APRIL 25, 2016

REPORT

FOUNDATION INVESTIGATION AND DESIGN REPORT

HOGG'S HOLLOW STORM SEWER PIPE REPLACEMENT
SOUTH OF HIGHWAY 401
WEST OF HOGG'S HOLLOW BRIDGE
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P. 2191-15-00

Submitted to:
MTO Foundations - Central Region
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FOUNDATION INVESTIGATION REPORT
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NORTH YORK
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the proposed replacement of the 760 mm diameter, corrugated steel pipe (CSP) storm sewer outfall running from Maintenance Hole (MH) No. 19, located west of the Highway 401 Hogg's Hollow Bridge over the Don River West Branch, to near the toe of the river valley slope in the Don Valley Golf Course.

The terms of reference and scope of work for the foundation investigation are outlined in MTO Work Item Order Form No. 5 of Agreement No. 4014-E-0012, dated February 2, 2016 and in Golder's Understanding of the Scope. The Authorization to Proceed was received from MTO via an email on February 10, 2016.

This report addresses the investigation carried out by Golder along the approximately 65 m long section of the storm sewer outfall pipe from MH No. 19, down the slope to near the toe of the slope. The pertinent borehole record from a previous Foundation Investigation Report[1] to this section of the storm sewer pipe near MH No. 19 was used in preparation of this report, and this borehole record is included in Appendix D of this report. A geophysical investigation had been completed by Golder to map the location of the sewer pipe from MH No. 19 down the slope and beyond (to the outlet at the Don River)[2]. The investigation area is shown on the Key Map on Drawing 1.

2.0 SITE DESCRIPTION

The 65 m long section of the storm sewer outfall pipe is planned to be replaced runs along the slope located on the south side of Highway 401 and west of the Hogg's Hollow Bridge over the Don River West Branch. The existing valley slope, which is densely covered with trees especially within its lower portion, is approximately 20 m high with a gradient of approximately 1.75 Horizontal to 1 Vertical (1.75H:1V) as shown on the site photographs included in Appendix E of this report. The Don Valley Golf Course is located south of the slope, within the floodplain of the Don River West Branch.

3.0 INVESTIGATION PROCEDURES

The field work was carried out between March 9 and 14 and on April 5, 2016, during which time a total of six boreholes were advanced along the storm sewer alignment. The locations of these boreholes, together with the location of a borehole from the previous investigation, are shown in plan on Drawing 1.

Boreholes 16-1 to 16-3 were advanced using a Big Beaver portable drill rig supplied and operated by Fisher Environmental of Markham, Ontario. The boreholes were advanced through the overburden using nominal 102 mm diameter solid stem augers. Soil samples were obtained at the ground surface and at intervals of depth of about 0.75 m, using a nominal 50 mm outside diameter split-spoon sampler driven by a manual hammer in accordance with the Standard Penetration Test (SPT) procedure. Boreholes 16-1 and 16-3 were advanced to refusal at depths of 5.4 m and 5.6 m, and Borehole 16-2 was advanced to a depth of

[1] Foundation Investigation and Design Report for Hogg's Hollow Bridge Sinkhole Remedial Measures SW Approach Embankment, by Peto MacCallum Ltd., dated November 25, 2015.

[2] Technical Memorandum for Geophysical Investigation Near Highway 401 at Yonge in Toronto, Ontario, by Golder Associates Ltd., dated January 22, 2016.

approximately 6 m. The lower portion of the slope was not accessible to portable drilling equipment, and therefore Boreholes 16-4 to 16-6 were advanced using hand auger equipment to depths ranging from approximately 1.5 m to 1.8 m (the physical limit of penetration using this method of sampling), to collect auger samples.

The groundwater conditions in the open boreholes were observed during and upon completion of drilling operations. Piezometers were installed in Boreholes 16-2 and 16-3 to permit monitoring of the groundwater level at these locations. The piezometers consist of 25 mm diameter PVC pipe, with a slotted screen at selected depths within the boreholes. The boreholes surrounding the piezometer pipes above the screen and sand pack were backfilled with bentonite pellets to the existing ground surface. The piezometer installation details and water level readings are noted on the Record of Boreholes 16-2 and 16-3 in Appendix A. Boreholes not instrumented with piezometers were backfilled upon completion of drilling/augering 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, completed the hand augering and examined 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, grain size distribution and Atterberg limits) was carried out on selected soil samples. The results of the geotechnical laboratory testing are included in Appendix B. Two samples were submitted to Maxxam Analytics of Mississauga, Ontario for soil analytical testing (pH, sulphate, chloride, resistivity and electrical conductivity); the results are included in Appendix C.

The as-drilled borehole locations and elevations were measured relative to the known site features. The base plan containing the topographic data was provided to Golder by MTO. The borehole locations provided on the Record of Borehole sheets and shown in plan on Drawing 1 are positioned using MTM NAD83 northing and easting coordinates, and the ground surface elevations are referenced to geodetic datum. The borehole locations, ground surface elevations and drilled depths are summarized below.

Borehole Number	Location (MTM NAD83)		Ground Surface Elevation (m)	Borehole Depth (m)	Drilling Method
	Northing (m)	Easting (m)			
16-1	4,845,482.0	311,739.0	158.2	5.4	Power Auger
16-2	4,845,486.0	311,746.0	156.6	5.8	Power Auger
16-3	4,845,481.0	311,752.0	153.6	5.6	Power Auger
16-4	4,845,489.6	311,766.4	152.7	1.8	Hand Auger
16-5	4,845,493.9	311,777.0	150.3	1.7	Hand Auger
16-6	4,845,493.5	311,785.7	148.0	1.5	Hand Auger

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The site is located south of the northern limit of the physiographic region known as the South Slope, according to *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)[3].

The South Slope is a smooth and drumlinized till plain that has formed as a result of glacial action and deposition of till materials just south of the Oak Ridges Moraine. The till is typically comprised of clayey silt to silty clay, with occasional sand to silt zones; it is mapped in this area as the Halton Till. Shallow, localized deposits of loose sand and 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, such as at this site. The recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand, silt and clay.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes advanced as part of the current investigation, together with the results of in situ and laboratory testing are presented on the Record of Borehole sheets and laboratory test summary figures provided in Appendices A and B, respectively. The Record of Borehole sheet from the previous investigation is contained in Appendix D.

The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from observations of drilling progress and non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In general, the subsurface conditions along the proposed sewer pipe replacement consist of cohesive and non-cohesive fill materials, underlain by a deposit of clayey silt till. A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Topsoil/Fill

An approximately 0.1 m thick layer of topsoil was encountered immediately below the ground surface in Borehole 16-3 at about Elevation 153.6 m.

Fill materials were encountered at the ground surface or below the topsoil in all boreholes. The top of the fill layer ranges from Elevations 160.4 m to 148.0 m at the investigated locations on the valley slope, and its thickness varies between 0.9 m and 4.3 m. The fill is comprised of non-cohesive silty sand to sand, some gravel, to gravelly sand, to sand and gravel, as well as cohesive clayey silt, sandy to with sand portions. The non-cohesive fill in places contains clayey silt seams.

The Standard Penetration Test (SPT) "N"-values measured within the cohesive fill generally range from 10 blows to 23 blows per 0.3 m of penetration, suggesting a stiff to very stiff state of consistency, and the SPT 'N'-values measured within the non-cohesive fill range from 7 blows to 59 blows per 0.30 m of penetration, indicating a loose to very dense state of compactness.

[3] Chapman, L.J. and Putman, D.F., 1984. The Physiography of Southern Ontario, Ontario Geological Society, Special Volume 2, Third Edition. Accompanied by Map p. 2715, Scale 1:600,000.

The water content measured on 12 samples of the fill, obtained during the current investigation, ranges from about 7 per cent to about 19 per cent.

The grain size distributions of two samples of the non-cohesive fill and two samples of the cohesive fill, obtained during the current investigation, are shown on Figures B1 and B2, respectively in Appendix B.

An Atterberg limits test was carried out on the fines portion of a sample of clayey silt with sand fill, and measured a liquid limit of about 24 per cent, a plastic limit of about 14 per cent, corresponding to a plasticity index of about 10 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure B3 in Appendix B and indicates that the material is classified as a clayey silt of low plasticity.

4.2.2 Glacial Till

A deposit of glacial till comprised of clayey silt, trace to some sand, trace to some gravel was encountered below the fill in all boreholes. The surface of the till layer was encountered at the investigation locations on the valley slope between Elevations 156.1 m and 146.8 m. Borehole 16-2 penetrated a 0.7 m thick layer of silt and sand till below the clayey silt till, at about Elevation 151.5 m. All boreholes were terminated within this deposit between Elevations 155.3 m and 146.5 m. The presence of cobbles and/or boulders was inferred from split-spoon sampler refusals noted within this deposit.

The SPT “N”-values measured within the glacial till deposit range from 30 blows per 0.10 m to 90 blows per 0.25 m of penetration, suggesting a hard consistency. One SPT “N”-value of 40 blows per 0.30 m of penetration was measured within the silt and sand till in Borehole 16-2, indicating a dense state of compactness.

The water content measured on seven samples of this deposit, obtained during the current investigation, ranges from about 14 per cent to 19 per cent.

The grain size distributions of two samples of the clayey silt till, obtained during the current investigation, are shown on Figure B4 in Appendix B.

Two Atterberg limits tests were carried out on samples of the clayey silt till deposit, and measured liquid limits of about 21 per cent and 25 per cent, plastic limits of about 14 per cent and 19 per cent, and plasticity indices of about 6 per cent and 7 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B5 in Appendix B and indicate that the material is classified as a clayey silt of low plasticity.

The grain size distribution of a sample of the silt and sand till, obtained during the current investigation, is shown on Figure B6 in Appendix B.

4.3 Groundwater Conditions

In general, the soil samples taken during the current investigations were moist. All boreholes were observed to be dry upon completion of drilling.

Piezometers were installed in Boreholes 16-2 and 16-3. These piezometers were noted to be dry in the subsequent visits as listed in the following table.

Borehole No.	Screened Deposit	Date	Depth (m)	Elevation (m)
16-2	Sand to Sand and Gravel Fill	March 14, 2016	Dry to 2.4	Dry to 154.2
		March 28, 2016	Dry to 2.4	Dry to 154.2
		April 5, 2016	Dry to 2.4	Dry to 154.2
16-3	Clayey Silt Till	March 10, 2016	Dry to 5.6	Dry to 148.0
		March 14, 2016	Dry to 5.6	Dry to 148.0
		March 28, 2016	Dry to 5.6	Dry to 148.0
		April 5, 2016	Dry to 5.6	Dry to 148.0

Although the groundwater level within the valley slope was below the shallow piezometers that were installed as part of this investigation, it should be noted that the groundwater level 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. In addition, groundwater may be “perched” locally in non-cohesive fill materials, atop the cohesive till deposit, particularly following periods of precipitation.

