east of Dwight, Ontario.

The purpose of this investigation is to establish the subsurface conditions at the proposed replacement and detour structure locations by borehole drilling, rock coring, in situ testing and laboratory testing on selected samples. The boreholes for the current investigation were located in the field by Golder relative to the centerline stakes laid out at the site by URS, based on the September 2008 GA's. The location of the investigated area is shown in plan on the Contract Drawings.

2.0 SITE DESCRIPTION

The site is situated in the Township of Algonquin Highlands on Highway 60 crossing Oxtongue River, approximately 12 km east of the village of Dwight, Ontario. The surrounding land is mainly comprised of scattered residences. Grass cover and tree cover extend beyond the limits of the site. An MTO "picnic rest area" is located on the southwest side of the bridge. The river is on a skew from northwest to southeast and is less than 30 m wide at the existing bridge location, increasing in width in the northwest and southeast quadrants.

We understand that the existing Oxtongue River bridge was constructed in 1947 and founded on timber piles. The existing seven span bridge has an overall deck length of about 42.6 m and an overall width of 11.0 m. We understand from URS that the embankments were rehabilitated in 1969 with the installation of gabion walls placed in front of the abutments. In 2003, emergency repairs were made to correct the failure of several timber piles.

The existing highway grade is about 4 m and 5 m above the measured water level (Nov. 2008) at the existing west and east abutments, respectively. The water level in the river was measured at Elevation 364.1 m in November 2008. The highwater level is at Elevation 364.8 m, as shown on the GAs.

3.0 INVESTIGATION PROCEDURES

A total of nine (9) boreholes advanced at the site between November 3, 2008 and January 12, 2009. Four boreholes (OX-1 to OX-4) were advanced for the proposed main bridge abutments and approaches and five boreholes (OX-6 to OX-9) were advanced for the detour bridge abutments, centre pier and approaches. The locations and elevations of the boreholes are shown on the Contract Drawings.

Boreholes OX-1 to OX-6, OX-8 and OX-9 were drilled using a track mounted D50 drill rig that was supplied and operated by Walker Drilling Ltd. (Walker) of Barrie, Ontario. Borehole OX-7 was advanced using a D-25 barge mounted drill rig in Oxtongue River supplied and operated by Walker.

The boreholes were advanced using either 108 mm inside diameter (I.D.) continuous flight hollow stem augers and/or NW casing with wash boring. Soil samples were obtained at intervals of depth of about 0.75 m to 2.5 m, using a 50 mm outer diameter (O.D.) split spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-99). Rock core samples were obtained using an 'NQ' size core barrel at OX-2, OX-3, and OX-6 to OX-8.



The boreholes were advanced to depths ranging from 9.8 m to 36.3 m below the existing ground, bridge deck or water surface. Boreholes OX-1, OX-4, OX-5 and OX-9, advanced for the approaches, were terminated prior to reaching refusal. A minimum of 3 m of rock core was obtained from the boreholes drilled at the foundation elements.

The groundwater conditions in the open boreholes were observed during the drilling operations and piezometers were installed in two boreholes, OX-5 and OX-9, at the west and east detour approaches, respectively, to allow monitoring of the groundwater level at these locations. The piezometers consisted of a 50 mm outside diameter rigid PVC tubing with a 1.5 m long slotted screen, sealed within the silt and sand to sandy silt stratum. The remaining boreholes were backfilled with bentonite as per Ontario Regulation 903 (as amended by O. Reg. 372) upon completion of drilling. The piezometers were backfilled in a similar manner after a final water level reading was obtained on November 25, 2008. The installation details and water level readings are presented on the Record of Borehole sheets in Appendix A.

The fieldwork was supervised throughout by members of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground service locations, supervised the drilling and sampling operations, logged the boreholes, and examined and cared for the soil and rock core 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 and/or ASTM Standards, as appropriate. Classification testing (water content and grain size distribution) was carried out on selected samples. In addition, uniaxial compressive strength (UCS) testing was carried out on selected specimens of the bedrock core recovered from the boreholes.

The proposed boreholes were laid out in the field by Golder relative to the proposed centreline alignment and offset stakes in the field surveyed by URS and based on the dimensions shown on the GAs supplied by URS in September 2008. The northings and eastings in MTM NAD 83 were determined by plotting the station and offset of the boreholes (relative to the stakes) on the September 2008 GAs and converting to the coordinate system. The ground surface and water surface elevations at the borehole locations were surveyed by Golder relative to the centerline stakes and are referenced to geodetic datum.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Published literature indicates that the site is located in the McClintock Domain of the Algonquin Terrane, which is located in the Grenville Province (Geology of Ontario; OGS Special Volume 4)¹. The bedrock of this domain generally consists of metasedimentary gneiss in granulite facies.

Based on terrain mapping (Ontario Geological Survey², the subsurface soils in the vicinity of the site consist of glaciofluvial plains comprising sandy deposits.

¹ Geology of Ontario, 1991. Ontario Geological Survey, special Volume 4, Part 1. Eds. P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott. Ministry of Northern Development and Mines, Ontario.

² Southern Ontario Engineering Geology Terrain Study



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 and rock samples, are given on the attached Record of Borehole and Drillhole sheets in Appendix A. The results of the laboratory tests carried out on selected soil and rock samples are presented in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and observations of drilling progress and cuttings. 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 based on the results of the borehole investigation at the bridge locations are shown on the Contract Drawings.

In general, the subsoils at the structure site consist of sand to sand and gravel fill underlain by strata consisting of sand, silty sand, silt and sand, sandy silt and/or silt. These deposits are underlain at depth by a sand to sand and gravel deposit, containing cobbles and boulders within a few meters of the bedrock surface. The thickness of overburden was between 21.4 m and 32.9 m, being thicker on the east side of the river.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Fill

In boreholes OX-1 to OX-4 (drilled through the existing roadway surface or the existing bridge deck), approximately 90 mm to 150 mm of asphalt was encountered. In boreholes OX-2 and OX-3, approximately 200 mm of concrete was encountered below the asphalt on the bridge deck. The road surface at these boreholes ranges from Elevation 367.8 m to 369.6 m.

All the boreholes at the site were advanced through the existing embankment fill. Boreholes OX-2 and OX-3 were advanced through the bridge deck, having an approximate 2.3 m air void between the deck and the fill. The upper 0.2 m of fill in Borehole OX-4 consisted of Granular A, B and chip and tar materials. Elsewhere the fill generally consisted of moist to wet, brown sand to gravely sand containing trace to some silt and trace clay. A small layer of grey, moist silt fill containing some clay and sand was noted within the fill in Borehole OX-6. Organics were noted in the upper 0.6 m of fill in Boreholes OX-5 and OX-6. Cobbles were noted within the fill in Boreholes OX-3, OX-4 and OX-7, on the east side of the river. The fill was noted to be layered and oxidized in Boreholes OX-5 and OX-6 on the west side of the river. The top of the fill stratum was encountered from Elevation 362.0 m to 370.4 m and the thickness ranged from 1.4 m to 5.0 m.

SPT 'N' values measured within the fill stratum typically ranged from 2 to 21 blows per 0.3 m of penetration indicating a very loose to compact relative density. In Borehole OX-5, 'N' values of 47 and 63 were encountered near the base of the fill, indicating the fill becomes very dense in this borehole.

Grain size distribution tests were carried out on several samples of the fill stratum and the results are shown on Figure B-1.

The natural water content measured on samples of the fill stratum range from about 4 percent to 25 percent.



4.2.2 Upper Sand to Silty Sand

Below the embankment fill in Boreholes OX-1, OX-2, OX-4 and OX-9, a deposit of moist, brown sand to silty sand containing trace silt and trace gravel was encountered. The top of this deposit ranged from Elevation 368.3 m to 361.5 m and the thickness ranged from 1.2 m to 5.1 m.

SPT 'N' values measured within the upper sand to silty sand deposit ranged from 4 to 28 blows per 0.3 m of penetration indicating a very loose to compact relative density.

Grain size distribution tests were carried out on several samples of this deposit and the results are shown on Figure B-2.

The natural water content measured on samples of the upper silt sand to silty sand deposit range from about 4 percent to 24 percent.

4.2.3 Silt and Sand to Sandy Silt

A deposit of moist to wet, light brown to grey, silt and sand to sandy silt containing trace clay and trace gravel was encountered below the upper sand to silty sand in boreholes OX-1, OX-2 and OX-4 and below the fill in Boreholes OX-3 and OX-5 to OX-8. The top of the deposit ranged from Elevation 360.3 m to 368.4 m and the thickness of the deposit ranged from 6.1 m to 18.9 m where it was fully penetrated. Boreholes OX-1, OX-4 and OX-5 were terminated within this stratum.

SPT 'N' values measured within the silt and sand to sandy silt deposit ranged from 2 to 35 blows per 0.3 m of penetration indicating a very loose to dense relative density.

Grain size distributions were carried out on several samples of the silt and sand to sandy silt deposit and the results are shown on three B-3 Figures.

The natural water content measured on samples of the silt and sand to sandy silt deposit range from about 10 percent to 30 percent.

