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GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN

Yonge Subway Extension
Underground Train Storage
Regional Municipality of York, Ontario

UPDATED REPORT

Submitted to:
Mr. K. Barber, P.Eng., Project Manager
McCormick Rankin Corporation
300-2655 North Sheridan Way
Mississauga, Ontario
L5K 2P8

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1.0 INTRODUCTION

This report has been prepared for the conceptual design of the Underground Train Storage (UTS) facilities that form part of the proposed Toronto Transit Commission's (TTC's) Yonge Subway Extension. The UTS structure is located in the Region of York, Ontario. The objectives of this report are to provide information on the anticipated subsurface soil and groundwater conditions at the proposed UTS facilities and to provide geotechnical recommendations for conceptual design. Preliminary soil parameters are provided, as well as discussions addressing the geotechnical aspects of excavation support and backfill, temporary and permanent works and foundation design and construction. The recommendations provided in this report are intended to provide conceptual design information that may be utilized toward planning and costing purposes.

It is proposed that the existing Yonge Subway be extended from the existing Finch Station terminus in Toronto northward beyond Highway 407 in Richmond Hill, in the Region of York. The Yonge Subway Extension project consists of an approximately seven kilometres (km) long new section of subway with five underground stations, a bridge crossing at the East Don River, tail tracks and underground train storage facilities at the north end of the extension. The UTS structure is located north of Highway 407 between Highway 7 and 16th Avenue, as shown on Figure 1. The UTS facilities includes four sections of triple-track, six-car train storage that is linked to the north end of Richmond Hill Centre Station.

It should be noted that at this conceptual design stage, the subsurface information for the UTS structure is insufficient for preliminary or final design. Following the completion of the conceptual design, additional explorations, testing, and review and revision of these recommendations will be necessary during later design stages for the proposed UTS facilities.

Previous geotechnical work associated with Yonge Street included an evaluation of the shallow soil conditions for a section of the bus transit service extension north of Steeles Avenue completed in 2003 as part of the Environmental Assessment for the Yonge Street Route Options for the York Rapid Transit Plan bus rapid transit system (Golder Associates Ltd., May 2003). For the Yonge Subway Extension project, a Preliminary Geotechnical Report was prepared for the Yonge Subway Extension Transit Project Assessment Process in 2009 (Golder Associates Ltd., January 2009). More recently, a preliminary geotechnical investigation in support of the conceptual design of the Yonge Subway Extension was carried out by SPL Consultants Limited (SPL Consultants Ltd., 2010).

This report, initially submitted on November 2011, was supplemented by completion of two additional boreholes in 2013 (Golder Associates Ltd.) and subsequently revised to reflect the updated information.

2.0 SITE AND PROJECT DESCRIPTION

The UTS facilities are proposed to be located north of Highway 407 between Highway 7 and 16th Avenue, approximately 230 metres (m) east of Yonge Street and immediately west of the CN/GO rail tracks, as shown on Figures 1 and 2. The UTS structure extends from approximately 160 m north of High Tech Road to approximately 350 m north of Bantry Avenue, west of the existing CN/GO rail tracks, between Stations 7+686 and 8+390. The UTS facilities include four sections of triple-track, six-car train storage areas with each section planned to be about 150 m long and 20 m wide. The underground storage structure is proposed to abut the north end of Richmond Hill Centre Station, forming the terminal section of the Yonge Subway Extension. At the north end of the UTS, a fan room and ventilation shaft is proposed. Various Emergency Exit Buildings (EEBs) are also located along the Yonge Subway Extension alignment with EEB No. 7 and EEB No. 8 located within and at the end of the UTS structure, respectively.

The area surrounding the UTS site is a mixed-use residential and commercial development area and is occupied by low-rise to mid-rise buildings, as well as the CN/GO rail tracks. The commercial properties generally include single storey warehouses to six storey buildings and are located between the CN/GO rail tracks and Yonge Street. Various paved parking areas are located between the commercial and residential buildings. The residential properties include two to eight storey buildings and are also located between the CN/GO rail tracks and Yonge Street. Low-rise residential buildings including two to three storey structures, as well as landscaped areas are also located on the east side of the CN/GO rail tracks. High Tech Road and Bantry Avenue cross the UTS site at approximately Stations 7+500 and 8+040, respectively. The nearest water body, a stormwater management pond is located south of the UTS site, west of the Richmond Hill Centre Station crossover structure and Highway 7. The East Don River Crossing on Yonge Street is located approximately 3 km south of the UTS site.

At the time this report was prepared, the conceptual design of the UTS considered that the structure would be constructed using cut and cover methods. Based on the current conceptual design drawings, the base of the underground storage structure varies from about elevation 182.5 m at the south end (adjacent to Richmond Hill Centre Station) to about elevation 185 m at the north end (end of extension line). The underground storage structure is planned to be about 20 m wide and is about 704 m long in total. The proposed top of rail and the top of the structure ranges from about elevation 184.5 m at the south end to about elevation 187 m at the north end and about elevation 190 m at the south end to about elevation 192 m at the north end, respectively. These dimensions result in the bottom of the structure being about 22.5 m to 24 m below the existing ground surface.

3.0 SOURCES OF INFORMATION

3.1 Geological Information

Relevant geotechnical and geological information for the conceptual design of the UTS was obtained from the reports and publications, listed in this section of the report.

3.1.1 Subsurface Data Reports

- "Geo-Engineering Factual Data Report, Conceptual Design Investigation, Yonge Subway Extension (Version 2), Contract Y85-10", SPL Consultants Ltd., November 15, 2010.
- "Preliminary Geotechnical Report, York Rapid Transit Plan, Yonge Subway Extension Transit Project Assessment Process, Toronto, Ontario", Golder Associates Ltd., January 2009.
- "Geotechnical Data Report, York Rapid Transit Plan, Yonge Subway Extension, Regional Municipality of York, Ontario", Golder Associates Ltd., January 2009.
- "Environmental Assessment, York Rapid Transit Plan, Yonge Street Corridor, Regional Municipality of York, Ontario", Golder Associates Ltd., May 2003.
- "Geotechnical Study for the Proposed Hi-Tech Road Overpass and Bantry Avenue Overpass Crossing CNR Line (Bala Subdivision) Yonge Street & Highway No. 7, Town of Richmond Hill, Ontario", Report No. 97-6428, Soil Probe Ltd., February 17, 1997.
- "Supplementary Geotechnical Data Report, York Rapid Transit Plan, Yonge Subway Extension, Regional Municipality of York, Ontario", Golder Associates Ltd., November 2013.

3.1.2 Geological References

- "Quaternary Geology Toronto and Surrounding Area, Southern Ontario, Ontario Geological Survey Preliminary Map P. 2240 Geological Series, Ministry of Natural Resources, Ontario", D.R. Sharpe, scale 1:100,000, 1980.
- "Bedrock Geology of Ontario, Southern Sheet, Ontario Geological Survey, Map 2544", scale 1:1,000,000, 1991.
- "Township of North York, County of York, Ontario, Showing Water Wells and Bedrock Contours, Map No. 1955-7", A.K. Watt, scale 1 inch to ½ mile, 1955.

- "The Physiography of Southern Ontario, Ontario Geological Survey Special Volume 2, Third Edition, Ministry of Natural Resources, Ontario", L.J. Chapman and D.F. Putnam, 1984.
- "Don River Watershed Plan, Geology and Groundwater Resources – Report on Current Conditions," prepared by Toronto and Region Conservation Authority, 2009.

3.1.3 Other Information

- "York-Peel-Durham-Toronto-Conservation Authorities Moraine Coalition (YPDT-CAMC) Groundwater Management Strategy Study", selected data reviewed from the database for the Yonge Subway Extension Project in November 2008.
- General Topographical Survey Data supplied in "Yonge Subway Extension Trackwork Alignment Plan and Profile STA. 0+500 to STA. 9+020" Sheets 1 to 13, McCormick Rankin Corporation and Hatch Mott MacDonald, February 28, 2011.
- Powers, J.P., Corwin, A.B., Schmall, P.C. and Kaeck, W.E., "Construction Dewatering and Groundwater Control, New Methods and Applications", Third Edition, John Wiley & Sons, Inc. 2007.

3.2 Conceptual Design Information

Information on the subway extension alignment and proposed structures has been obtained from the sources listed in this section of the report.

- "Yonge Subway Extension Trackwork Alignment Plan and Profile STA. 0+500 to STA. 9+020", Sheets 1 to 13, McCormick Rankin Corporation and Hatch Mott MacDonald, February 28, 2011.

4.0 SUBSURFACE CONDITIONS

4.1 Regional Geology

The Quaternary geology for the Region of York, north of Highway 407 and Highway 7, generally consists of glacial till deposits, glaciolacustrine and glaciofluvial sand, silt and clay deposits. These deposits were laid down by glacial ice sheets and associated glacial lakes and rivers. Recent alluvial deposits are typically located in the river or stream valleys and within their flood plains.

The Quaternary deposits overlie the Georgian Bay Formation bedrock, comprising shale interbedded with dolomitic siltstone and minor limestone. The Georgian Bay Formation is about 250 m thick and generally declines to the southeast at about 5 m per km. Based on the Township of North York, County of York, Ontario Map No. 1955-7 Showing Water Wells and Bedrock Contours and the bedrock data obtained from the York-Peel-Durham-Toronto-Conservation Authorities Moraine Coalition (YPDT-CAMC) Groundwater Management Strategy Study database, the elevation of the bedrock for the UTS facilities general area is anticipated to be between about elevation 135 m and 140 m. The thickness of the overburden at the general UTS structure area is between approximately 65 m and 70 m.