5.0 CLOSURE

Mr. Martin Legroulx, B.A.Sc., of Golder's Geotechnical Engineering Group, supervised the borehole investigation program. This Foundation Investigation Report was prepared by Messrs. Martin Legroulx and Al Varshoi, P.Eng., and was reviewed by Ms. Lisa Coyne, P.Eng., senior geotechnical engineer and a Principal of Golder. Mr. Fin Heffernan, P.Eng. Golder's Designated MTO Foundations Contact for this project conducted an independent quality control review of the report.

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PART B

FOUNDATION DESIGN REPORT
HOGG'S HOLLOW STORM SEWER PIPE
SOUTH OF HIGHWAY 401, WEST OF HOGG'S HOLLOW BRIDGE
NORTH YORK
G.W.P. 2191-15-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATION

6.1 General

This section of the report provides foundation design recommendations for the proposed replacement of an approximately 65 m long section of the storm sewer pipe along the slope located south of Highway 401 and west of the Hogg's Hollow Bridge over the Don River West Branch. The recommendations are based on interpretation of the factual data obtained from available borehole information.

The interpretation and recommendations presented in this report are intended to provide the designers with sufficient information to complete the detail design of the proposed sewer outfall pipe replacement.

Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

Based on the terms of reference for this assignment, it is understood that a sinkhole developed south of Highway 401, due to a failure in the 760 mm diameter storm sewer pipe running parallel to Highway 401; that section of pipe, which was addressed in a previous study by others, is to be replaced in an upcoming contract. The MTO Central Region Planning and Design Section proposes to replace the 65 m long section of the storm sewer outfall pipe southeast of MH No. 19 down the slope to near the toe, concurrent with the replacement of the failed pipe parallel to Highway 401 at the top of the slope. It is understood that the section of the pipe along the slope consists of two segments that are linked with a drop structure approximately 25 m southeast of MH No. 19. It is also understood that the depth to the pipe obvert ranges from about 0.4 m to 3.4 m, but is generally less than about 1.5 m.

6.2 Replacement/Rehabilitation Options

The soils to and at the existing pipe invert generally consist of stiff to very stiff/compact to very dense cohesive and non-cohesive fill, underlain by a hard clayey silt till deposit. The groundwater level was generally below a depth of approximately 5 m at the borehole locations, based on observations during the drilling investigation and in the installed piezometers.

The replacement storm sewer pipe may be installed by traditional open-cut excavations or by means of trenchless methods. It is understood that it may be desirable to use a trenchless method for replacement of the storm sewer pipe to minimize tree removals on the valley slope. The tunnelling method will be subjected to difficult alignment control conditions, given the variable compactness/consistency of the soil strata and the presence of hard glacial till soils with possible cobbles and/or boulders underlying fill materials at the pipe horizon, as mixed face conditions will likely be present. Consideration may be given to non-tunnelling procedures of trenchless installation such as Pipe Lining. The replacement of the existing storm sewer pipe by Pipe Lining must consider the limitations of pipe size (diameter), potential loss of flow capacity given the slightly smaller diameter of the replacement pipe compared to the existing pipe and the need for access/excavation near the toe of the valley slope, where a maintenance hole/drop structure does not exist.

A comparison between open-cut excavations, tunnelling trenchless methods (including micro-tunnelling and open face shield tunnelling) and a non-tunnelling trenchless method (i.e. pipe lining), based on advantages, disadvantages, risks and relative cost, is provided in Table 1 following the text of this report. From a foundations perspective and given the subsurface soil and groundwater conditions along the storm sewer pipe and the relatively short length of the new installation, it is considered that the most feasible construction methods for replacement of the existing storm sewer pipe on the same vertical/longitudinal alignment would be by open-cut excavations or Pipe Lining.

The following sections of this report provide recommendations for open-cut excavations and discuss various trenchless methods in more detail.

6.2.1 Open-Cut and Backfill

Excavations

The storm sewer pipe installation may be carried out using conventional open-cut methods in accordance with Ontario Provincial Standard Specification (OPSS) 410 (Pipe Sewer Installation in Open-Cut). It is assumed that the invert level of the new pipe will be similar to the existing pipe, and as such the excavation depth would range from approximately 1.5 m to 4.5 m to account for typical bedding. Based on the borehole information and the assumed depth, the founding soils consist of generally stiff to very stiff/compact to dense fill and hard clayey silt till as shown on Drawing 1.

The fill and native soils at this site are generally considered suitable for supporting the proposed storm sewer pipe. Organics, softened/loosened and deleterious soils are considered not suitable for supporting the proposed storm pipe. These soils, if encountered, should be sub-excavated to competent native soils and additional bedding material should be added to reach the design invert elevation. Where loose fill materials are encountered at the proposed invert levels, proof-rolling will be required.

Pipe Bedding and Cover

The bedding and cover for the pipe should be compatible with the size, type and class of pipe and the surrounding subsoil and the requirements of OPSS 401 (Trenching, backfilling and compacting). If granular bedding is deemed to be acceptable, the bedding material should meet the gradation specifications for OPSS.PROV 1010 Granular “A” material with a thickness of 0.15 times pipe diameter, but not less than 150 mm. The granular bedding should be compacted to 100 per cent of its Standard Proctor maximum dry density (SPMDD) in accordance with OPSS.PROV 501 (Compacting). Any wet or disturbed subgrade soils should be removed prior to placement of the bedding. Clear stone is not recommended for use as bedding material because it would allow infiltration of fines from the soils adjacent to the service trench into the void space of the stone, which would in turn lead to settlement of the ground adjacent to and beneath the service. From springline to at least 300 mm above the pipe obvert, sand cover should be used. The sand cover should be compacted to 95 per cent of the material’s SPMDD in accordance with OPSS.PROV 501 (Compacting).

Trench Backfill

Chemically inert excavated on-site soils would be suitable for use as general fill for backfilling the trench above the pipe cover, provided it is free of organics and other deleterious materials. The majority of fill and native subsoils were noted to be generally near the optimum water content for compaction and can be used for trench backfilling during dry weather periods.

All oversized cobbles and boulders (i.e. particles greater than 150 mm in size) should be removed from the backfill. Care should be taken to minimize the potential for over-wetting of the soils during the construction operations. Difficulties with compaction and/or backfill performance should be anticipated for fine-grained soils where the water content is above the optimum for compaction purposes. Should construction extend to the winter months, care must be taken to ensure that frozen material is not used as backfill.

Given that the trench is along the slope away from paved roads or trails, normal post-construction settlement of the compacted trench backfill is not considered to be an issue; however the majority of such settlement would take place within about 6 months following the completion of trench backfilling operations. It is recommended to place topsoil in accordance with OPSS 802 (Topsoil) on the trench backfill along the slope to reduce surface water erosion. The erosion protection should be placed in accordance with OPSS.PROV 804 (Seed and Cover) or pegged sod in accordance with OPSS 803 (Sodding).

Ground Anchors for Pipe Support

The new sewer pipe may need to be anchored to resist the pressures induced by the flow inside the pipe. Consideration was given to the use of helical piles as ground anchors for the replacement section of pipe along the valley slope. However, the hard nature of the native soils at this site, together with the presence of cobbles and/or boulders (as noted during the borehole drilling) will pose risks to successfully install helical piles. It is recommended that consideration be given to using “drilled-in” soil anchors to resist these stresses, where required. The design and installation of ground anchors should be completed in accordance with OPSS 942 (Prestressed Soil and Rock Anchors).

The capacity of ground anchors may be calculated using the method provided in the Canadian Foundation Engineering Manual, 2006 (CFEM, 2006). The design of ground anchors drilled into the hard till deposit at this site should be based on the unfactored pull-out resistance of 60 kN per metre of bond length, based on an assumed 150 mm diameter for the anchor drill hole. The appropriate geotechnical resistance factor in accordance with Table 6.2 of the Canadian Highway Bridge Design Code (CHBDC, 2014) should be applied to the pull-out resistance.

The design capacity of the ground anchors will need to be verified on site using proof tests. The capacity of ground anchors can be improved by multi-stage secondary grouting of the bond zone. Secondary grouting may also be used, if proof testing shows a particular anchor to be deficient. It should be noted that the secondary grout pressure should be sufficient to fracture primary grout and the surrounding soil mass. Golder can provide additional information regarding secondary grouted anchors if higher resistances are required.

6.2.2 Pipe Lining

Lining of the existing corrugated steel pipe entails inserting a longitudinal folded HDPE or PVC pipe of a suitable diameter (usually the same as the internal diameter of the existing pipe) into the existing pipe. Subsequently, the liner will be inflated (by steam under pressure) such that the liner expands and intimately contacts the inside of the existing pipe. The primary limitation to lining the existing pipe is restriction of available liner diameter; whereas PVC liner sizes range up to about 910 mm (36 inches, which size was installed recently at a Highway 401/Winston Churchill Boulevard area crossing), HDPE liner sizes are restricted to maximum 400 mm (16 inches) for folded liners and 600 mm (24 inches) for rigid liners. Folded liners offer the advantage of installation via existing maintenance holes. Pipe Lining requires that the locations of any appurtenances/laterals are clearly established prior to drilling operations, so that the lines can then be cut/reamed at the lateral locations to re-establish proper in-flow connection.

If consideration is given to using the Pipe Lining technique, a condition survey of the host pipe should be carried out to ensure that the host pipe is intact. Lining of the existing storm sewer pipe results in a slightly smaller inside diameter of the finished installation, which reduces the flow capacity of the storm sewer. However, the smoother flow characteristics provided by the smooth nature of the pipe and the steep gradient at this site may partially compensate for the size reduction.

6.2.3 Trenchless Installation

Successful completion of any trenchless installation largely depends on appropriate selection of equipment and methods and the skills and experience of the Contractor. The final selection of the trenchless method should be made by the Contractor based on his experience and equipment capabilities and his assessment of the subsurface conditions. Any trenchless method used will likely require excavations for access/exit shafts for equipment, at maintenance holes and/or at connections to existing pipes. Adequate cover must be available for trenchless installations and, in general, should not be less than two times the pipe diameter to assist with minimizing surface settlement and the potential for uncontrolled ground losses. Further, the geometry of the slope, tunnel equipment entry and exit points and the interference with the Don Valley Golf Course property should be considered.

The presence of the existing storm sewer pipe adjacent to the alignment of the new pipe could pose an obstruction to trenchless installation, and the quality of the existing bedding/cover/backfill soil may negatively impact the installation operations. Further, the location (depth/alignment), type and tolerances to movement and vibrations of any existing buried utilities would have to be clearly established prior to any trenchless installation operation.