A 1.5 m thick layer of sand containing trace silt was encountered within the silt and sand to sandy silt deposit in Borehole OX-6. The grain size distribution for this sample is shown on Figure B-5.

4.2.4 Silt to Sandy Silt

A 3.0 m thick deposit of wet, brown, silt containing some sand, trace clay and sand layers was encountered below the silt and sand to sandy silt deposit at Elevation 361.0 m in Borehole OX-8. In Borehole OX-9, this deposit was classified as a sandy silt and was encountered at Elevation 363.2 m; Borehole OX-9 terminated within this deposit after 2.6 m. In Boreholes OX-2 and OX-4, a 1.5 m to 2.2 m thick seam of wet, brown silt containing trace sand was encountered within the silt and sand to sandy silt deposit at Elevation 354.4 m and 362.4 m, respectively.

SPT 'N' values measured within the silt ranged from 4 to 17 blows per 0.3 m of penetration indicating a loose to compact relative density.

Grain size distribution tests were carried out on samples of the silt and the results are shown on Figure B-4.

The natural water content measured on samples of the sand and silt seam range from about 24 percent to 27 percent.



4.2.5 Sand to Sand and Gravel

Beneath the silt and sand to sandy silt stratum in Boreholes OX-2, OX-3, OX-6 and OX-7, and beneath the silt in Borehole OX-8, a deposit of wet, brown, sand to sand and gravel containing trace silt was encountered. The top of this deposit was encountered from Elevation 345.5 m to 358.0 m and the thickness of the deposit was between 8.1 m and 13.9 m. Cobbles and boulders were typically encountered throughout the deposit and with more frequency within about 3 m of the bedrock surface. Boulders were cored in Boreholes OX-3, OX-6 and OX-7 for 0.3 m to 1.1 m thickness and were encountered between Elevation 336.1 m and 342.8 m.

SPT 'N' values measured within the sand to sand and gravel deposit ranged from 7 to 69 blows per 0.3 m of penetration indicating a loose to very dense relative density. The higher 'N' values were typically measured near the base of the deposit.

Grain size distribution tests were carried out on several samples, retrieved within the 36.5 mm I.D. sampler, of the sand to sand and gravel deposit and the results are shown on Figure B-5. These tests do not reflect the full range of particle sizes, particularly the coarser gravel, cobbles and boulders.

The natural water content measured on samples of the sand to sand and gravel deposit range from about 8 percent to 27 percent.

4.2.6 Bedrock

Bedrock was encountered in Boreholes OX-2, OX-3 and OX-6 to OX-8. The depth to and elevation of the bedrock surface in these holes is summarized below.

Location	Borehole	Depth to Bedrock Surface* (m)	Bedrock Surface Elevation (m)
Main Bridge WA	OX-2	32.6	335.5
Main Bridge EA	OX-3	27.6	341.5
Detour Bridge WA	OX-6	32.9	333.3
Detour Bridge Pier	OX-7	23.6	340.7
Detour Bridge EA	OX-8	29.7	340.0

* Depth below ground surface, bridge deck or water surface

Based on a review of the bedrock core samples, the bedrock at the site generally consisted of pink/grey fine to medium grained, fresh to slightly weathered, gneiss. Healed, partially healed and open joints were noted as well as layers, banding and foliation. In Boreholes OX-6 and OX-7 the gneiss comprised feldspar, quartz, amphibole and biotite with granitic alterations.

The Rock Quality Designation (RQD) measured on the core samples typically ranged from about 80 percent to 100 percent, indicating rock mass of excellent quality. In Boreholes OX-3 and OX-8, RQD was measured between 23 and 65 percent in the upper portion of the rock core, increasing with depth. The Total Core Recovery (TCR) during bedrock coring was generally 100 percent.

Laboratory UCS testing was carried out on four samples of the gneiss bedrock from Boreholes OX-3 and OX-6 to OX-8. The UCS results range between about 57 MPa and 136 MPa, indicating strong to very strong rock, using the "Intact Rock Strength Classification" table. The depths and corresponding elevations of the tested samples and results of the UCS testing are presented in Table B-1, in Appendix B.



4.2.7 Groundwater Conditions

The water levels were noted during and after the drilling and coring operations in the boreholes. Piezometers were installed with screened sections sealed within the silt and sand to sandy silt deposit in Boreholes OX-5 and OX-9. Details of the piezometer installations are shown on the Record of Borehole Sheets reported in Appendix A. In general, the soil samples taken in the boreholes were noted to be moist to wet.

The water level of Oxtongue River was measured at Elevation 364.3 m in November 2008 during the field investigation by Golder. The water level was measured by others in April 2008 at Elevation 364.1 m. The water levels in the piezometers and open holes during drilling and upon completion of drilling are summarized below and they are between 1.2 m higher and 0.9 m lower than the November 2008 river level.

Borehole	Installation	Groundwater Level Depth (m)	Groundwater Level Elevation (m)	Date
OX-1	Open Borehole	4.4	363.4	January 12, 2009
OX-2	Open Borehole	3.8	364.3	November 21, 2008
OX-3	Open Borehole	3.6	365.5	November 18, 2008
OX-4	Open Borehole	5.6	364.0	November 17, 2008
OX-5	Piezometer	3.2	363.9	November 25, 2008
OX-6	Open Borehole	1.6	364.9	November 11, 2008
OX-7	Open Borehole	0.0	364.3	November 3, 2008
OX-8	Open Borehole	5.0	364.7	November 13, 2008
OX-9	Piezometer	5.6	364.8	November 25, 2008

It should be noted that the groundwater levels in the area are subject to seasonal fluctuations and after precipitation events. The high water level for the Oxtongue River is Elevation 364.8 m.

5.0 CLOSURE

The field personnel supervising the drilling program was Mr. Ed Savard and Mr. Trevor Moxam. This report was prepared by Mr. Tim Rancourt, EIT, and Mr. André Bom, P.Eng., and the technical aspects were reviewed by Mrs. Sarah Coyne, P.Eng., an Associate with Golder. A quality control review of the report was provided by Mr. Fintan J. Heffernan, P.Eng., Golder's Designated MTO Contact for this project.



Report Signature Page

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APPENDIX A

RECORD OF BOREHOLES AND DRILLHOLES

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
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. 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

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

(a) Index Properties (continued)

w	water content
w_L	liquid limit
w_p	plastic limit
I_p	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_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(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

Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 Shear strength = (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
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.).

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

Piezcone Penetration Test (CPT)

An 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) Cohesionless Soils

Density Index (Relative Density)	N 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.

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING 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 texture and structure are preserved.

BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very thickly bedded	> 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	< 6 mm

JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very wide	> 3 m
Wide	1 – 3 m
Moderately close	0.3 – 1 m
Close	50 – 300 mm
Very close	< 50 mm

GRAIN SIZE

<u>Terms</u>	<u>Size*</u>
Very Coarse Grained	> 60 mm
Coarse Grained	2 – 60 mm
Medium Grained	60 microns – 2 mm
Fine Grained	2 – 60 microns
Very Fine Grained	< 2 microns

* Note: Grains > 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 varies 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 separation) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) 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 abbreviated description of the discontinuities, whether naturally occurring separation such as fractures, bedding planes and foliation planes or mechanically induced fractures 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

B - Bedding	P - Polished
FO - Foliation / Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane / Zone	R - Ridged / Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
MF - Mechanical Fracture	C - Curved
- Parallel To	⊥ - Perpendicular To

PROJECT <u>07-1191-0001-OX</u>			RECORD OF BOREHOLE No OX-1			1 OF 1 METRIC											
W.P. <u>5550-04-00</u>			LOCATION <u>N 5027330.2 ; E 351126.5</u>			ORIGINATED BY <u>TDM</u>											
DIST <u> </u> HWY <u>60</u>			BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers</u>			COMPILED BY <u>MM</u>											
DATUM <u>Geodetic</u>			DATE <u>January 12, 2009</u>			CHECKED BY <u>SEMC</u>											
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 × REMOULDED									
367.8	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT (150 mm)		1	AS	-		367							○			23 62 (15)
0.2	Gravelly sand, some silt (FILL) Loose Brown Moist		2	AS	-												
			3	SS	9		366										
365.5																	
2.3	Silty SAND, some silt, trace gravel Compact Light brown Moist		4	SS	23		365							○			1 76 (23)
			5	SS	28												
			6	SS	20		364										
			7	SS	19		363										
							362										
361.7																	
6.1	SILT and SAND Compact Grey Wet		8	SS	15		361							○			0 37 (63)
			9	SS	20		360										
							359										
358.1			10	SS	27												
9.7	End of Borehole																
	Note: 1. Water level in open borehole at a depth of 4.4 m below ground surface (Elev. 363.4 m) upon completion of drilling.																