The overburden materials were deposited over the course of at least two glaciations and one interglacial period. According to the Quaternary Geology of Toronto and Surrounding Area Preliminary Map P.2204, the native sedimentary deposits for the general site area consists of Peel Ponds (deeper-water deposits including silt and clay), overlying geologically young tills (Halton, clayey silt till and sandy silt till), overlying Older Lake Deposit (shallow water deposits consisting of sand). Based on the YPDT-CAMC database, the native sedimentary deposits at the general UTS area consists of Halton Till (silt and clay diamict), overlying Oak Ridges Moraine Complex (sand and silt and locally gravel), Newmarket Till (silt and clay diamict), Thorncliffe Formation (silt and sand), Sunnybrook Formation, Scarborough Formation (silt and sand) and Shale bedrock. The relatively broad East Don River valley was likely formed during the most recent retreat of glacial ice sheets from the area. During the last ice retreat, ponds or lakes formed in low-lying regions and within broad glacial river valleys. These water bodies have been designated with the geologic name Peel Ponds. Sediments deposited within the Peel Ponds are typically well-sorted and consist of relatively loose and stratified sand and silt or soft to stiff varved silt and clay. The present watercourse has since formed smaller channels and meanders within this broad glacial and post-glacial East Don River valley.

Recent alluvial deposits (sand, silt, gravel and organic material) should be expected in areas within the immediate vicinity of watercourses and flood plains including the East Don River area. Recent outwash moraine, or ablation deposits may also be encountered overlying the most geologically recent basal till unit in some areas. Urban fill materials should be expected generally in the top 1 m to 5 m except for areas where extensive development has taken place. Fill materials to depths ranging from 8 m at Highway 7 to 9.5 m at High Tech Road may be expected.

4.2 Topography

The UTS structure is planned to be located between High Tech Road and 16th Avenue, immediately west of the CN/GO rail tracks and about 230 m east of Yonge Street. Based on the topographical survey data provided on the current conceptual design drawings (McCormick Rankin Corporation and Hatch Mott MacDonald), the ground surface along the alignment of the Yonge Subway Extension from Richmond Hill Centre Station to the end of the extension line toward 16th Avenue generally increases in elevation from about elevation 201 m near Richmond Hill Centre Station (north of High Tech Road) to about elevation 209 m at the end of the extension line (near Coburg Crescent). In the areas where High Tech Road and Bantry Avenue cross the subway extension line and the existing CN/GO rail tracks, the road embankment surface increases by about 8 m to 10 m to approximately elevation 208 m and 215 m, respectively.

4.3 Stratigraphy

The subsurface conditions for the proposed UTS structure is based on the borehole data obtained from various geotechnical investigations. An initial investigation was carried out by Golder Associates Ltd. (2009) to provide data for the Transit Project Assessment Process for the Yonge Subway Extension Environmental Assessment. A supplementary geotechnical investigation was carried out by SPL Consultants Ltd. (2010) to provide conceptual design information along Yonge Street between the Canadian National Rail tracks and High Tech Road between approximately Stations 3+300 and 7+400. This geotechnical information for the proposed underground storage site was further supplemented with existing available Soil Probe Ltd. (1997) and Ministry of Transportation, Ontario (MTO) borehole data, as well as borehole and well record data researched through the YPDT-CAMC Groundwater Management Strategy Study in 2008. Subsequent to the conceptual design report issued by Golder in 2011 for the UTS, additional investigations were carried out by Golder in 2013 to better define subsurface conditions in the northern areas of the UTS. The following boreholes have been utilized to compile an interpreted stratigraphic profile for the UTS general site area:

- Golder Associates Ltd. (2009) – Borehole 14.
- SPL Consultants Ltd. (2010) – Borehole 124.
- Soil Probe Ltd. (1997) – Boreholes 206, 212 and 214.
- Ministry of Transportation, Ontario (1990 to 1993) – Boreholes MTO-30M14-210/01 and MTO-30M14-214/08.
- YPDT-CAMC Database (data reviewed in November 2008) – Boreholes MTO-30M14-211/40, 6902904, 6906180 and 6902908.
- Supplementary boreholes 126 and 128 completed by Golder in 2013.

The boreholes drilled on or within the immediate vicinity of the proposed UTS structure, as well as along the Yonge Subway Extension alignment generally encountered variable ground conditions in both horizontal and vertical directions consisting of topsoil or asphaltic concrete overlying layers of fill underlain by relatively thin granular deposits (sand to sandy silt till) and successive major deposits alternating between cohesive soils (silty clay to clayey silt glacial till) and granular sand and silt soils.

The locations of the boreholes on or within the immediate vicinity of the proposed UTS and the Yonge Subway Extension alignment are presented on Figure 2. The available subsurface data for the UTS site is limited at this conceptual design stage. Therefore, data from the Richmond Hill Centre Station area, to the south of the UTS site has also been used to provide context for the interpreted subsurface conditions in the vicinity of the underground storage site, as shown on Figure 3A. The interpreted stratigraphic profile for the general UTS area is shown on Figures 3A and 3B. It should be noted that these figures are a simplification of the subsurface conditions encountered at the borehole locations. Variations in the stratigraphic boundaries between boreholes will exist and are to be expected. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling, observations of the drilling progress and results of the Standard Penetration Tests (SPTs) and therefore, represent transitions between and beyond the borehole locations. It is expected that additional subsurface investigations will be undertaken during later stages of the project to further determine and assess the deposit boundaries and subsurface water levels for detail design and construction of the UTS facilities.

The investigation carried out in 2013 suggest that the correlation between major deposits classified by their grain size distribution and regional geologic units may require some reinterpretation pending future and more detailed investigations. For the purposes of this updated report, categorization and labelling of the major soil deposits used in the previous report have been retained and, in some cases, supplemented with updated geologic interpretations.

The most recent glacial till deposit, found closest to the ground surface in the UTS area is likely consistent with the geologically-mapped “Halton Till”. In the previous reports prepared for the proposed northern extension of the Yonge Subway line the native soil types were grouped into one of three major soil deposits and the uppermost glacial till deposit in the UTS area represents a fourth major deposit interpreted to exist along the proposed subway line route.

Beneath the planned Richmond Hill Centre Station, loose to dense granular soils were encountered overlying the Upper Till. These granular soils were previously grouped together as the Recent Granular Deposits based on the interpreted range of relative compactness and stratigraphic position. Layers of cohesive soils and granular till were also encountered within the Recent Granular Deposits. Based on the supplementary boreholes completed in 2013, however, the granular silt and sand deposits that underlie the Halton Till in the UTS area and beneath the Fill in the Richmond Hill Station area are likely geologically associated with the Oak Ridges Moraine Complex (ORMC) based on the sequence of sediments and available geologic mapping and interpretations (e.g., TRCA 2009). Therefore, the simplified stratigraphy illustrated on Figures 3A and 3B includes an additional designation related to the reinterpretation of this glacial geology unit. Future explorations carried out for later stages of design may provide additional insight regarding the continuity and likely geologic unit correlations in this area.

The previously identified Upper Till Deposit, as shown on Figures 3A and 3B, was defined based on the continuity, elevations and consistency of the generally very stiff to hard cohesive and till materials (clayey silt to sandy silt till) generally underlying urban fill extending along the majority of the Yonge Subway Extension line, though previous designations of “Upper”, “Middle” and “Lower” were based largely on stratigraphic positions of these deposits south of Richmond Hill. Geologically, the Upper Till Deposit is likely representative of basal till associated with the ice sheet advance associated with the geological “Newmarket Till”. In the area of the Highway 7 Yonge Street ramp at about Station 7+300, south of the UTS site, the Upper Till Deposit between elevation 189 m and 193 m typically exhibits lower SPT N[1] values than in other areas along the proposed subway alignment.

Beneath the Upper Till, extensive deposits of granular soils that appear to be hydraulically connected were encountered beneath the planned Richmond Hill Centre Station, south of the UTS facilities. The 2013 supplemental boreholes at the UTS site extended below the Upper Till Deposit at the location of borehole 126, however the Upper Till Deposit was not fully penetrated further north at the location of borehole 128. These granular soils, composed of fine sand and sandy silt to sand and gravel, have been grouped together as the Upper Granular Deposit.

Based on the YPDT-CAMC database, bedrock may have been observed at about elevation 151 m or approximately 54 m below the existing ground surface from a water well located at approximately Station 8+100 at the UTS site.

4.4 Engineering Characteristics of Soils

Soils encountered in the boreholes completed by Golder Associates Ltd. (2009) and SPL Consultants Ltd. (2010) were classified in accordance with the TTC Geotechnical Standards, Version 5, Parts A to E including associated appendices in effect at the time the Yonge Subway extension conceptual design phase was initiated. While the soil types and groupings have changed since that time, the previous system has been retained for this report for consistency with earlier reports. Under this system, a total of twelve soil types (Types 1 to 12), typically encountered in the Greater Toronto Area, were used to describe and classify the range of soil deposits observed in the boreholes. These soil types, described on the Record of Borehole sheets in the Golder Associates Ltd. (2009 and 2013) and SPL Consultants Ltd. (2010) geotechnical data reports (listed in Section 3) have been illustrated using corresponding graphical symbols on Figures 3A and 3B and are summarized as follows:

- Type 1 – Fill
- Type 2 – Organics
- Type 3 – Gravel
- Type 4 – Sand and Gravel/Gravelly Sand
- Type 5 – Sand

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[1] Standard Penetration Test (SPT) N value represents the number of blows by a 140 pound (63.5 kg) hammer free falling 30 inches (0.75 m) required to drive a split-spoon sampler a distance of 1 foot (0.3 m) into the ground after having first penetrated 6 inches (0.15 m) in general accordance with ASTM D1586.