Potential trenchless methods for consideration include micro-tunnel boring machine (MTBM) and open face shield tunneling (hand mining). Horizontal Directional Drilling (HDD) is not considered feasible for the size, length, geometry and use of the pipe at this site, and due to relatively high risk of hydraulic fracture (“frac-out”) in variable and shallow soil/fill conditions. Jack and Bore and Pipe Ramming methods are not considered feasible due to the relatively high risk of alignment deviation considering the geometry of the installation (installation under an existing slope with a gradient of 1.75H:1V) and presence of cobbles and/or boulders in the native till deposit.

Micro-Tunnel Boring Machine (MTBM)

Micro-Tunnel Boring Machines (MTBMs) utilize pressurized bentonite slurry to counterbalance the earth and water pressures acting at the tunnel face. A rotating cutter head is used to excavate soil in a controlled manner at the face and together with the pressurized slurry, these act to minimize loss of ground during tunnel advance. The slurry is circulated back through the tunnel to transport cuttings to a settling tank. The MTBM can also be specified and equipped to crush boulders. Given the machine’s ability to control soil and water pressures at the face, dewatering of granular fill/native soils along the tunnel alignment is unnecessary with this tunnelling method.

MTBM is typically considered to be the method that can best minimize the risk of loss of ground and ground surface settlement, although this site is away from paved areas and minor settlement should be acceptable. It is relatively expensive to mobilize this type of machine, and the availability of machines with the suitable diameter bore and the mobilization costs for such equipment may constrain their use on this project. To minimize the risk of slurry losses to the surface, use of MTBM systems is generally not recommended for installations where cover is less than 2.5 m. On this basis, micro-tunnelling is considered not practical at this site due to slope geometry, the high price for the equipment and the potential for “frac-out” due to the relatively shallow cover depth.

Micro-tunnelling can be fully obstructed if sufficient numbers and sizes of cobbles and/or boulders are encountered, due to the lack of access to the face and the smaller diameter of the equipment precluding manual removal of obstructions from the face. If micro-tunnelling is chosen for this project (for example, if the sewer alignment is deepened to minimize the risk of potential “frac-out”), the selected cutting tools and methods should be compatible with the hard/dense soils containing cobbles and boulders. Properly selected rock cutter discs should be used to cut the hard/dense soils and break cobbles and boulders at the face into sufficiently smaller fragments to pass through the apertures in the face. Alternatively, depending on the particular MTBM configuration, slurry properties and advance rate, some MTBMs can sometimes incorporate a crushing head, which can draw cobbles and boulders into the shield and crush them. However, large boulders or many cobbles can choke internal crushers such that the obstructions cannot be cleared or ingested by the machine and the alignment will have to be either abandoned or a rescue shaft advanced to free the MTBM and remove the obstructions.

In Ontario, some trenchless contractors use “small boring units” and present this system as “micro-tunnelling”. In general, the small boring units often consist of a rotating cutter head system that is temporarily welded to the lead end of a steel casing. The ground is cut using a variety of face tools (similar to MTBMs described above), but the spoil is transported to the surface using an auger system, much like conventional jack and bore systems. Face openings on the small boring units are typically much smaller than the auger opening on conventional jack and bore systems and the risk of uncontrolled ingress of ground into the lead end of the casing is lower for this system as compared to jack and bore methods. These systems do not, however, provide consistent and positive support to the ground at all face openings with any slurry or cuttings, unlike the slurry-based MTBMs described above. Therefore, while the small boring units are more suitable and advantageous for cutting through many soil types as well as hard cohesive glacial till when fitted with the proper cutting tools, they should only be used with caution if saturated granular soils could be encountered.

Open Face Shield Tunnelling (Hand Mining)

Open face shield tunnelling involves excavating the soils using a hydraulic excavator arm or manual labour with pneumatic spades, working within a full-circumference tunnelling shield. Typically, the liner pipe would consist of a solid steel casing, jacked in sections from the launching shaft. Unlike auger jack and bore, this method allows personnel to enter the tunnel to allow more control over the operations such as for removal of obstructions or control of groundwater seepage or localized instabilities. However, personnel-entry is only permitted for pipe diameters greater than 750 mm, as stipulated in the OH&S Act and Regulations.

Soils that are classified as “flowing” or “running” are not considered suitable for open face shield tunneling of the risk for uncontrolled inflows into the casing that would lead to increased settlement (and potentially formation of sink holes) at the ground surface and danger to any labourers within the pipe. These methods can be utilized only if the granular soil deposits are dewatered/depressurized such that the groundwater level is lowered to below the tunnel invert along the full alignment. In a moist, depressurized condition, the granular soils would behave as “ravelling” to “cohesive-running”, providing the ability to advance the tunnel with minimal ground losses providing the excavation is undertaken on a continuous controlled basis.

Based on the borehole information, neither “flowing” nor “running” soil conditions are anticipated within the likely tunnelling horizon, and therefore the soil conditions would be suitable for this trenchless installation method. In addition, this method would avoid the potential for “frac-out” and deepening of the sewer alignment that would be required with the MTBM method. However, the disadvantages associated with this method are the minimum tunnel size required and the relatively high cost (particularly as related to Pipe Lining). Also, it is noted that due to the presence of the drop structure mid-way along the storm sewer pipe, any tunnelling option would require work in two separate sections, with associated entry and exit points, unless a new sewer alignment with no drop structure were to be constructed.

If open shield tunnelling is selected, the contractor should have a means to readily secure the face if inward ground deformation is encountered or if unanticipated work stoppages are necessary (pre-fabricated breasting boards, etc.). Further, tunnelling work should be continuous from start to finish (24 hours per day, 7 days per week). If it is necessary to stop the tunnelling operations, the contractor should be prepared to immediately support the face (such as by pre-cut breasting boards). Filling of the annular space between the liner and native ground should be carried out as soon as the liner is installed (bentonitic grout/lubricant in the case of jacked pipes, with cementitious grout provided at the completion of construction).

6.3 Lateral Earth Pressure for Design

The parameters (unfactored) provided below may be used to calculate the lateral earth pressures acting on ancillary structures such as maintenance holes or temporary protection systems for excavation support, if required:

Fill Type	Angle of Internal Friction (Deg)	Unit Weight (kN/m^3)	Coefficients of Static Lateral Earth Pressure		
			At-Rest, K_o	Active, K_a	Passive, K_p
New Granular Fill	35	22	0.43	0.27	3.69
Existing Fill	30	21	0.50	0.33	3.00
Glacial Till	34	22	0.44	0.28	3.54

The unit weight of water may be taken as 10 kN/m^3; although the groundwater level was not encountered within the investigated depth, it is recommended that the groundwater level be assumed to be at a depth of 6 m below the valley slope surface, for design purposes If the structure allows for lateral yielding, active earth pressures may be used in the design of the structure(s). If the structure does not allow for lateral yielding, at-rest earth pressures should be assumed for design. The movement to allow active pressures to develop within the supported material, and thereby assume an unrestrained structure, may be taken as presented in Figure C6.16 and Table C6.6 of the Commentary to the *CHBDC (2014)*.

6.4 Construction Consideration

6.4.1 Excavations and Groundwater Control

Excavations will be required for open-cut installation or entry and exit points for the tunnelling trenchless methods, if adopted.

Care should be taken to direct surface water away from the open excavations and all temporary excavations should be carried out in accordance with Ontario Regulation 213 (Ontario Occupational Health and Safety Act, OHSA, for Construction Projects). The existing fill and native hard till soils are classified as Type 3 and Type 1 soils. If an excavation contains more than one type of soil, the soil should be classified as the type with the highest number, and as such temporary open-cut excavations above groundwater in these soils should be made with side slopes no steeper than 1H:1V. These excavations are expected to be above the groundwater level and minor inflow to the excavations is expected to be handled by pumping from sumps located at the bottom of excavations. Stockpiles of excavated materials should be avoided at the edge of the excavation and top of the slope.

For the open-cut excavations and/or entry and exit points (pits) excavations, the highest risk from a foundations perspective is the selection of the temporary shoring. A properly designed and engineered shoring system (e.g. soldier pile and lagging, a slide-rail system, etc.) will be required. Temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems) and a minimum performance level of 3 should be considered.

6.4.2 Obstructions

The till deposit encountered at this site contains cobbles and/or boulders, which could affect the installation of temporary protection systems or trenchless installations. If conditions warrant, an NSSP should be included in the Contract Documents to identify to the contractor the possible presence of cobbles and/or boulders within the overburden soils. A sample NSSP to address obstructions is included in Appendix F

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Al Varshoi, P.Eng and reviewed by Ms. Lisa Coyne, P.Eng., senior geotechnical engineer and a Principal with Golder. Mr. Fin Heffernan, P.Eng. Golder's Designated MTO Contact for this project conducted an independent quality control review of the report.

GOLDER ASSOCIATES LTD.

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ARV/LCC/FJH/rb

n:\active\2014\1111\1413191 mto - foundations eng retainer - east on\5 - hoggs hollow sewer\7 - reporting\final\1413191 rpt 2016-04-25 hogg's hollow storm pipe replacement- lcc rev.1.docx

REFERENCES

Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual, 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd, British Columbia.

Canadian Highway Bridge Design Code (CHBDC) and Commentary, 2014. CAN CSA Group.

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.

Golder Associates Ltd. 2016. Technical Memorandum for Geophysical Investigation near Highway 601 at Yonge in Toronto, Ontario. Project No. 13-1184-0123/15.

Occupational Health and Safety Act and Regulations, Construction Projects (O.Reg 213/91), 2015.

Peto MacCallum Ltd., 2015. Foundation Investigation and Design Report for Hogg's Hollow Bridge Sinkhole Remedial Measures SW Approach Embankment, Don River Bridge, Highway 401 Eastbound, Toronto, Ontario, Agreement No. 2013-E-0039 Task No. 2013-E-0039-007A.

