GOLDER
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REPORT

Hydrogeological Report

Hydrogeology
Coleraine Drive
Caledon, Ontario

Submitted to:

CIMA+
3027 Harvester Road
Suite 400
Burlington, Ontario
L7N 3G7

Submitted by:

Golder Associates Ltd.
210 Sheldon Drive, Cambridge, Ontario, N1T 1A8, Canada
+1 519 620 1222

1665649 (2000)

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Executive Summary

This report presents the results of an investigation to determine the hydrogeological conditions along a section of Coleraine Drive as part of a Class Environmental Assessment of various reconfiguration alternatives including different road-rail grade separation options.

Boreholes advanced along Coleraine Drive revealed soil conditions consisting of a mixture of fine-textured and low permeability glaciolacustrine sediments and glacial till beneath shallow fill deposits. These soils are characterized by a low hydraulic conductivity and groundwater control in temporary construction excavations should present no unusual difficulties. The predicted radius of influence for temporary (or permanent) dewatering is less than the distance to environmentally sensitive receptors or water supply wells.

The stabilized groundwater table is relatively shallow and the soils are potentially susceptible to internal erosion. Any road-under-rail grade separation will require measures to permanently manage groundwater seepage and adequate systems to prevent ground loss.

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by CIMA+ (CIMA) on behalf of the Regional Municipality of Peel (Region) to provide geotechnical and pavement engineering services in support of the Class Environmental Assessment study for a road-rail grade separation of Coleraine Drive from Holland Drive to Harvest Moon Drive, in the Town of Caledon, Ontario (see Figure 1).

The scope of Golder's assignment included the review of background information and the completion of technical studies as part of the Class Environmental Assessment (EA) process (Schedule "C"). It is understood that consideration is being given to widening of the existing road plus a multi-use trail and boulevard in each direction. The widening of the road will also require re-alignment of the retaining wall, south of Harvest Moon Drive and grade separation between the road and the CP rail line. It is understood that a retaining wall will be required in this area to support the widening of Coleraine Drive.

This report provides a summary of subsurface soil and groundwater conditions at the site by means of a limited number of boreholes and, based on our interpretation of the data, provides preliminary engineering recommendations on the hydrogeological aspects of design of the project. This report should be read in conjunction with the accompanying geotechnical and pavement investigation report. While the hydrogeological and geotechnical aspects of the work were closely integrated, this document is focused on the hydrogeological aspects of the work.

2.0 SITE DESCRIPTION

The subject lands are located along the northern edge of a gently undulating plain with an elevation ranging from 250 to 260 mASL and having a gradual southward slope in the direction of Lake Ontario. To the immediate north of the site, the ground surface falls away toward the main branch of the Humber River which occurs at an elevation of approximately 220 mASL. A tributary of the Humber River crosses the northern portion of the Site. A storm water management ("SWM") pond is present west of the northern portion of Coleraine Drive which drains to this tributary.

The area is underlain by shale and limestone bedrock of the upper Ordovician Age Queenston and Georgian Bay Formations. The Queenston Formation weathers readily to a sticky red clay material and is prone to formation of "badlands" topography. Below the Queenston shale is another thick shale unit (Georgian Bay Formation) composed of layers of dark grey shale with thin limestone interbeds. Overlying the bedrock is a thick sequence made up of multiple glacial till deposits intercalated with fine-textured glaciolacustrine strata and localized sands and gravels that occur as localized lenses of buried alluvium within valleys eroded in the buried bedrock surface. Halton Till forms the upper glacial till in the area. The till was deposited during the Port Huron Stadial (about 13,000 years ago) by glacial ice advancing from the Lake Ontario basin. Halton Till is a fine textured clayey silt material that is frequently fractured, particularly in locations where the in situ moisture content of the material is below the plastic limit.

Shallow, localized deposits of loose silt and/or soft clay can overlie this uppermost till sheet, and these represent relatively recent deposits, formed in small glacial meltwater ponds scattered throughout the Peel Plain and concentrated near river valleys. The recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand and silt.

Regional groundwater flow in the underlying aquifers is typically to the southeast toward Lake Ontario although local groundwater flow is expected to be influenced by the Humber River, with tributaries located north and south of the Site. Buried utilities, underground structures, and septic systems can affect local (shallow) groundwater flow conditions. This section of Coleraine Drive is located within an urbanized area where full municipal services are available throughout. Groundwater is not generally used as a source of potable water supply in the immediate area.

3.0 INVESTIGATION PROCEDURES

The initial task in the hydrogeological investigation was a review of available information to characterize existing groundwater conditions and identify any potential issues associated with the permanent infrastructure or construction dewatering activities. Information sources include topographic and geologic mapping, aerial photography and Ministry of the Environment, Conservation and Parks (MECP) Water Well Records. Our work focussed on the shallow aquifers that could be affected by the grade separation. In addition, a site and area reconnaissance was carried out to identify any private wells or septic systems that may exist within the likely radius of groundwater influence for any site works. The need for construction dewatering was assessed including estimating flow rates and determining the zone of influence. The dewatering assessment was conducted to determine if a MECP Permit to Take Water (PTTW) or Environmental Activity and Sector Registry (EASR) registrations will be required for construction of the works.

The field work for the geotechnical and pavement investigation at Coleraine Drive was carried out between March 20, 2017 and July 14, 2017, during which time a total of fifteen boreholes (designated as Borehole BH17-01 to BH17-15) were advanced at the locations shown on Figure 1, Borehole Location Plan.

The boreholes were advanced using a CME-75 truck-mounted drill rig supplied and operated by a specialist drilling contractor, subcontracted to Golder. Standard Penetration Testing (SPT) and sampling were carried out at regular intervals of depth in the boreholes using conventional 35 mm internal diameter split spoon sampling equipment advanced using an automatic hammer in accordance with ASTM D1586 99[1]. The shallow groundwater conditions were noted in the open boreholes during drilling. Four monitoring wells were installed at the location of Borehole BH17-04, BH17-07, BH17-09 and BH17-14, to permit further monitoring of the groundwater levels and future groundwater sampling. The standpipe piezometers consist of 50 mm diameter PVC pipe, with a slotted screen sealed at a selected depth within the boreholes. The borehole and annulus surrounding the piezometer pipe above the screen sand pack was backfilled to the ground surface with bentonite pellets/grout, in accordance with Ontario Regulation 903 (as amended). Standpipe piezometer installation details and water level readings are described on the Record of Borehole sheets presented in Appendix A. In the boreholes not instrumented with a standpipe piezometer, a cement/bentonite grout or bentonite pellets were used to backfill the boreholes in accordance with Ontario Regulation 903 (as amended) and restored with asphalt at road surface upon completion of drilling.

The field work was observed by a member of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground utilities, supervised the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's geotechnical laboratory in Mississauga, Ontario

[1] ASTM D1586-11 – Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.

where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to ASTM standards, as appropriate. Classification testing (water content determination, grain size distribution, and Atterberg limits) was carried out on selected soil samples the results of which are provided in Appendix B.

An in situ hydraulic conductivity test (falling head) was carried out for the standpipe piezometer installed in Borehole 17-09 on March 29, 2017. An instantaneous slug of a known volume was deployed down the standpipe piezometer and the falling hydraulic head was recorded with pressure transducers below the slug. The data obtained from the datalogger during the falling head testing is presented in Appendix C.

4.0 SUBSURFACE CONDITIONS

The subsurface soil and shallow groundwater conditions encountered in the boreholes, as well as the results of the field and laboratory testing, are shown in detail on the Record of Boreholes sheets, following the text of this report. Method of Soil Classification and Symbols and Terms Used on Records of Boreholes are provided to assist in the interpretation of the borehole logs. It should be noted that the boundaries between the strata have been inferred from drilling observations and non-continuous samples. They generally represent a transition from one soil type to another and should not be inferred to represent an exact plane of geological change. Further, conditions will vary between and beyond the boreholes. The following is a summarized account of the subsurface conditions encountered in the boreholes drilled during this investigation, followed by more detailed descriptions of the major soil strata and shallow groundwater conditions.

4.1 Soil Conditions

In general, boreholes encountered the pavement structure at ground surface, underlain by granular fill materials comprised of gravelly sand to sand and gravel to gravelly silty sand, underlain by a silty clay fill (disturbed/reworked till). The fill material is underlain by a till deposit consisting of stiff to hard silty clay in all boreholes. In Borehole BH17-08 and BH17-09 the till material is underlain by deposit of silt deposit which in turn is underlain by a cohesive silty clay/clayey silt deposit.

Details of the observations of the groundwater during and upon completion of drilling are provided on the Record of Boreholes and summarized below:

Fill – (SP-SM) to (SM) Gravelly Sand to Silty Sand

A 180 mm to 240 mm thick layer of asphalt (average thickness of 212 mm) was encountered at ground surface in all boreholes.

Approximately 0.4 m to 2.8 m of non-cohesive (granular) fill was encountered below the asphalt layer in all boreholes locations. The non-cohesive fill is comprised of sand and gravel to gravelly sand to silty sand and extends to depths of 0.6 m to 3 m.

The SPT ‘N’-values measured within the non-cohesive fill layer range from 6 blows to 67 blows per 0.3 m of penetration, indicating a loose to very dense state of compactness.

The natural water contents measured on samples of the fill range from about 4 per cent to 12 per cent.

The results of grain size analyses carried out on five samples of the non-cohesive fill are presented on Figure B1. In general, the samples were within the gradation envelope of Granular 'B' Type I with the exception of the material passing the 75 µm sieve which exceeded the allowable limit.

Fill – (CL/CI) Silty Clay

Approximately 0.4 m to 1.5 m of cohesive fill was encountered underlying the granular fill in Boreholes BH17-02, BH17-03, BH17-06, BH17-07, BH17-08, BH17-11 and BH17-14. The cohesive fill is comprised of low to intermediate plasticity silty clay and generally contains organics and brick and wood fragments.

The SPT 'N'-values of the fill material typically range from 5 blows to 22 blows per 0.3 m of penetration, suggesting a firm to very stiff consistency.

The natural water content typically ranges from about 10 per cent to 23 per cent.

(CL/CI) Silty Clay

A deposit of silty clay was encountered below the fill in Boreholes BH17-01, BH17-07 to BH17-13 and BH17-15. In Boreholes BH17-01, BH17-08, BH17-09 and BH17-15, the silty clay deposit was found to be between 1.1 m and 3.4 m thick. All other boreholes were terminated within this deposit at a depth of 5.2 m, corresponding to depths of penetration up to 4.3 m into the deposit. The SPT 'N'-values within this deposit range from 7 to 25 blows per 0.3 m penetration, suggesting a firm to very stiff consistency.

The natural water contents measured on samples from this deposit range from about 21 per cent to 28 per cent.

The results of grain size analyses carried out on samples of this deposit are presented on Figure B2. The grain size analyses that were completed indicated that the material has a low frost susceptibility.

Atterberg limits tests were carried out on four samples of the silty clay deposit and measured liquid limits between 26 and 49 per cent, plastic limits between 14 and 21 per cent, corresponding to plasticity indices between 12 and 28 per cent as shown on Figure B3.

In Borehole BH17-15, a 1.6 m thick silt interlayer was encountered within the silty clay deposit at a depth of 2.1 m. The SPT 'N'-values of the silt interlayer range from 28 blows to 44 blows per 0.3 m of penetration, indicating a very stiff to hard consistency.

A natural water content of 17 per cent was measured on a sample of silt interlayer.

An Atterberg limits test was carried out on a sample of silt deposit and measured a liquid limit about 22 per cent, a plastic limit about 20 per cent, corresponding to a plasticity index about 2 per cent. The result of the Atterberg limits tests is shown on the plasticity chart on Figure B4 and indicated that the material is classified as a silt of slight plasticity.

(CL/CI) Silty Clay Till – Upper

A cohesive till deposit comprised of silty clay was encountered below the fill or the silty clay deposit in Boreholes BH17-01 to BH17-06, BH17-08, BH17-09 and BH17-14 to BH17-16 at depths ranging from 0.9 m to 5.5 m. In Boreholes BH17-08 and BH17-09, the silty clay till deposit was 9 m and 6.1 m respectively. Boreholes BH17-01 to 17-06 were terminated within this deposit at a depth of 5.2 m, corresponding to depths of penetration up to 4.3 m.

