



September 18, 2015

FOUNDATION INVESTIGATION REPORT

**Retaining Wall (Station 15+350 to 15+460)
Highway 400 Widening From North of King Road to
South Canal Bank Road
King City, Ontario
G.W.P. 2835-02-00**

Submitted to:

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Distribution:

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REPORT





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1.0 INTRODUCTION

Golder Associated Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the detail design for the widening of Highway 400 from north of King Road to north of South Canal Bank Road in the Regional Municipality of York, Ontario.

The Terms of Reference for the foundation engineering services are outlined in the Terms of Reference of MTO's Request for Proposal, dated May 2008 that form part of the Consultant's Agreement (Number 2007 E 0002) for this project, and in subsequent change requests. The work has been carried out in accordance with Golder's Supplemental Specialty Quality Control Plan for this project, dated October 2010.

This report addresses the foundation investigation carried out for the detail design of an approximately 110 m long retaining wall along the west side Highway 400 southbound lanes (SBL), between 15th Sideroad and 16th Sideroad in King City, in the Regional Municipality of York.

2.0 SITE DESCRIPTION

The proposed retaining wall is located on the west side of Highway 400 SBL between approximately Station 15+350 and Station 15+460; this is approximately 700 m south of 16th Sideroad.

In general, the topography in the area of the overall project site consists of rolling terrain including agricultural fields and densely treed areas. Commercial facilities are also found adjacent to the Highway 400 corridor. The area around the retaining wall is swampy and flat near the central portion of the wall, and slopes upward toward the north and south limits of the wall, with the existing ground surface at the toe of the slope varying from about Elevation 303 m near the south end, to Elevation 302 m in the central portion, to Elevation 308 m near the north end. The existing Highway 400 grade slopes downward to the south, from about Elevation 315 m to Elevation 311 m within the limits of the proposed retaining wall area.

The existing Highway 400 embankment is approximately 7.5 m in height (relative to the ground surface at the west embankment toe) at the north and south limits of the proposed wall, increasing to a maximum height of approximately 11 m in the central section. The existing west embankment side slope is sloped at approximately 2 horizontal to 1 vertical (2H:1V).

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out in December 2010, at which time three boreholes, designated as Boreholes RW1-1 to RW1-3, were advanced.

The field investigation was carried out using a Diedrich D-25 track-mounted drill rig, supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The boreholes were advanced to depths ranging from 11.3 m to 14.3 m below the existing ground surface near the highway embankment toe. The boreholes were advanced using either 108 mm outer diameter continuous flight hollow stem augers, or 108 mm diameter continuous flight solid stem augers. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using 50 mm outside diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT)



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procedure. (ASTM D1586-08a – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of the Soil).

The groundwater conditions in the open boreholes were observed during and immediately following the drilling operations. A standpipe piezometer was installed in Borehole RW1-3 to permit monitoring of the water level at this site. The piezometer consists of a 25 mm diameter PVC pipe, with a slotted screen sealed at a select depth within the borehole. The borehole and annulus surrounding the piezometer pipe above the screen sand pack were backfilled to the surface with bentonite pellets/grout. Piezometer installation details and water level readings are provided on the borehole records in Appendix A. All boreholes in which standpipe piezometers were not installed were backfilled with bentonite upon completion in accordance with Ontario Regulation 903 (as amended).

The field work was observed by a member of Golder's engineering 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 Golder's Mississauga 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, Atterberg limits and grain size distribution) was carried out on selected samples. The results of the geotechnical laboratory testing are presented on the borehole records and included in Appendix B.

The borehole locations were surveyed by Callon Dietz, a licensed land surveyor retained by URS. The borehole locations, including MTM NAD 83 northing and easting coordinates, and the ground surface elevations referenced to geodetic datum, are presented on the borehole records in Appendix A and are summarized below.

Borehole	Location (MTM NAD 83)		Ground Elevation (m)	Depth Drilled (m)
	Northing	Easting		
RW1-1	4,867,765.6	298,897.5	303.3	14.3
RW1-2	4,867,809.7	298,885.8	302.1	14.3
RW1-3	4,867,853.6	298,880.7	304.9	11.3

4.0 SUBSURFACE CONDITIONS

4.1 Regional Geology

The 23 km section of Highway 400 included in this overall highway widening project traverses, in a south–north direction, the physiographic regions known as South Slope, Oak Ridges Moraine and Simcoe Lowlands, according to *The Physiography of Southern Ontario (Chapman and Putman, 1984)*¹. Along Highway 400, the South Slope is present south of King Road, the Oak Ridge Moraines extends from north of King Road to south of Highway 9 and the Simcoe Lowlands occupy a 4 km wide strip extending from south of Highway 9 to Holland River. This retaining wall site is located within the Oak Ridges Moraine physiographic region.

¹ Chapman, L.J. and Putnam, D.F. 1984. The Physiography of Southern Ontario, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P. 2715, Scale 1:600,000.



The surficial soils of the South Slope region are generally cohesive tills. The Oak Ridges Moraine predominately consists of sand and gravel, although in the King Township area these soils are often overlain by till. It is understood that during grading for the initial construction of Highway 400 in this area, deep cuts exposed up to about 10 m of till overlying the sands and gravels.

The Holland River valley, which crosses Highway 400 in the vicinity of Highway 9 and South Canal Road, is located within the Simcoe Lowlands region. This valley extends to the southwest from Cook Bay at the south end of Lake Simcoe, and was once a shallow extension of the lake. The floor of the valley consists of peat, soft clays and loose sands. It is understood that during initial construction of Highway 400, a layer of peat about 2 m to 3 m thick was removed in order to construct the road upon the underlying sand and clay.

4.2 Subsurface Conditions

As part of the subsurface investigation, three boreholes were advanced in the area of the proposed retaining wall location. The detailed subsurface soil and groundwater conditions encountered in the boreholes, and the results of in situ and laboratory testing, are presented on the borehole records contained in Appendix A. The results of geotechnical laboratory testing are also presented in Appendix B.

The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. The interpreted stratigraphic profile along the retaining wall, shown on Drawing 1, is a simplification of the subsurface conditions. Variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In summary, the subsoils encountered along the proposed retaining wall generally consist of a surficial layer of topsoil and/or fill and an upper deposit of silty sand to silt, or clayey silt; in the central portion of the retaining wall, a layer of organic silt was encountered in Borehole RW1-2. These deposits are underlain by clayey silt till, which contains clayey silt interlayers; a lower silt deposit was encountered in one of the boreholes. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following subsections.

4.2.1 Topsoil

Approximately 200 mm of topsoil was encountered immediately below the existing ground surface in Borehole RW1-1.

4.2.2 Fill

Fill material was encountered underlying the topsoil in Borehole RW1-1 and immediately below the ground surface in Borehole RW1-2. The fill is 0.7 m and 1.9 m thick, with the base of the fill extending to about Elevation 302.4 m and Elevation 300.2 m in Boreholes RW1-1 and RW1-2, respectively.