MIS-MTO 001 OXTONGUE_LOGS_1DECIMAL.GPJ GAL-MISS.GDT 24/11/09

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[illegible]

PROJECT <u>07-1191-0001-OX</u>				RECORD OF BOREHOLE No OX-2				3 OF 3 METRIC									
W.P. <u>5550-04-00</u>		LOCATION <u>N 5027338.7 ;E 351133.2</u>				ORIGINATED BY <u>EHS</u>											
DIST <u> </u> HWY <u>60</u>		BOREHOLE TYPE <u>NW Casing, Wash Boring</u>				COMPILED BY <u>MM</u>											
DATUM <u>Geodetic</u>		DATE <u>November 20 and 21, December 22 and 23, 2008</u>				CHECKED BY <u>SEMC</u>											
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									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
	SAND, trace gravel, trace silt, with gravel layers Loose to very dense Brown Wet		19	SS	57		338										
							337										
							336										
335.6	GNEISS (BEDROCK)																
32.5	Bedrock cored from 32.5 m to 35.6 m depth. For coring details, refer to Record of Drillhole OX-2.		1	RC	REC 92%		335										RQD = 79%
			2	RC	REC 100%		334										RQD = 100%
			3	RC	REC 95%		333										RQD = 95%
332.5	End of Borehole																
35.6	Notes: 1. Water level in open borehole at a depth of 3.8 m below ground surface (Elev. 364.3 m) upon completion of drilling. 2. No recovery in samples 2, 3 and 18 on the first attempt. 3. Borehole stopped on Nov. 21, 2008 due to weather at 32.5 m depth. Casing left in the hole. Borehole (rock coring) resumed on Dec. 22, 2008.																

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Walker Drilling

CHECKED: SEMC

MIS-RCK 004 OXTONGUE_LOGS_1DECIMAL.GPJ GAL-MISS.GDT 24/11/09

PROJECT <u>07-1191-0001-OX</u>				RECORD OF BOREHOLE No OX-3				1 OF 3 METRIC								
W.P. <u>5550-04-00</u>		LOCATION <u>N 5027355.8 ; E 351163.7</u>				ORIGINATED BY <u>EHS</u>										
DIST <u> </u> HWY <u>60</u>		BOREHOLE TYPE <u>NW Casing, Wash Boring</u>				COMPILED BY <u>MM</u>										
DATUM <u>Geodetic</u>		DATE <u>November 18 and 19, 2008</u>				CHECKED BY <u>SEMC</u>										
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 × REMOULDED								
369.1	GROUND SURFACE															
0.0	ASPHALT (90mm)															
0.3	CONCRETE (200mm)															
	VOID (Beneath Bridge)															
366.5																
2.6	Gravelly sand, trace silt and occasional cobbles (FILL) Very loose to loose Brown Moist to wet Concrete and asphalt rubble above 3.7 m depth.		1	SS	2											
			2	SS	6											
			3	SS	6											
			4	SS	6											
			5	SS	7											
			6	SS	2											
361.5			7	SS	4											
7.6	SILT and SAND to Sandy SILT, trace clay, layered Very loose to compact Light brown Wet		8	SS	3											
			9	SS	6											
			10	SS	15											
			11	SS	10											

Continued Next Page

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

PROJECT <u>07-1191-0001-OX</u>		RECORD OF BOREHOLE No OX-3		2 OF 3 METRIC	
W.P. <u>5550-04-00</u>		LOCATION <u>N 5027355.8 ;E 351163.7</u>		ORIGINATED BY <u>EHS</u>	
DIST <u> </u> HWY <u>60</u>		BOREHOLE TYPE <u>NW Casing, Wash Boring</u>		COMPILED BY <u>MM</u>	
DATUM <u>Geodetic</u>		DATE <u>November 18 and 19, 2008</u>		CHECKED BY <u>SEMC</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)			GR	SA	SI	CL	
	--- CONTINUED FROM PREVIOUS PAGE ---																			
	SILT and SAND to Sandy SILT, trace clay, layered Very loose to compact Light brown Wet		12	SS	14		354													
							353													
			13	SS	11		352													
							351													
			14	SS	11		350										0 25 75 0			
349.6							349													
19.5	SAND and GRAVEL, trace silt, occasional cobbles, layered Dense to very dense Light brown Wet Difficult to advance casing below 19.8 m depth Oxidized layer 12 mm thick at 20.1 m depth.		15	SS	35		348													
							347													
			16	SS	69		346													
							345													
			17	SS	51		344													
							343													
342.8							342													
26.3	BOULDERS						341										RQD = 65%			
342.3							340													
26.8	COBBLES in a sand and gravel matrix																			
341.5																				
27.6	GNEISS (BEDROCK) Bedrock cored from 27.6 m to 31.1 m depth. For coring details, refer to Record of Drillhole OX-3.		1	RC	REC 100%															
			2	RC	REC 100%												RQD = 97%			

Continued Next Page

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

MIS-MTO-001 OX-TONGUE LOGS_1.DECIMAL.GPJ GAL-MISS.GDT 24/11/09

PROJECT <u>07-1191-0001-OX</u>				RECORD OF BOREHOLE No OX-3				3 OF 3 METRIC									
W.P. <u>5550-04-00</u>		LOCATION <u>N 5027355.8 ;E 351163.7</u>				ORIGINATED BY <u>EHS</u>											
DIST <u> </u> HWY <u>60</u>		BOREHOLE TYPE <u>NW Casing, Wash Boring</u>				COMPILED BY <u>MM</u>											
DATUM <u>Geodetic</u>		DATE <u>November 18 and 19, 2008</u>				CHECKED BY <u>SEMC</u>											
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									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)				
								20	40	60	80	100	10	20	30		
338.0			3	RC	REC 100%		339										
31.1	End of Borehole Note: 1. Water level in open borehole at a depth of 3.6 m below ground surface (Elev. 365.5 m) upon completion of drilling. 2. No recovery in samples 2 to 4 and 6 on first attempt.						338										

PROJECT: 07-1191-0001-OX

RECORD OF DRILLHOLE: OX-3

SHEET 1 OF 1

LOCATION: N 5027355.8 ;E 351163.7

DRILLING DATE: November 18 and 19, 2008

DATUM: Geodetic


INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D50 Turbo Bomb

DRILLING CONTRACTOR: Walker Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE min/m	COLOUR % RETURN	JN - Joint FLT - Fault SHR- Shear VN - Vein CJ - Conjugate	BD- Bedding FO - Foliation CO- Contact OR - Orthogonal CL - Cleavage	PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular	PO- Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break	BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES WATER LEVELS INSTRUMENTATION														
														RECOVERY TOTAL CORE % SOLID CORE % % R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec				Diametral Point Load Index (MPa)	RMC -Q' AVG.		
																B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 ⁻⁶	10 ⁻⁵			10 ⁻⁴	10 ⁻³
28	NQ Coring Nov. 19, 2008	Refer to Previous Page		341.49 27.61	1	Grey 100							UCS = 108.5 MPa														
29														2	Grey, pink 100												
30																						3	Grey, pink 100				
31	End of Drillhole		338.01 31.09																								
32																											
33																											
34																											
35																											
36																											
37																											

PROJECT <u>07-1191-0001-OX</u>				RECORD OF BOREHOLE No OX-4				1 OF 1 METRIC									
W.P. <u>5550-04-00</u>		LOCATION <u>N 5027366.9 ; E 351183.9</u>				ORIGINATED BY <u>EHS</u>											
DIST <u> </u> HWY <u>60</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers</u>				COMPILED BY <u>MM</u>											
DATUM <u>Geodetic</u>		DATE <u>November 16 and 17, 2008</u>				CHECKED BY <u>SEMC</u>											
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									
369.6	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT (120 mm)																
369.2	Granular A (140 mm), Granular B (30 mm) and Chip and Tar (30 mm) (FILL)																
0.4	Gravelly sand, trace silt, occasional cobble, layered, oxidized (FILL) Loose to compact Brown Moist		1	SS	21												
			2	SS	7												
			3	SS	9												
366.7																	
2.9	SAND, trace to some gravel, trace silt, layered, oxidized Very loose to loose Brown Moist		4	SS	5												
			5	SS	5												
			6	SS	4												
364.0																	
5.6	SILT and SAND to Sandy SILT, trace clay, trace organics, occasional sand seam, layered Compact Light brown Wet		7	SS	14												
	A 1.5 m thick, light brown, wet, silt, trace sand layered at 7.2 m depth.		8	SS	17												
359.9			9	SS	2												
9.7	End of Borehole																
	Note: 1. Water level in open borehole at a depth of 5.6 m below ground surface (Elev. 364.0 m) upon completion of drilling.																