In general, the SPT 'N'-values within the upper till deposit range from 13 blows to 35 blows per 0.3 m of penetration, suggesting a stiff to hard consistency.

The natural water contents measured on samples of the till deposit range from about 12 per cent to 25 per cent.

The results of grain size analyses carried out on samples of the silty clay till deposit are shown on Figure B5.

An Atterberg limits test was carried out on a sample of the cohesive till deposit and measured a liquid limit of about 24 per cent, a plastic limit of about 13 per cent, and a corresponding plasticity index of about 10 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure B6 and indicates that the material is classified as a silty clay of low plasticity.

(CL-ML) Silty Clay-Clayey Silt

In Boreholes BH17-08 and BH17-09, a cohesive deposit of silty clay-clayey silt, between 6 m and 7.6 m thick, was encountered below the till deposit at depths of 11.8 m and 12.1 m, respectively.

The SPT 'N'-values within the silty clay-clayey silt deposit range from 11 blows to 32 blows per 0.3 m of penetration, suggesting a stiff to hard consistency.

The natural water contents measured on samples of this deposit range from about 17 per cent to 29 per cent.

A grain size distribution analysis was carried out on a sample of this deposit as shown on Figure B7.

(CL) Sandy Silty Clay to Silty Clay (Till) – Lower

A lower till deposit comprised of sandy silty clay to silty clay was encountered below the silty-clay-clayey silt deposit at depths of 17.8 m and 19.4 m, respectively. The lower till deposit is between 1.1 m and 2.7 m thick prior to depth of borehole termination.

The SPT 'N'-values within the lower till deposit range from 16 blows to 32 blows per 0.3 m of penetration, suggesting a very stiff to hard consistency.

The natural water content measured on a sample of the till deposit is about 14 per cent.

A grain size distribution analysis was carried out on a sample of this deposit as shown on Figure B8.

An Atterberg limits test was carried out on a sample of this deposit and measured a liquid limit of about 21 per cent, a plastic limit of about 13 per cent, and a corresponding plasticity index of about 8 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure B9 and indicates that the material is classified as a silty clay of low plasticity.

4.2 Groundwater Conditions

Details of the groundwater levels observed in the open boreholes and monitoring wells are summarized on the Records for Boreholes in Appendix A of this report. No free groundwater was observed in the boreholes during drilling. As the groundwater table is judged to be relatively shallow in the area based on water levels observed in the monitoring wells, the absence of free groundwater during drilling is an indication of low soil permeability rather than a low groundwater elevation.

A summary of the measured groundwater levels in the open boreholes on completion of drilling and in the monitoring wells are presented in Table 1 below:

Table 1: Summary of Groundwater Conditions

Borehole Number	Depth to Groundwater Level below Existing Ground Surface (m)	Approximate Elevation of Groundwater Level (m)	Date
BH17-04	2.7	253.2	July 14, 2017
BH17-07	2.8	255.8	July 14, 2017
BH17-09	4.4	254.7	July 14, 2017
BH17-14	Dry	--	July 14, 2017

Note: Borehole elevations have been estimated by interpolation and should not be used for design purposes.

The absence of free groundwater in some of the boreholes is consistent with the low hydraulic conductivity estimated from in situ slug testing on BH17-09 and from grain size distribution analyses (i.e. Hazens method). Some of the levels provided in the above table are for boreholes drilled in low permeability materials and would not have stabilized by the time that the borehole was backfilled. The water level at the site will also fluctuate seasonally in response to changes in precipitation and snow melt and is expected to be higher during wet periods of the year.

4.3 Hydraulic Conductivity of Overburden Soils

The permeability of the soil was estimated using the results of the slug test performed on BH17-09 and using the Hazen method (d_{10}^2) based on the results of the grain size distribution tests carried out on selected soil samples. The estimates of hydraulic conductivity are summarized in Table 2:

Table 2: Summary of Hydraulic Conductivity Estimates

Borehole	Sample	Depth (m)	K (m/s)	Method	Soil Description
BH17-09	N/A	16.7 – 19.7	5.0×10^{-6}	Hvorslev	Silt and Clayey Silt
BH17-09	6	3.81 - 4.42	9.0×10^{-10}	Hazen	Silty Clay
BH17-09	14	15.24 - 15.85	2.3×10^{-8}	Hazen	Clayey silt
BH17-09	17	19.85 - 20.42	8.1×10^{-9}	Hazen	Silty Clay

The hydraulic conductivity estimates values range from approximately 5×10^{-6} m/s to 9×10^{-10} m/s with an arithmetic mean of 1.3×10^{-6} m/s^{-1}, a geometric mean of 3×10^{-8} m s^{-1}.

Many of the tested samples are clay-rich and cohesive, which violates the empirical foundation for Hazen's method. The estimates made using the Hazen method are included for reference purposes, but it is understood that fracture permeability likely predominates for clay-rich and cohesive samples where such samples have in situ moisture contents close to or below the plastic limit (and hence able to maintain open fractures).

5.0 DEWATERING IN SUPPORT OF CONSTRUCTION

The construction of underground services (water, storm, and sanitary sewer) involve the excavation of service trenches along a portion of Coleraine Drive and these will penetrate below the groundwater table over much of the alignment. Deeper excavations will also be required for the road-under-rail grade separation alternative. Preliminary drawings show that the road-under-rail alternative would have a road surface of approximately 250 mASL at the invert. This elevation is approximately 7 m below the stabilized groundwater table in the area.

Groundwater control can likely be achieved for shallow temporary excavations (e.g. service trenches) using conventional pumping equipment in properly constructed and filtered sumps. For deeper and permanent excavations (i.e. a road-under-rail grade separation) dewatering measures will be permanent and must include the provision of filter layers to prevent progressive soil loss through internal erosion. We note that O.Reg. 63/16 permits EASR registration for temporary construction dewatering projects that exceed 50,000 L/day combined stormwater and groundwater but that do not exceed 400,000 L/day. EASR registration does not apply for permanent dewatering systems such as the road-under-rail grade separation contemplated for the site. Permanent dewatering systems would require a PTTW should they exceed the 50,000 L/day threshold.

5.1 Dewatering Radius of Influence

Based on the grain size analysis and slug test results, the arithmetic mean hydraulic conductivity of the predominant clayey silt soils is 1.3×10^{-6} m s^{-1} with lenses of higher permeability strata likely present in localized areas. It is assumed that the dewatering is carried out in perpetuity for a road-under-rail grade separation with an invert 7 m below the groundwater level. The dewatering zone of influence may be estimated using the Sichardt formula:

$$R = r_e + 1750(H - h)\sqrt{K} \quad (1)$$

Where,

R is the radius of influence in an unconfined aquifer (m);

r_e is the equivalent radius of the excavation (m);

H is the initial saturated head in the unconfined aquifer (m);

h is the hydraulic head of the dewatered aquifer; and

K is hydraulic conductivity (m/s).

This approach yields a radius of influence of approximately 35 m. We note that localized zones of higher permeability soils will be associated with a locally greater radius of influence. Excavations of the installation of utility trenches will have a smaller zone of influence than that estimated for the road-under-rail grade separation.

5.2 Estimated Dewatering Rates (Steady State)

Based on the hydraulic conductivity of the predominant clayey silt soils and the estimated radius of influence, the steady-state inflows may be estimated using the method of Marinelli and Niccoli (1998):

$$h_0 = \sqrt{h_p{}^2 + \frac{W}{k_h}\left[r_o{}^2 \ln\left(\frac{r_0}{R}\right)\right] - \frac{(r_0{}^2 - R^2)}{2}} \quad (2)$$

Where,

h_0 is the height of the water table at radius of influence (m);

h_p is the saturated thickness of the seepage face (m);

k_h is the horizontal hydraulic conductivity (m/d);

r_0 is the radius of the excavation (m);

R is the radius of influence (m); and

W is the groundwater recharge flux (m/d).

Alternatively, the method of Mansur and Kaufman (1962) may be used:

$$Q = \left(0.73 + 0.27\frac{(H-h\ )}{H}\right)\frac{Kx}{2R}(H^2 - h^{\ 2}) \quad (3)$$

Q is the pumping rate (m^3/day);

K is hydraulic conductivity (m/day);

R is the radius of influence (m);

H is the initial saturated head in the unconfined aquifer at radius of influence R (m);

h is the hydraulic head of the dewatered aquifer; and

x is the length of the base of the excavation (m).

Both methods yield similar estimates of between 40 and 50 m^3/day under steady-state conditions. Use of the lower geometric mean conductivity (3×10^{-8} m s^{-1}) results in a significantly lower estimate of steady-state dewatering rates.

5.3 Estimated Dewatering Rates (Transient)

Transient inflows were estimated using a method developed by Carslaw and Jaeger (1959), for unconfined flow of bank storage into an excavation and using the Charni (1951) approximation for effective transmissivity. This method gives an estimated Q (m^3/day) through a unit “slice” perpendicular to the excavation perimeter and is calculated as follows:

$$Q\big|_{x=0} = -T\frac{\partial h}{\partial x} = T\frac{\partial}{\partial x}\left[H_o erf\left\{\left(\frac{\eta_e x^2}{4\bar{T}t}\right)^{0.5}\right\}\right]\Bigg|_{x=0} \quad (4)$$

$$= H_0 \sqrt{\frac{\eta_e \overline{T}}{\pi t}} P$$

Where,

Q = pumping rate (m^3/day);

η_e = effective porosity (assume 0.2 for most overburden soils)

$\overline{T}$ = effective transmissivity using the Charni (1951) approximation (i.e. $\overline{T} = 0.347T$)

t = time in days

H_0 = height of dewatering (approx. 7 m); and

P = Perimeter of excavation (m).

This solution results in an estimate of total inflow as a function of time. Care should be taken in interpreting maximum daily flow from this data due both to the uncertainties involved in parameter estimation and because construction of the modelled 200 m long excavation cannot occur instantaneously. The modelled 200 m length of excavation is also conservative as the depth of the excavation would on average be less than 7 m below the groundwater table. Estimated groundwater influx as a function of time is summarized in Table 3.

Table 3: Modelled Construction Dewatering Rates (road-under-rail)

Model parameters	Modelled Scenario	
	Arithmetic mean	Geometric mean
K (m s^{-1})	1.3 x 10^{-6}	3.0 x 10^{-8}
Effective Porosity, η_e	0.2	0.2
Perimeter of Excavation (m)	450	450
Dewatering Elevation, h (m)	3	3
Initial Groundwater height, h_0 (m):	10	10
Initial Transmissivity	0.786	0.018
Ave. Charni Transmissivity	0.273	0.006
Model results		
Time (days)	Q (m^3/day)	Q (m^3/day)
1	415.1	63.1
2	293.5	44.6
3	239.7	36.4

Model parameters	Modelled Scenario	
	Arithmetic mean	Geometric mean
5	185.7	28.2
10	131.3	19.9
30	75.8	11.5
60	53.6	8.1

1. Method is Carslaw and Jaeger (1959), for unconfined flow from bank storage
2. Assumes a fully penetrating slot 200 m in length into a homogeneous unconfined aquifer of infinite extent
3. Surface water inputs have been ignored

Using the estimated arithmetic hydraulic conductivity of the overburden soils (1.3 x 10^{-6} m s^{-1}) and an assumed effective porosity of 0.2, the groundwater inflow to the excavation is estimated to initially be in the range of 400 m^3/day decreasing to about 75 m^3/day after about 30 days. Repeating the same analysis using the geometric mean of the estimated hydraulic conductivity values (i.e. K = 3 x 10^{-8} m s^{-1}) results in an initial influx of approximately 60 m^3/day decreasing to approximately 10 m^3/day after 30 days. The dewatering rate for the proposed excavation should also consider the removal of stormwater from direct precipitation inflow. However, if the trench is appropriately bermed to divert overland flow, the amount of direct precipitation falling into the trench will be minor due to the small footprint of the excavation.

Based on the transient estimate of groundwater inflows, it is likely that construction dewatering for temporary service trench excavations would exceed 50 m^3/day and require an EASR unless the service trenching was carried out in short sections. A hypothetical permanent dewatering system for a road-under-rail grade separation is predicted to pump less than 50 m^3/day and hence will not require a PTTW nor EASR (assuming that stormwater management is handled separately).