In Borehole RW1-1, the fill is generally non-cohesive and comprised of silty sand, containing zones of clayey silt. In Borehole RW1-2, the upper 0.5 m of the fill is cohesive and consists of silty clay containing trace sand and rootlets; this is underlain by about 1.4 m of non-cohesive sand and silt fill, containing zones of clayey silt.

The natural water content measured on one sample of the non-cohesive fill was about 13 per cent, and the natural water content measured on one sample of the cohesive fill was about 31 per cent.



The Standard Penetration Test (SPT) “N”-values measured within the non-cohesive fill ranged from 7 to 17 blows per 0.3 m of penetration, suggesting that the material has a loose to compact relative density. An SPT “N”-value of 10 blows per 0.3 m of penetration was measured within the cohesive portion of the fill, suggesting that the cohesive fill has a stiff consistency.

4.2.3 Upper Clayey Silt

A 1.6 m thick upper layer of clayey silt was encountered immediately below the existing ground surface at the location of Borehole RW1-3, near the north limit of the retaining wall. The surface of this deposit was encountered at Elevation 304.9 m, and its base at Elevation 303.3 m.

The deposit is comprised of clayey silt with sand, containing rootlets and organic matter. One water content of approximately 22 per cent was measured on this deposit.

SPT “N” values of 4 and 9 blows per 0.3 m were measured in this deposit, suggesting a firm to stiff consistency.

4.2.4 Upper Silty Sand to Silt and Organic Silt

Within the “low point” in the central portion of the proposed retaining wall (refer to the interpreted stratigraphic section on Drawing 1), a 1.5 m thick layer of organic silt was encountered immediately below the fill, extending between Elevation 300.2 m and 298.7 m. This organic silt is underlain by about 2.2 m of low plasticity silt that extends to a total depth of 5.6 m (Elevation 296.5 m). Toward the south limit of the proposed wall, in Borehole RW1-2, an approximately 3.5 m thick layer of silty sand was encountered below the fill, and atop the till deposit; the base of the silty sand was encountered at approximately Elevation 298.9 m in this location.

This upper deposit varies in composition from silty sand to silt containing trace to some sand, to organic silt. A 0.3 m thick layer of clayey silt till was encountered in the lower portion of the silty sand deposit in Borehole RW1-1. The results of grain size distribution tests completed on one sample of silty sand and one sample of organic silt are presented on Figure B1 in Appendix B.

Atterberg limits testing was completed on one sample of the organic silt and measured a plastic limit of about 35 per cent, a liquid limit of about 40 per cent, and a corresponding plasticity index of about 5 per cent; this test result, which is plotted on a plasticity chart on Figure B2 in Appendix B, confirms that this portion of the deposit consists of low plasticity organic silt. Atterberg limits testing was also completed on a sample of the silt from Borehole RW1-2, and measured a plastic limit of about 14 per cent, a liquid limit of about 17 per cent, and a plasticity index of 3 per cent; this result, which is also shown on the plasticity chart on Figure B2, confirms that the tested sample is a silt of slight plasticity. The natural water content measured on samples of the silty sand to silt varied from about 16 to 20 per cent, and the natural water content measured on samples of the organic silt ranged from about 27 to 44 per cent. An organic content test was carried out on one sample of the organic silt and measured an organic content of approximately 4 percent.

The measured SPT “N” values in the organic silt layer are 3 and 4 blows per 0.3 m of penetration, suggesting a soft to firm consistency. The SPT “N”-values recorded within the silty sand to silt deposit range from 8 to 17 blows per 0.3 m of penetration, suggesting that this deposit has a loose to compact relative density.

4.2.5 Clayey Silt Till

A deposit of brown to grey cohesive till was encountered below the upper silty sand to silt in Boreholes RW1-1 and RW1-2, and below the upper clayey silt in Borehole RW1-3. The surface of the till was encountered at



approximately Elevation 298.9 m near the south limit of the wall, dipping to about Elevation 296.5 m in the central portion of the wall, and rising to about Elevation 303.3 m near the north limit of the wall (refer to the interpreted stratigraphic profile on Drawing 1).

The cohesive till deposit is comprised of clayey silt, trace to some sand, and trace gravel. The results of grain size distribution tests completed on four samples of the till are presented on Figure B3 in Appendix B.

Atterberg limits testing was conducted on five samples of the till and measured plastic limits of about 12 to 16 per cent, liquid limits of about 22 to 26 per cent, and plasticity indices of about 7 to 10 per cent. These test results, which are plotted on a plasticity chart on Figure B4 in Appendix B, confirm that the deposit consists of clayey silt of low plasticity. The natural water content measured on selected samples of the till ranges from about 14 to 18 per cent, near the plastic limit for the material.

The SPT “N”-values measured within the clayey silt till range from 12 to 55 blows per 0.3 m of penetration. The SPT “N” value of 12 blows per 0.3 m of penetration was measured immediately below the upper clayey silt, at the top of the till deposit in Borehole RW1-3. All other SPT “N” values were generally above 20 blows per 0.3 m of penetration, suggesting that the clayey silt till typically has a very stiff to hard consistency.

4.2.6 Clayey Silt Interlayers

Clayey silt interlayers were encountered within the till deposit in Boreholes RW1-1 and RW1-3 (refer to the stratigraphic profile on Drawing 1). The interlayer is approximately 4.6 m thick in Borehole RW1-1, where it was fully penetrated, and at least 4.1 m thick in Borehole RW1-3; the borehole was terminated within this layer at that location. The interlayers extend from a surface elevation of approximately 297.7 m in both boreholes, to 293.1 m in Borehole RW1-1 and to below 293.6 m in Borehole RW1-3.

The deposit consists of clayey silt containing trace sand; sand seams were noted within the samples in Borehole RW1-1. The results of grain size distribution tests completed on two samples of the clayey silt interlayer are presented on Figure B5 in Appendix B.

Atterberg limits testing was completed on two samples of the interlayers and measured plastic limits of about 17 per cent, liquid limits of 22 and 34 per cent, and plasticity indices of 5 and 17 per cent; these results, which are plotted on a plasticity chart on Figure B6 in Appendix B, confirm that the tested samples of the interlayers consist of clayey silt of low plasticity. The natural water content measured on selected samples varies from about 17 to 30 per cent.

The SPT “N”-values recorded within these interlayers range from about 8 to 19 blows in Borehole RW1-1, and about 25 to 33 blows in Borehole RW1-3, suggesting a stiff to hard consistency.

4.2.7 Lower Silt

A lower silt layer was encountered below the clayey silt till in Borehole RW1-2, at a depth of 9.2 m (Elevation 292.9 m). The borehole was terminated within the lower silt after penetrating it for a thickness of 5.1 m; the lower silt may represent an interlayer within the till, or a deposit underlying the till.

This deposit consists of silt containing trace clay. The result of a grain size distribution test completed on one sample of the deposit is shown on Figure B7 in Appendix B. An Atterberg limits test was completed on one selected sample of the lower silt, and confirmed that the deposit is non-plastic. The natural water content measured on four samples of the deposit range from about 17 to 19 per cent.