PROJECT <u>07-1191-0001-OX</u>				RECORD OF BOREHOLE No OX-5				1 OF 1 METRIC											
W.P. <u>5550-04-00</u>				LOCATION <u>N 5027316.4 ; E 351120.1</u>				ORIGINATED BY <u>EHS</u>											
DIST <u> </u> HWY <u>60</u>				BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers</u>				COMPILED BY <u>MM</u>											
DATUM <u>Geodetic</u>				DATE <u>November 10, 2008</u>				CHECKED BY <u>SEMC</u>											
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 × REMOULDED											
							20	40	60	80	100		10	20	30				
367.1	GROUND SURFACE																		
0.0	Sand and gravel, trace silt, containing organics, oxidized, layered (FILL)		1	SS	5														
366.5	Loose Brown Moist																		
0.6	Sand, some gravel, trace silt, oxidized (FILL)		2	SS	11													16 74 (10)	
	Compact to very dense Brown Moist to wet		3	SS	47														
			4	SS	63														
364.1	SILT and SAND to Sandy SILT, trace clay, occasional gravel layers, oxidized Very loose to dense Light brown and grey Wet		5	SS	35												0 66 32 2		
3.0			6	SS	15														
			7	SS	16												0 22 76 2		
			8	SS	4														
			9	SS	7												0 67 32 1		
			10	SS	3														
357.4	End of Borehole																		
9.7	Notes: 1. Water level measured in piezometer at a depth of 2.2 m below ground surface (Elev. 367.1 m) on November 11, 2008. 2. Water level measured in piezometer at a depth of 3.2 m below ground surface (Elev. 363.9 m) on November 25, 2008.																		

RECORD OF BOREHOLE No OX-6

1 OF 3 **METRIC**

PROJECT 07-1191-0001-OX

W.P. 5550-04-00

LOCATION N 5027326.1 :E 351137.5

ORIGINATED BY EHS

DIST HWY 60





BOREHOLE TYPE 108 mm Hollow Stem Augers, NW Casing, Wash Boring

COMPILED BY MM

DATUM Geodetic

DATE November 10 to 12, 2008

CHECKED BY SEMC




SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa										WATER CONTENT (%)		
366.2	GROUND SURFACE						20	40	60	80	100	10	20	30					
0.0	Gravelly sand, trace silt with organics (FILL)		1	SS	9		366												
365.6	Loose Brown Moist																		
0.6																			
365.1	Sand, trace gravel and silt, oxidized (FILL)		2	SS	2		365											0 13 70 17	
1.1	Very loose Wet																		
364.5	Silt, some clay and sand, oxidized (FILL)																		
1.7	Very loose Mottled grey Moist		3	SS	19		364												
	SILT and SAND to Sandy SILT, trace to some gravel, trace silt, trace clay, oxidized, layered Loose to compact Light brown to grey Wet																	1 68 28 3	
				4	SS		21												
				5	SS		27	363											
				6	SS	16	362												
				7	SS	20	361												
				8	SS	15	360												
			9	SS	8	359													

Continued Next Page

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

MIS-MTO 001 OXTONGUE_LOGS_1DECIMAL.GPJ GAL-MISS.GDT 24/11/09

[illegible]

PROJECT <u>07-1191-0001-OX</u>		RECORD OF BOREHOLE No OX-6				3 OF 3 METRIC						
W.P. <u>5550-04-00</u>		LOCATION <u>N 5027326.1 ; E 351137.5</u>				ORIGINATED BY <u>EHS</u>						
DIST <u> </u> HWY <u>60</u>		BOREHOLE TYPE <u>108 mm Hollow Stem Augers, NW Casing, Wash Boring</u>				COMPILED BY <u>MM</u>						
DATUM <u>Geodetic</u>		DATE <u>November 10 to 12, 2008</u>				CHECKED BY <u>SEMC</u>						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa		WATER CONTENT (%)		
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	W _p W W _L	10 20 30	
336.1 335.8	BOULDER						336					
30.4	SAND, with gravel and cobbles, layered Light brown Wet						335					
							334					
333.3							333					
32.9	GNEISS (BEDROCK) Bedrock cored from 32.9 m to 36.3 m depth. For coring details, refer to Record of Drillhole OX-6.		1	RC	REC 100%		332					
			2	RC	REC 100%		331					
			3	RC	REC 100%		330					
329.9 36.3	End of Borehole Note: 1. Water level in open borehole at a depth of 1.6 m below ground surface (Elev. 364.6 m) upon completion of drilling.											

PROJECT: 07-1191-0001-OX

RECORD OF BOREHOLE: OX-6

SHEET 1 OF 1

LOCATION: N 5027326.1 ;E 351137.5

DRILLING DATE: November 10 to 12, 2008

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D50 Turbo Bomb

DRILLING CONTRACTOR: Walker Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	PENETRATION RATE min/m	FLUSH % RETURN	COLOUR % RETURN	JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break	BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
				DEPTH										RECOVERY TOTAL CORE %	SOLID CORE %	R.Q.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA					HYDRAULIC CONDUCTIVITY			Diametral Point Load Index (MPa)	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
				(m)														B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	K, cm/sec	10 ⁻⁶			10 ⁻⁵	10 ⁻⁴	10 ⁻³																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
		Refer to Previous Page		333.31 32.89																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														

UCS = 136.4 MPa

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: SEMC

MIS-RCK 004 OXTONGUE LOGS_1DECIMAL.GPJ GAL-MISS.GDT 24/11/09

PROJECT 07-1191-0001-OX		RECORD OF BOREHOLE No OX-7		1 OF 2 METRIC	
W.P. 5550-04-00		LOCATION N 5027345.3 ; E 351172.6		ORIGINATED BY EHS	
DIST HWY 60		BOREHOLE TYPE NW Casing, Wash Boring		COMPILED BY MM	
DATUM Geodetic		DATE November 3 to 5, 2008		CHECKED BY SEMC	

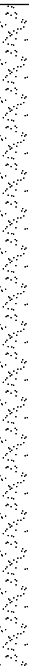



SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20	40	60	80	100			W _p	W	W _L
364.3	GROUND SURFACE																
0.0	WATER																
362.0																	
2.3	Sand and gravel, with silt, trace organics, occasional cobbles (FILL) Compact Brown Wet		1	SS	13							○					
			2	SS	12												
360.7																	
3.6	SILT and SAND, trace gravel, layered, oxidized Very loose to compact Brown to light brown Wet		3	SS	17							○				39 36 23 2	
			4	SS	3												
			5	SS	9								○			3 64 33 0	
			6	SS	11												
			7	SS	7												
			8	SS	9							○				6 55 39 0	
			9	SS	11												
354.6																	
9.7	SAND to SAND and GRAVEL, trace silt, oxidized, layered Loose to compact Brown Wet		10	SS	9												
			11	SS	14							○				3 91 6 0	
	Grinding of casing on dense layers throughout.		12	SS	26												
									</								

Continued Next Page

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

MIS-MTO 001 OXTONGUE LOGS_1DECIMAL.GPJ GAL-MISS.GDT 24/11/09

PROJECT 07-1191-0001-OX		RECORD OF BOREHOLE No OX-7		2 OF 2 METRIC	
W.P. 5550-04-00		LOCATION N 5027345.3 ; E 351172.6		ORIGINATED BY EHS	
DIST HWY 60		BOREHOLE TYPE NW Casing, Wash Boring		COMPILED BY MM	
DATUM Geodetic		DATE November 3 to 5, 2008		CHECKED BY SEMC	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
								20 40 60 80 100				w _p w w _L					
--- CONTINUED FROM PREVIOUS PAGE ---																	
342.7 21.6	SAND to SAND and GRAVEL, trace silt, oxidized, layered Loose to compact Brown Wet		13	SS	21		349									36 61 (3)	
			14	SS	24		348										
			15	SS	30		347										
			16	SS	26		346										
341.6 22.7	BOULDER Boulder cored from 21.6 m depth to 22.7 m depth.			RC		345									53 43 (4)		
						344											
						343											
340.7 23.6	Gravelly SAND, with cobbles					342									RQD = 85%		
						341											
						340											
337.6 26.7	GNEISS (BEDROCK) Bedrock cored from 23.7 m to 26.7 m depth. For coring details, refer to Record of Drillhole OX-7.		1	RC	REC 100%	339									RQD = 95%		
			2	RC	REC 100%	338											
			3	RC	REC 100%												
337.6 26.7	End of Borehole Notes: 1. No recovery in samples 2, 3 and 14 on the first attempt. 2. Difficult casing advance below 21.6 m depth.														RQD = 85%		

MIS-MTO 001 OXTONGUE LOGS_1DECIMAL.GPJ GAL-MISS.GDT 24/11/09

PROJECT 07-1191-0001-OX		RECORD OF BOREHOLE No OX-8		1 OF 3 METRIC	
W.P. 5550-04-00		LOCATION N 5027366.3 ; E 351205.5		ORIGINATED BY EHS	
DIST HWY 60		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY MM	
DATUM Geodetic		DATE November 13, 2008		CHECKED BY SEMC	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
369.7	GROUND SURFACE																
0.0	Fine to medium sand, trace gravel, trace silt (FILL) Loose to compact Light brown Moist		1	SS	4							○					
			2	SS	10												
368.3																	
1.4	SILT and SAND to Silty SAND, trace gravel, layered Compact to dense Light brown Moist to wet		3	SS	10							○		2 70 (28)			
			4	SS	10												
			5	SS	13												
			6	SS	16							○		0 64 (36)			
			7	SS	12							○		1 72 27 0			
			8	SS	21												
			9	SS	19												
361.0																	
8.7	SILT, some sand, trace clay, containing sand layers Loose to compact Light brown Wet		10	SS	17							○		0 17 80 3			
			11	SS	4												
358.0																	
11.7	SAND to SILT and SAND Compact to dense Light brown Wet		12	SS	32							○		0 79 21 0			
			13	SS	25												