5.4 Potential Effects Related to Construction Dewatering

This section of Coleraine Drive is located within the urban area where full municipal services are available throughout. Groundwater is not generally used as a source of potable water supply in this area, however, precipitation infiltrating within the area contributes to the regional groundwater system, which sustains baseflow to a number of small creeks and wetland features.

The area and its surrounding lands are located outside any mapped Wellhead Protection Areas (WHPA). No water supply wells are located within the estimated ZOI for the water taking. No significant wetland areas or cold water fisheries are known to occur within the estimated ZOI of the water taking. For these reasons, potential to impact drinking water supply wells or environmental/ecological features in the vicinity of the site is considered low provided that adequate measures are taken to ensure that water discharged from construction excavations is low in suspended solids and dissolved contaminants.

Lowering of the groundwater table during the temporary excavation work has the potential to cause settlement of the soils within the depth of dewatering, due to an increase in the effective vertical stress and, for clayey soils, changes in the porewater pressure. Lowering the water table by a maximum of approximately 7 m will increase the vertical effective stress to the underlying soils by approximately 23 kPa, with the pressure increasing linearly with increasing drawdown. This magnitude of load increase is estimated to result in negligible settlement to neighbouring structures.

6.0 PERMANENT GROUNDWATER CONTROL (ROAD-UNDER-RAIL GRADE SEPARATION)

Because the road-under-rail option for grade separation will extend up to approximately 7 m below the groundwater level, permanent management of groundwater seepage will be required for this option. The potential for impacts to water supply wells or environmental/ecological features is the same as described for temporary construction dewatering but water management (i.e. treatment and conveyance) measures appropriate for temporary construction excavations may not be cost-effective or practical for permanent groundwater control. The conveyance of seepage waters to a properly designed passively functioning stormwater management facility should be assumed for this grade separation alternative.

Design of any road-under-rail grade separation must also take into account the potential for internal erosion and ground loss from beneath structures and paved surfaces. Internal erosion or piping is the progressive loss of fines through erosion by seepage. It is a function of the soil susceptibility and seepage velocity with the former primarily controlled by gradation, compaction, and plasticity while the latter is a function of hydraulic gradient, and anisotropy in hydraulic conductivity. While the bulk hydraulic conductivity at the site is quite low, it will not be uniform and localized seams of higher permeability material should be assumed. Using Sherard’s classification system (Eddleston and Wan, 2014), the shallow (upper 10 m) soils at the subject site would be classified as Category 2 and 3 soils (intermediate piping resistance and least piping resistance respectively). A road-under-rail grade separation must therefore be provided with appropriate filter and drain systems to control seepage velocities.

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Signature Page

Golder Associates Ltd.

Chad Davis
Project Manager - Senior Technologist

John Piersol, M.S.c., P.Geo
Senior Hydrogeologist and Associate

CD/JP/ll

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FIGURES

Figure 1 – Borehole Location Plan

LEGEND

- APPROXIMATE BOREHOLE LOCATION
- ROAD ALIGNMENT
- CP TRACKS

REFERENCES

BASE DATA - MNRF LIO, OBTAINED 2016
PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2017
IMAGERY - © 2010 DIGITALGLOBE IMAGE COURTESY OF USGS EARTHSTAR GEOGRAPHICS SIO © 2017 MICROSOFT CORPORATION
ROAD ALIGNMENT - PROVIDED BY REGION OF PEEL, 2017

PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

NOTES

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CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2017-08-16
PREPARED	PR
DESIGN	PR
REVIEW	CD
APPROVED	-

PROJECT
COLERAINE DRIVE, CALEDON, ONTARIO

TITLE
BOREHOLE LOCATION PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
1665649	0003	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

Path: S:\Clients\Region_of_Peel\Coleraine_Dr_Caledon\99_PROJ\1665649_Coleraine_EA\40_PROD\0003_Geotechnical\1665649-0003-BG-0001.mxd

APPENDIX A

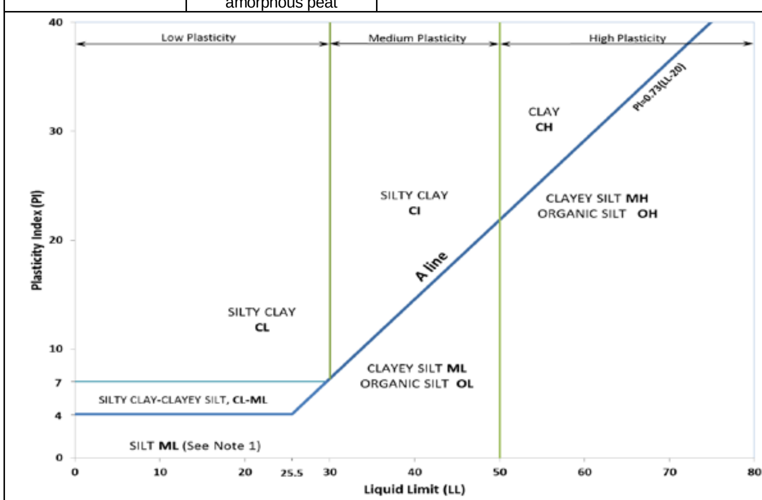
Method of Soil Classification
Abbreviations and Terms used on Records of Boreholes and Test Pits
List of Symbols
Record of Borehole Sheets
(BH17-01 to BH17-16, inclusive)

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil		Laboratory Tests	Field Indicators: Dilatancy	Field Indicators: Dry Strength	Field Indicators: Shine Test	Field Indicators: Thread Diameter	Field Indicators: Toughness (of 3 mm thread)	Organic Content	USCS Group Symbol	Primary Name
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS	(Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
					Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
					Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
				Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
					None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS	(PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% **(see Note 2)**	CL	SILTY CLAY
				Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
				Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures								30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat								75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.
Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.
For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.
For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.
A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

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.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)
An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); 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

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , 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, Gs)
DS	direct shear test
GS	specific gravity
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 (FV)	field vane (LV-laboratory vane test)
γ	unit weight

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.
2. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

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

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
υ	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 multiplied by acceleration due to gravity)

(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 = $(w_l - w_p)$
NP	non-plastic
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

Notes:
1 $\tau = c' + \sigma' \tan\phi'$
2 shear strength = (compressive strength)/2

PROJECT: 1665649

LOCATION: See Figure 1

RECORD OF BOREHOLE: BH17-01

BORING DATE: March 29, 2017

SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	HEX HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] (ND = Not Detected)	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING
		GROUND SURFACE	257.60						
0	Power Auger, 83 mm I.D. Hollow Stem Augers	ASPHALT (200mm)	0.00						
		FILL - (SP) gravelly SAND, some fines; brown; non-cohesive, moist, compact	257.40 / 0.20	1	SS	16	ND	○	M
1				2A	SS	10	ND		
		(CL) SILTY CLAY, trace sand, trace gravel; brown, mottled; cohesive, w~PL, stiff to very stiff	256.53 / 1.07	2B			ND		
2				3	SS	22	ND		
		(CL) SILTY CLAY, some sand, trace gravel; grey (TILL); cohesive, w<PL, very stiff	255.40 / 2.20	4	SS	28	ND	○	
3				5	SS	16	ND		
4				6	SS	18	ND		
5				7	SS	15	ND	○	
		END OF BOREHOLE	252.42 / 5.18						

NOTE:

1. Borehole dry upon completion of drilling.

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}

IBL HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ND = Not Detected

Wp — W — Wl

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: MC

CHECKED: EM

PROJECT: 1665649

LOCATION: See Figure 1

RECORD OF BOREHOLE: BH17-02

BORING DATE: March 20, 2017

SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

BORING METHOD: Power Auger; 83 mm I.D. Hollow Stem Augers

HEX HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ (*ND = Not Detected*)

IBL HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □ (*ND = Not Detected*)

HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3})

WATER CONTENT PERCENT (Wp, W, Wl; 10, 20, 30, 40)

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	HEX HEADSPACE [PPM]	ADDITIONAL LAB. TESTING
GROUND SURFACE	256.60					
ASPHALT (240 mm)	0.00 / 256.36					
FILL - (SM) SILTY SAND, some gravel; brown; non-cohesive, moist, compact to dense	0.24	1	SS	39	ND	MH
		2A	SS	17	ND	
FILL - (CL) SILTY CLAY, trace to some sand, trace to some gravel; grey to brown, mottled, containing organics and brick fragments; cohesive, w<PL, very stiff	255.53 / 1.07	2B			ND	
		3	SS	16	ND	
		4A	SS	25	ND	
(CL) SILTY CLAY, trace sand, trace gravel; brown (TILL); cohesive, w~PL, very stiff to hard	254.01 / 2.59	4B			ND	
		5	SS	29	ND	
		6	SS	34	ND	
		7	SS	32	ND	
END OF BOREHOLE	251.42 / 5.18					

NOTE:

1. Borehole dry upon completion of drilling.

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MC

CHECKED: EM

GTA-BHS 001 S:\CLIENTS\REGION_OF_PEEL\COLERAINE_DR_CALEDON\02_DATA\GINT\1665649.GPJ GAL-MIS.GDT 5/12/17

RECORD OF BOREHOLE: BH17-03

PROJECT: 1665649
LOCATION: See Figure 1
BORING DATE: March 19, 2017
SHEET 1 OF 1
DATUM: Local
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT PERCENT (W)
		GROUND SURFACE	256.00				
0	Power Auger, 83 mm I.D. Hollow Stem Augers	ASPHALT (230 mm)	0.00 / 255.77				
		FILL - (SW/SM) SAND and GRAVEL to gravelly SAND to SILTY SAND and GRAVEL; brown to dark brown; non-cohesive, moist, compact to very dense	0.23	1	SS	56	
1		- Layers of silty clay with organics encountered at a depth of 1.1 m		2A, 2B	SS	31	
				3	SS	33	~5
2				4A, 4B	SS	25	
3		FILL - SILTY CLAY, some sand, some gravel; brown to black; cohesive, with organics, w~PL, very stiff	253.03 / 2.97	5	SS	22	~15
4		(CL) SILTY CLAY, trace sand, trace gravel; brown, mottled (TILL); cohesive, w>PL, very stiff to hard	252.27 / 3.73	6	SS	32	
5				7	SS	31	
		END OF BOREHOLE	250.82 / 5.18				

NOTE:

1. Borehole dry upon completion of drilling.

Column headings also include: DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20, 40, 60, 80); SHEAR STRENGTH Cu, kPa (nat V. +, Q - ●, rem V. ⊕, U - ○; 20, 40, 60, 80); HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT Wp — W — Wl (10, 20, 30, 40); STRATA PLOT; ADDITIONAL LAB. TESTING; PIEZOMETER OR STANDPIPE INSTALLATION.