The SPT “N”-values measured within the lower silt range from 18 to 55 blows per 0.3 m of penetration, suggesting a compact to very dense relative density.

4.2.8 Groundwater Conditions

The groundwater levels in the open boreholes were measured upon completion of drilling operations. A standpipe piezometer was installed in Borehole RW1-3, sealed within the clayey silt interlayer in the till deposit, to permit monitoring of the groundwater level at this site. Details of the piezometer installation and measured groundwater levels are shown on the borehole record in Appendix A. The groundwater levels recorded in the open boreholes and piezometers are summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
RW1-1	303.3	2.5*	300.8*	December 20, 2010	Open Borehole
RW1-2	302.1	1.1*	301.0*	December 21, 2010	Open Borehole
RW1-3	304.9	0.2*	304.7*	December 21, 2010	Open Borehole
		1.5	303.4	January 2, 2011	Piezometer
		0.7	304.2	July 4, 2011	Piezometer

* Water level measurements in open borehole may not represent stabilized groundwater level.

In addition to the above water level observations, samples from the upper soil deposits in Boreholes RW1-1 and RW1-2 were observed to be wet below a depth of approximately 1 m to 1.5 m; this may represent a “perched” water table within the upper silty sand to silt and organic silt soils at these locations.

The groundwater level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and periods of precipitation.



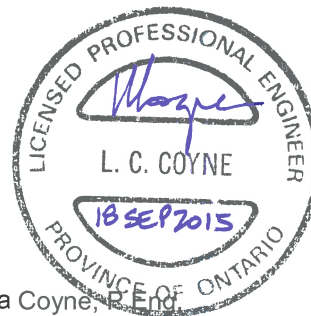
5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Haley Schafer, EIT, and reviewed by Ms. Nikol Kochmanova, P.Eng., a geotechnical engineer with Golder. Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact and Principal with Golder, conducted an independent quality control review of this report.

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REFERENCES

Chapman, L.J., and Putnam, D.F. 1984. *The Physiography of Southern Ontario*. Ontario Geological Survey, Special Volume 2, 3rd Edition. Ontario Ministry of Natural Resources.

ASTM International

ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split Barrel Sampling of Soils

ASTM D2573 Standard Test Method for Field Vane Shear Test in Cohesive Soil.

Ontario Water Resources Act

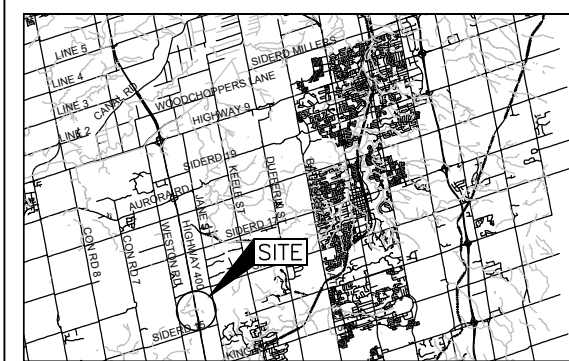
Ontario Regulation 903 Wells (as amended)

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

CONT No.
GWP No. 2835-02-00



HIGHWAY 400 WIDENING
RETAINING WALL
BOREHOLE LOCATIONS AND
SOIL STRATA



KEY PLAN
SCALE

4 0 4 8 km



LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- Standard Penetration Test Value
- Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on April 7, 2011
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
RW1-1	303.3	4867765.6	298897.5
RW1-2	302.1	4867809.7	298885.8
RW1-3	304.9	4867853.6	298880.7

NOTES

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.

REFERENCE

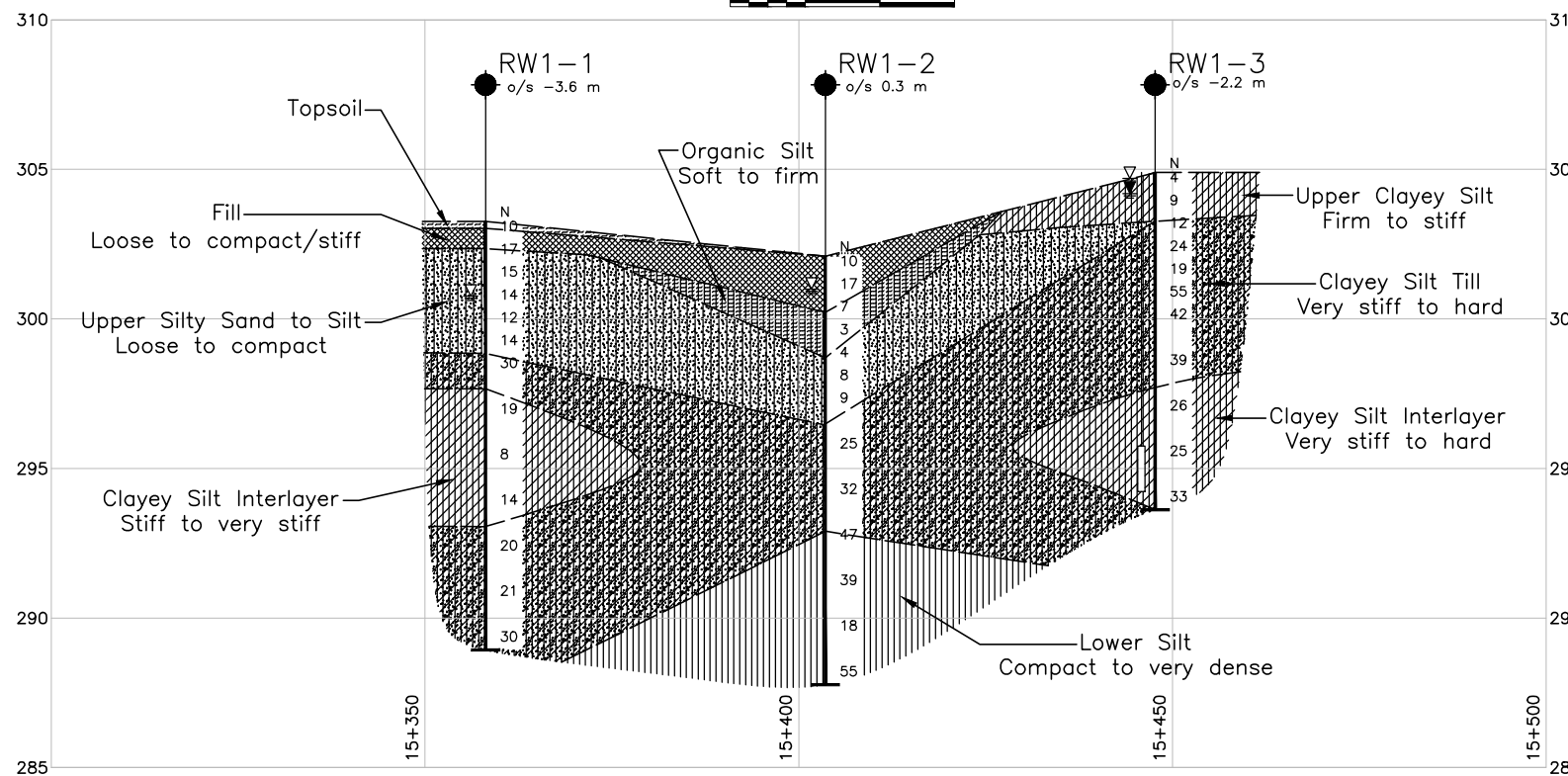
Base plans provided in digital format by URS, drawing file Hwy400_plan.dwg, received July 28, 2014 and Hwy400_contours.dwg, received July 12, 2011.