Continued Next Page

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

MIS-MTO-001 OXTONGUE_LOGS_1DECIMAL.GPJ GAL-MISS.GDT 24/11/09


PROJECT 07-1191-0001-OX		RECORD OF BOREHOLE No OX-8		2 OF 3 METRIC	
W.P. 5550-04-00		LOCATION N 5027366.3 ; E 351205.5		ORIGINATED BY EHS	
DIST HWY 60		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY MM	
DATUM Geodetic		DATE November 13, 2008		CHECKED BY SEMC	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)			GR	SA	SI	CL
								20	40	60	80	100		W _p	W	W _L				
	--- CONTINUED FROM PREVIOUS PAGE ---																			
	SAND to SILT and SAND Compact to dense Light brown Wet		14	SS	18		354													
							353													
			15	SS	36															
							352													
			16	SS	19		351													
							350													
							349													
			17	SS	38		348													
							347													
							346													
			18	SS	32		345													
							344													
							343													
			19	SS	48		342													
							341													
340.6							340													
29.1	COBBLES and BOULDERS in a sand and gravel matrix																			
340.0																				
29.7																				

Continued Next Page

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

MIS-MTO-001 OXTONGUE LOGS_1DECIMAL.GPJ GAL-MISS.GDT 24/11/09

PROJECT <u>07-1191-0001-OX</u>				RECORD OF BOREHOLE No OX-8				3 OF 3 METRIC									
W.P. <u>5550-04-00</u>		LOCATION <u>N 5027366.3 ; E 351205.5</u>				ORIGINATED BY <u>EHS</u>											
DIST <u> </u> HWY <u>60</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring</u>				COMPILED BY <u>MM</u>											
DATUM <u>Geodetic</u>		DATE <u>November 13, 2008</u>				CHECKED BY <u>SEMC</u>											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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 (%)				
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100	W _p	W	W _L			
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED										
							20	40	60	80	100	10	20	30			
	GNEISS (BEDROCK)		1	RC	REC 97%												RQD = 23%
	Bedrock cored from 29.7 m to 33.1 m depth.		2	RC	REC 100%												RQD = 64%
	For coring details, refer to Record of Drillhole OX-8.		3	RC	REC 100%												RQD = 88%
336.6																	
33.1	End of Borehole																
	Note: 1. Water level in open borehole at a depth of 5.0 m below ground surface (Elev. 364.7 m) upon completion of drilling.																

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Walker Drilling

CHECKED: SEMC

MIS-RCK 004 OXTONGUE_LOGS_1DECIMAL.GPJ GAL-MISS.GDT 24/11/09

PROJECT <u>07-1191-0001-OX</u>				RECORD OF BOREHOLE No OX-9				1 OF 1 METRIC										
W.P. <u>5550-04-00</u>				LOCATION <u>N 5027377.0 ; E 351223.8</u>				ORIGINATED BY <u>EHS</u>										
DIST <u> </u> HWY <u>60</u>				BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers</u>				COMPILED BY <u>MM</u>										
DATUM <u>Geodetic</u>				DATE <u>November 12, 2008</u>				CHECKED BY <u>SEMC</u>										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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 × REMOULDED					WATER CONTENT (%) W _p — W — W _L					
370.4 0.0	GROUND SURFACE Fine to medium sand, trace gravel, trace silt (FILL) Loose to compact Light brown Moist	[Pattern]	1	SS	6	370												
			2	SS	7	369												4 93 (3)
			3	SS	11	368												
368.3 2.1	SAND, trace to some silt, trace gravel, layered with black metallic seams Compact Light brown Moist to wet	[Pattern]	4	SS	10	368												
			5	SS	11	367												2 94 (4)
			6	SS	15	366												
			7	SS	15	365												
			8	SS	14	364												0 82 17 1
363.2 7.2	Sandy SILT, trace clay, layered Compact Light brown with dark brown specs Wet	[Pattern]	9	SS	11	363												
			10	SS	17	361												0 22 77 1
360.7 9.7	End of Borehole Notes: 1. Water level measured in piezometer at 5.8 m and 5.7 m (Elev. 364.6 m and 364.7 m) on November 13 and 14, 2008 respectively. 2. Water level measured in piezometer at a depth of 5.6 m below ground surface level (364.8 m) on November 25, 2008.																	

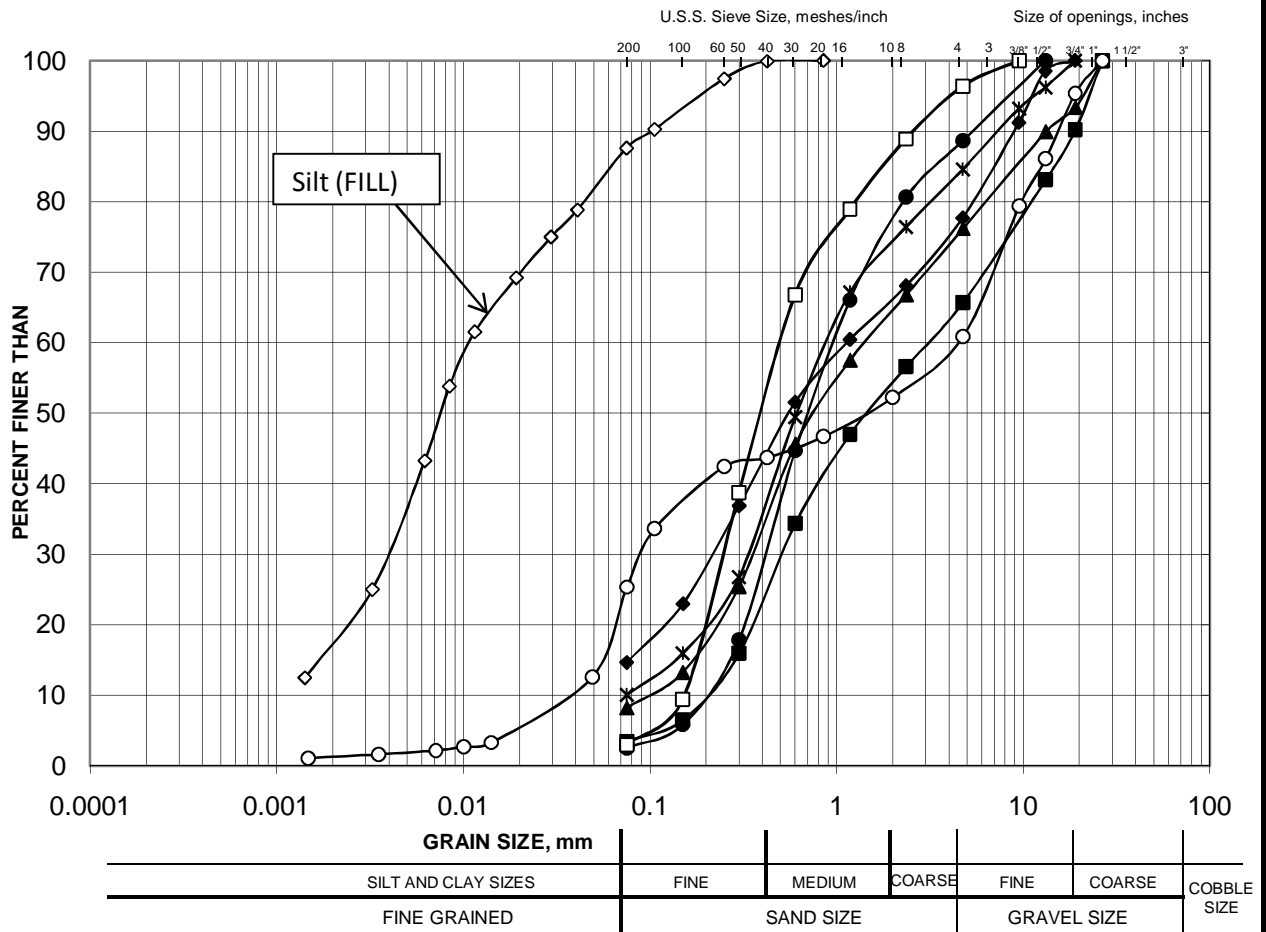


APPENDIX B

LABORATORY TEST RESULTS

GRAIN SIZE DISTRIBUTION Sand to Sand and Gravel (FILL)

**FIGURE
B-1**



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	OX-1	2	366.7
●	OX-2	3	362.4
■	OX-3	4	363.4
▲	OX-4	3	367.1
✱	OX-5	2	366.0
◇	OX-6	2	365.0
○	OX-7	3	360.7
□	OX-9	2	369.4