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MC
CHECKED: EM

PROJECT: 1665649

LOCATION: See Figure 1

RECORD OF BOREHOLE: BH17-04

BORING DATE: March 24, 2017

SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	HEX HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ / IBL HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □ (ND = Not Detected)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	255.90							
0	Power Auger; 83 mm I.D. Hollow Stem Augers	ASPHALT (200 mm)	0.00							
		FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, compact to dense	255.70 / 0.20	1	SS	45	ND			
				2A			ND			
1		(CL/CI) SILTY CLAY, trace sand, trace gravel; brown to grey (TILL); cohesive, w~PL to w>PL, very stiff to hard	254.99 / 0.91	2B	SS	15	ND			Hole Plug
2				3	SS	23	ND	W ≈ 12		
				4	SS	23	ND			▽
3				5	SS	32	ND			Sand
4				6	SS	17	ND	W ≈ 10		Screen
5				7	SS	25	ND			Cave In
		END OF BOREHOLE	250.72 / 5.18							

NOTES:

1. Borehole dry upon completion of drilling.

2. Water level measured in monitoring well at a depth of about 2.7 m below ground surface on July 14, 2017.

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MC

CHECKED: EM

RECORD OF BOREHOLE: BH17-05

PROJECT: 1665649
LOCATION: See Figure 1
BORING DATE: March 19, 2017
SHEET 1 OF 1
DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC

BORING METHOD: Power Auger, 83 mm I.D. Hollow Stem Augers

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING
GROUND SURFACE	256.60					
ASPHALT (230 mm)	0.00					
FILL - (SP) gravelly SAND; brown; non-cohesive, moist, compact	256.37 / 0.23	1	SS	21	○ (approx. 7)	M
		2A	SS	10		
(CL/CI) SILTY CLAY, trace sand, trace gravel; brown to grey, mottled (TILL); w~PL to w>PL, stiff to very stiff	255.53 / 1.07	2B				
		3	SS	22	○ (approx. 15)	
		4	SS	24		
		5	SS	26		
		6	SS	25	○ (approx. 14)	
- Grey below a depth of 4.9 m below ground surface		7	SS	27		
END OF BOREHOLE	251.42 / 5.18					

NOTE:

1. Borehole dry upon completion of drilling.

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: MC
CHECKED: EM

RECORD OF BOREHOLE: BH17-06

PROJECT: 1665649
LOCATION: See Figure 1
BORING DATE: March 20, 2017
SHEET 1 OF 1
DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC

Boring method: Power Auger; 83 mm I.D. Hollow Stem Augers

DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	HEX HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] (ND = Not Detected)	WATER CONTENT PERCENT
GROUND SURFACE	257.30					
ASPHALT (230 mm)	0.00					
FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, compact	257.07 / 0.23	1	SS	28	ND	
FILL - (CL) SILTY CLAY, trace to some sand, trace to some gravel; dark grey, containing organics; cohesive, w~PL, stiff to very stiff	256.54 / 0.76	2	SS	19	ND	~10
		3	SS	13	ND	
(CL/CI) SILTY CLAY, trace sand, trace gravel; brown to grey (TILL); cohesive, stiff to very stiff	255.10 / 2.20	4	SS	22/0.05		
		5	SS	17	ND	
		6	SS	14	ND	
		7	SS	21	ND	
END OF BOREHOLE	252.12 / 5.18					

NOTE:

1. Borehole dry upon completion of drilling.

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: MC
CHECKED: EM

RECORD OF BOREHOLE: BH17-07

PROJECT: 1665649

LOCATION: See Figure 1

BORING DATE: March 30, 2017

SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT PERCENT (W)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	258.60						
0	Power Auger, 83 mm I.D. Hollow Stem Augers	ASPHALT (200 mm)	258.40 / 0.00						
		FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, compact to very dense	0.20	1	SS	66			Hole Plug
1			257.53	2A	SS	11			
		FILL - (CI) SILTY CLAY, trace sand, trace gravel; brown to grey, containing organics; cohesive, firm to stiff	1.07	2B					
				3	SS	8	~22		
2			256.39						
		(CI) SILTY CLAY, trace sand; brown, mottled; cohesive, w~PL, stiff to very stiff	2.21	4	SS	18			Sand
3				5	SS	23	Wp ~21, W ~21, Wl ~48	MH	Screen
4				6	SS	9			
5			253.42	7	SS	13			Cave In
		END OF BOREHOLE	5.18						

NOTES:

1. Borehole dry upon completion of drilling.

2. Groundwater level measured in monitoring well at a depth of 2.8 m below ground surface on July 14, 2017.

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MC

CHECKED: EM

PROJECT: 1665649

LOCATION: See Figure 1

RECORD OF BOREHOLE: BH17-08

BORING DATE: March 27, 2017

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

BORING METHOD: Power Auger, 83 mm I.D. Hollow Stem Augers

Description	Elev. (m) / Depth (m)	Sample Number	Type	Blows/0.3m	Water Content	Additional Lab. Testing
GROUND SURFACE	259.10					
ASPHALT (240 mm)	0.00					
FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, compact	258.86 / 0.24	1	SS	20		
FILL - (CI) SILTY CLAY, trace sand, trace gravel; brown to grey, containing organics and brick fragments; cohesive, w~PL, firm	258.34 / 0.76	2	SS	7	○	
		3	SS	5		
(CL) SILTY CLAY, trace gravel; brown; cohesive, w~PL, very stiff	256.89 / 2.21	4	SS	18		
		5	SS	20	○	
(CL/CI) SILTY CLAY, trace sand to sandy, trace gravel; brown to grey (TILL); cohesive, w~PL to w>PL, very stiff to hard	255.37 / 3.73	6	SS	20		
		7	SS	22	○	
		8	SS	32		
- Grey below a depth of about 6.5 m below ground surface						
		9	SS	23	Wp–W–Wl	MH
		10	SS	24		

CONTINUED NEXT PAGE

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: MC

CHECKED: EM

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PROJECT: 1665649

LOCATION: See Figure 1

RECORD OF BOREHOLE: BH17-08

BORING DATE: March 27, 2017

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

Boring method: Power Auger, 83 mm I.D. Hollow Stem Augers

--- CONTINUED FROM PREVIOUS PAGE ---

Depth (m)	Description	Elev. / Depth (m)	Sample Number	Type	Blows/0.3m	Water content (%)
10	(CL/CI) SILTY CLAY, trace sand to sandy, trace gravel; brown to grey (TILL); cohesive, w~PL to w>PL, very stiff to hard					
11			11	SS	32	
11.75	(CL-ML) SILTY CLAY - CLAYEY SILT; grey; cohesive, w<PL, stiff to very stiff	247.35 / 11.75				
12			12	SS	11	
14			13	SS	24	
15			14	SS	18	
17			15	SS	11	
17.75	(CL) SILTY CLAY; grey (TILL); cohesive, w~PL, very stiff to hard	241.35 / 17.75				
18			16	SS	16	
20			17	SS	32	

CONTINUED NEXT PAGE

PROJECT: 1665649

LOCATION: See Figure 1

RECORD OF BOREHOLE: BH17-08

BORING DATE: March 27, 2017

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp —○W— Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
20		(CL) SILTY CLAY; grey (TILL); cohesive, w~PL, very stiff to hard		238.68	17	SS	32				
		END OF BOREHOLE		20.42							
		NOTE:									
21		1. Borehole dry upon completion of drilling.									
22											
23											
24											
25											
26											
27											
28											
29											
30											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MC

CHECKED: EM

PROJECT: 1665649

LOCATION: See Figure 1

RECORD OF BOREHOLE: BH17-09

BORING DATE: March 28, 2017

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	HEX HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] (ND = Not Detected)	WATER CONTENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	259.10							
0	Power Auger, 83 mm I.D. Hollow Stem Augers	ASPHALT (200 mm)	0.00							
		FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, most, compact	258.90 / 0.20	1	SS	15	ND			
				2A			ND	○		
1		FILL - (CL) SILTY CLAY, trace sand, trace gravel; brown; cohesive, w~PL to w>PL, stiff	258.19 / 0.91	2B	SS	8	ND			
				3	SS	14	ND			
2		(CL) SILTY CLAY; brown; cohesive, w>PL to w~PL, stiff to very stiff	256.90 / 2.20	4	SS	20	ND	○		
3				5	SS	17	ND			
4				6	SS	16	ND	Wp ├─○─┤ Wl	MH	▽
5				7	SS	14	ND			Hole Plug
6		(CL) SILTY CLAY, trace sand, trace gravel; grey (TILL); cohesive, w~PL, stiff to very stiff	253.46 / 5.64	8	SS	16	ND	○		
8				9	SS	13	ND			
9				10	SS	21	ND	○		
10										

Chart axes: HEX HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ (20, 40, 60, 80); IBL HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □ (20, 40, 60, 80); HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT, Wp ├─○W─┤ Wl (10, 20, 30, 40).

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MC

CHECKED: EM

PROJECT: 1665649

LOCATION: See Figure 1

RECORD OF BOREHOLE: BH17-09

BORING DATE: March 28, 2017

SHEET 2 OF 3

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

BORING METHOD: Power Auger, 83 mm I.D. Hollow Stem Augers

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV. / DEPTH (m)	SOIL PROFILE DESCRIPTION
	(CL) SILTY CLAY, trace sand, trace gravel; grey (TILL); cohesive, w~PL, stiff to very stiff
247.37 / 11.73	(CL-ML) SILTY CLAY - CLAYEY SILT to sandy SILT; grey; cohesive, w~PL, stiff to hard
239.75 / 19.35	(CL) Sandy SILTY CLAY, trace gravel; grey (TILL); cohesive, w~PL, very stiff

SAMPLE NUMBER	TYPE	BLOWS/0.3m	HEX HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM]	IBL HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM]	ADDITIONAL LAB. TESTING
11	SS	20	ND		
12	SS	16	ND		
13	SS	13	ND		
14	SS	19	ND		MH
15	SS	32	ND		
16	SS	14	ND		
17	SS	24			

ND = Not Detected

PIEZOMETER OR STANDPIPE INSTALLATION: Hole Plug; Sand; Screen; Cave In

CONTINUED NEXT PAGE

PROJECT: 1665649

LOCATION: See Figure 1

RECORD OF BOREHOLE: BH17-09

BORING DATE: March 28, 2017

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	HEX HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ (ND = Not Detected) / IBL HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □ (ND = Not Detected)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT PERCENT (Wp — W — Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
20		(CL) Sandy SILTY CLAY, trace gravel; grey (TILL); cohesive, w~PL, very stiff		238.68 / 20.42	17	SS	24	⊕ ND		MH	Cave In
		END OF BOREHOLE									

NOTES:

1. Borehole dry upon completion of drilling.

2. Groundwater level measured in monitoring well at a depth of 4.4 m below ground surface on July 14, 2017.

Depth scale: 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

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DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MC

CHECKED: EM

RECORD OF BOREHOLE: BH17-10

PROJECT: 1665649
LOCATION: See Figure 1
BORING DATE: March 24, 2017
SHEET 1 OF 1
DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC

Depth (m)	Description	Elev. / Depth (m)	Sample Number	Type	Blows/0.3m	Hex Headspace Combustible Vapour [PPM]	IBL Headspace Organic Vapour [PPM]	Water Content (%)	Additional Lab. Testing
	GROUND SURFACE	259.50							
0	ASPHALT (230 mm)	259.50 / 0.00							
	FILL - (SP) gravelly SAND; brown; non-cohesive, moist, dense	259.27 / 0.23	1	SS	44	ND		○	M
			2A			ND			
1	(CL) SILTY CLAY, trace sand, trace gravel; brown; cohesive, w~PL, stiff to very stiff	258.59 / 0.91	2B	SS	10	ND			
			3	SS	8	ND			
			4	SS	17	ND		○	
3			5	SS	22	ND			
4			6	SS	17	ND		○	
5			7	SS	11	ND			
	END OF BOREHOLE	254.32 / 5.18							

Boring Method: Power Auger, 83 mm I.D. Hollow Stem Augers (0 to 5.18 m)

Legend: HEX HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕, ND = Not Detected (scale 20, 40, 60, 80); IBL HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □, ND = Not Detected (scale 20, 40, 60, 80); HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT Wp —○W— Wl (scale 10, 20, 30, 40); PIEZOMETER OR STANDPIPE INSTALLATION

NOTE:

1. Borehole dry upon completion of drilling.

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: MC
CHECKED: EM

PROJECT: 1665649

LOCATION: See Figure 1

RECORD OF BOREHOLE: BH17-11

BORING DATE: March 30, 2017

SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		260.00							
0	Power Auger; 83 mm I.D. Hollow Stem Augers	ASPHALT (220 mm)		0.00							
		FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, loose to very dense		259.78 / 0.22	1	SS	51				
1		FILL - (CL) SILTY CLAY. trace gravel; dark grey; cohesive, w~PL, firm		258.93 / 1.07	2A / 2B	SS	6		○ (~22)		
		(CL) SILTY CLAY, trace sand, trace gravel; brown to grey; cohesive, w~PL, firm to very stiff		258.50 / 1.50	3	SS	7				
2					4	SS	14				
3		- Grey below a depth of 3.0 m below ground surface.			5	SS	17				
4					6	SS	13				
5					7	SS	9		○ (~22)		
		END OF BOREHOLE		254.82 / 5.18							
		NOTE:									
6		1. Borehole dry upon completion of drilling.									
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MC