Ontario Provincial Standard Specifications (OPSS)

OPSS 401	Construction Specification for Trenching, Backfilling, and Compacting
OPSS 410	Construction Specification for Pipe Sewer Installation in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS 802	Construction Specification for Topsoil
OPSS 803	Construction Specification for Sodding
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS 942	Construction Specification for Prestressed Soil and Rock Anchors
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Table 1: Evaluation of Alternatives for Replacement of Storm Sewer Pipe along the Slope South of Highway 401, West of Hogg's Hollow Bridge

Installation Method	Advantages	Disadvantages	Relative Costs	Relative Risks
Open-Cut and Backfill	▪ Conventional construction; ▪ Excavations can easily be advance through cobbles and boulders and other obstructions; ▪ Existing pipes can be removed as new pipes are installed; and, ▪ Allows for daylighting of buried services.	▪ Tree and tree roots removals will be required.	▪ Relatively low cost.	▪ Risk of inadequate groundwater control systems and shoring systems that do not properly support ground.
Pipe Lining	▪ Relatively fast installation; ▪ Liner offers better flow characteristics; ▪ Installation from existing maintenance holes.	▪ HDPE replacement pipe likely not available in required size for this site (max dia. 400 mm).	▪ Unable to obtain.	▪ Specialist contactor/applications.
Micro-Tunnelling Boring Machine (MTBM)	▪ Machine is able to counterbalance earth and water pressures in a controlled manner, thereby reducing the risk of ground losses during tunnelling.	▪ Lack of availability of machines with the suitable diameter bore; ▪ Must establish location of buried utilities as trenchless installation is "blind"; and, ▪ Would have to establish new alignment as existing sewer pipe would constitute an obstruction.	▪ High mobilization cost and relatively expensive.	▪ Time delay in obtaining a suitable diameter machine(s) is likely; and ▪ Risk of "frac-out" with less than 2.5 m of cover; tunnel horizon to be deepened.
Open Face Shield Tunnelling (Hand mining)	▪ Better suited for penetrating through potential obstructions such as cobbles and boulders than other tunnelling methods.	▪ Multiple jacking pits required for many short section of pipe; ▪ Must establish location of buried utilities as trenchless installation is "blind"; and, ▪ Would have to establish new alignment as existing sewer pipe would constitute an obstruction.	▪ Relatively expensive.	▪ Potential for loss of ground into shield particularly where none-cohesive materials and/or wet ground conditions are encountered.

DRAWING

MINISTRY OF TRANSPORTATION, ONTARIO

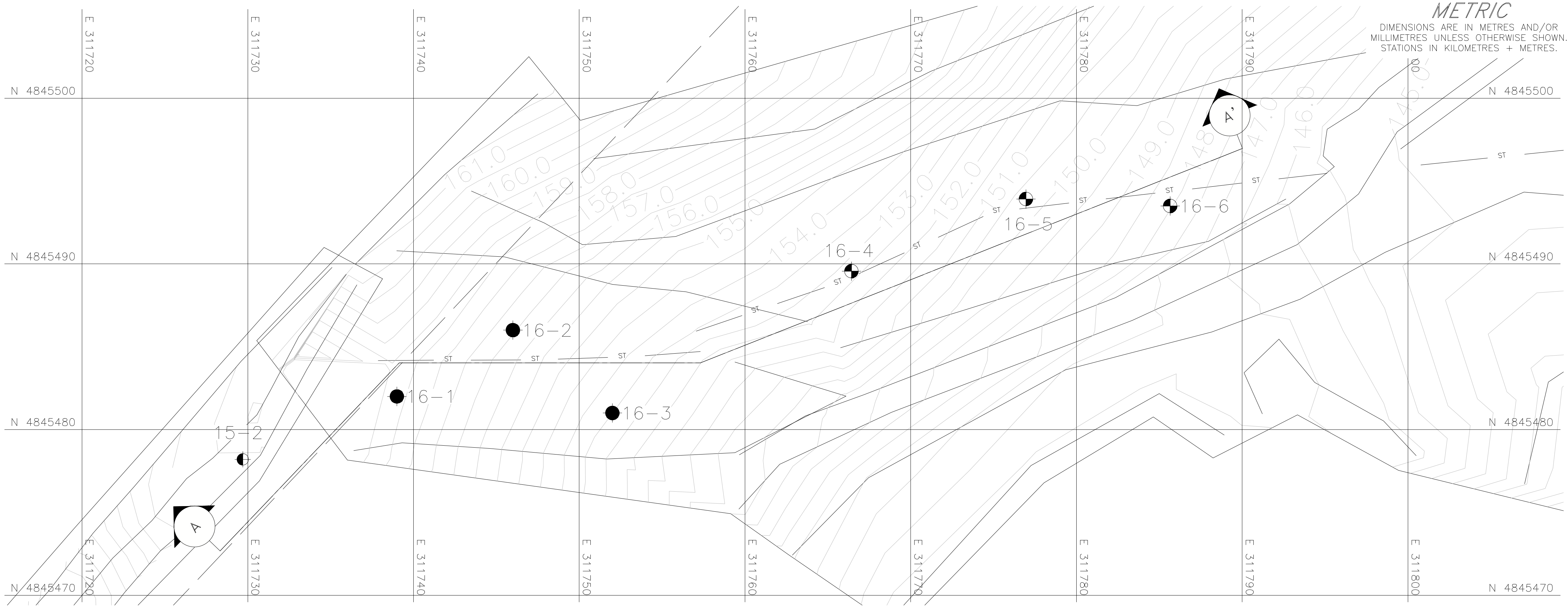
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2191-15-00

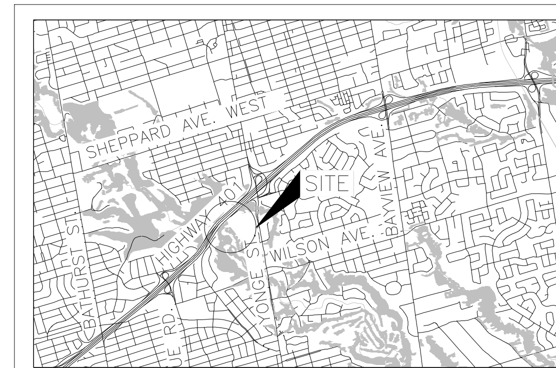
HOGG'S HOLLOW STORM SEWER PIPE REPLACEMENT BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Golder Associates



PLAN
SCALE
3 0 3 6 m



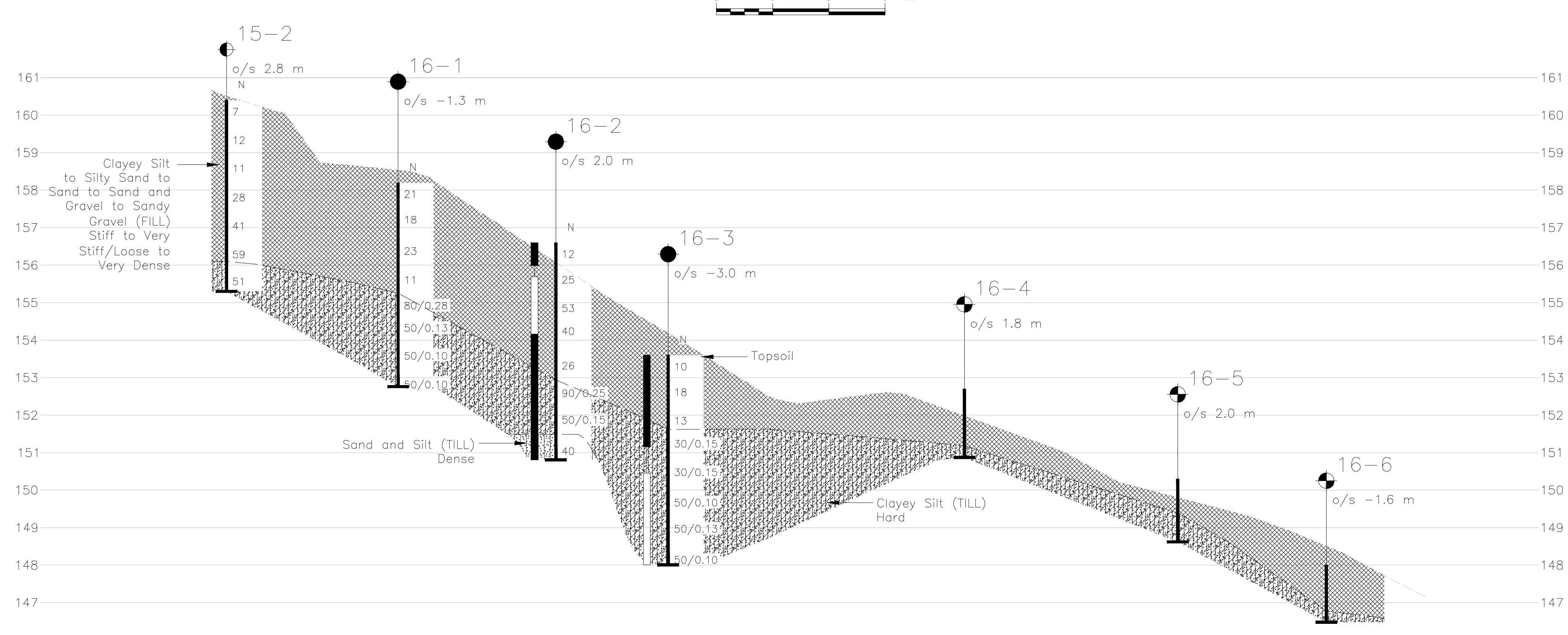
KEY PLAN
SCALE
1 0 1 2 km

LEGEND

- Borehole – Current Investigation
- Borehole – Previous Investigation
- Borehole – Hand Auger
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
15-2	160.4	4845478.2	311729.7
16-1	158.2	4845482.0	311739.0
16-2	156.6	4845486.0	311746.0
16-3	153.6	4845481.0	311752.0
16-4	152.7	4845489.6	311766.4
16-5	150.3	4845493.9	311777.0
16-6	148.0	4845493.5	311785.7



CROSS SECTION A – A"
SCALE HORIZONTAL
3 0 3 6 m
SCALE VERTICAL
1.5 0 1.5 3.0 m

NOTES

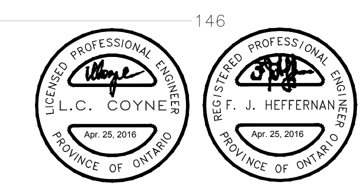
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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 MTO, drawing file nos. W1527108-Dec2015.dwg, received March 15, 2016 and W1527108.dwg, received March 29, 2016.