- Type 6 – Silty Sand
- Type 7 – Sandy Silt/Sand and Silt
- Type 8 – Silt
- Type 9 – Clayey Silt
- Type 10 – Clay/Silty Clay
- Type 11 – Silty Clay Till/Clayey Silt Till
- Type 12 – Sandy Silt TILL/Silty Sand TILL/Sand and Silt Till

Soil Types 11 and 12 are commonly interpreted as a till deposit (lodgement or basal till) on the basis of their heterogeneous structure, the relative broad grain size distribution and the published local geology.

It is understood that the MTO boreholes were classified in accordance with the MTO standard of soil descriptions in use at the time of the explorations.

The Soil Probe Ltd. borehole records (1997) were reinterpreted to be consistent with the current TTC classification scheme. It should be noted that the subsurface conditions presented on Figures 3A and 3B are based on interpretation of the soil description provided in the Record of Borehole sheets and the limited data available for this report. Borehole or water well geologic data obtained from the YPDT-CAMC database were not prepared by Golder Associates Ltd., SPL Consultants Ltd., Soil Probe Ltd. or MTO. Many of the soil descriptions included in the YPDT-CAMC database were developed based on visual and textural classification of drilling fluids and cuttings during water well drilling. Therefore, some uncertainty remains regarding the material classification. The colours and the numbering on the borehole cross sections are intended to provide a broad indication of the reported material classification. For the conceptual design of the UTS facilities, greater emphasis should be placed on the subsurface conditions identified from the investigations undertaken by Golder Associates Ltd, SPL Consultants Ltd., Soil Probe Ltd, and MTO. The interpreted stratigraphic profiles presented on Figures 3A and 3B may be used for conceptual design.

The deposits encountered in the recent subsurface investigation boreholes (1997, 2009, 2010 and 2013) and MTO boreholes have been grouped in accordance with the TTC Geotechnical Standards soil type classifications (Types 1 to 12) and are presented in the following sections of this report. For this conceptual design report, the engineering properties of the soil types encountered at or near the UTS structure have been reported in order of their soil type number. Summaries of SPT N values, water contents and Atterberg limits for the native soils obtained from the recent investigations (1997, 2009, 2010 and 2013) and investigations carried out for or on behalf of the MTO are presented on Figures 4 and 5. Plasticity data and grain size distributions for the fill and native soils are presented on Figures 6 to 15.

4.4.1 Topsoil and Fill (Types 2 and 1)

Topsoil was encountered below the ground surface in boreholes 14, 124, MTO-30M14-210/01, MTO-30M14-214/08, 126, and 128 and was encountered overlying layers of granular and cohesive fill.

In borehole 214, topsoil was encountered beneath a 0.2 m thick layer of granular fill. The thickness of the topsoil layers ranged from about 0.1 metres (m) to about 0.4 m. Measured water contents for the topsoil samples ranged from 12 to 22 per cent, exclusive of the frozen topsoil sample. Materials designated as topsoil in this report were classified solely based on visual and textural evidence. Testing of organic content or for other nutrients was not carried out. Therefore, the use of materials classified as topsoil cannot be relied upon for support and growth of landscaping vegetation.

With the exception of boreholes 14 and MTO-30M14-210/01, fill material was encountered below the ground surface or beneath topsoil in all of the boreholes (boreholes 124, 126, 128, 206, 212, 214 and MTO-30M14-214/08) and ranged from about 0.3 m to 4.5 m thick. The thickness of the fill material within the immediate vicinity of the underground storage area could range from about 1 m to 5 m thick. In the area of High Tech Road and Bantry Avenue, the interpreted thickness of fill could range from about 5 m to 9.5 m and 10 m to 11 m, respectively, based on borehole information compared to topographic data and previous construction of bridge approach embankments and roadway grading.

The fill materials generally include layers of granular (silty sand to sandy silt) and cohesive soils (clayey silt to silty clay) and were encountered between approximately elevation 189.2 m and 205.3 m. Evidence of topsoil, rootlets and organic material was encountered within the fill layers below the ground surface in borehole 206 at approximately elevation 199.6 m, borehole 212 at approximately elevation 205.3 m, borehole 214 at approximately elevation 205.2 m and in borehole MTO-30M14-214/08 at a depth of 0.2 m or approximately elevation 189.2 m. Rootlets and decomposed organic matter were also encountered within the fill in boreholes 126 and 128. Asphalt fragments were also encountered within the fill layers in borehole MTO-30M14-214/08 at a depth of 0.2 m or approximately elevation 189.2 m.

Standard Penetration Test N values measured for the cohesive fill ranged from 3 to 16 blows per 0.3 m indicating a firm to very stiff consistency. An SPT N value of 13 blows per 0.3 m was measured for the granular fill indicating a compact relative density. Standard Penetration Test N values ranging from 11 to 38 blows per 0.3 m was measured for frozen granular fill in boreholes 206, 212 and 212. Measured water contents for the cohesive and granular fill ranged from 5 to 22 and 10 to 28 per cent, respectively. An individual grain size distribution test completed on Type 1 soils for the UTS project is shown on Figure 7.

4.4.2 Native Soils

The general characteristics of each soil type encountered within the UTS area are reported below, in order of their soil type number.

4.4.2.1 Sand and Gravel/Gravelly Sand (Type 4)

A very dense layer of sand and gravel to gravelly sand was encountered in borehole 14 at approximately elevation 172.9 m. The sand and gravel to gravelly sand layer was encountered beneath sand and silt. Borehole 14 was terminated in the sand and gravel to gravelly sand after exploring the layer for 4.0 m.

In addition, based on the drilling activities and field observation of the return fluid during drilling borehole 126, it was inferred that a layer of sand and gravel is present between approximately elevation 183.7 m and 184.3 m. Three SPT N values measured for the sand and gravel to gravelly sand were over 100 blows per 0.3 m and measured water contents were 8, 12 and 37 per cent, though these water contents may not be representative of in situ conditions because of the coarse nature of the soil and consequent difficulty in preserving saturation during sampling. The higher water content of 37 per cent is likely to have been measured on a sand and gravel sample containing significant clay content. Summaries of N values and water contents are presented on Figures 4 and 5. Figure 8 illustrates an envelope of grain size distribution data that is typical of Type 4 soils encountered and tested for the Yonge Subway Extension project and other TTC subway projects in the northern limits of Toronto. Two individual grain size distribution tests completed on Type 4 soils for the UTS project are also shown for comparison on Figure 8.

4.4.2.2 Sand to Silty Sand (Types 5 and 6)

Layers of sand were encountered beneath sandy silt, silty clay and sand and silt in borehole 14 between approximately elevation 174 m and 193.9 m and borehole 126 between approximately elevation 194.8 m and 196.4 m. The thickness of the sand layers ranged approximately from 1.5 m to 4.6 m. Standard Penetration Test N values measured for the sand varied between the weight of the sampler and rods only to 66 blows per 0.3 m. The single relatively low N value was encountered upon penetration of the overlying cohesive Upper Till and was likely the result of groundwater pressures in the granular soils being greater than within the borehole. This single relatively low N value is considered unrepresentative of the in situ relative density. In general, the relative density of these layers can be classified as compact. Measured water contents varied from 12 to 22 per cent. Summaries of N values and water contents are presented on Figures 4 and 5. Figure 9 illustrates an envelope of grain size distribution data that is typical of Type 5 soils encountered and tested for the Yonge Subway Extension project and other TTC subway projects in the northern limits of Toronto. Individual grain size distribution tests completed on Type 5 soils for the UTS project are also shown for comparison on Figure 9.

Silty sand layers were encountered in boreholes 14, 126, 206, 212, 214 and MTO-30M14-210/01 between elevation 191.3 m and 201.5 m. In borehole 126 silty sand layers were also encountered between elevation 175.3 and 180.5 m. The silty sand layers were encountered beneath fill and sandy silt, beneath cohesive silt and clay and glacial till soils, and between sandy silt till layers. The thickness of the silty sand layers ranged from 0.7 m to 6.2 m. Borehole 206 was terminated in the silty sand after exploring the lower layer for 5.8 m. Evidence of organic material was encountered in the silty sand at a depth of 0.2 m or approximately elevation 198.3 m in borehole 14. With the exception of two relatively low SPT N values, the N values ranged from 12 to over 100 blows per 0.3 m, generally indicating a compact to very dense relative density. An N value of 8 blows per 0.3 m was measured at the interface between fill and silty sand in borehole 14 at a depth of 0.8 m or approximately elevation 197.7 m. In borehole 206, an N value of 7 blows per 0.3 m was measured for the silty sand overlying dense sandy silt till at a depth of 6.0 m or approximately elevation 193.6 m. Measured water contents varied between 8 and 23 per cent, though the lowest values may not be representative of in situ conditions. Summaries of N values and water contents are presented on Figures 4 and 5. Figure 10 illustrates an envelope of grain size distribution data that is typical of Type 6 soils encountered and tested for the Yonge Subway Extension project and other TTC subway projects in the northern limits of Toronto. Two individual grain size distribution tests completed on Type 6 soils for the UTS project are also shown for comparison on Figure 10.