Project Number: 07-1191-0001-OX

Checked By: SEMC

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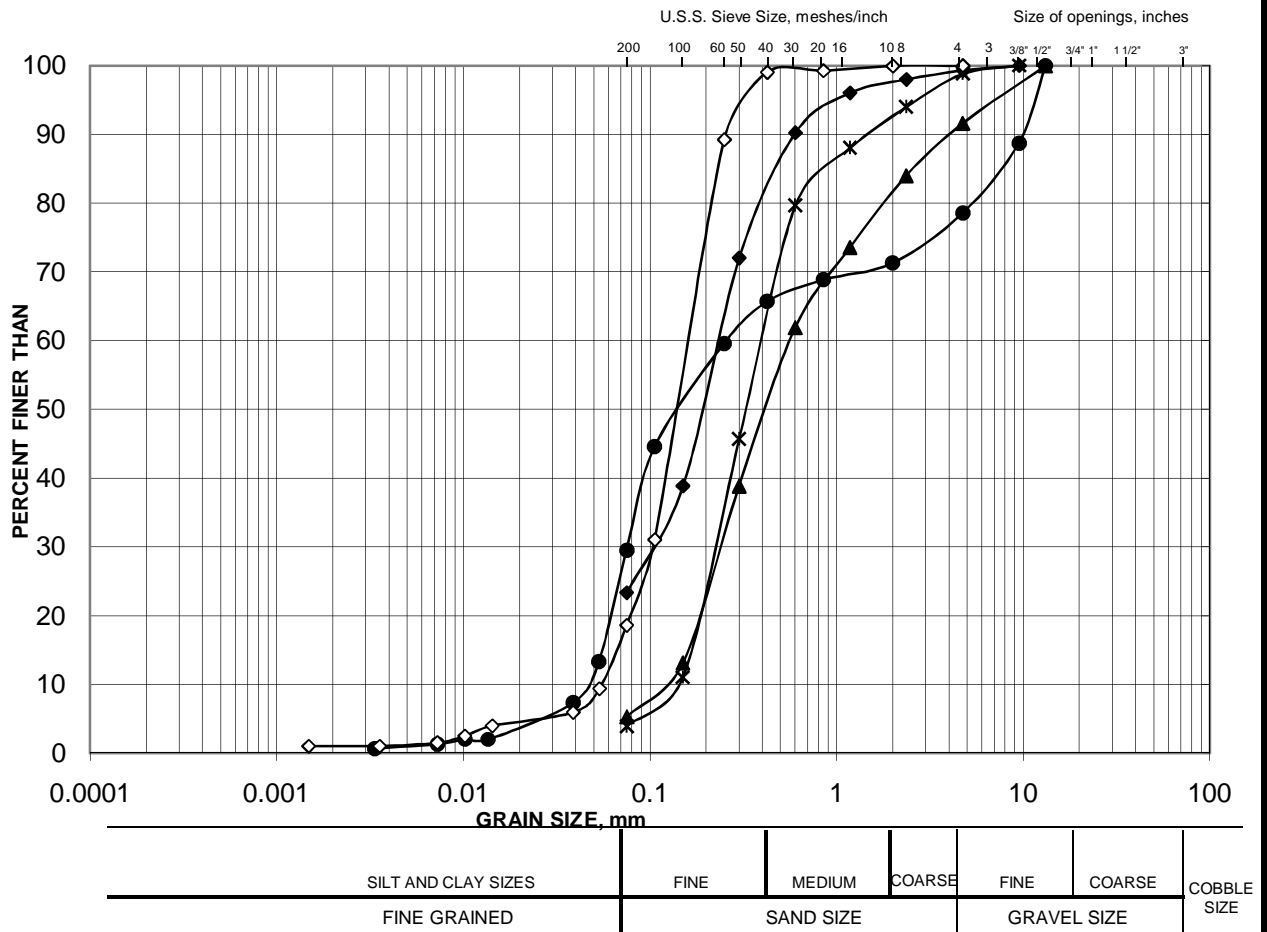
Date:

November 2009

GRAIN SIZE DISTRIBUTION

Upper Sand to Silty Sand

**FIGURE
B-2**



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	OX-1	5	364.5
●	OX-2	4b	361.5
▲	OX-2	6a	360.4
✱	OX-9	5	367.1
◇	OX-9	8	364.1

Project Number: 07-1191-0001-OX

Checked By: SEMC

Golder Associates

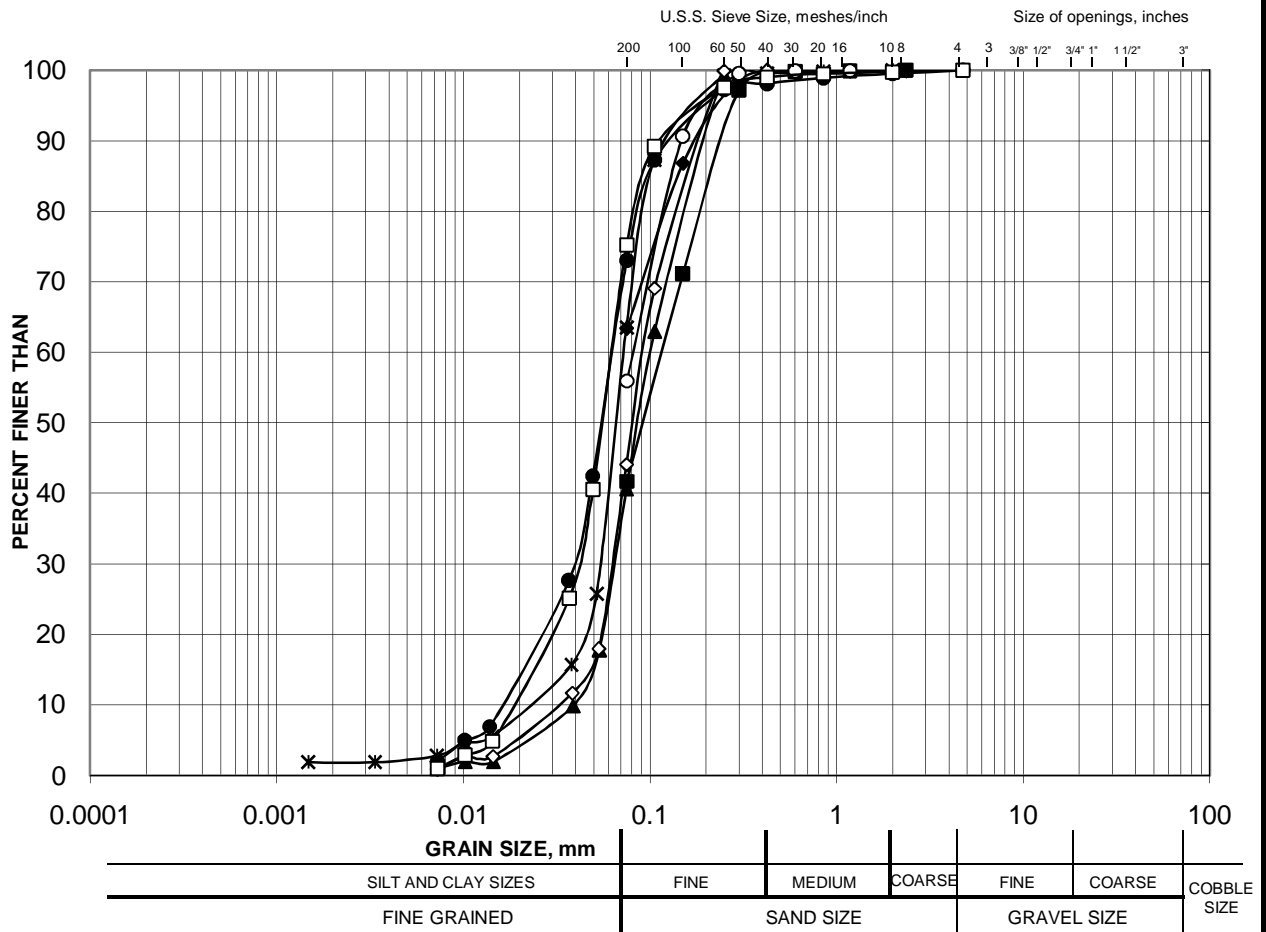
Date:

November 2009

GRAIN SIZE DISTRIBUTION

Silt and Sand to Sandy Silt

FIGURE
B-3
page 1 of 3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—●—	OX-1	8	361.4
—●—	OX-2	6b	360.1
—■—	OX-2	8	358.6
—▲—	OX-2	15	347.9
—*—	OX-3	7	361.2
—◇—	OX-3	9	358.1
—○—	OX-3	11	355.0
—□—	OX-3	14	350.6