NO.	DATE	BY	REVISION

Geocres No. 30M11-263

HWY. 401		PROJECT NO. 1413191	DIST.
SUBM'D. MPL	CHKD. ARV	DATE: 4/12/2016	SITE:
DRAWN: DD	CHKD. ARV	APPD. LCC	DWG. 1

PLOT DATE: April 25, 2016
FILENAME: S:\Clients\MTO\Hwy_401_Yonge\99_PROJ\1413191_Sewer\40_PROD\0001_Pipe_Replacement\1413191_0001_BG_0001.dwg

APPENDIX A

Borehole Records from Current Investigation

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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_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 $= (w_l - w_p)$
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 $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

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

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

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
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, 60º 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 cm^2 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 / Relative Density	**N — Blows/300 mm or Blows/ft**
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils
Consistency

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

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

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

Description and Notes

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

Abbreviations

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

Golder Associates

RECORD OF BOREHOLE No 16-1

SHEET 1 OF 1 **METRIC**

PROJECT 1413191			
G.W.P. 2191-15-00	LOCATION N 4845482.0 ;E 311739.0		ORIGINATED BY ML
DIST HWY	BOREHOLE TYPE Power Auger, 102 mm O.D. Solid Stem Augers		COMPILED BY NN
DATUM Geodetic	DATE March 14, 2016		CHECKED BY ARV

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
158.2	GROUND SURFACE						
0.0	Sandy clayey silt, trace gravel (FILL) Very stiff Brown Moist	1	SS	21	158		
157.5 / 0.7	Sand, some gravel, trace silt (FILL) Compact Brown Moist	2	SS	18	157	w ≈ 12	
156.8 / 1.4	Clayey silt with sand, trace gravel (FILL) Stiff to very stiff Mottled brown with oxidation staining Moist	3	SS	23		w_P ≈ 14, w ≈ 17, w_L ≈ 24	4 43 38 15
		4	SS	11	156	w ≈ 14	
155.3 / 2.9	CLAYEY SILT, some sand, trace to some gravel (TILL) Hard Brown, becoming grey below a depth of 4.6 m Moist	5	SS	80/0.28	155	w ≈ 17	
		6	SS	50/0.13	154		
		7	SS	50/0.10		w ≈ 17	
152.8 / 5.4	SPLIT-SPOON SAMPLER REFUSAL END OF BOREHOLE	8	SS	50/0.10	153		

NOTE:

1. Borehole dry upon completion of drilling.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

RECORD OF BOREHOLE No 16-2

SHEET 1 OF 1

METRIC

PROJECT 1413191

G.W.P. 2191-15-00 | LOCATION N 4845486.0 ;E 311746.0 | ORIGINATED BY ML

DIST ___ HWY ___ | BOREHOLE TYPE Power Auger, 102 mm O.D. Solid Stem Augers | COMPILED BY NN

DATUM Geodetic | DATE March 10, 2016 | CHECKED BY ARV

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
156.6	GROUND SURFACE									
0.0	Sandy clayey silt, some gravel, trace organics (FILL) Stiff Brown Moist	1	SS	12	156					
155.9 / 0.7	Sand and gravel to sandy gravel, trace to some silt, trace to some clay, containing clayey silt seams below a depth of 2.1 m (FILL) Compact to very dense Brown Moist	2	SS	25		o	32	57	10	1
		3	SS	53	155	o	45	25	18	12
		4	SS	40	154	o				
		5	SS	26		o				
152.9 / 3.7	CLAYEY SILT, some sand (TILL) Hard Grey Moist	6	SS	90/0.25	153	o (with plastic/liquid limits)	0	13	67	20
		7	SS	50/0.15	152					
151.5 / 5.1	SILT and SAND, trace to some gravel, trace to some clay (TILL) Dense Brown Moist	8	SS	40	151		11	34	46	9
150.8 / 5.8	END OF BOREHOLE									

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

NOTES:

1. Borehole dry upon completion of drilling.

2. Groundwater level measurements in piezometer:

Date	Depth (m)
03/14/16	Dry to 2.4 m
03/28/16	Dry to 2.4 m
04/05/16	Dry to 2.4 m

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

Golder Associates

RECORD OF BOREHOLE No 16-3

SHEET 1 OF 1 | METRIC

PROJECT 1413191

G.W.P. 2191-15-00 | LOCATION N 4845481.0 ;E 311752.0 | ORIGINATED BY ML

DIST ___ HWY ___ | BOREHOLE TYPE Power Auger, 102 mm O.D. Solid Stem Augers | COMPILED BY NN

DATUM Geodetic | DATE March 9, 2016 | CHECKED BY ARV

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
153.6	GROUND SURFACE						
0.0 / 0.1	TOPSOIL						
	Sandy clayey silt, some gravel, trace organics (FILL) Stiff Mottled brown and grey Moist	1	SS	10	153		
152.7 / 0.9		2	SS	18		o	
152.2 / 1.4	Sand, some gravel, trace silt (FILL) Compact Brown with oxidation staining Moist	3	SS	13	152	o	9 32 42 17
151.6 / 2.0	Clayey silt with sand, trace to some gravel (FILL) Stiff Brown Moist	4	SS	30/0.15	151	o	
	CLAYEY SILT, trace sand (TILL) Brown, becoming grey below a depth of 2.4 m Hard Moist	5	SS	30/0.15		o (with plastic/liquid limits)	0 1 83 16
		6	SS	50/0.10	150	o	
		7	SS	50/0.13	149		
	Silty sand seam from depths of about 5.3 m to 5.5 m	8A 8B	SS	50/0.10			
148.0 / 5.6	SPLIT-SPOON SAMPLER REFUSAL END OF BOREHOLE						

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³.

NOTES:

1. Auger refusal encountered at a depth of 2.0 m in the first two attempts of borehole advancement. Borehole was moved about 3.0 m east of the original location and samples were taken below a depth of 2.3 m to borehole termination depth of 5.6 m.

2. Borehole dry upon completion of drilling.

3. Groundwater level measurements in piezometer:

Date	Depth (m)
03/10/16	Dry to 5.6 m
03/14/16	Dry to 5.6 m
03/28/16	Dry to 5.6 m
04/05/16	Dry to 5.6 m

$+^3, \times^3$: Numbers refer to Sensitivity　　○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-4

SHEET 1 OF 1 **METRIC**

PROJECT 1413191

G.W.P. 2191-15-00 LOCATION N 4845489.6 ;E 311766.4 ORIGINATED BY ML

DIST ____ HWY ____ BOREHOLE TYPE Hand Auger COMPILED BY ML

DATUM Geodetic DATE April 5, 2016 CHECKED BY ARV

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
152.7	GROUND SURFACE								
0.0	Silty sand, trace to some gravel (FILL) Brown Moist	1	AS	-					
		2	AS	-					
		3	AS	-		152			
		4	AS	-					
151.2		5	AS	-					
	CLAYEY SILT, some sand, trace gravel (TILL) Brown Moist	6	AS	-		151			
150.9 1.8	END OF BOREHOLE								

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%): 10 20 30

NOTE:

1. Borehole dry upon completion of hand augering.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 16-5

SHEET 1 OF 1 **METRIC**

PROJECT 1413191
G.W.P. 2191-15-00 LOCATION N 4845493.9 ;E 311777.0 ORIGINATED BY ML
DIST ___ HWY ___ BOREHOLE TYPE Hand Auger COMPILED BY ML
DATUM Geodetic DATE April 5, 2016 CHECKED BY ARV

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
150.3	GROUND SURFACE										
0.0	Sandy clayey silt, trace to some gravel (FILL) Brown Moist		1	AS	-		150				
			2	AS	-						
149.4			3	AS	-				○ (~19)		
0.9	Sandy CLAYEY SILT, trace to some gravel (TILL) Brown Moist		4	AS	-						
			5	AS	-		149				
148.6			6	AS	-						
1.7	END OF BOREHOLE										

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

RECORD OF BOREHOLE No 16-6

SHEET 1 OF 1

METRIC

PROJECT 1413191

G.W.P. 2191-15-00

LOCATION N 4845493.5 ;E 311785.7

ORIGINATED BY ML

DIST ____ HWY ____

BOREHOLE TYPE Hand Auger

COMPILED BY ML

DATUM Geodetic

DATE April 5, 2016

CHECKED BY ARV

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
148.0	GROUND SURFACE										
0.0	Silty sand, trace gravel (FILL) Brown Moist		1	AS	-						
			2	AS	-						
147.1			3	AS	-						
146.8	Sandy clayey silt (FILL) Brown Moist		4	AS	-		147		o (approx. 22)		
146.5 1.5	CLAYEY SILT, some sand, trace gravel (TILL) Brown Moist		5	AS	-						
	END OF BOREHOLE NOTE: 1. Borehole dry upon completion of hand augering.										

+³, ×³: Numbers refer to Sensitivity

O 3% STRAIN AT FAILURE

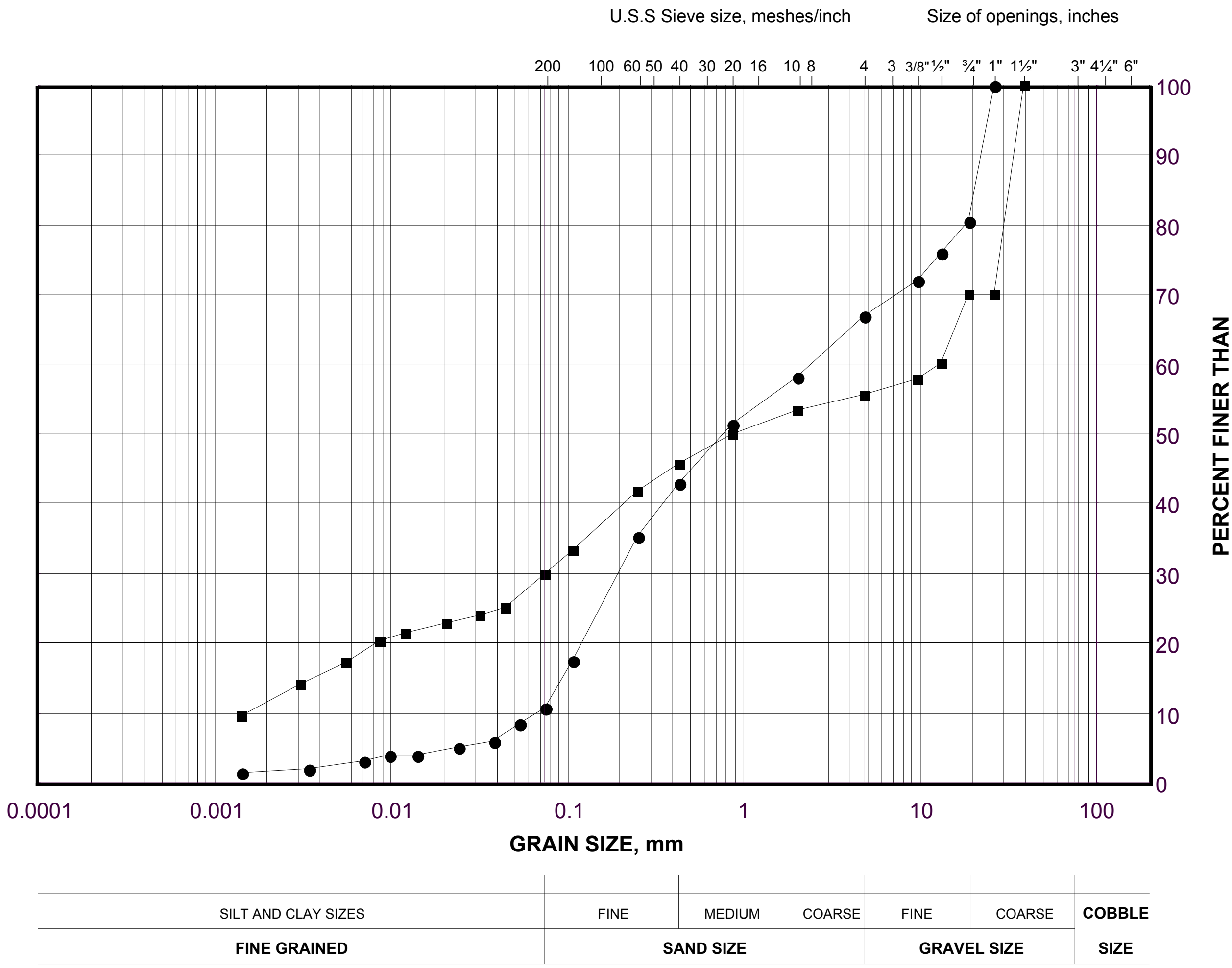
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Sand and Gravel to Sandy Gravel (Fill)