NO.	DATE	BY	REVISION
Geocres No. 30M13-213			
HWY. 400		PROJECT NO. 09-1111-0018	DIST. CENTRAL
SUBM'D. HLS	CHKD. NK	DATE: 8/21/2015	SITE: .
DRAWN: JFC	CHKD. NK	APPD. LCC	DWG. 1



PLAN
SCALE

10 0 10 20 m



PROFILE
A-A'

HORIZONTAL SCALE

10 0 10 20 m

VERTICAL SCALE

2.5 0 2.5 5 m



APPENDIX A

Borehole Records



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes: 1
2

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

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



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

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

PROJECT		2835-02-00		LOCATION		N 4867765.6 ; E 298897.5		ORIGINATED BY		TT				
DIST		Central HWY 400		BOREHOLE TYPE		D-25 Track Mount, 108 mm Outside Diameter Solid and Hollow Stem Auger		COMPILED BY		ARM				
DATUM		Geodetic		DATE		December 17 & 20, 2010		CHECKED BY		LCC				
SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	20 40 60 80 100			20 40 60 80 100	W _p W W _L	WATER CONTENT (%)			
303.3	GROUND SURFACE													
0.0	TOPSOIL													
0.2	Silty sand, containing zones of clayey silt (FILL)		1	SS	10									
302.4	Compact Brown Moist		2	SS	17									
0.9	Silty SAND, trace clay													
	Compact Brown Wet		3	SS	15									
			4	SS	14									
			5	SS	12									
299.9	CLAYEY SILT, trace to some sand, trace gravel (TILL)													
299.6	Stiff Brown and grey Moist		6	SS	14									
3.7	Silty SAND													
298.9	Compact Grey Wet		7	SS	30									
4.4	CLAYEY SILT, trace to some sand, trace gravel (TILL)													
297.7	Hard Grey Moist													
5.6	CLAYEY SILT, containing sand seams		8	SS	19									
	Stiff to very stiff Grey Moist													
			9	SS	8									
			10	SS	14									
293.1	CLAYEY SILT, trace to some sand, trace gravel (TILL)													
10.2	Very stiff to hard Grey Moist		11	SS	20									
			12	SS	21									
			13	SS	30									
289.0	END OF BOREHOLE													
14.3														

Continued Next Page

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

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

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PROJECT 09-1111-0018		RECORD OF BOREHOLE No RW1-2				SHEET 1 OF 2		METRIC				
W.P. 2835-02-00		LOCATION N 4867809.7 ; E 298885.8				ORIGINATED BY TT						
DIST Central HWY 400		BOREHOLE TYPE D-25 Track Mount, 108 mm Outside Diameter Hollow Stem Auger				COMPILED BY MAS						
DATUM Geodetic		DATE December 20 & 21, 2010				CHECKED BY LCC						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w		
302.1	GROUND SURFACE											
0.0	Silty clay, trace sand, containing rootlets (FILL)		1	SS	10							
301.6	Stiff Brown Moist											
0.5	Sand and silt, containing zones of clayey silt (FILL)		2	SS	17							
	Loose to compact Brown Moist becoming wet at a depth of 1.4 m											
300.2	Organic SILT, some sand, trace to some clay, containing rootlets, wood fragments and organics shell fragments		3	SS	7							
1.9	Soft to firm Black Wet		4	SS	3							
298.7	Containing peat at a depth of 3.4 m		5	SS	4							
3.4	SILT, trace to some sand, trace clay											
	Loose Grey Wet		6	SS	8							
			7	SS	9							
296.5	CLAYEY SILT, trace to some sand, trace gravel (TILL)											
5.6	Very stiff to hard Brown Moist		8	SS	25							
	Containing sand seams at a depth of 7.6 m											
	Becoming grey at a depth of 7.8 m		9	SS	32							
292.9	SILT, trace clay											
9.2	Compact to very dense Grey Moist		10	SS	47							
	Becoming wet at a depth of 11.7 m											
	Becoming moist at a depth of 13.3 m		12	SS	18							
			13	SS	55							
287.8	END OF BOREHOLE											
14.3												

Continued Next Page

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

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O.C. = 4.1
0 13 73 14

1 9 60 30

N.P.
0 0 93 7

PROJECT <u>09-1111-0018</u>		RECORD OF BOREHOLE No RW1-2		SHEET 2 OF 2		METRIC	
W.P. <u>2835-02-00</u>		LOCATION <u>N 4867809.7 ; E 298885.8</u>		ORIGINATED BY <u>TT</u>			
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>D-25 Track Mount, 108 mm Outside Diameter Hollow Stem Auger</u>		COMPILED BY <u>MAS</u>			
DATUM <u>Geodetic</u>		DATE <u>December 20 & 21, 2010</u>		CHECKED BY <u>LCC</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL			
								20	40	60	80	100	20	40	60		80	100	10	20	30		
	--- CONTINUED FROM PREVIOUS PAGE --- NOTES: 1. Water level in open borehole at a depth of 1.1 m (Elev. 301.0 m) upon completion of drilling. 2. Borehole caved at a depth of 6.5 m (Elev. 295.6 m) upon completion of drilling.																						

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PROJECT 09-1111-0018		RECORD OF BOREHOLE No RW1-3		SHEET 1 OF 1		METRIC	
W.P. 2835-02-00		LOCATION N 4867853.6 ; E 298880.7		ORIGINATED BY TT			
DIST Central HWY 400		BOREHOLE TYPE D-25 Track Mount, 108 mm Outside Diameter Hollow Stem Auger		COMPILED BY ARM			
DATUM Geodetic		DATE December 21, 2010		CHECKED BY LCC			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT 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
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	20	40	60	80	100	W _P	W		W _L			
304.9	GROUND SURFACE																			
0.0	CLAYEY SILT with sand, containing rootlets and organics Firm to stiff Brown Moist becoming wet at a depth of 0.8 m		1	SS	4															
			2	SS	9									○						
303.3																				
1.6	CLAYEY SILT, some sand, trace gravel (TILL) Stiff to hard Brown and grey Moist		3	SS	12									○						
			4	SS	24									● —				2	13	
			5	SS	19									○				58	27	
			6	SS	55									○						
	Containing zones of oxidation at a depth of 4.6 m		7	SS	42									○ —						
	Containing a sand seam at a depth of 6.2 m		8	SS	39									○						
297.7																				
7.2	CLAYEY SILT Very stiff to hard Grey Wet		9	SS	26									○						
			10	SS	25									— ●				0	0	
																		90	10	
293.6			11	SS	33									○						
11.3	END OF BOREHOLE NOTES: 1. Water level in open borehole at a depth of 0.2 m (Elev. 304.7 m) upon completion of drilling. 2. Borehole caved at a depth of 9.8 m (Elev. 296.4 m) upon completion of drilling. 3. Water level measurements in piezometer: Date Depth (m) Elev. (m) 02/01/11 1.5 303.4 04/07/11 0.7 304.2																			