4.4.2.3 Sandy Silt/Sand and Silt (Types 7 and 8)

Layers of silt to sand and silt were encountered in boreholes 14, 124, 126, 128, 206, 212, 214 and MTO-30M14-210/01 between elevation 169.5 m and 202.3 m. The sandy silt to sand and silt layers were encountered beneath clayey silt, sand and sand and silt till, as well as between granular and/or cohesive soil glacial till layers and ranged from approximately 0.7 m to 3.1 m thick. Borehole 124 was terminated in sandy silt after exploring the layer for about 3.8 m. Borehole 126 was terminated in very dense silt at about elevation 172.9 m. Standard Penetration Test N values varied between 22 and over 100 blows per 0.3 m indicating a compact to very dense state. Measured water contents for the silt to sand and silt ranged from 8 to 24 per cent with an average value of about 17 per cent, though the lowest values may not be representative of in situ conditions. Summaries of N values and water contents are presented on Figures 4 and 5. Figure 11 illustrates an envelope of grain size distribution data that is typical of Type 7 and 8 soils encountered and tested for the Yonge Subway Extension project and other TTC subway projects in the northern limits of Toronto. Individual grain size distribution tests completed on Type 7 soils for the UTS project are also shown for comparison on Figure 11.

4.4.2.4 Clayey Silt to Silty Clay (Types 9 and 10)

Thin layers of clayey silt were encountered beneath topsoil and silty sand in boreholes 14 and MTO-30M14-210/01 between approximately elevation 194.6 m and 196.9 m. In borehole 128, a relatively thin clayey silt to silty clay layer was encountered between elevations 198.8 and 200.4 m. The clayey silt layer thickness in these boreholes ranged from about 0.4 m to 1.5 m. SPT N values within these relatively thin layers ranged from about 9 to 20 blows per 0.3 m indicating a stiff to very stiff consistency. Summaries of N values and water contents are presented on Figures 4 and 5. Figures 6, 12 and 13 provide envelopes of the plasticity and grain size distribution data, respectively, that are typical of Type 9 and 10 soils encountered and tested for the Yonge Subway Extension project and TTC subway projects in the northern limits of Toronto that may be considered representative for the Type 9 and 10 soils encountered for the UTS project.

Silty clay and clayey silt layers were also encountered in boreholes 14, 124, 126 and 128 between elevation 173.4 m and 190.3 m. The silty clay to clayey silt layers ranged from 1 m to as much as 6 m thick and were interbedded within or below silty clay till to clayey silt till layers. Standard Penetration Test N values measured for the silty clay varied between 15 and over 100 blows per 0.3 m indicating a very stiff to hard consistency. Measured water contents ranged from 17 to 32 per cent. Atterberg limits testing indicated the clayey silt to silty clay to be of low plasticity based on plastic limit range of 15 to 20 per cent and liquid limit and plasticity index ranges of 20 to 32 and 5 to 12 per cent, respectively. Summaries of N values, water contents and Atterberg limits are presented on Figures 4 and 5. Figures 6, 12 and 13 illustrate envelopes of plasticity and grain size distribution data, respectively, that are typical of Type 9 and 10 soils encountered and tested for the Yonge Subway Extension project and other TTC subway projects in the northern limits of Toronto.

4.4.2.5 Silty Clay Till/Clayey Silt Till (Type 11)

Silty clay till to clayey silt till layers were encountered in boreholes 14, 124, 126, 128, 212 and MTO-30M14-214/08 between elevation 167.5 m and 206.8 m. The cohesive till layers were encountered beneath fill, sand, silt and sandy silt till. In boreholes 14, 124, 126 and 128, the cohesive till layers were interbedded within or overlying silty clay and/or clayey silt layers. The thickness of the silty clay till to clayey silt layers ranged from 1.4 m to 7.6 m thick. Borehole MTO-30M14-214/08 was terminated in the clayey silt till after exploring the lower layer for 6.7 m. Evidence of boulders were encountered within the clayey silt till layers at a depth of about 14.9 m or approximately elevation 174.5 m in borehole MTO-30M14-214/08.

With the exception of three relatively low SPT N values measured in borehole 124 between elevation 189 m and 193 m, two relatively low values in borehole 126 between elevation 201.6 m and 202.8 m, and five relatively low values in borehole 128 between elevation 195 m and 207 m, the N values ranged from 19 to over 100 blows per 0.3 m generally indicating a very stiff to hard consistency. A firm to stiff layer of cohesive till with SPT N values ranging from 5 to 15 blows per 0.3 m was encountered below the fill or between the more characteristic very stiff to hard silty clay till to clayey silt till in borehole 124 between depths of 3.8 m and 7.7 m or approximately between elevation 189 m and 193 m, in borehole 126 between depths of 3.7 m and 4.9 m or approximately between elevation 201.6 m and 202.8 m, and in borehole 128 between depths of 2.2 m and 14 m or approximately between elevation 195 m and 207 m. Measured water contents for the very stiff to hard cohesive till varied between 8 and 20 per cent. Water contents of 10 to 25 per cent were measured for the firm to stiff cohesive till in boreholes 124, 126 and 128. Atterberg limits testing indicated the very stiff to hard cohesive till to be of low to intermediate plasticity based on plastic limit, liquid limit and plasticity index ranges of 9 to 20, 14 to 35 and 4 to 16 per cent, respectively. Three Atterberg limits tests for the firm to stiff cohesive till indicated the material to be of low plasticity based on plastic limit of 13 per cent and liquid limit and plasticity index ranges of 19 to 23 and 6 to 10 per cent, respectively. Summaries of N values, water contents and Atterberg limits are presented on Figures 4 and 5. Figures 6 and 14 illustrate envelopes of grain size distribution data that are typical of Type 11 soils encountered and tested for the Yonge Subway Extension project and other TTC subway projects in the northern limits of Toronto. Individual plasticity and grain size distribution tests completed on Type 11 soils for the UTS project are also shown for comparison on Figures 6 and 14, respectively.

4.4.2.6 Sandy Silt Till to Gravelly Sand Till (Type 12)

Layers of sandy silt till to gravelly sand till were encountered in boreholes 124, 206, 212, 214, MTO-30M14-210/01 and MTO-30M14-214/08 between elevation 181.0 m and 204.9 m. The granular till layers were encountered beneath fill, silty clay and silty sand, as well as interbedded with clayey silt till layers. A layer of clayey silt till was encountered between the granular till layers in borehole 124 at a depth of about 16.5 m or approximately elevation 180.1 m. Silty sand to sandy silt layers were encountered between the granular till layers at depths of 2.9 m or approximately elevation 196.7 m in borehole 206, 3.8 m or approximately elevation 201.5 m in borehole 212 and 3.0 m or approximately elevation 202.2 m in borehole 214.

With the exception of four relatively low SPT N values, the N values measured in the granular till varied between 21 and over 100 blows per 0.3 m indicating a compact to very dense relative density. Relatively lower SPT N values ranging from 8 to 13 blows per 0.3 m were generally measured at the interface between fill material and the granular till layers at depths of 1.4 m or approximately elevation 198.2 m in borehole 206, 1.4 m or approximately elevation 203.9 m in borehole 212 and 0.6 m or approximately elevation 204.6 m in borehole 214. Measured water contents for the granular till ranged from 5 to 21 per cent with an average value of about 12 per cent, though the lowest values may not be representative of in situ conditions. Summaries of N values and water contents are presented on Figures 4 and 5. Figure 14 illustrates an envelope of grain size distribution data that is typical of Type 12 soils encountered and tested for the Yonge Subway Extension project and other TTC subway projects in the northern limits of Toronto. Individual grain size distribution tests completed on Type 12 soils for the UTS project are also shown for comparison on Figure 15.

4.5 Groundwater Conditions

Groundwater levels were observed during and after drilling of the boreholes. To observe the groundwater pressures in the overburden soils, boreholes 14, 124, 126, 128 and MTO-30M14-210/01 were instrumented with slotted well screen observation wells[2]. Groundwater level monitoring was carried out between November 3 and December 16, 2008 in borehole 14 at two to four week intervals. In borehole 124, groundwater level monitoring was carried out between August 26 and October 14, 2010 at one to two week intervals. Groundwater levels in boreholes 126 and 128 were measured between July 3, 2013 and September 30, 2013. The frequency and duration of the groundwater monitoring was not confirmed for borehole MTO-30M14-210/01. While observation wells were not installed in boreholes 206, 212 and 214, observed groundwater levels during drilling were recorded on the Record of Boreholes and were used to generally assess possible groundwater levels within the immediate vicinity of the UTS area. The groundwater level monitoring data recorded for these boreholes are presented in Table 1, below.

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[2] Typically, a 3.1 m slotted well screen was installed in selected boreholes during the 2009 and 2013 subsurface investigations. The screened zones were generally sealed above and below using bentonite or cement bentonite grout. Therefore, the observed groundwater monitoring pressures in the observation wells are representative of the groundwater pressure at the depth of the screened interval.

Table 1: Summary of Groundwater Monitoring Data

Borehole	Installation	Monitoring Zone Elevation (m)	Groundwater Monitoring in Soil Type	Approximate Groundwater Elevation (m)
14	Observation well	173.0 to 176.1	Upper Granular Deposit (Types 5 and 7)	188.8 (Dec. 2, 2008)
124	Observation well	166.4 to 169.5	Upper Granular Deposit (Type 7)	189.2 (Oct. 14, 2010)
126	Observation well	173.1 to 176.2	Upper Granular Deposit (Types 6, 7 and 8)	191.6 (Sep. 30, 2013)
	Observation well	192.2 to 195.8	Recent Granular Deposit /ORMC (Types 5, 7 and 8)	196.5 (Sep. 30, 2013)
128	Observation well	174.4 to 177.5	Upper Till Deposit (Types 9, 10 and 11)	193.5 (Sep. 30, 2013)
	Observation well	195.8 to 199.5	Recent Granular Deposit /ORMC (Type 8)	200.8 (Sep. 30, 2013)
MTO-30M14-210/01	Observation well	189.3 to 190.1	Upper Till Deposit (Type 12)	193.8 (Dec. 15, 1990)
206*	-	-	-	195.8 (Feb. 6, 1997)
212*	-	-	-	201.2 (Feb. 7, 1997)
214*	-	-	-	200.8 (Feb. 11, 1997)

Note: * Groundwater levels indicated in boreholes 206, 212 and 214 were based on observed water levels encountered during drilling.