FIGURE B1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	16-2	2	155.6
■	16-2	3	154.8

Project Number: 1413191

Checked By: PKS

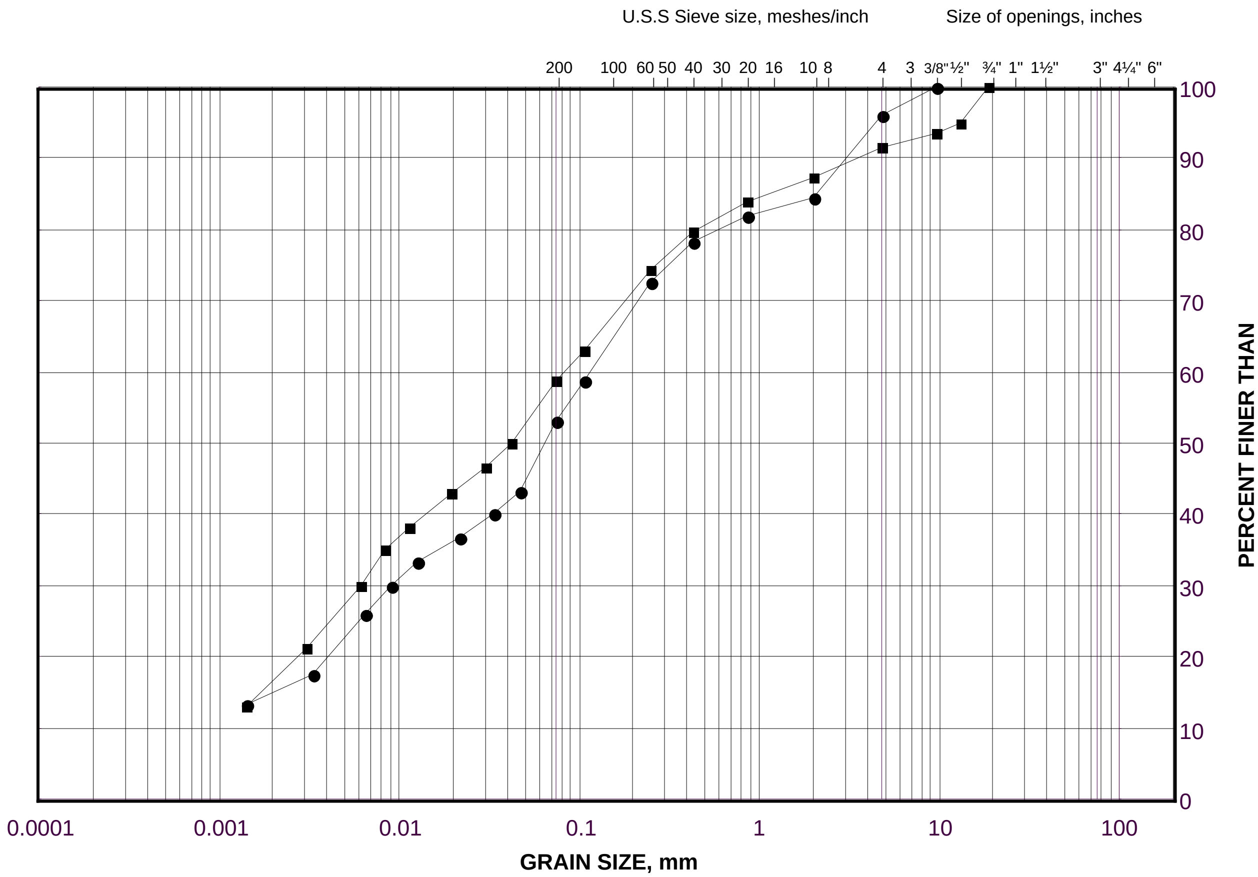
Golder Associates

Date: 31-Mar-16

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Fill)

FIGURE B2



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

LEGEND

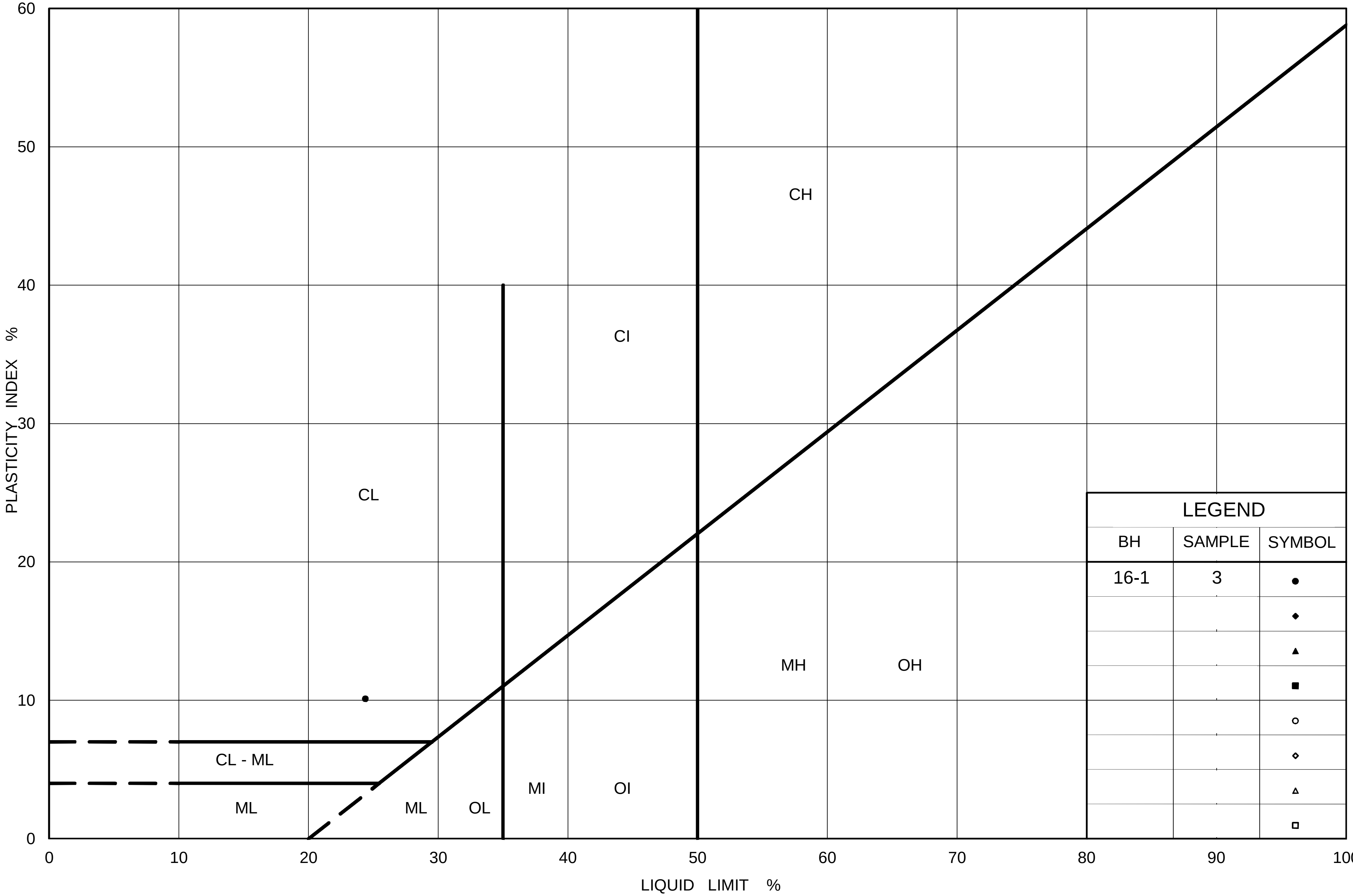
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	16-1	3	156.4
■	16-3	3	151.8

Project Number: 1413191

Checked By: PKS

Golder Associates

Date: 31-Mar-16



Ministry of Transportation

Ontario

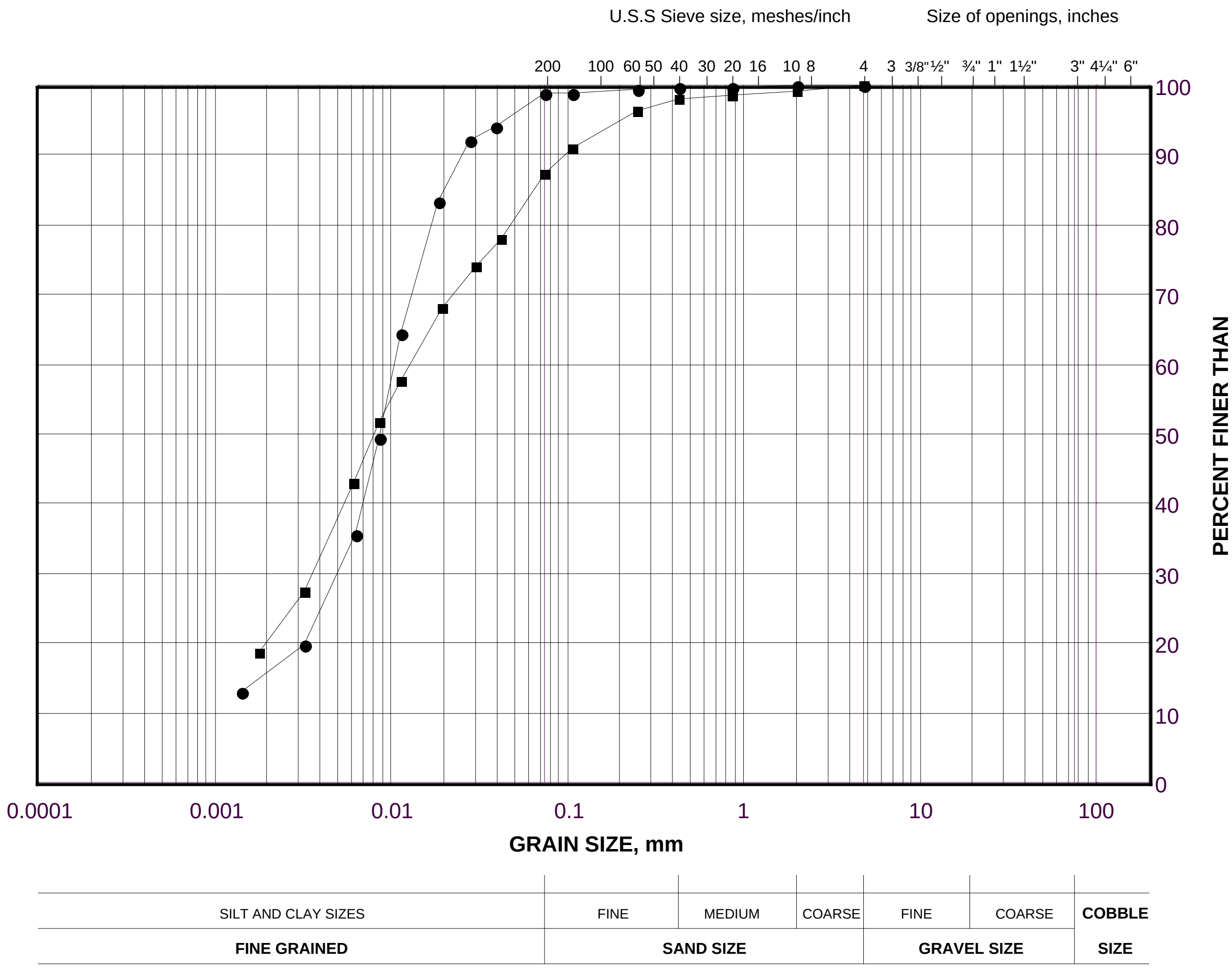
PLASTICITY CHART
Clayey Silt with Sand - Fines Portion (Fill)