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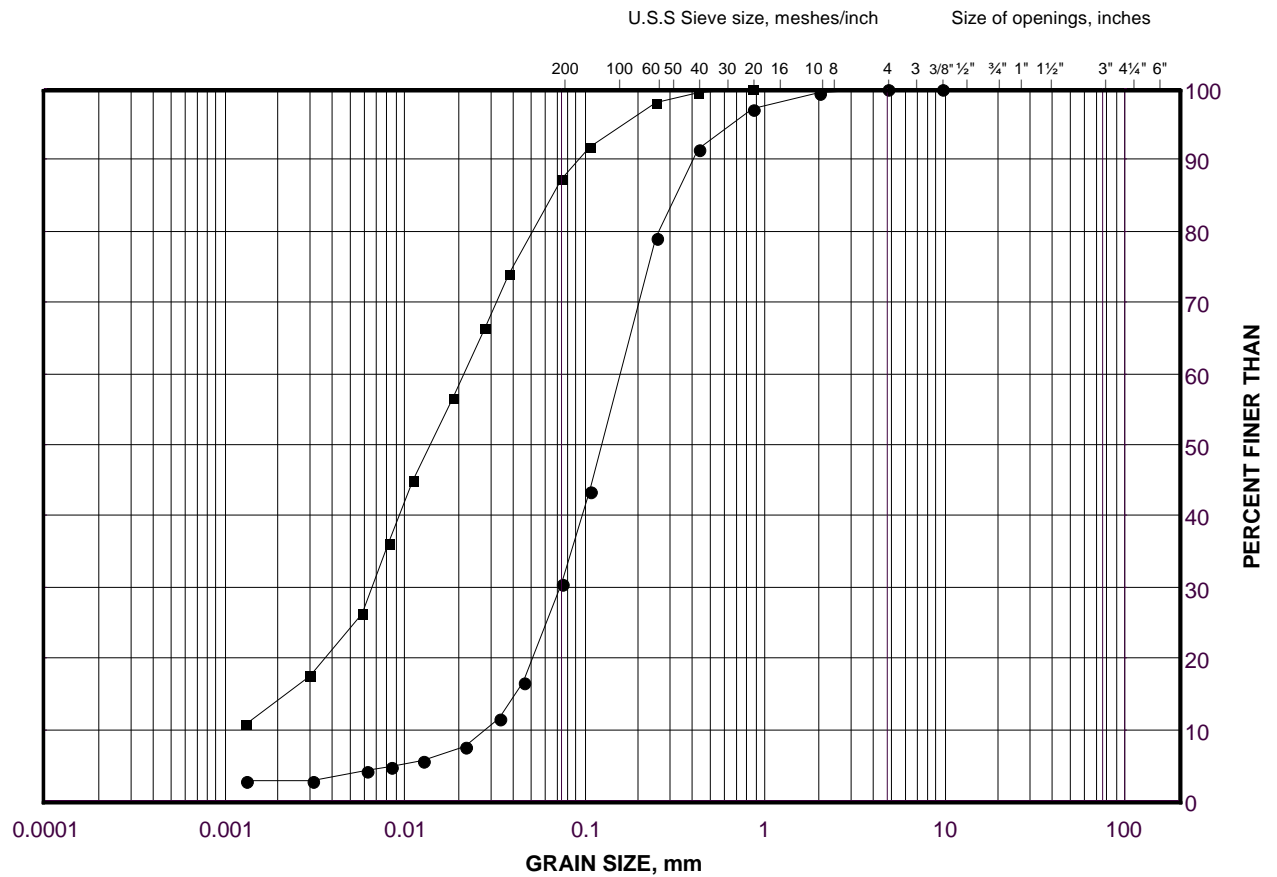
APPENDIX B

Geotechnical Laboratory Test Results

Upper Silty Sand and Organic Silt

Upper Silty Sand and Organic Silt

FIGURE B1



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

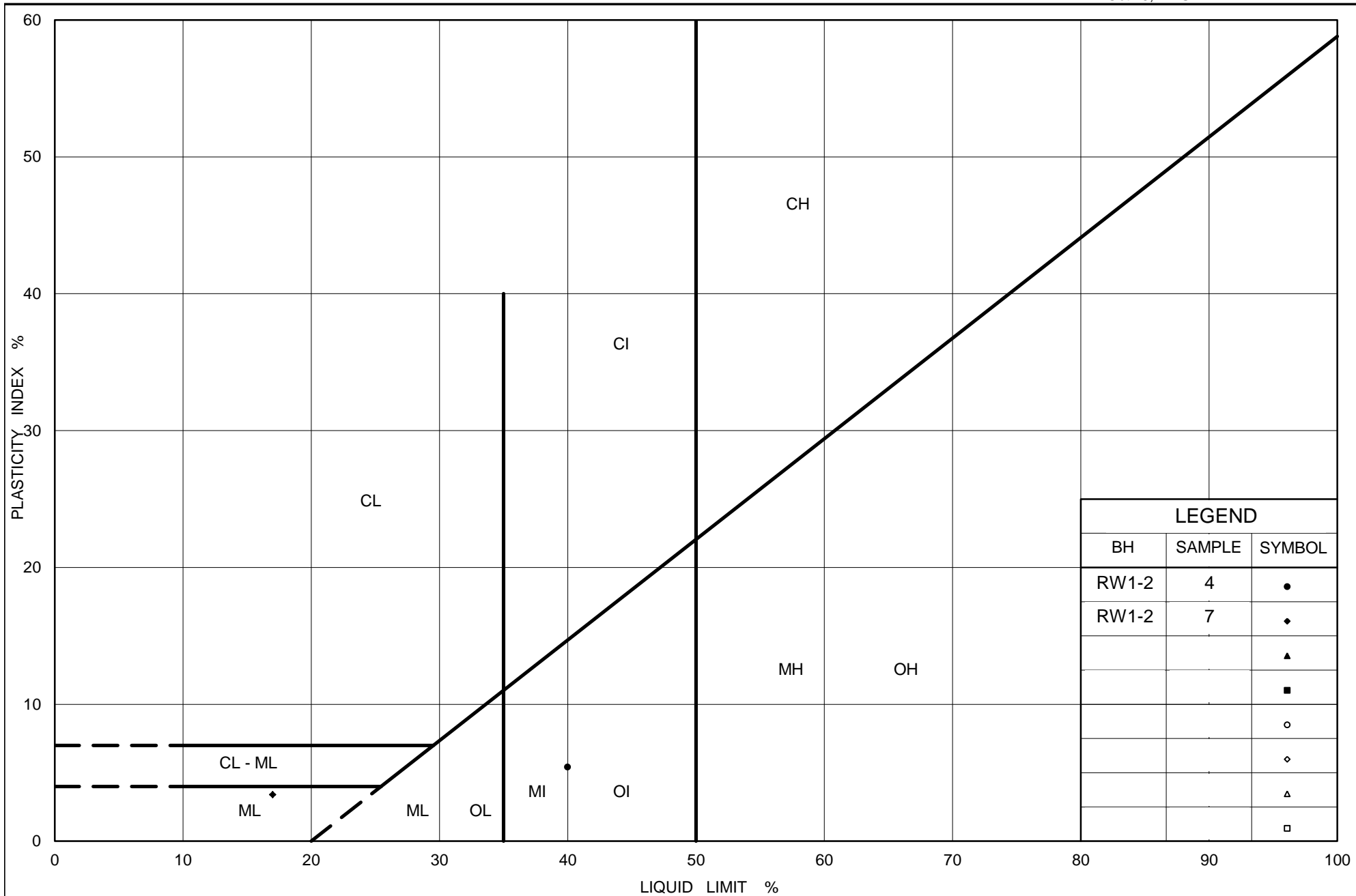
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	RW1-1	4	300.7
■	RW1-2	4	299.5