Project Number: 07-1191-0001-OX

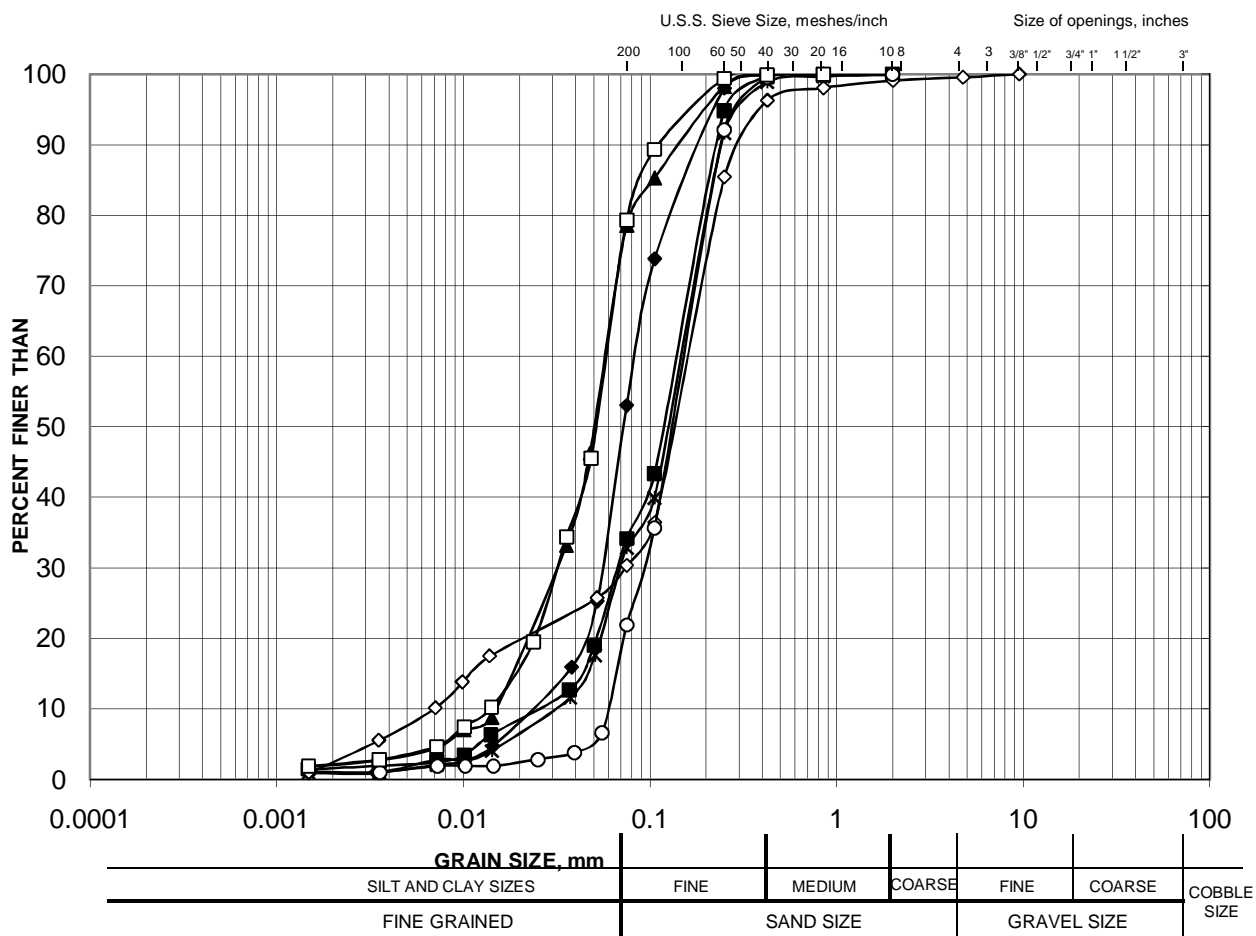
Checked By: SEMC

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Date:

November 2009

FIGURE
B-3
page 2 of 3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
	OX-4	7	363.2
	OX-5	5	363.8
	OX-5	7	362.2
	OX-5	9	359.2
	OX-6	4	363.7
	OX-6	9	358.3
	OX-6	11	355.3

Project Number: 07-1191-0001-OX

Checked By: SEMC

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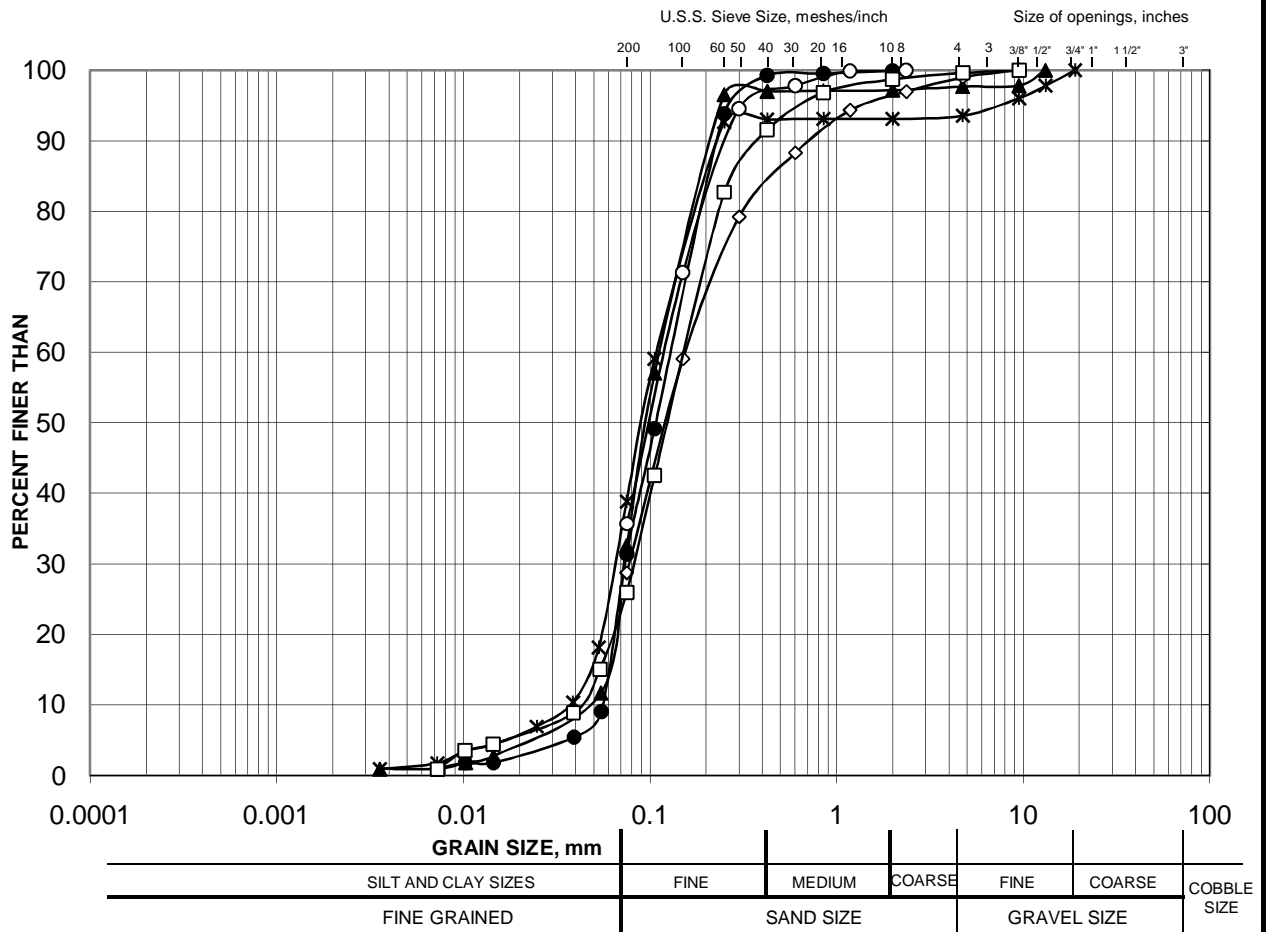
Date:

November 2009

GRAIN SIZE DISTRIBUTION

Silt and Sand to Sandy Silt

FIGURE
B-3
page 3 of 3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	OX-6	16	347.7
▲	OX-7	5	359.2
✱	OX-7	8	356.8
◇	OX-8	3	367.9
○	OX-8	6	365.7
□	OX-8	7	364.8