Figure No. B3

Project No. 1413191

Checked By: PKS

# GRAIN SIZE DISTRIBUTION Clayey Silt (Till)	FIGURE B4



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	16-3	5	150.5
■	16-2	6	152.7

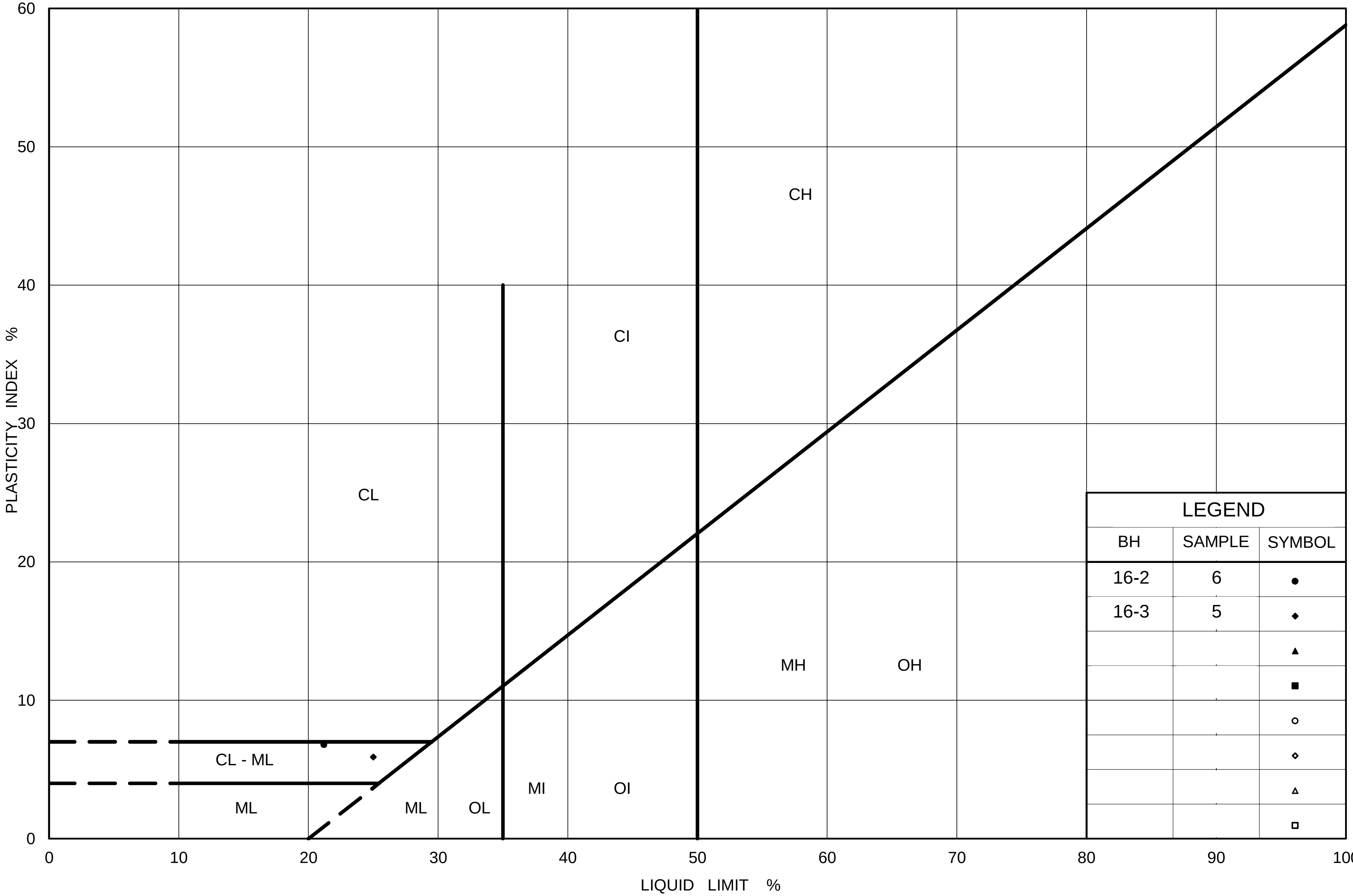
Project Number: 1413191

Checked By: PKS

Golder Associates

Date: 31-Mar-16

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
16-2	6	●
16-3	5	◆
		▲
		■
		○
		◇
		△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt (Till)

Figure No. B5

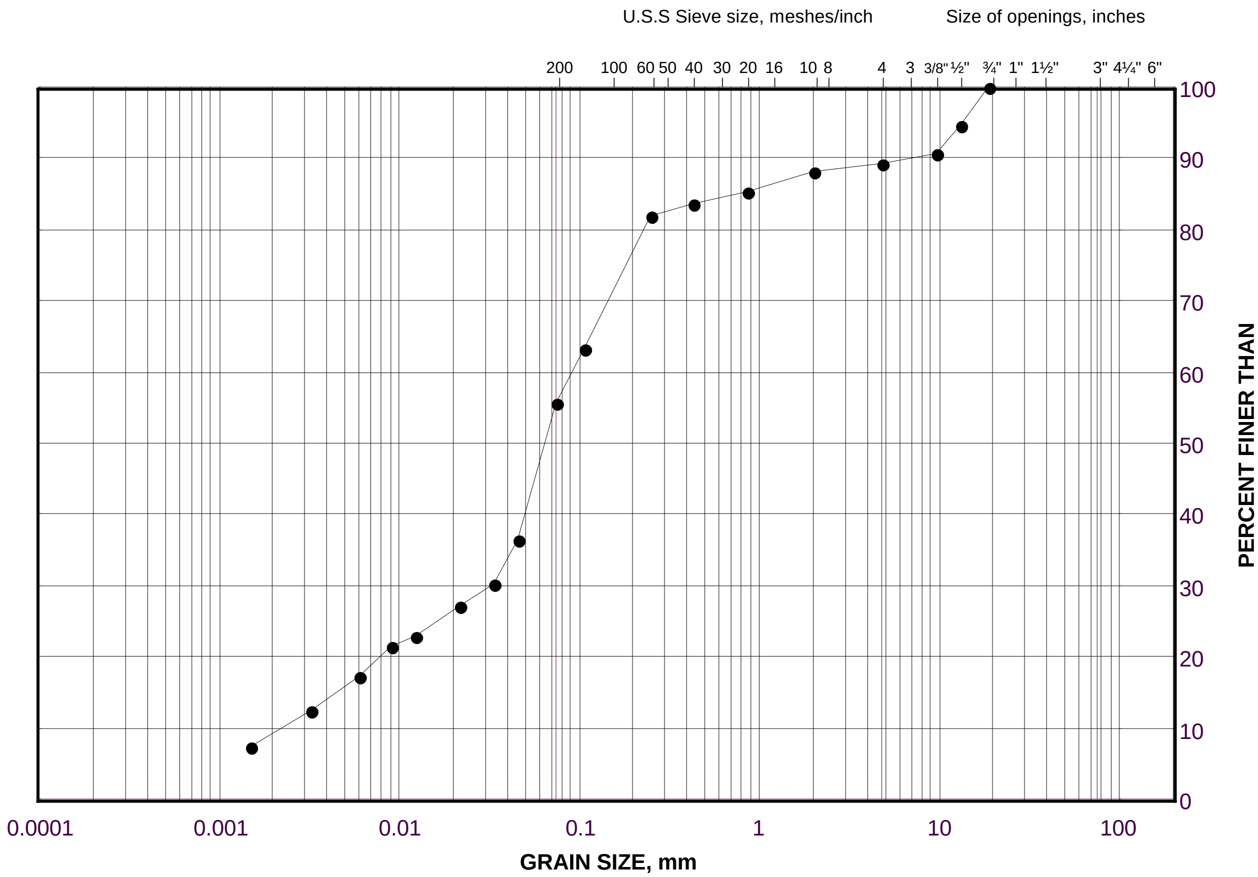
Project No. 1413191

Checked By: PKS

GRAIN SIZE DISTRIBUTION

Silt and Sand (Till)

FIGURE B6



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	16-2	8	151.1

Project Number: 1413191

Checked By: ARV

Golder Associates

Date: 11-Apr-16

APPENDIX C

Analytical Laboratory Test Results

Maxxam
A Bureau Veritas Group Company

Your Project #: 1413191
Site Location: HOGG'S HOLLOW
Your C.O.C. #: 70732

Attention:Al Varshoi

Golder Associates Ltd
Mississauga - Standing Offer
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2016/03/31
Report #: R3946728
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B658815
Received: 2016/03/23, 18:40

Sample Matrix: Soil
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	2	N/A	2016/03/30	CAM SOP-00463	EPA 325.2 m
Conductivity	2	N/A	2016/03/30	CAM SOP-00414	OMOE E3138 v2 m
pH CaCl2 EXTRACT	1	2016/03/29	2016/03/29	CAM SOP-00413	EPA 9045 D m
pH CaCl2 EXTRACT	1	2016/03/30	2016/03/30	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	2	2016/03/23	2016/03/30	CAM SOP-00414	SM 22 2510 m
Sulphate (20:1 Extract)	2	N/A	2016/03/30	CAM SOP-00464	EPA 375.4 m

Remarks:

Maxxam Analytics has performed all analytical testing herein in accordance with ISO 17025 and the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. All methodologies comply with this document and are validated for use in the laboratory. The methods and techniques employed in this analysis conform to the performance criteria (detection limits, accuracy and precision) as outlined in the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act.