CHECKED: EM

PROJECT: 1665649

LOCATION: See Figure 1

RECORD OF BOREHOLE: BH17-12

SHEET 1 OF 1

BORING DATE: March 2017

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	HEX HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ (ND = Not Detected) / IBL HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □ (ND = Not Detected)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		260.30							
0	Power Auger; 83 mm I.D. Hollow Stem Augers	ASPHALT (200 mm)		0.00							
		FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, loose to compact		260.10 / 0.20	1	SS	25	ND			
					2A	SS	6	ND			
1		(CL/CI) SILTY CLAY, trace sand, trace gravel; brown to grey; cohesive, w~PL, firm to very stiff		259.23 / 1.07	2B			ND			
					3	SS	11	ND			
2					4	SS	16	ND			
3					5	SS	19	ND			
4					6	SS	13	ND			
5					7	SS	12	ND			
		END OF BOREHOLE NOTE: 1. Borehole dry upon completion of drilling.		255.12 / 5.18							
6											
7											
8											
9											
10											

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: MC

CHECKED: EM

PROJECT: 1665649

LOCATION: See Figure 1

RECORD OF BOREHOLE: BH17-13

BORING DATE: March 29, 2017

SHEET 1 OF 1

DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	HEX HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ (ND = Not Detected) / IBL HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □ (ND = Not Detected)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		260.30							
0	Power Auger, 83 mm I.D. Hollow Stem Augers	ASPHALT (200 mm)		0.00							
		FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, compact		260.10 / 0.20	1	SS	28	ND			
1					2A	SS	10	ND	W ≈ 6		
		(CL/CI) SILTY CLAY, trace sand, trace gravel; brown to grey; cohesive, w~PL, stiff to very stiff		259.23 / 1.07	2B			ND			
2					3	SS	25	ND			
					4	SS	16	ND	W ≈ 21		
3					5	SS	13	ND			
4					6	SS	17	ND			
5					7	SS	13	ND			
		END OF BOREHOLE		255.12 / 5.18							

NOTE:

1. Borehole dry upon completion of drilling.

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: MC

CHECKED: EM

RECORD OF BOREHOLE: BH17-14

PROJECT: 1665649
LOCATION: See Figure 1
BORING DATE: March 2017
SHEET 1 OF 1
DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC

Boring method: Power Auger, 83 mm I.D. Hollow Stem Augers

Depth (m)	Description	Elev. / Depth (m)	Sample Number	Type	Blows/0.3m	Hex Headspace Combustible Vapour [PPM]	IBL Headspace Organic Vapour [PPM]	Water Content	Additional Lab. Testing	Piezometer or Standpipe Installation
	GROUND SURFACE	259.90								
0	ASPHALT (180 mm)	0.00 / 259.72								
	FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, compact	0.18	1A	SS	13	~25	ND			Hole Plug
	FILL - (CI) SILTY CLAY, trace sand, trace gravel; dark brown to grey; cohesive, w~PL, firm	259.29 / 0.61	1B			ND				
1			2	SS	5					
			3A	SS	5	ND				
2	(CI) SILTY CLAY, some sand, some gravel; brown to grey (TILL); cohesive, w~PL, stiff to very stiff	258.07 / 1.83	3B			ND				
			4	SS	15	ND		Wp–W–Wl	MH	
3			5	SS	15	ND				Sand
4			6	SS	19	ND		W		Screen
5			7	SS	16	ND				
	END OF BOREHOLE	254.72 / 5.18								

NOTE:

1. Borehole dry upon completion of drilling.

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MC
CHECKED: EM

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RECORD OF BOREHOLE: BH17-15

PROJECT: 1665649
LOCATION: See Figure 1
BORING DATE: March 2017
SHEET 1 OF 1
DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC

Boring method: Power Auger, 83 mm I.D. Hollow Stem Augers

DEPTH (m)	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT	ADDITIONAL LAB. TESTING
	GROUND SURFACE	259.50					
0	ASPHALT (180 mm)	0.00					
	FILL - (SM) gravelly SILTY SAND; brown; non-cohesive, moist, compact to very dense	259.32 / 0.18	1	SS	67		
			2A			○	M
1	(CL/CI) SILTY CLAY, trace sand, trace gravel; brown; cohesive, w<PL, very stiff	258.59 / 0.91	2B	SS	19		
			3	SS	19		
2	(ML) SILT, trace sand, trace gravel; brown; non-cohesive, moist, compact to very dense	257.29 / 2.21	4	SS	28	○ ⊢⊣	
3			5	SS	44		
4	(CL) sandy SILTY CLAY, trace gravel; grey (TILL); cohesive, stiff	255.76 / 3.74	6A	SS	35		
			6B				
5			7	SS	14	⊢○—⊣	MH
	END OF BOREHOLE	254.32 / 5.18					

NOTE:

1. Borehole dry upon completion of drilling.

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: MC
CHECKED: EM

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RECORD OF BOREHOLE: BH17-16

PROJECT: 1665649
LOCATION: See Figure 1
BORING DATE: March 29, 2017
SHEET 1 OF 1
DATUM: Local

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC

BORING METHOD: Power Auger; 83 mm I.D. Hollow Stem Augers

DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	HEX HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM]
GROUND SURFACE	259.20				
ASPHALT (180 mm)	259.02 / 0.00				
FILL - (SP/GP) SAND and GRAVEL; brown; non-cohesive, moist, compact to dense	0.18	1	SS	36	ND
		2A	SS	14	ND
(CI) SILTY CLAY, trace sand, trace gravel; brown (TILL); cohesive, w~PL to w>PL, very stiff	258.13 / 1.07	2B			ND
		3	SS	23	ND
		4	SS	23	ND
		5	SS	23	ND
		6	SS	22	ND
		7	SS	23	ND
END OF BOREHOLE	254.02 / 5.18				

NOTE:

1. Borehole dry upon completion of drilling.

Column headings: DEPTH SCALE METRES; BORING METHOD; SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m)); SAMPLES (NUMBER, TYPE, BLOWS/0.3m); HEX HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕, ND = Not Detected (20, 40, 60, 80); IBL HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □, ND = Not Detected (20, 40, 60, 80); HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT Wp —○W— Wl (10, 20, 30, 40); ADDITIONAL LAB. TESTING; PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MC
CHECKED: EM

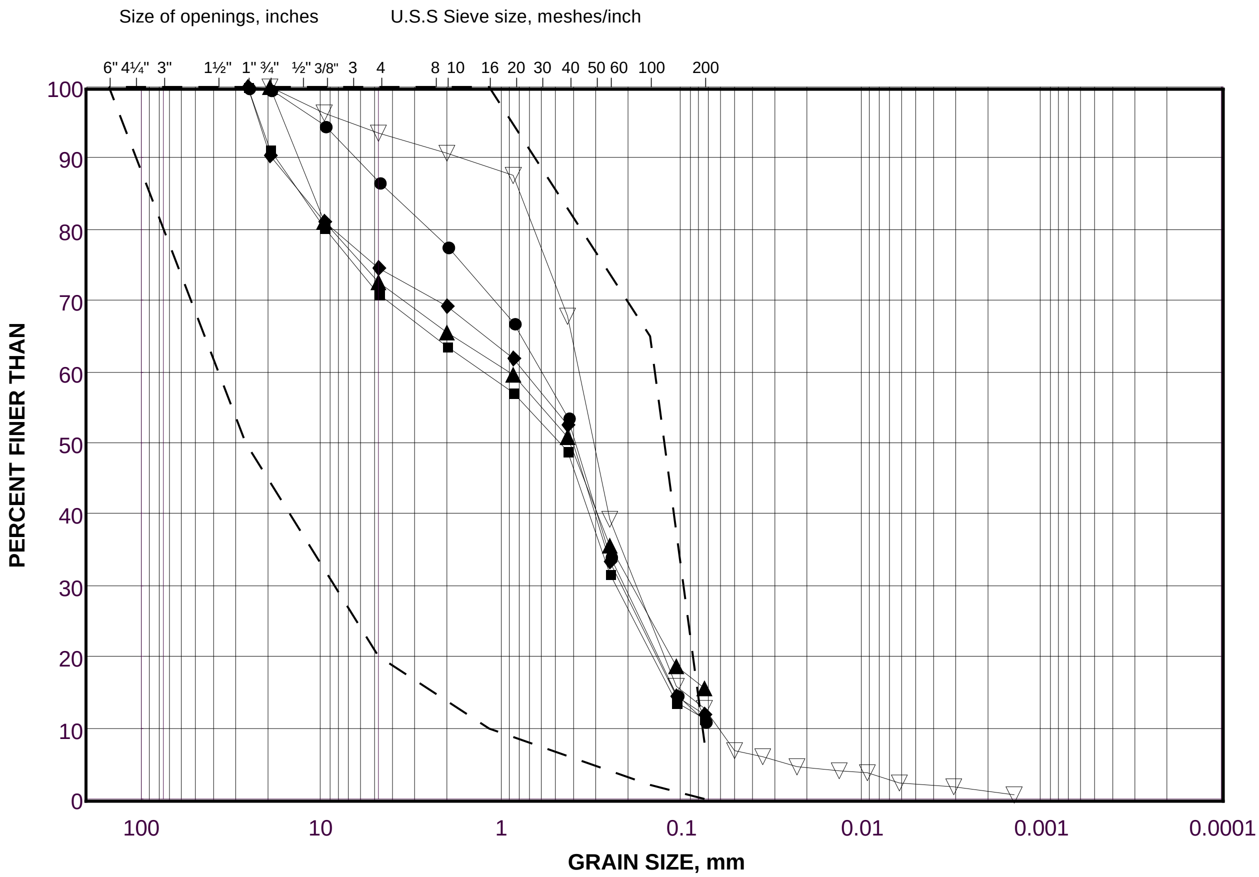
APPENDIX B

Geotechnical Laboratory Results

GRAIN SIZE DISTRIBUTION

FILL - (SP-SM) to (SM) GRAVELLY SAND TO SILTY SAND

FIGURE B1



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

LEGEND

SYMBOL	Borehole	SAMPLE	DEPTH(m)
●	17-01	1	0.21 - 0.61
■	17-10	1/2 Combined	0.24 - 0.61
◆	17-05	1/2A Combined	0.24 - 1.07
◻	17-15	2A	0.24 - 0.61
⬩	17-02	2A	0.76 - 1.07

Project Number: 1665649 (1000)

Checked By:

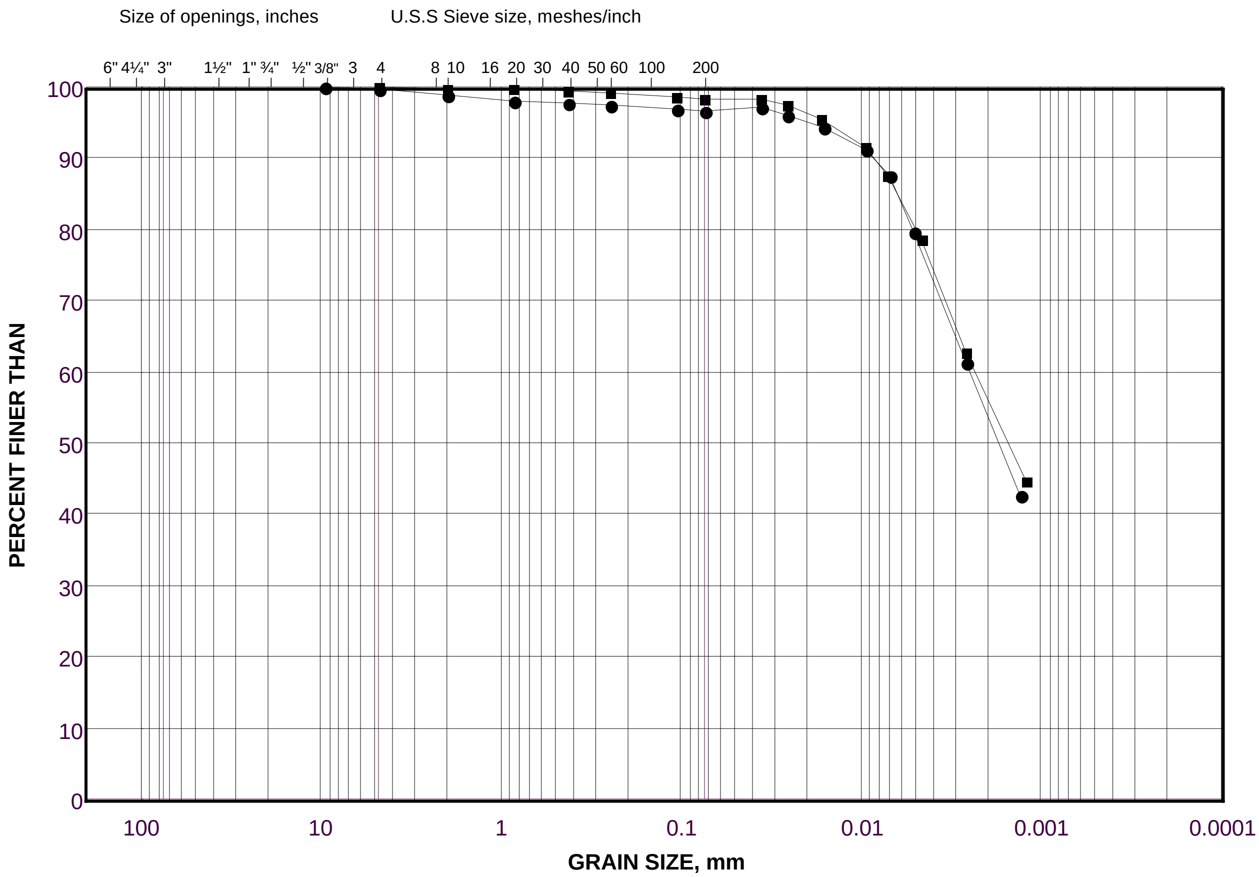
Golder Associates

Date: 05-Dec-17

GRAIN SIZE DISTRIBUTION

(CL/CI) SILTY CLAY - UPPER

FIGURE B2



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

LEGEND

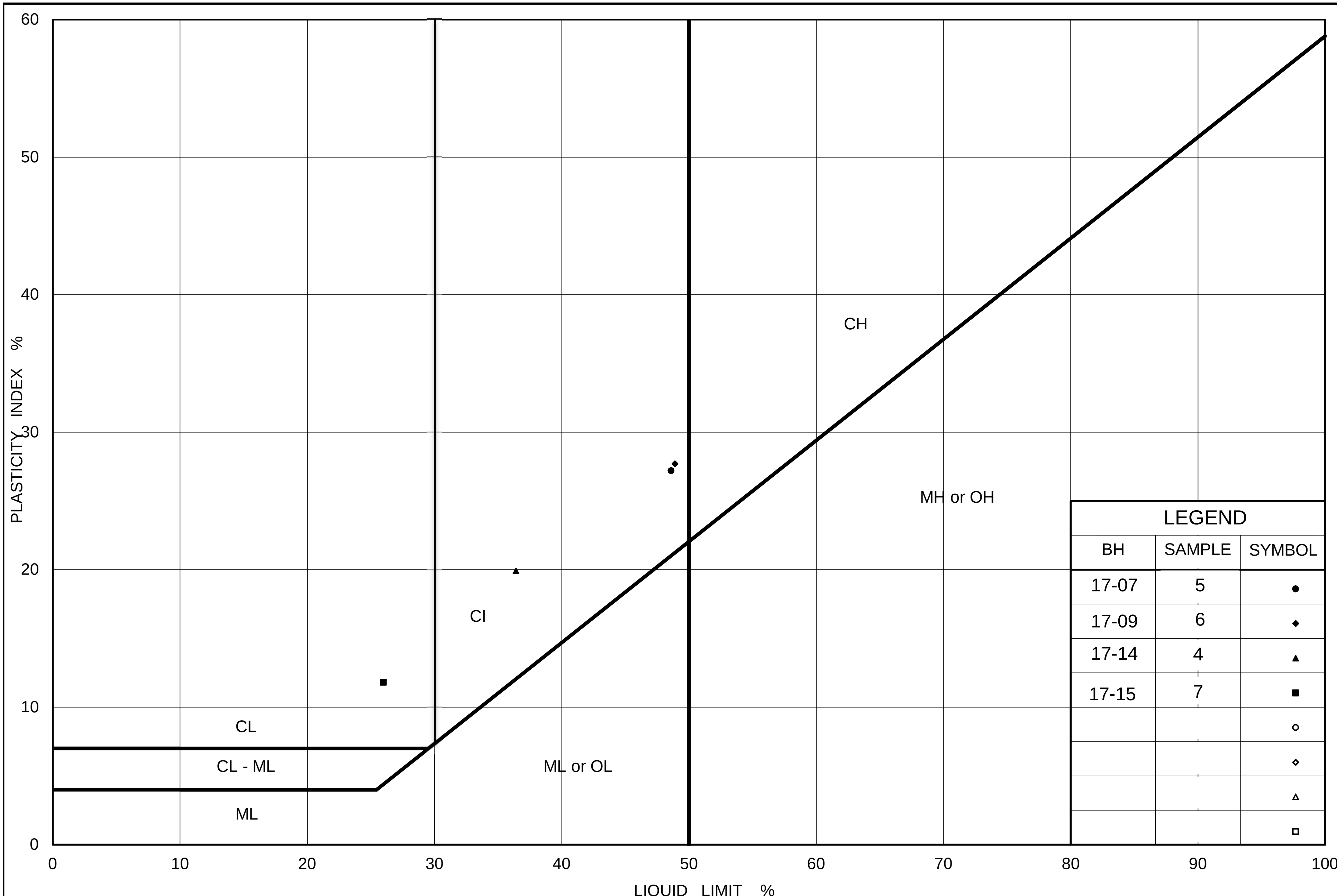
SYMBOL	Borehole	SAMPLE	DEPTH(m)
●	17-07	5	3.05 - 3.66
■	17-09	6	3.81 - 4.42

Project Number: 1665649 (1000)

Checked By:

Golder Associates

Date: 05-Dec-17



LEGEND

BH	SAMPLE	SYMBOL
17-07	5	●
17-09	6	◆
17-14	4	▲
17-15	7	■
		○
		◇
		△
		□

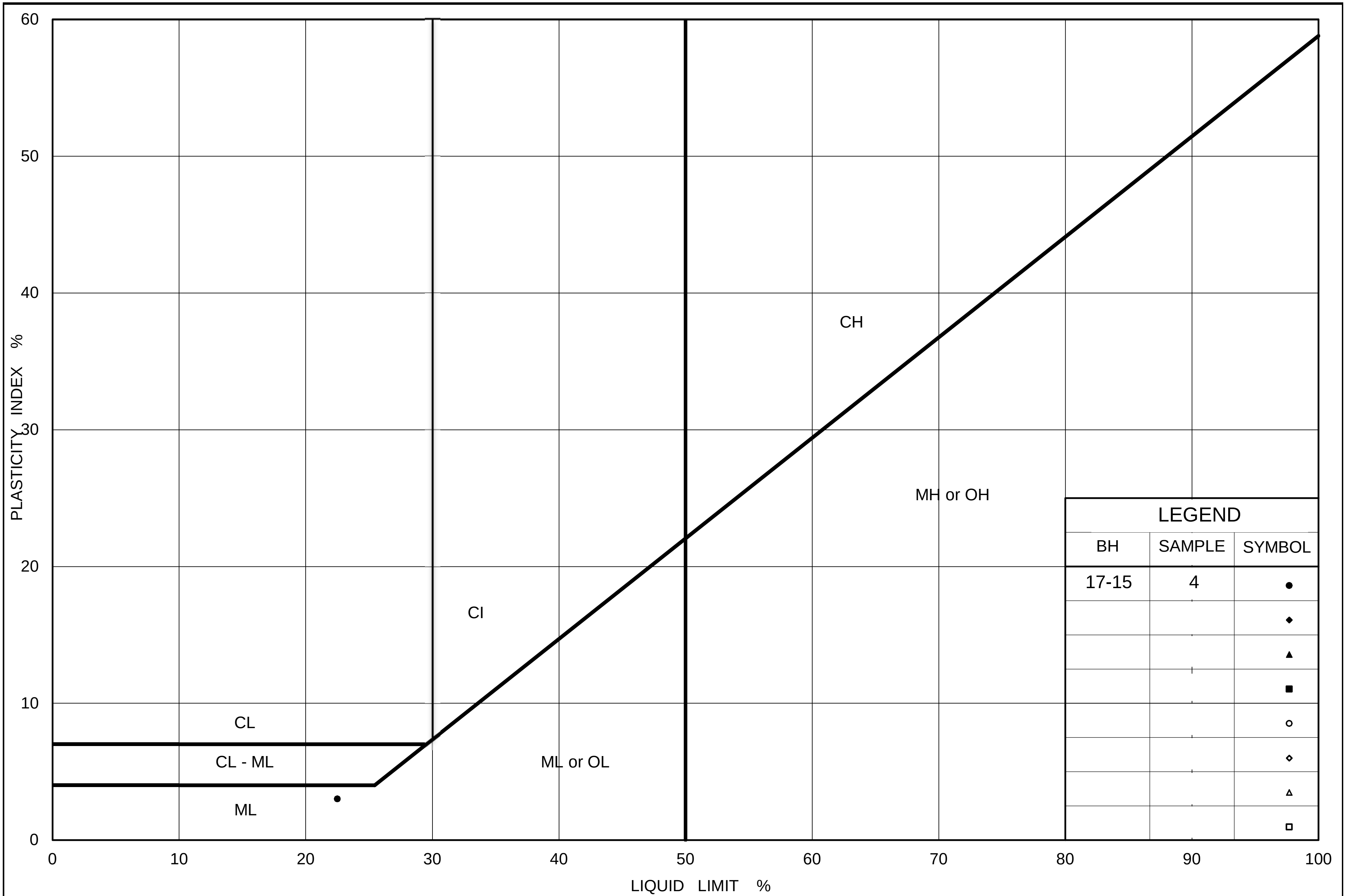
Golder Associates

PLASTICITY CHART
(CI/CL) SILTY CLAY - UPPER

Figure No. B3

Project No. 1665649 (1000)

Checked By: EM



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PLASTICITY CHART
(ML) SILT

Figure No. B4

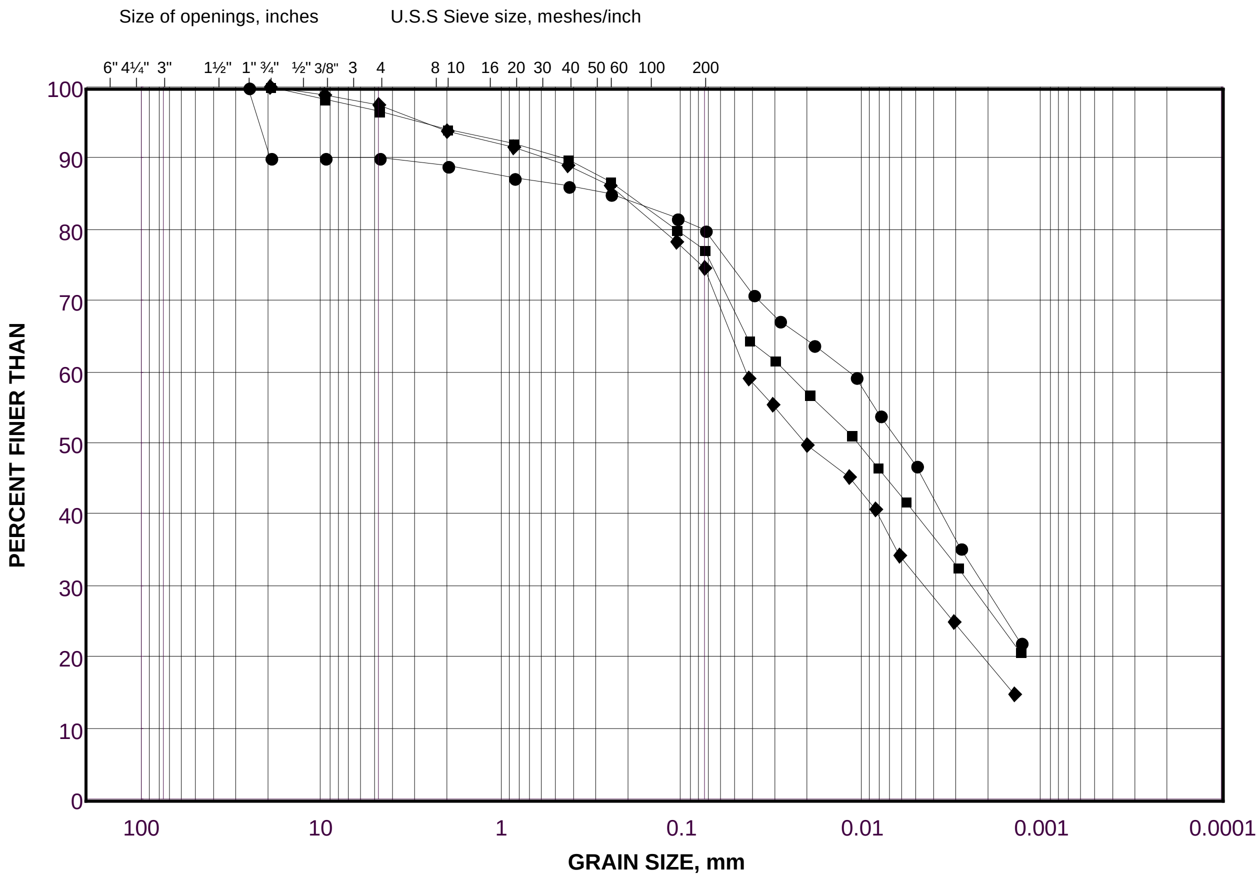
Project No. 1665649 (1000)