Project Number: 07-1191-0001-OX

Checked By: SEMC

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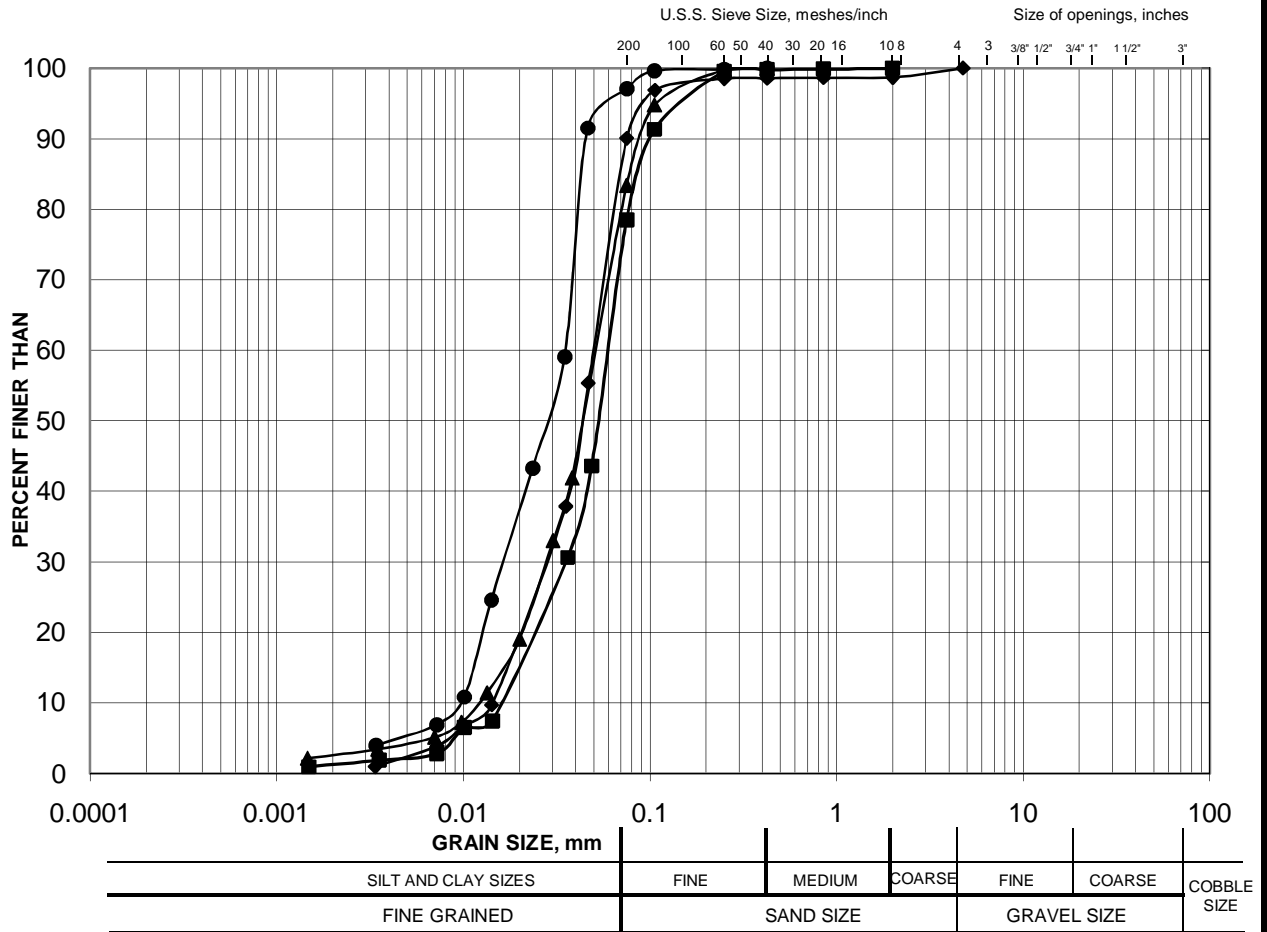
Date:

November 2009

GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt

**FIGURE
B-4**



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—●—	OX-2	11	354.1
—●—	OX-4	8	361.8
—▲—	OX-8	10	360.3
—■—	OX-9	10	361.0

Project Number: 07-1191-0001-OX
Checked By: SEMC

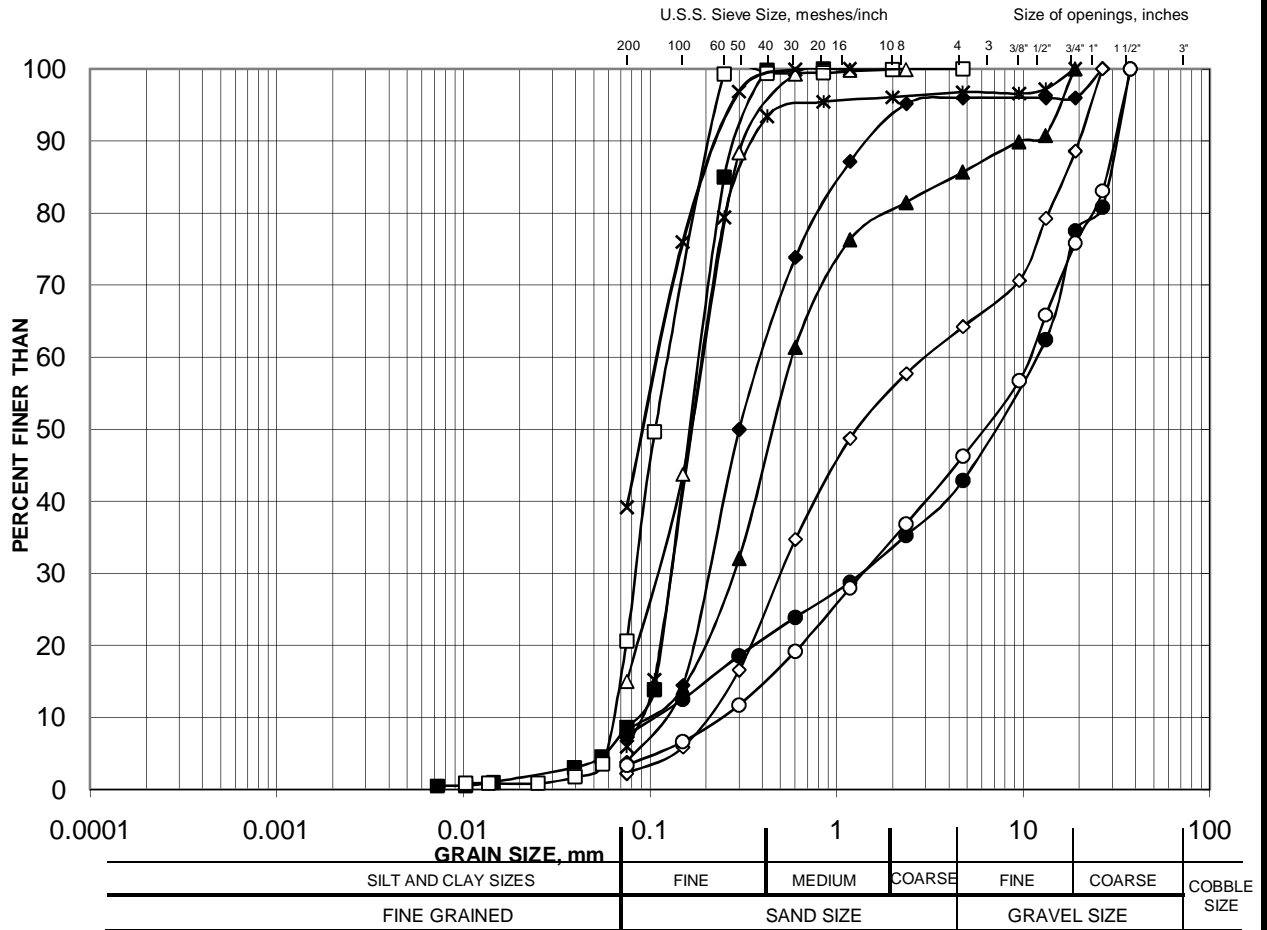
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Date: November 2009

GRAIN SIZE DISTRIBUTION

Sand to Sand and Gravel

**FIGURE
B-5**



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	OX-2	18	340.4
●	OX-3	16	347.5
■	OX-6	14	351.0
▲	OX-6	18	343.1
✱	OX-7	11	352.3
◇	OX-7	14	347.8
○	OX-7	16	344.7
□	OX-8	12	357.2
△	OX-8	15	352.7
✕	OX-8	17	348.1

Project Number: 07-1191-0001-OX

Checked By: SEMC

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Date:

November 2009

TABLE B-1
UNIAXIAL COMPRESSIVE STRENGTH TEST RESULTS
HIGHWAY 60 OXTONGUE RIVER BRIDGE AND DETOUR
G.W.P 5550-04-00, SITE NO. 44-002

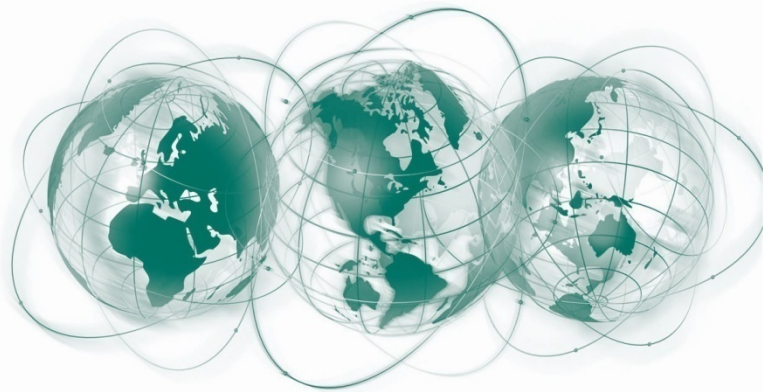
Borehole Number	Sample Depth (m)	Sample Elevation (m)	Rock Type	Core Diameter (mm)	Uniaxial Compressive Strength (MPa)
OX-3	29.7	339.4	Gneiss	47.5	108.5
OX-6	35.7	330.5	Gneiss	47.5	136.4
OX-7	24.1	340.2	Gneiss	47.5	56.8
OX-8	30.9	338.8	Gneiss	47.5	87.1

Compiled by: TR
Checked by: SEMC
Reviewed By: FJH

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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