Maxxam Analytics is accredited for all specific parameters as required by Ontario Regulation 153/04. Maxxam Analytics is limited in liability to the actual cost of analysis unless otherwise agreed in writing. There is no other warranty expressed or implied. Samples will be retained at Maxxam Analytics for three weeks from receipt of data or as per contract.

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829

==

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B658815
Report Date: 2016/03/31

Golder Associates Ltd
Client Project #: 1413191
Site Location: HOGG'S HOLLOW
Sampler Initials: ML

RESULTS OF ANALYSES OF SOIL

Maxxam ID		CBP366		CBP367	CBP367			
Sampling Date		2016/03/14 15:00		2016/03/09 15:00	2016/03/09 15:00			
COC Number		70732		70732	70732			
	UNITS	**BH16-1 SA 8**	**QC Batch**	**BH16-3 SA 2B**	**BH16-3 SA 2B Lab-Dup**	**RDL**	**QC Batch**	**MDL**
Calculated Parameters								
Resistivity	ohm-cm	570	4430571	3000			4430571	
Inorganics								
Soluble (20:1) Chloride (Cl)	ug/g	830	4436221	110		20	4436221	20
Conductivity	umho/cm	1760	4436220	330	331	2	4436220	1
Available (CaCl2) pH	pH	7.77	4435556	7.64			4435019	
Soluble (20:1) Sulphate (SO4)	ug/g	170	4436222	<20		20	4436222	N/A

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B658815
Report Date: 2016/03/31

Golder Associates Ltd
Client Project #: 1413191
Site Location: HOGG'S HOLLOW
Sampler Initials: ML

TEST SUMMARY

Maxxam ID: CBP366
Sample ID: BH16-1 SA 8
Matrix: Soil

Collected: 2016/03/14
Shipped:
Received: 2016/03/23

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4436221	N/A	2016/03/30	Deonarine Ramnarine
Conductivity	AT	4436220	N/A	2016/03/30	Lemeneh Addis
pH CaCl2 EXTRACT	AT	4435556	2016/03/30	2016/03/30	Neil Dassanayake
Resistivity of Soil		4430571	2016/03/30	2016/03/30	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	4436222	N/A	2016/03/30	Deonarine Ramnarine

Maxxam ID: CBP367
Sample ID: BH16-3 SA 2B
Matrix: Soil

Collected: 2016/03/09
Shipped:
Received: 2016/03/23

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4436221	N/A	2016/03/30	Deonarine Ramnarine
Conductivity	AT	4436220	N/A	2016/03/30	Lemeneh Addis
pH CaCl2 EXTRACT	AT	4435019	2016/03/29	2016/03/29	Neil Dassanayake
Resistivity of Soil		4430571	2016/03/30	2016/03/30	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	4436222	N/A	2016/03/30	Deonarine Ramnarine

Maxxam ID: CBP367 Dup
Sample ID: BH16-3 SA 2B
Matrix: Soil

Collected: 2016/03/09
Shipped:
Received: 2016/03/23

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	4436220	N/A	2016/03/30	Lemeneh Addis

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	16.0°C

Results relate only to the items tested.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B658815
Report Date: 2016/03/31

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1413191
Site Location: HOGG'S HOLLOW
Sampler Initials: ML

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
4435019	Available (CaCl2) pH	2016/03/29			99	97 - 103			0.17	N/A
4435556	Available (CaCl2) pH	2016/03/30			98	97 - 103			0.051	N/A
4436220	Conductivity	2016/03/30			99	90 - 110	<2	umho/cm	0.30	10
4436221	Soluble (20:1) Chloride (Cl)	2016/03/30	NC	70 - 130	111	70 - 130	<20	ug/g	5.6	35
4436222	Soluble (20:1) Sulphate (SO4)	2016/03/30	NC	70 - 130	106	70 - 130	<20	ug/g	NC	35

N/A = Not Applicable

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

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Maxxam Job #: B658815
Report Date: 2016/03/31

Golder Associates Ltd
Client Project #: 1413191
Site Location: HOGG'S HOLLOW
Sampler Initials: ML

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Brad Newman, Scientific Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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IMMEDIATE TEST

Maxxam
A Bureau Veritas Group Company

6740 Campobello Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266
CAM FCD-01191/2

CHAIN OF CUSTODY RECORD 70732

Page ____ of ____

Invoice Information		Report Information (if differs from invoice)		Project Information (where applicable)		Turnaround Time (TAT) Required
Company Name:	Golder Associates	Company Name:		Quotation #:		[X] Regular TAT (5-7 days) Most analyses
Contact Name:	Al Varshoi	Contact Name:		P.O. #/ AFE#:		PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS
Address:	6925 Century Ave, Suite#100 Mississauga ON, K	Address:		Project #:	1413191	Rush TAT (Surcharges will be applied) [ ] 1 Day [ ] 2 Days [ ] 3-4 Days
				Site Location:	Hogg's Hollow	
Phone:	~~[illegible]~~ 905-567-4444 Fax: 905-567-6561	Phone:	Fax:	Site #:		Date Required:
Email:	AVarshoi@golder.com	Email:		Sampled By:		Rush Confirmation #:

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Regulation 153: [ ] Table 1 [ ] Res/Park [ ] Med/ Fine [ ] Table 2 [ ] Ind/Comm [ ] Coarse [ ] Table 3 [ ] Agri/ Other [ ] Table ____
FOR RSC (PLEASE CIRCLE) Y / N

Other Regulations: [ ] CCME [ ] Sanitary Sewer Bylaw [ ] MISA [ ] Storm Sewer Bylaw [ ] PWQO Region ____ [ ] Other (Specify) ____ [ ] REG 558 (MIN. 3 DAY TAT REQUIRED)

Include Criteria on Certificate of Analysis: Y / N

SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

Analysis Requested (REFER TO BACK OF COC)

	SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTEX/ PHC F1	PHCs F2 - F4	VOCs	REG 153 METALS & INORGANICS	REG 153 ICPMS METALS	REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B)	Sulphate	EC	Chloride	PH	Resistivity			HOLD- DO NOT ANALYZE	COMMENTS
1	BH 16-1 SA 8	2016/03/14	3:00pm	Soil	2								X	X	X	X	X				
2	BH 16-3 SA 2B	2016/03/09	3:00pm	Soil	2								X	X	X	X	X				
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					

LABORATORY USE ONLY

CUSTODY SEAL Y / (N) — Present | Intact

COOLER TEMPERATURES: 16/16/16

COOLING MEDIA PRESENT: Y / (N)

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)
Martin Legroulx [signature]	2016/03/23	6:00pm	[signature] RACHEL DEVLIN	2016/03/23	18:40

23-Mar-16 18:40
Ema Gitej
B658815
RGN ENV-086

COC-1004 (10/14) - ENV. ENG.

APPENDIX D

Borehole Record from Previous Investigation

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No 15-2

METRIC

G.W.P. 2013-E-0039-007A LOCATION Coords: 4 845 478.2 N; 311 729.7 E ORIGINATED BY F.P.

DIST Central HWY 401 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.K.

DATUM Geodetic DATE August 13 & 14, 2015 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
160.4	Ground Surface							
0.0	Silty sand occasional gravelly zones Loose to dense (FILL)	1	SS	7		160	o	
		2	SS	12		159	o	
		3	SS	11			o	
		4	SS	28		158	o	7 58 30 5
		5	SS	41		157	o	
		6	SS	59		156		
	clayey silt zones Hard	7	SS	51			o	0 3 84 13
155.3 / 5.1	End of borehole							

* Borehole dry

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

+7, ×5: Numbers refer to Sensitivity

20 / 15 –○– 5 / 10 (%) STRAIN AT FAILURE

APPENDIX E

Site Photographs

PROJECT

Hogg's Hollow Sewer Replacement
GWP 2191-15-00

TITLE

Site Photograph
Upper portion of the slope looking up slope

Golder Associates

PROJECT No.	1413191		FILE No.	----	
DESIGN	MPL	APR 16	SCALE	NTS	REV.
CADD					
CHECK	MPL	APR 16	FIGURE 1		
REVIEW	AV	APR 16			

PROJECT

Hogg's Hollow Sewer Replacement
GWP 2191-15-00

TITLE

Site Photograph
Lower portion of the slope looking up slope

Golder Associates

PROJECT No.	1413191	
DESIGN	MPL	APR 16
CADD		
CHECK	MPL	APR 16
REVIEW	AV	APR 16

FILE No.	----	
SCALE	NTS	REV.

FIGURE 2

PROJECT

Hogg's Hollow Sewer Replacement
GWP 2191-15-00

TITLE

Site Photograph
Lower portion of the slope looking downslope

Golder Associates

PROJECT No.	1413191	
DESIGN	MPL	APR 16
CADD		
CHECK	MPL	APR 16
REVIEW	AV	APR 16

FILE No.	----	
SCALE	NTS	REV.

FIGURE 3

PROJECT

Hogg's Hollow Sewer Replacement
GWP 2191-15-00

TITLE

Site Photograph
Upper portion of the slope looking downslope

Golder Associates

PROJECT No.	1413191	
DESIGN	MPL	APR 16
CADD		
CHECK	MPL	APR 16
REVIEW	AV	APR 16

FILE No.	----	
SCALE	NTS	REV.

FIGURE 4

PROJECT

Hogg's Hollow Sewer Replacement
GWP 2191-15-00

TITLE

Site Photograph
Storm sewer alignment on upper portion of slope

Golder Associates

PROJECT No.	1413191	
DESIGN	MPL	APR 16
CADD		
CHECK	MPL	APR 16
REVIEW	AV	APR 16

FILE No.	----	
SCALE	NTS	REV.

FIGURE 5

PROJECT

Hogg's Hollow Sewer Replacement
GWP 2191-15-00

TITLE

Site Photograph
Upper portion of the slope looking upslope

Golder Associates

PROJECT No.	1413191		FILE No. ----
DESIGN	MPL	APR 16	SCALE NTS REV.
CADD			
CHECK	MPL	APR 16	FIGURE 6
REVIEW	AV	APR 16	

APPENDIX F

Non-Standard Special Provision

OBSTRUCTIONS

Special Provision

SCOPE

Cobbles and boulders were encountered within the existing fill and hard clayey silt till deposit during advancement of the boreholes. Consideration of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for excavation works including cut-and-cover construction and the installation of temporary protection systems or permanent drop structures, as part of the storm sewer pipe replacement.

BASIS OF PAYMENT

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

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

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