Based on very limited groundwater data for the UTS site, groundwater levels in the fill and Recent Granular Deposit/ORMC were generally consistent with a piezometric level of about elevation 196 m at the southern end of the UTS rising gradually to about 201 m near Bantry Avenue and remaining near this level to the north end of the proposed UTS facility. Groundwater pressures in the Upper Granular Deposit are interpreted to be about elevation 189 m near the Richmond Hill Centre Station area and rise to the north to about elevation 194 m near the north end of the proposed UTS structure. Upper Granular Deposit was not encountered at the location of borehole 128; however, measured groundwater pressures indicate that granular seams or thin un-sampled layers within the Upper Till Deposit appear to be hydraulically connected to the Upper Granular Deposit.

The upper and lower groundwater regimes in the UTS area are generally separated by the Upper Till Deposit encountered between elevation 179 m and 196 m. Interpreted and simplified groundwater pressure profiles for both water-bearing units are provided on Figures 3A and 3B for conceptual design purposes.

4.6 Subsurface Hazards

Some geological and environmental conditions have the potential to affect the design and construction of the proposed UTS structure. Special consideration should be given in various stages of design and construction to ensure these potentially hazardous conditions are adequately managed so to minimize the effect on the proposed project.

4.6.1 Cobbles and Boulders

The native soil deposits at the Yonge Subway Extension project site were glacially derived and therefore, construction of the UTS structure is likely to encounter cobbles and boulders. Cobbles are defined as rock fragments that cannot pass through a screen with square openings measuring 75 mm and a maximum dimension less than 300 mm. Boulders are defined as rock fragments with a maximum dimension being equal or greater than 300 mm. Evidence of boulders was recorded at a depth of 14.9 m or approximately elevation 174.5 m in borehole MTO-30M14-214/08. It should be noted that boulders and cobbles were not cored in this borehole. The presence of cobbles and boulders should be anticipated in the native deposits due to the depositional history of the material. The size and frequency of cobbles and boulders that will be encountered at the UTS site may be assessed during later design development stages with additional subsurface explorations and soil data.

For other TTC projects, a method of estimating the concentration of boulders within the soil mass was developed based on correlation of observed drilling behaviour and observed boulder frequency. The data available for this conceptual design report are not sufficient to estimate boulder prevalence in the general UTS area. However, other TTC work indicates that the number of boulders that could be encountered could range between 10 and 30 boulders per 1,000 m^3 of excavated soil.

4.6.2 Natural Gas

Methane gas is generally known to be present and has also been encountered in the Toronto-area soils, typically found in granular layers capped by cohesive till deposits. It should be noted that insignificant levels of methane gas were observed in the surficial soils in borehole 14 during the 2009 subsurface investigation. Further, insignificant levels of methane gas were measured in the surficial soils in borehole 124 during the 2010 subsurface investigation. Methane is a potential hazard for excavation and construction work. Care should be taken to avoid creating areas in temporary or permanent structures where there is no air movement, as this could lead to long-term build up of gas concentrations. It should also be noted that changes in groundwater pressure that may be caused by dewatering or seepage in underground spaces, can also lead to migration of gaseous or dissolved methane. Hydrogen sulphide has also been encountered as a by-product of dewatering activities in the Greater Toronto Area. Hydrogen sulphide gas can be toxic. The absence of significant methane and/or hydrogen sulphide concentrations from investigations carried out for the underground storage site (and nearby TTC projects) should not be construed to indicate that there is no risk of the presence of methane in the future. Investigations and testing to be completed during later stages of design should be planned to monitor and measure potential methane or other natural gases and adequately characterize the natural groundwater chemistry for methane gas and indicators of hydrogen sulphide.

5.0 MAN-MADE FEATURES SIGNIFICANT TO DESIGN AND CONSTRUCTION

Consideration should be given to the existing man-made features that may potentially affect or be affected by the design and construction of the proposed UTS structure. Excavations as deep as 20 m at the south end and 24 m at the north end are anticipated for the construction of the UTS structure. In the area of Bantry Avenue, excavations could be as deep as 31 m. Construction through the fill material and native deposits could encounter obstructions due to the presence of buried utilities, former shallow foundations and uncontrolled backfilled material from historical construction to the east of Yonge Street and adjacent to the CN/GO rail tracks. Environmentally impacted soil and/or groundwater associated with existing and adjacent site use and former boreholes or wells that were not abandoned in compliance with current regulations, may also affect the proposed development. This report section outlines the key features that may influence the conceptual design of the UTS facilities. Further investigation of nearby features should be undertaken prior to construction to fully assess the risks associated with man-made features that may be present within the zone of influence of the proposed underground storage facilities including temporary works (excavation and dewatering).

5.1 Adjacent Properties, Structures and Utilities

At the time of preparing this conceptual design report, detailed information about the existing structures within the UTS area is limited. Based on the current background information, the underground storage facilities site is located within a mixed-use commercial and residential development area consisting of low to mid-rise structures. These structures are generally located between Yonge Street and the CN/GO rail tracks. Low-rise residential structures are located on the east side of the CN/GO rail tracks. In addition, two bridges are located across the UTS site at High Tech Road and Bantry Avenue. The ground surface at the UTS site generally increases northward from about elevation 201 m to about elevation 209 m. In the areas of High Tech Road and Bantry Avenue, the ground surface increases to about 208 m and 215 m, respectively, because of the bridge approach embankments. Typically, between 1 m and 5 m of fill should be expected beneath the UTS site. In the areas of High Tech Road and Bantry Avenue, fill between 5 m and 9.5 m, and 10 m and 11 m, respectively, may be expected.

The existing low-rise structures located between Yonge Street and the CN/GO rail tracks are likely to be supported by shallow spread footing foundations. Where basements are present, the shallow foundations for these structures may be about 2 m below the lowest adjacent ground surface. For low-rise structures without basements, the shallow foundations for these structures may be at between 1.2 m and 1.5 m below the existing ground surface. For low to mid-rise commercial buildings and mid-rise residential structures (four to six storey buildings) built within the last 30 years, shallow spread footings between 1.5 m and 2 m below the existing ground surface or short drilled shafts extending to 5 m to 8 m below the ground surface are likely to have been used.

It is expected that numerous buried and over ground utilities including street lighting, are located on or within the immediate vicinity of the UTS site. Relocation and maintenance of these existing buried and/or over ground utilities will be required during construction.

The available Soil Probe Ltd. report (1997), referenced in Section 3, indicates that driven steel H piles were contemplated for the design of the Bantry Avenue bridge structure. Pile load capacities at Serviceability Limit States (SLS) and Ultimate Limit States (ULS) ranging from 650 kN to 900 kN and 1,000 kN to 1,400 kN, respectively, were provided for driven H piles with tip depths ranging from 11.5 m to 17.5 m below the ground surface at the time the boreholes were drilled. These pile tip depths represent elevations of about 187.5 m to 193.5 m, approximately 3.5 m to 9.5 m above the base of the planned UTS excavation. The geotechnical report prepared for the bridge indicated that battered piles were to be used for resistance to lateral loading. At the time of this report, it was unknown whether or not such battered piles were installed and, if so, whether or not the battered piles might be within the construction envelope of the UTS structure.

For the three-span bridge structure that crosses over the CN/GO rail tracks at Bantry Avenue, a detailed review of available design or as-built drawings should be undertaken to assess the types, locations, and elevations of the foundations, as well as the structural tolerances to displacement, which together may influence the design and construction of the UTS facilities including temporary excavations and dewatering.

Based on the conceptual design plans, the alignment of the UTS crosses Bantry Avenue between the location of the west Bantry Avenue bridge abutment and the pier supporting the western bridge span. At the time this report was prepared, it was unknown whether this bridge structure would remain in service or be closed, removed, and replaced as part of the UTS construction. For this report, it has therefore been assumed that the bridge structure will be replaced since support of the existing structure and maintaining traffic require complex underpinning or excavating support schemes under low headroom conditions.

5.2 Soil and Groundwater Chemistry

The environmental chemistry of the UTS site has not been assessed as part of this conceptual design report. An environmental assessment for the Yonge Street Corridor titled “Environmental Assessment, YRTP, Yonge Street Corridor, Golder Associates Ltd. Report No. 03-1111-001” dated May 2003, was undertaken for Yonge Street from Steeles Avenue to 19th Avenue (Gamble Road) and may be reviewed to provide a general indication of environmental risks associated with the general underground storage facilities area. A detailed geo-environmental assessment should be undertaken to fully assess the risks related to environmental chemistry that may affect the design and construction of the UTS facilities.

5.3 Boreholes and Wells

The general location of existing boreholes and wells for the general underground storage facilities area are presented on Figure 2, where boreholes or wells are known to have been completed. It should be noted that the regulations for monitoring and groundwater supply well decommissioning have changed since the early development of the area. Therefore, reliable records of past wells or drilling may not exist, and therefore, consideration should be given to possible open wells or boreholes that may exist near the underground storage facilities site. Such open wells or boreholes may influence subsurface movement of groundwater and/or environmental chemistry.