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Checked By: LCC

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Date: 21-Aug-15



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PLASTICITY CHART

Upper Silt and Organic Silt

Figure No. B2

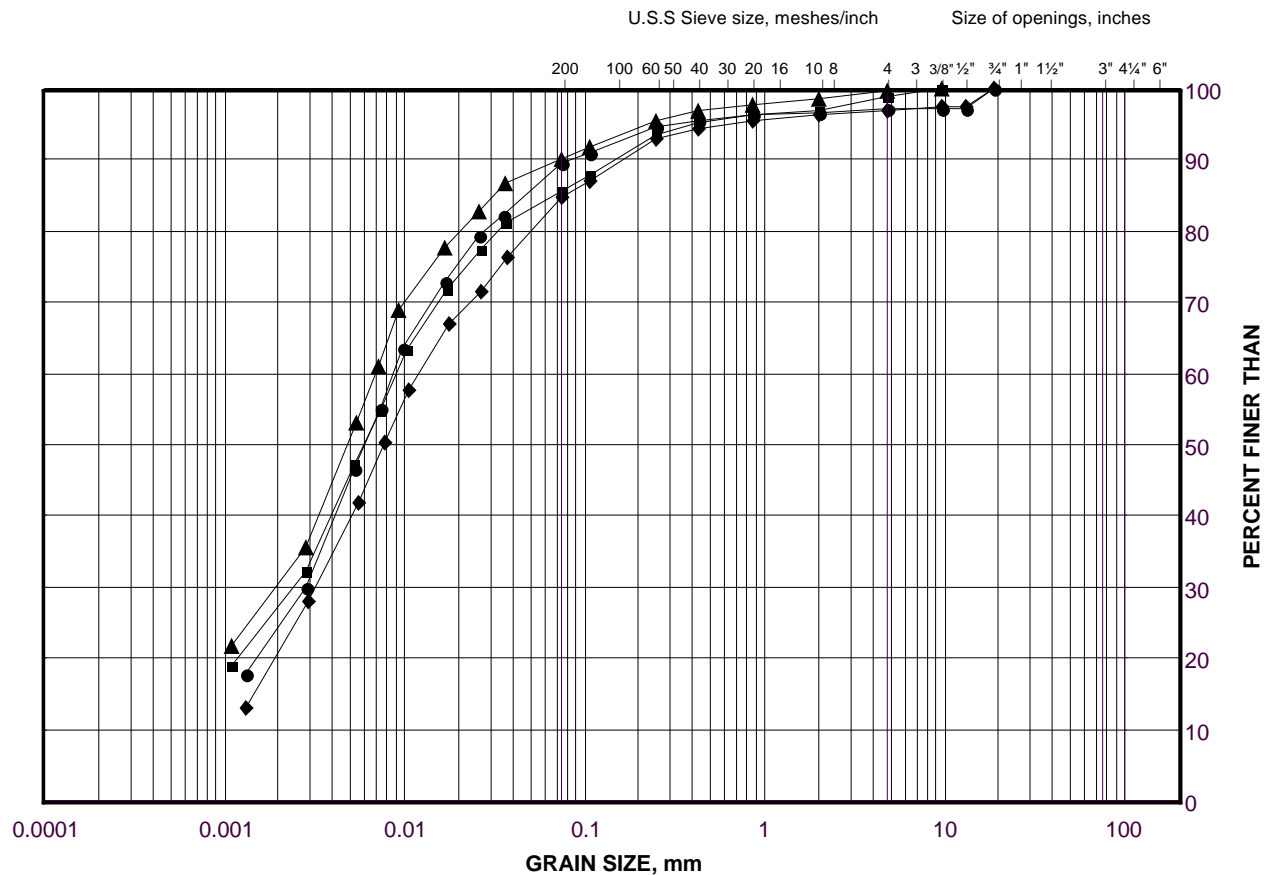
Project No. 09-1111-0018

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GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIGURE B3