Checked By: AJ

GRAIN SIZE DISTRIBUTION

(CL/CI) sandy SILTY CLAY (TILL) - Upper

FIGURE B5



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

LEGEND

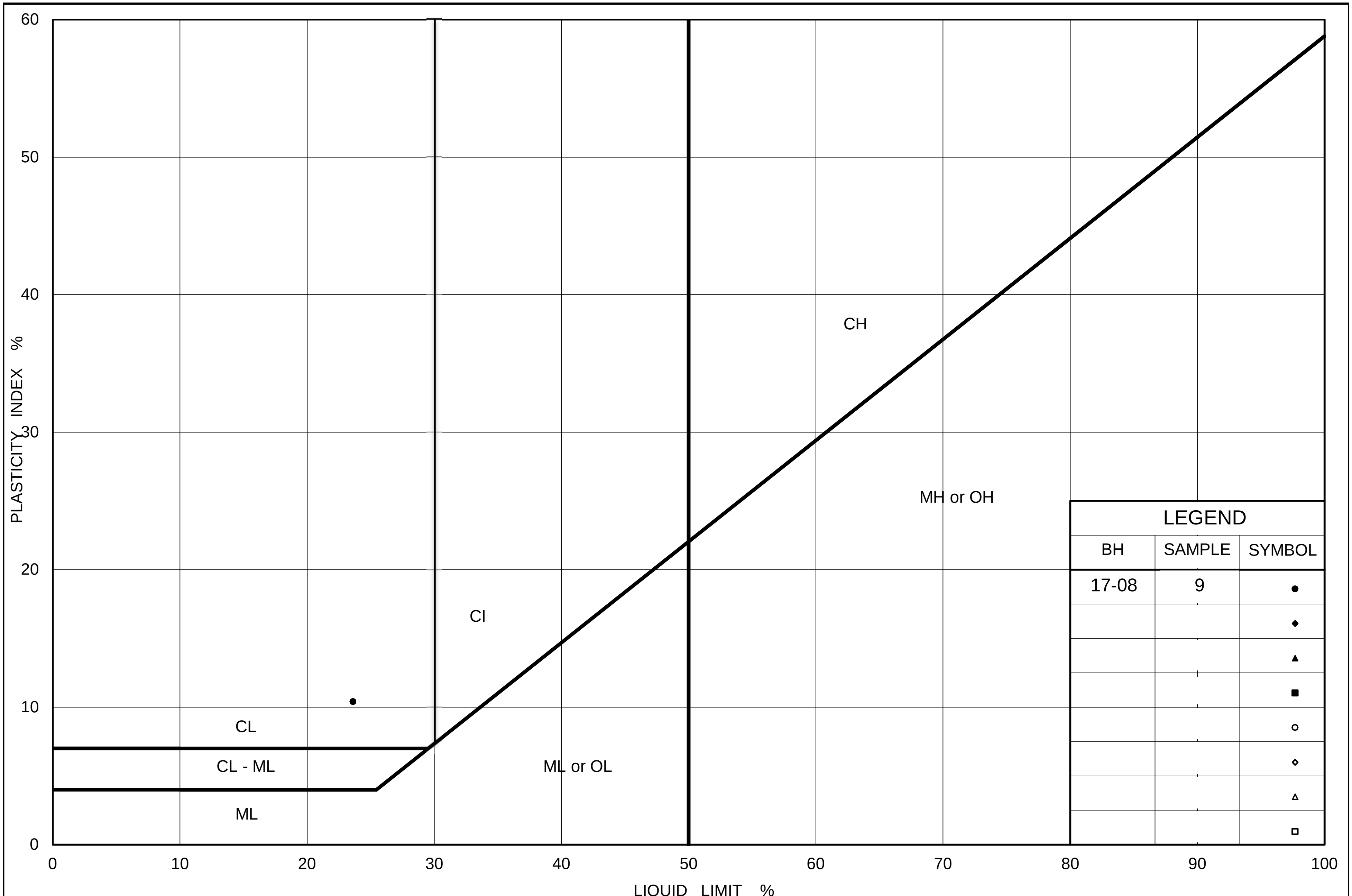
SYMBOL	Borehole	SAMPLE	DEPTH(m)
●	17-14	4	2.29 - 2.90
■	17-15	7	4.57 - 5.18
◆	17-08	9	7.62 - 8.23

Project Number: 1665649 (1000)

Checked By:

Golder Associates

Date: 05-Dec-17



PLASTICITY CHART
(CL/CI) SILTY CLAY (Till) (Upper)

Figure No. B6

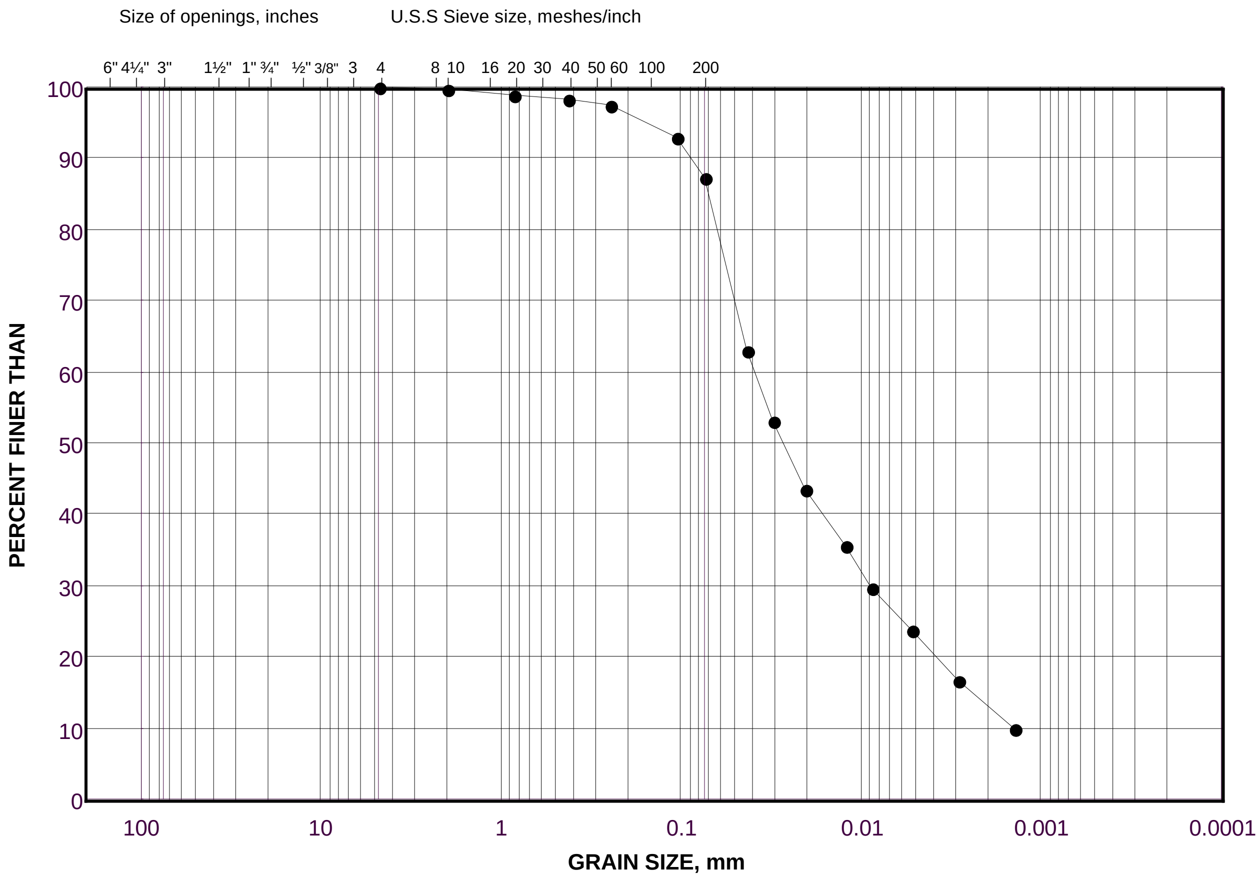
Project No. 1665649 (1000)

Checked By:

GRAIN SIZE DISTRIBUTION

(CL-ML) SILTY CLAY - CLAYEY SILT

FIGURE B7



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

LEGEND

SYMBOL	Borehole	SAMPLE	DEPTH(m)
●	17-09	14	15.24 - 15.85

Project Number: 1665649 (1000)

Checked By:

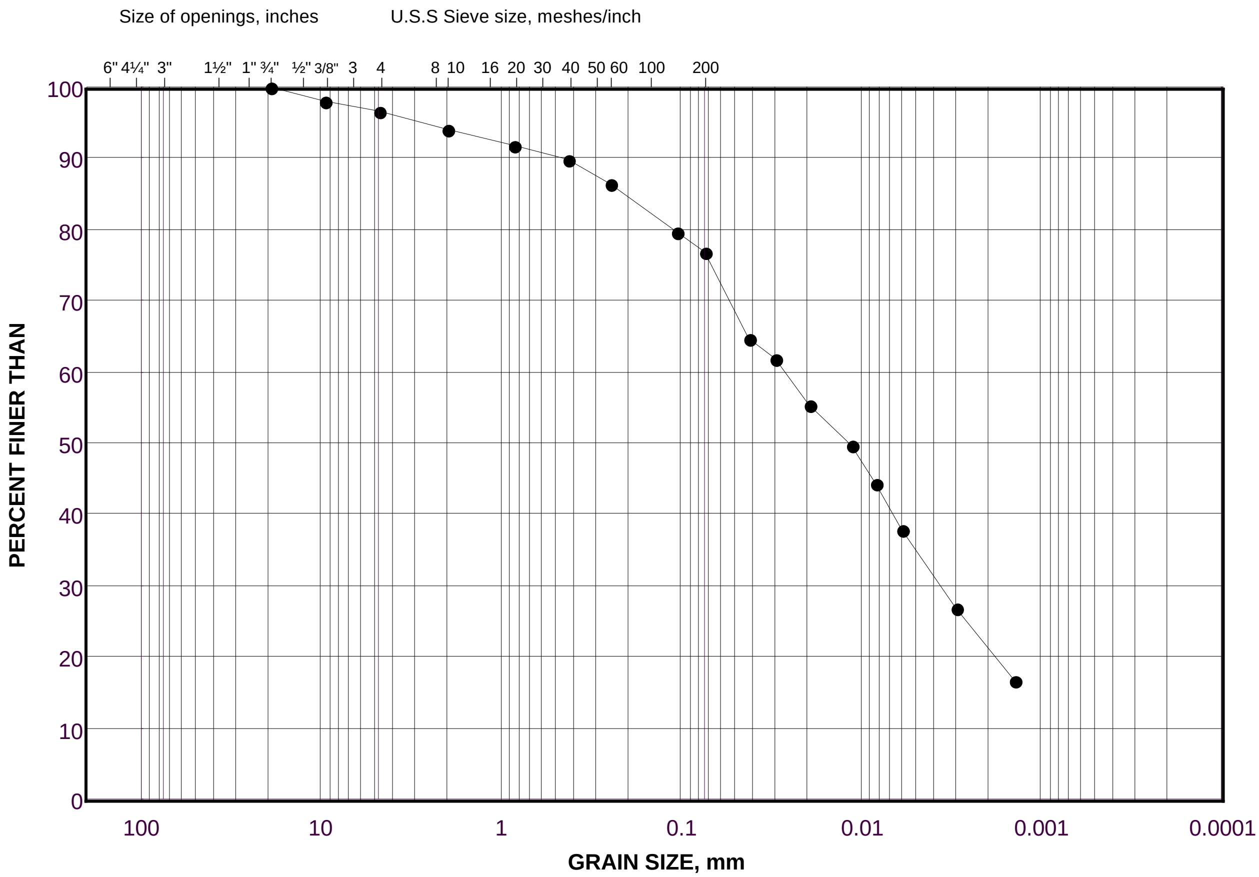
Golder Associates

Date: 05-Dec-17

GRAIN SIZE DISTRIBUTION

(CL/CI) sandy SILTY CLAY (TILL) - LOWER

FIGURE B8



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

LEGEND

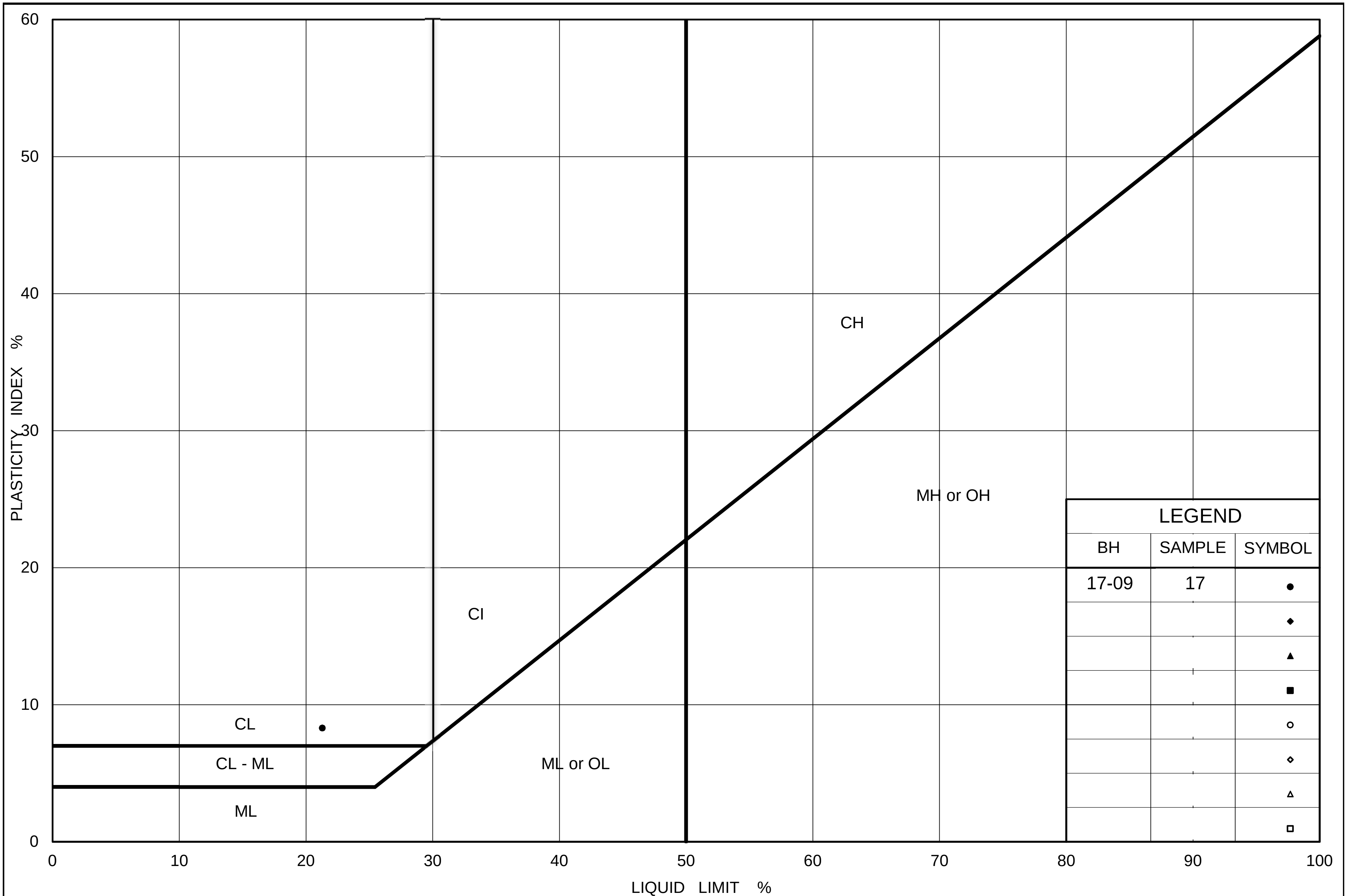
SYMBOL	Borehole	SAMPLE	DEPTH(m)
●	17-09	17	19.60 - 20.10

Project Number: 1665649 (1000)

Checked By:

Golder Associates

Date: 05-Dec-17



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PLASTICITY CHART
(CL/CI) sandy SILTY CLAY (TILL) (LOWER)

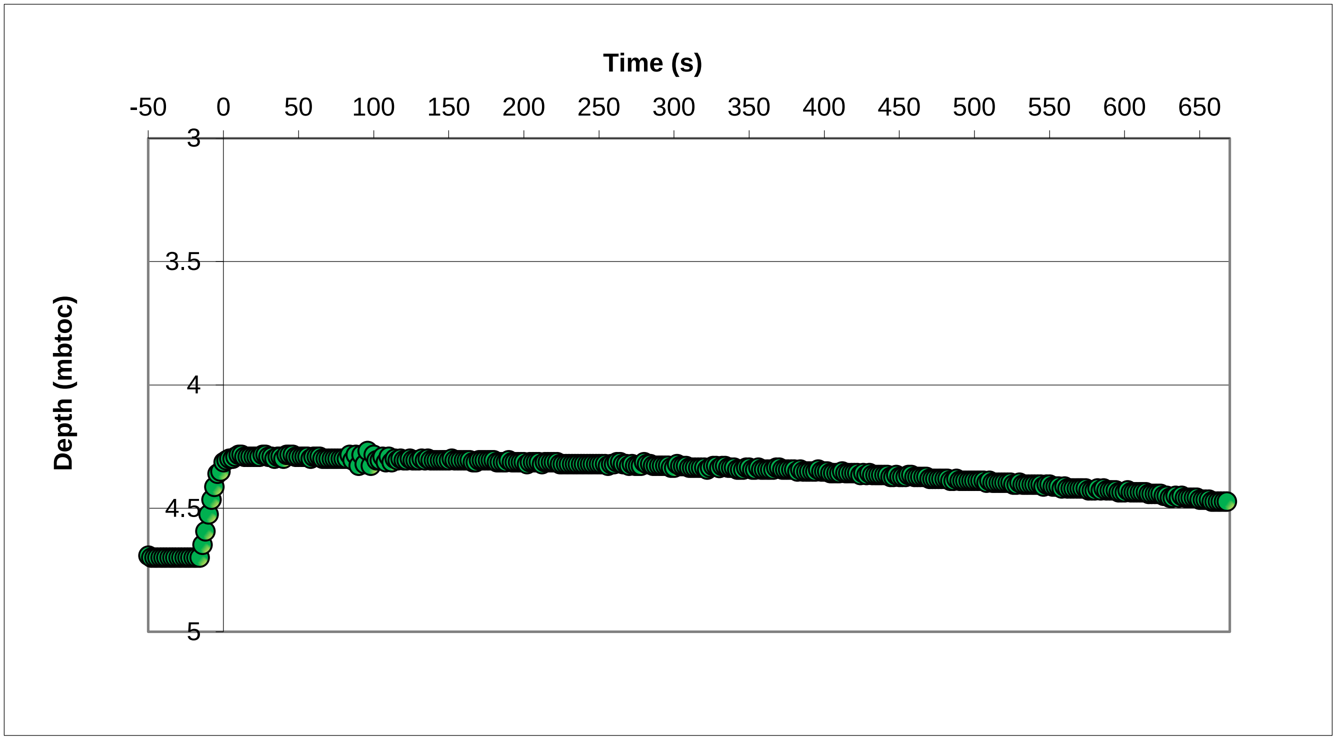
Figure No. B9

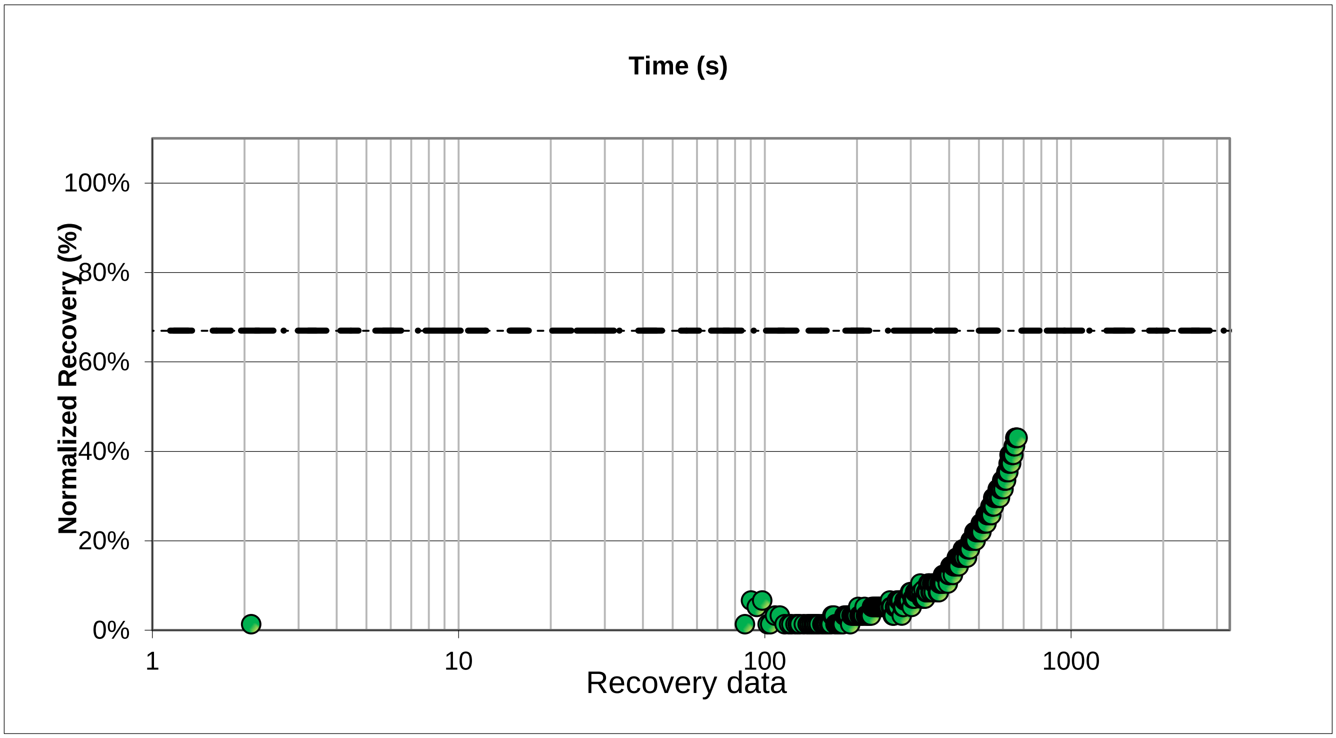
Project No. 1665649 (1000)

Checked By: EM

APPENDIX C

Slug Testing Results





Test Well: BH17-09
Date of Test: March 29, 2017
Test Type: Falling head
Test Method: Hvorslev

T_0 = 690 s
K = 5 x10^{-6} ms^{-1}

CLIENT
CIMA+

PROJECT
HYDROGEOLOGICAL ASSESSMENT
COLERAINE DRIVE, CALEDON, ONTARIO

GOLDER

YYYY-MM-DD	2017-06-12
PREPARED	CM
DESIGN	CM
REVIEW	
APPROVED	

TITLE
SINGLE WELL RESPONSE TEST ANALYSIS
MONITORING WELL 17-09

PROJECT No.	XXXXXXX	Rev	FIGURE
1665649	2000	R01	C-1

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