6.0 SOIL UNITS RELATED TO EXCAVATION

Cut and cover techniques will likely be adopted for the construction of the UTS structure. Deep excavations for the construction of EEB No. 7, EEB No. 8, a fan room and ventilation shaft structures are likely required. Shallow excavations may be required for construction of footing foundations or foundation caps for driven piles or drilled shafts or caissons for other ancillary structures associated with the UTS facilities project.

The stratigraphic interpretation of the subsurface conditions for the UTS structure, presented on Figures 3A and 3B, may be used for conceptual design to assess the soil and groundwater conditions at the general site. The stratigraphic profile is based on widely spaced borehole data available at the time this report was prepared. The actual site conditions, in particular, the strata boundaries, are likely to vary from those illustrated. It is expected that further subsurface investigations will be undertaken at appropriate stages of the project to further assess the soil and groundwater conditions for design and construction of the UTS structure, EEB No. 7, EEB No. 8, a fan room and ventilation shaft structures, as well as associated ancillary structures. The following report sections describe the soils likely to be encountered during construction, based on the available borehole records and the stratigraphic interpretation described above.

6.1 Underground Train Storage Structure

The ground surface at the UTS site generally increases from about elevation 201 m at the south end to about elevation 209 m at the north end. Excavations to depths of between 20 m at the south end and 24 m at the north end for the cut and cover construction of the UTS is anticipated. In the area of Bantry Avenue, the excavation depth could be about 31 m because of the neighbouring roadway embankment. The planned base of the underground storage facilities is at about elevation 182.5 m at the south end and at about elevation 185 m at the north end (end of extension line). Based on the limited subsurface investigation data, excavation for the underground storage facilities will likely be carried out through 1 m to 5 m of fill, as much as 8 m of the cohesive Halton Till at the north end of the structure, 3 m to 10 m of the Recent Granular Deposits/ORMC (silty sand to sandy silt till) and at least 8 m of the Upper Till Deposit (clayey silt till to sandy silt till). The excavation base for the underground storage facilities is likely to be formed in the Upper Till Deposit (silty clay till to clayey silt till) with interbedded granular layers encountered within the Upper Till. The supplementary boreholes completed in 2013 indicate that the water-bearing Upper Granular Deposit could exist within about 3 metres depth below the base of the excavation at the south end of the structure. At the north end of the UTS borehole 128 did not encounter the Upper Granular Deposits. However, measured groundwater pressures indicate that granular seams or thin unsampled layers within the Upper Till Deposit are hydraulically connected to the Upper Granular Deposit within 5 to 10 metres of the excavation base.

Based on the observed groundwater levels in boreholes 212 and 214 and the groundwater monitoring data for boreholes 14, 126 and 128 the groundwater levels in the upper aquifer, within the fill and Recent Granular Deposit/ORMC from south to north, respectively, ranges between about elevation 196 m to about elevation 201 m for the UTS area. It is anticipated that the groundwater pressures in the Upper Granular Deposit are likely to exhibit a pressure head near about elevation 189 m in the Richmond Hill Centre Station area rising to near elevation 194 m toward the north end of the UTS site. Based on the available subsurface and groundwater information it is anticipated that the groundwater pressure level in the Upper Granular Deposit for the UTS area will likely need to be lowered by about 7 m to prevent hydraulic uplift failure of the excavation base.

6.2 Ancillary Structures

Deep excavations for the construction of EEB No. 7, EEB No. 8, a fan room and ventilation shaft structures located at the north end of the UTS at approximately Stations 8+180 and 8+380 will likely be required. It is also anticipated that shallow excavations may be required for the construction of shallow footings and/or foundation caps for driven piles or drilled shafts/caissons for other ancillary structures. At the time this conceptual design report was prepared, other potential ancillary structures associated with the UTS project other than EEB No. 7, EEB No. 8, a fan room and ventilation shaft structures, were not defined. Excavations ranging from about 17 m to 22 m are likely required for the construction of the deeper ancillary structures. Based on the available subsurface investigation data, the deeper excavations are likely to be carried out through fill, Halton Till, Recent Granular Deposits/ORMC and the Upper Till. Shallow excavations are anticipated to be carried out through fill and either the Halton Till and/or Recent Granular Deposit/ORMC including interbedded cohesive layers. Excavations through 1 m to 5 m of fill should be anticipated along the alignment of the UTS area. In the area of the Bantry Avenue approach embankment, excavations through or removal of extensive fill material may be required.

Shallow foundations and/or foundation caps for shallow ancillary structures should be founded on compact to dense Recent Granular Deposit/ORMC or stiff to hard cohesive deposits. Shallow foundations should not be supported on the existing fill material without further subsurface investigation. At conceptual design stage, it should be assumed that the existing fill material will not be suitable for support of shallow foundations. Excavations for the construction of these structures are likely to be carried out at about or above the interpreted groundwater level in the fill and the Recent Granular Deposit/ORMC. Where deep foundations are required, these are likely to be constructed through the fill and Recent Granular Deposit/ORMC and founded in the very stiff to hard Upper Till. While dewatering of the fill and the Recent Granular Deposit/ORMC are likely not required for the construction of the shallow ancillary structures above 3.5 m, properly filtered sump pits and pumps will be required in addition to provisions for surface water management within the fill and the Recent Granular Deposit/ORMC. For the construction of EEB No. 7, EEB No. 8, a fan room and ventilation shaft structures, it is anticipated that dewatering within the fill and Recent Granular Deposits/ORMC will be required for the excavation to between approximately elevation 187 m and approximately elevation 192 m. Based on the interpreted subsurface conditions and groundwater information, it is anticipated that the groundwater pressure level in the Upper Granular Deposit for EEB No. 7, EEB No. 8 will likely need to be lowered by a depth of about 6 m, to prevent hydraulic uplift failure of the excavation base.

7.0 RECOMMENDATIONS FOR CONCEPTUAL DESIGN

This section of the report provides an interpretation of the geotechnical data obtained for conceptual design of the UTS structure and includes engineering comments and recommendations related to geotechnical aspects of the proposed project. It should be noted that the subsurface data for the underground storage facilities area is very limited and is based on limited borehole data obtained at widely-spaced discrete locations at or near the proposed structure location. Additional subsurface information will be required during subsequent stages of design and construction. The underground storage facilities structure will likely be constructed using cut and cover construction methods. Footing foundations and/or deep foundations are likely required for the construction of EEB No. 7, EEB No. 8, a fan room and ventilation shaft structures and other associated ancillary structures.

7.1 Box Structure Conceptual Design

For conceptual design of the underground storage facilities structure, the soil and groundwater conditions presented on Figures 3A and 3B may be used in combination with the soil parameters provided in Table I, provided at the conclusion of this report text. In general, the recommendations provided below are consistent with design of typical structures for previous TTC projects and consistent with the TTC Design Manual.

The design of the roof of the underground storage facilities structure will be required to resist the total overburden pressures including additional dead and live load surcharges acting on the roof. In accordance with the TTC Design Manual, the total overburden pressure acting on the roof is calculated as follows:

$$\sigma_v = (\gamma)\ (z)$$

where γ = Bulk unit weight (as provided in Table I) (kN/m^3)

z = Depth below ground surface (m)

The roof of the underground storage facilities structure will likely be below the groundwater levels between Stations 7+680 and 8+380, therefore, consideration of additional groundwater pressures acting on the roof will be required at this location. Consideration will also need to be given to waterproofing the box structure against groundwater present in new backfill, existing fill and native deposits.

The walls for the underground storage facilities structure should be designed to resist a conventional triangular lateral earth pressure distribution with an allowance for dead and live surcharge loads at the ground surface, assuming “at rest” conditions. The in situ ratio of horizontal to vertical earth pressures, K_o, may be greater than 1.0 for the over-consolidated glacial soils present at the site. However, during the excavation process for underground storage facilities structure construction, some stress relief is likely to take place resulting in significantly lower values of horizontal stress compared with the existing in situ conditions. The stress relief may be offset over long-term conditions as the permanent structure is generally restrained against displacement. Therefore, for conceptual design of permanent structures, a lateral earth pressure coefficient of 0.5 is recommended for assessing lateral stresses acting on the underground storage facilities structure. To determine the horizontal effective stresses, σ'_h, acting on the walls, the following equations may be used:

Above groundwater level: $\sigma'_h = K (\gamma) (z)$

where K = 0.5

γ = Bulk unit weight (kN/m^3)

z = Depth below ground surface (m)

Below groundwater level: $\sigma'_h = K (\gamma) (z) + K (\gamma') (z_w)$

where K = 0.5

γ'= Effective unit weight (kN/m^3)

γ = Bulk unit weight (kN/m^3)

z = Depth below ground surface to the groundwater level (m)

z_w = Depth below groundwater level (m)

The walls of the UTS structure should be designed to resist the short term and long term groundwater pressures acting on the walls. To determine the long term groundwater pressures acting on the permanent structures, the following equation should be used:

$\sigma'_w = \gamma_w (z_w)$

where $\gamma_w = 9.8$ kN/m^3 (unit weight of water)

For conceptual design of the base slab or invert of the underground storage facilities structure, it is anticipated that the geotechnical vertical load resistance (i.e., “bearing capacity”) will not govern design since construction of the structure will result in a net unloading of the ground. If conceptual design will involve initial structural design of the UTS structure base, it may be convenient to utilize “beam-on-elastic foundation” concepts, in which a spring constant is assigned to represent the soil response to loading. In this case, spring constant values ranging between 20 MN/m^3 and 30 MN/m^3 may be used for the underground storage structure. This range of values is provided based on considerations of the rigidity and thickness of walls and base slabs typically used for design of TTC cut and cover structures. It should be noted that the spring constant and “beam-on-elastic” foundation approach is relatively crude and that the spring constants are not an intrinsic soil property. Although these recommendations are suitable for conceptual design, potential soil-structure interaction must be reviewed and refined during later stages of design.