LEGEND

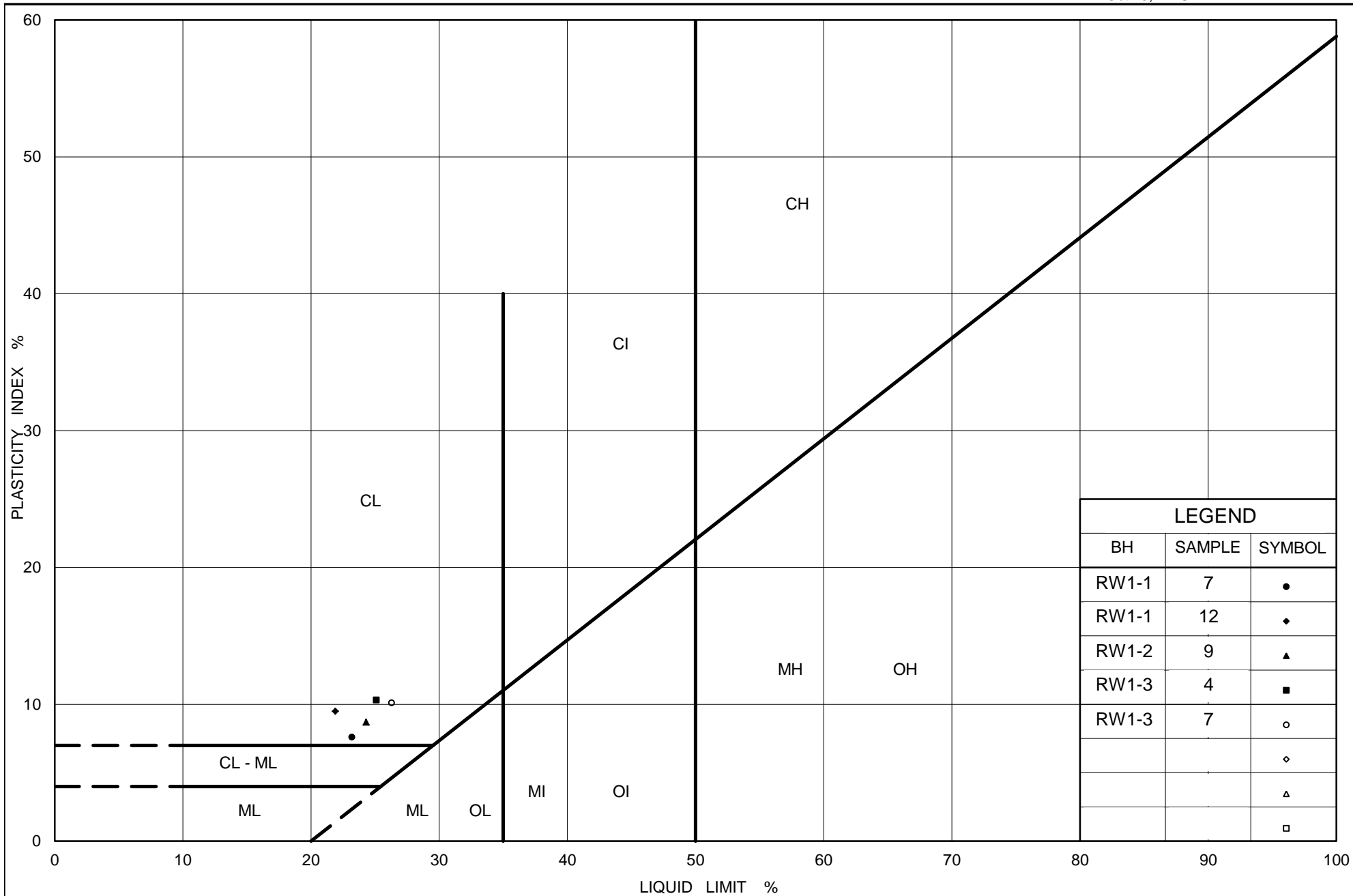
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	RW1-1	12	290.8
■	RW1-3	4	302.3
◆	RW1-1	7	298.4
▲	RW1-2	9	294.2

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PLASTICITY CHART

Clayey Silt Till

Figure No. B4

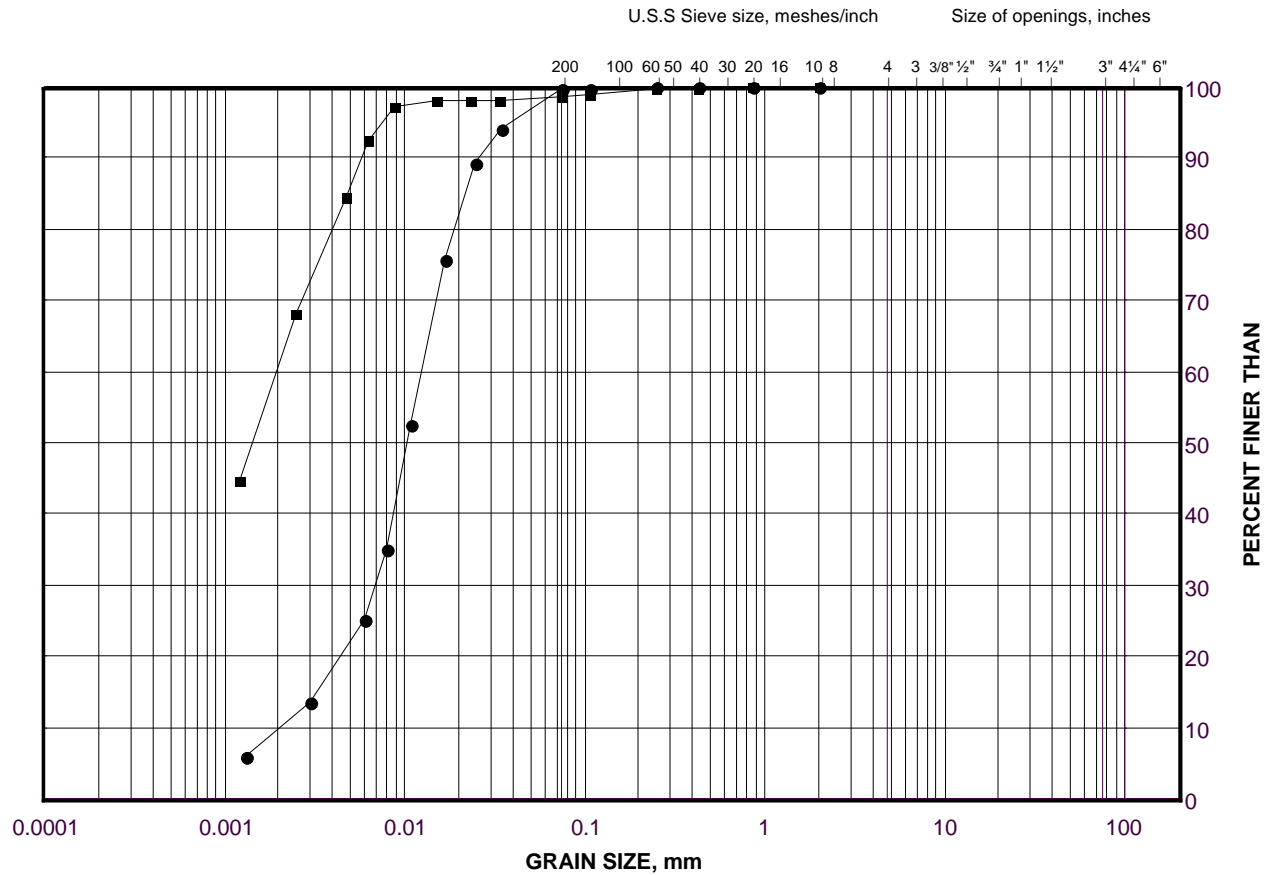
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GRAIN SIZE DISTRIBUTION