The base of the underground storage structure is likely to be founded on very stiff to hard Upper Till (silty clay to sandy silt till) and/or dense to very dense granular soil layers interbedded within the Upper Till.

Cohesive deposits are sensitive to disturbance due to construction traffic and wetting/drying cycles. Therefore, a mudcoat consisting of lean concrete (approximately 75 mm to 100 mm thick) should be placed directly on exposed subgrades following geotechnical inspection of the subgrade. The mudcoat is intended to provide surface protection to the subgrade while providing a working platform during construction.

Settlement of the underground storage facilities structure will depend on the strength and stiffness of the underlying soil, the final structure design and construction sequence. Settlement of the UTS structure should be analyzed during subsequent design stages so that the settlement is compatible with the anticipated settlement of the adjoining twin tunnels. Based on the proposed founding elevation for the underground storage facilities structure, a net unloading is anticipated and therefore, excessive settlement is unlikely. However, the sequences of soil unloading and reloading will likely result in some small differential movements of the underground storage structure and connecting twin tunnels. Such differential displacements will likely occur during the period of construction and should not present long-term settlement issues.

7.2 Conceptual Foundation Design

7.2.1 Ancillary Structures

At the time of preparing this report, EEB No. 7 and EEB No. 8, approximately 10 m long by 6 m wide, were planned at the north end of the UTS structure at approximately Stations 8+180 and 8+380. A fan room and ventilation shaft structures, approximately 22 m long and 20 m wide, were also proposed abutting the north end of the UTS at approximately Station 8+360. Design details of EEB No. 7, EEB No. 8, a fan room and ventilation shaft and any other ancillary structures associated with the UTS facilities were not defined. Based on the available subsurface information for the UTS area, shallow foundations are recommended to be founded on the dense to very dense Recent Granular Deposit and/or interbedded very stiff to hard cohesive soils within the Recent Granular Deposit/ORMC. Shallow foundations should not be supported on the existing fill material without further subsurface investigation. Typically, between 1 m and 5 m of fill is likely to be encountered across the UTS area. In the area of the Bantry Avenue approach embankments, extensive fill and/or loose Recent Granular Deposit/ORMC may be encountered and therefore, deep foundations may be required. The interpreted groundwater pressure level in the fill and the Recent Granular Deposit/ORMC for the UTS area ranges from about elevation 196 m at the south end to about elevation 201 m at the north end or approximately 5 m to 8 m below the existing ground surface between Stations 7+680 and 8+400.

For conceptual design, a factored geotechnical resistance at ULS for dense to very dense Recent Granular Deposit/ORMC would likely range between 300 kPa and 400 kPa for 2 m to 4 m wide spread footing foundations founded at least 1.2 m below ground surface. For foundations supported on very stiff to hard interbedded cohesive soils (undisturbed) located within the Recent Granular Deposit/ORMC factored resistances at ULS would likely range from about 200 kPa to 300 kPa for similar size footings founded at least 1.2 m below existing ground surface. The equivalent geotechnical resistance at SLS for these shallow spread footing foundations would range from about 200 kPa to 300 kPa for footings founded on granular soils and 150 kPa to 200 kPa for footings founded on cohesive soils. Where a raft foundation founded on native deposits below elevation 195 m is considered, a factored resistance at ULS and SLS of 300 kPa and 200 kPa, respectively, may be considered for foundation design.

For ancillary structures that are located within areas of significant fill material (> 3 m) or where heavy loads are anticipated for ancillary structures that include heavily loaded foundations such as replacement bridge foundations that are intolerant of typical load and differential settlement magnitudes, deep foundations may be considered and these may include:

- Driven steel H-piles; and
- Drilled cast-in-place concrete piles (i.e., drilled shafts or caissons).

In selecting the type of foundation, consideration will need to be given to the methods of installation and special construction requirements (e.g., the use of temporary liners, construction through obstructions, control of groundwater pressures), as well as the geotechnical resistances at ULS and SLS including settlement performance characteristics. The geotechnical resistances of deep foundations for ULS and SLS should be developed and refined when the design of EEB No. 7, EEB No. 8, the fan room and ventilation shaft structures and any other ancillary structures that are further defined. However, for conceptual design purposes, ranges of geotechnical resistance values for deep foundations are provided below.

The available subsurface information indicates that in the general area of the UTS, between 1 m and 5 m of fill may be encountered except in the area of the Bantry Avenue bridge approach embankments where between 10 m and 11 m of fill may be encountered. For deep foundation design, shaft resistance should be considered negligible in the fill and resistance for driven piles should be obtained from shaft resistance only. For drilled shafts or caissons, the geotechnical resistance should be obtained from a combination of shaft and end bearing resistance. For conceptual design, a factored axial resistance at ULS and SLS of 650 kN to 1,000 kN and 500 kN to 800 kN, respectively for driven steel H-piles with a minimum length of about 15 m in native soil deposits (excluding 5 m to 10 m of fill) may be considered. Table 2, below, provides a range of estimated axial resistance at SLS for two common drilled shaft or caisson diameters of varying lengths. For the drilled shaft or caisson lengths and diameters provided below, factored ULS resistance values may be taken as approximately 125 per cent of the SLS values for conceptual design purposes.

Table 2: Axial Resistance of Drilled Shaft or Caisson Foundations at SLS for Conceptual Design

Minimum Drilled Shaft or Caisson Length (m) in Native Soils	Axial Resistance at SLS for Drilled Shaft or Caisson Diameter (kN)	
	0.9 m	1.2 m
10	800 to 1,000	1,000 to 1,250
15	1,100 to 1,300	1,400 to 1,600

The drilled shafts or caissons are assumed to be constructed through the fill into dense to very dense Recent Granular Deposit/ORMC and very stiff to hard Upper Till. A higher vertical resistance capacity may be possible if full-scale load tests are carried out. The above estimated capacities are based on the assumption that the drilled shaft or caisson base is cleaned prior to concreting and the concrete forming the drilled piles is placed using tremie methods and that temporary liners are used to prevent ingress of loose fill and granular materials. To control the groundwater pressures and the Recent Granular Deposit, temporary support fluid may also be required for the construction of drilled shaft or caissons, particularly where such foundations may penetrate below groundwater levels.

Geotechnical resistance of foundations to lateral loading has not been provided within this report since the need for significant lateral load resistance will depend on the configuration of EEB No. 7, EEB No. 8, the fan room and ventilation shaft structures and any other ancillary structures. Lateral load resistance values should be developed at such time that details of the ancillary structures are better defined.

7.3 Temporary Ground Support Systems

7.3.1 Conceptual Design Considerations

The selection of temporary ground support systems will require consideration of the anticipated excavation depth, temporary surcharges (live and dead loads) that may be acting immediately behind the temporary retaining wall, groundwater levels and tolerance of nearby facilities to ground displacements. In some cases, decking for example, vertical loads may need to be supported by the temporary shoring system. The main objective of the temporary ground support is to control the vertical and lateral ground movements induced from temporary excavations that may affect adjacent facilities including buildings and basements, buried utilities and paved areas. For the construction of the UTS, secant piles (contiguous caisson) or concrete diaphragm walls (“slurry walls”) may be considered for the temporary excavation support. Groundwater cut-off is likely to be achieved for the secant piles or concrete diaphragm walls. While soldier piles with lagging may also be considered, an appropriate dewatering scheme is required to be in place for this option. The dewatering scheme is likely to require a network of pumps, sumps and multi-stage eductors for dewatering layered deposits.

Temporary support systems for deep excavations will require lateral supports at regular intervals. Depending on the site and surrounding area constraints (e.g., basements, foundations, utilities and available easements), soil anchors or internal strut systems may be used. A detailed assessment will be required to fully explore the temporary support options and develop design and construction criteria for the anticipated ground conditions at the UTS site.

Excavations between depths of 20 m at the south end and 24 m at the north end are anticipated for construction of the UTS structure. In the area of the Bantry Avenue approach embankments, excavations to a depth of about 31 m is likely required. Selection of the methods needs to take into consideration the relatively high groundwater pressures in the fill and Recent Granular Deposits/ORMC, as well as the potential for man-made obstructions in the fill and cobbles and boulders in the native soil deposits. A suitably stiff system will need to be in place to ensure ground movement is limited while also minimizing ground loss in the Recent Granular Deposits/ORMC. Based on the available data, secant piles or concrete diaphragm walls (“slurry walls”) may be considered feasible temporary support options for the underground storage facilities structure. Pre-bored soldier piles with lagging can also be considered provided that groundwater is adequately controlled prior to excavation.

7.3.1.1 Continuous Concrete Walls

Where stiff temporary support systems are required to control the ground movement, such as adjacent to existing bridge foundations, or where groundwater cut off is required, continuous concrete wall options such as secant piles (contiguous caissons) and diaphragm walls may be considered. Continuous concrete walls are typically more costly compared with flexible wall systems (e.g., soldier piles with lagging). In general, concrete diaphragm walls (“slurry walls”) are seldom used in the Toronto area because substantial working areas are required for the management of construction fluids (slurry) and specialized equipment is required that is not readily available in the Toronto area.