Clayey Silt Interlayers

FIGURE B5



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

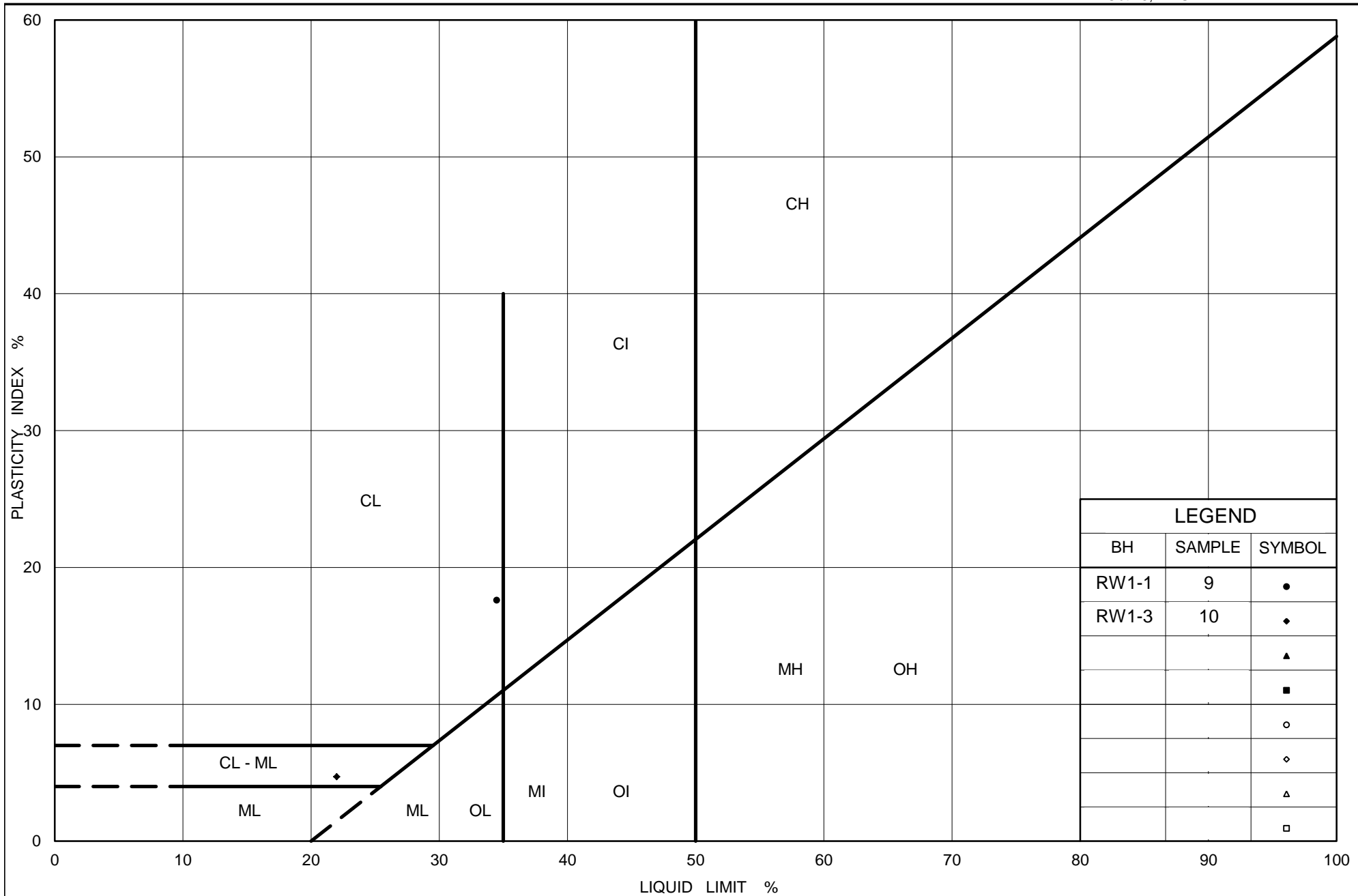
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	RW1-3	10	295.5
■	RW1-1	9	295.4

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PLASTICITY CHART

Clayey Silt Interlayers

Figure No. B6

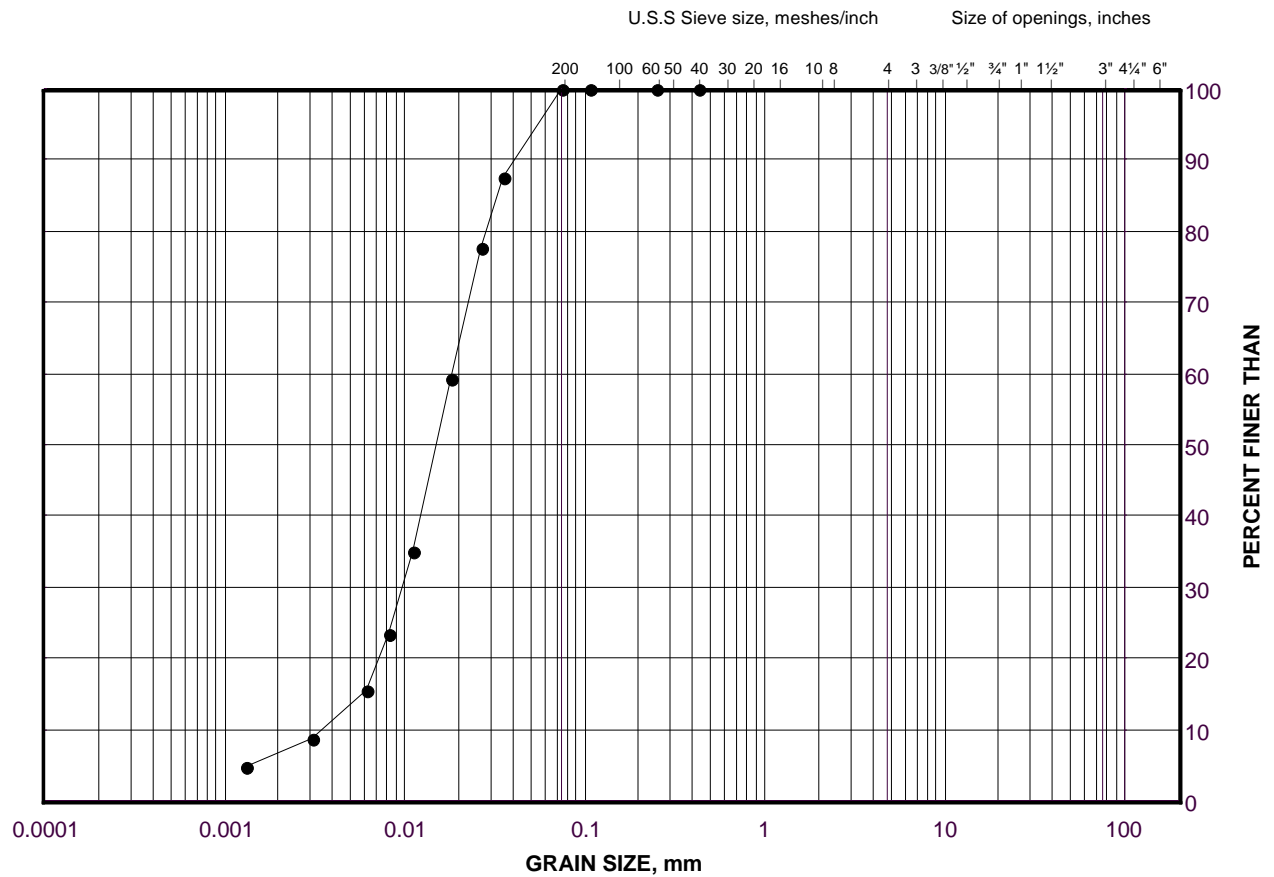
Project No. 09-1111-0018

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GRAIN SIZE DISTRIBUTION

Lower Silt

FIGURE B7



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	RW1-2	11	291.1

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Date: 21-Aug-15

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