At the UTS site, groundwater pressure levels in the Recent Granular Deposit/ORMC are between approximately 13.5 m at the south end and 16 m at the north end above the excavation base and between about 7 m (south end) and 9 m (north end) above the excavation base in the Upper Granular Deposit. The excavation base is likely to be founded in the Upper Till Deposit. The available data indicate that the thickness of the Upper Till Deposit below the excavation base may be 3 m or less in the southern end of the UTS facility. Insufficient information is available to adequately assess the potential thickness of cohesive Upper Till soils that may exist below the UTS excavation bottom, though supplementary borehole 128 indicates that the Upper Till thickness increases northward. While the records of two wells in the area (6906180 and 6902908) indicate that the cohesive soils may exist to well below the base of the excavation, the classification information from these records is not considered suitably reliable and, for conceptual design, the conditions identified by supplementary borehole 126 should be considered more representative of subsurface conditions.

The cohesive layers below the excavation base may not be sufficiently thick to resist groundwater pressures in the underlying Upper Granular Deposit that may exist below the excavation base. Therefore, dewatering systems will likely be needed to depressurise these soils to avoid uplift failure of the excavations. For conceptual design of the UTS, it would be prudent to consider the need for depressurization of the Upper Granular Deposit for the construction of the UTS structure. Enclosing the excavations with continuous wall systems that penetrate to well below the excavation base, supplemented with internal dewatering or water pressure relief systems, may be necessary for this project pending additional subsurface investigations and evaluation of the necessary groundwater extraction rates to achieve sufficient pressure relief in the Upper Granular Deposit.

7.3.1.2 Soldier Piles with Lagging

Soldier piles with lagging excavation support is typically constructed by installing the soldier piles first within pre-bored holes, followed by installing lagging boards concurrent with the excavation progress. While the ground loss is likely to be minimal in the till deposits, some localized ground loss may be anticipated during the lagging installation in the Recent Granular Deposit/ORMC, particularly in the silty sand and sand layers. This option should only be considered where an appropriate dewatering scheme is in place. It should be noted that the soldier piles and lagging walls are a more flexible support system compared with secant piles or continuous concrete diaphragm walls. Soldier piles and lagging with dewatering is typically considered suitable where ground movements are permitted to some degree; i.e., where sensitive structures or utilities are not located adjacent to the planned excavation. For areas where control of ground movement is critical, a secant pile or concrete diaphragm wall system should be considered.

7.3.2 Lateral Earth Pressures

Preliminary assessment of the lateral pressures acting on the temporary support system may be estimated using the soil parameters outlined in Table I. The design of the shoring system is required to account for horizontal earth pressures including lateral loads induced by surcharges (live and dead loads) and other external loads acting behind the wall, as well as pressures induced by groundwater. The actual lateral pressure distribution behind the temporary support system will depend on the final design (e.g., type of horizontal support, number of support levels, elevations and inclination angles of supports).

For flexible wall systems such as soldier piles with lagging, the apparent distribution of lateral pressure is likely to take on a trapezoidal shape. The lateral pressure distribution for secant piles or concrete diaphragm walls may be similar to a conventional active earth pressure distribution. Figures 16 and 17 provide preliminary pressure distributions suitable for assessing temporary support requirements.

Requirements for shoring systems should be developed following additional investigations and further development of the conceptual design of the UTS facilities. Design and specification of the selected shoring system is likely to be an iterative process considering interaction of lateral pressures, horizontal supports (e.g., struts or tie-backs), permissible ground displacements, groundwater control and the requirements for the permanent structure design. The maximum passive factored resistance, $P_{p(f)}$, that may be mobilized at any depth in front of the embedded section of temporary support systems may be estimated using the following equations:

For individual soldier piles embedded within granular deposits:

Portion above groundwater level: $P_{p(f)} = \Phi\ [3K_p\ \gamma z B]$

Portion below groundwater level: $P_{p(f)} = \Phi\ [3K_pB\ (\gamma D_w + (\gamma\text{-}\gamma_w)\ (z\text{-}D_w))]$

where $P_{p(f)}$ = Factored resistance at any depth below base of excavation (kN/m)

Φ = Resistance factor
Φ = 0.6 for Limit States Design
Φ = 0.5 for Working Stress Design

γ = Bulk unit weight of soil (as provided in Table I) (kN/m^3)

γ_w = Unit weight of water = 9.8 kN/m^3

B = Socket diameter, assumed to be < 1/3 pile centre-to-centre spacing (m)

D_w = Depth of groundwater below excavation base (m)

z = Depth below the base of excavation (m)

K_p = Coefficient of passive pressure (as provided in Table I)

Where localized dewatering is required to maintain a dry working area at base slab elevation, the groundwater level below the excavation base, D_w, should be assumed to equal zero for design purposes.

For individual soldier piles embedded within cohesive soils:

$$P_{p(f)} = \Phi\ 3B[\gamma z+2S_u]$$

where $P_{p(f)}$ = Factored resistance at any depth below base of excavation (kN/m)

Φ = Resistance factor
Φ = 0.6 for Limit States Design
Φ = 0.5 for Working Stress Design

γ = Bulk unit weight of soil (as provided in Table I) (kN/m^3)

B = Socket diameter, assumed to be < 1/3 pile centre-to-centre spacing (m)

z = Depth below the base of excavation (m)

S_u = Undrained shear strength (as provided in Table I) (kPa)

Similarly, passive resistance, $P_{p(f)}$, for a continuous wall can be calculated using the following equations:

For continuous walls embedded in granular deposits:

Portion above groundwater level: $P_{p(f)} = \Phi\ [K_p\ \gamma z]$

Portion below groundwater level: $P_{p(f)} = \Phi\ K_p\ [\gamma D_w + (\gamma\text{-}\gamma_w)\ (z\text{-}D_w)]$

Where $P_{p(f)}$ = Factored resistance at any depth below base of excavation (kN/m^2)

Φ = Resistance factor
Φ = 0.6 for Limit States Design
Φ = 0.5 for Working Stress Design

γ = Bulk unit weight of soil (as provided in Table I) (kN/m^3)

γ_w = Unit weight of water = 9.8 kN/m^3

D_w = Depth of groundwater below excavation base (m)

z = Depth below the base of excavation (m)

K_p = Coefficient of passive pressure (as provided in Table I)

Where localized dewatering is required to maintain a dry working area at base slab elevation, the groundwater level below the excavation base, D_w should be assumed to be zero for design purposes.

For continuous walls embedded in cohesive soils:

$$P_{p(f)} = \Phi\ [\gamma z + 2S_u]$$

where $P_{p(f)}$ = Factored resistance at any depth below base of excavation (kN/m)

Φ = Resistance factor
Φ = 0.6 for Limit States Design
Φ = 0.5 for Working Stress Design

γ = Bulk unit weight of soil (as provided in Table I) (kN/m^3)

z = Depth below the base of excavation (m)

S_u = Undrained shear strength (as provided in Table I) (kPa)

In the vicinity of Bantry Avenue, different support systems may be required to avoid obstructions due to existing deep foundations located adjacent to the temporary works.

While the generalized equations provided above may be useful for conceptual design purposes, control of groundwater pressures will have a significant influence on the passive pressures that could be achieved. A detailed evaluation of passive pressure resistance available for wall support will have to be made during subsequent stages of design in order to adequately account for planned dewatering system details.

7.3.3 Soil Anchors

In place of horizontal supports or struts, soil anchors may be used to provide unrestricted access to the excavation areas. Soil anchors are generally designed by specialist Contractors, who will supply, install and undertake appropriate tests to confirm the soil anchors meet the temporary works design criteria. The design criteria will need to include design loads, minimum factors of safety, deflection limits, design life of soil anchors, proof testing requirements and de-commissioning requirements.

Use of anchors can prove advantageous in situations where unrestricted access to the excavation is desirable. Further, in some cases, anchors can be more cost effective than struts when the struts can not be re-used or where the excavation is of such width that intermediate strut supports would otherwise be required.

For anchors to be used, sufficient temporary construction easements will be necessary. Typically, anchors extend perpendicularly from the line of the excavation a distance equal to about 1.5 to 2 times the excavation depth. Although after construction the anchors will no longer be needed, the grouted steel cables or rods will remain in the ground. Planning for easements will need to consider these short-term and long-term issues.

The design of soil anchors is dependent on the ground conditions in which the anchors will be installed. For the underground storage facilities structure, soils anchors may be required to be constructed through extensive fill material, Recent Granular Deposit/ORMC and the Upper Till. In areas where anchors are required to be installed through fill material, further consideration should be given as to the likely increased ground and excavation support movements compared to systems supported with anchors installed in the native deposits. Fill materials are not well-suited for providing capacity (bond zone) though past TTC construction projects have made use of temporary anchors installed in fill materials, albeit it with more significant ground and excavation support displacements (e.g., east cut and cover structure on the Sheppard Subway).

Groundwater conditions at the time of anchor installation will also be critical to successful use of anchors. In general, the anchor head elevation should be above the groundwater pressure elevation when drilling through granular soils to avoid ground loss during drilling. Unless dewatering is carried out, this issue may affect the use of anchors below approximately elevation 196 m at the south end to elevation 204 m at the north end for the UTS structure.

7.3.4 Open Cut Slopes

Where there is sufficient working area and the excavation depth is relatively shallow, open cut excavations may be considered. In areas where space is restricted and groundwater levels are relatively high, temporary supports are required for excavation. Based on the ground conditions identified in the existing borehole and well records for Richmond Hill Centre Station and UTS, temporary excavations may be made with side slopes of 1 horizontal to 1 vertical (1H:1V) in cohesive soils above groundwater levels. For open excavations in the fill and Recent Granular Deposit//ORMC above groundwater levels, side slopes of 1.5H:1V may be considered.

Surface groundwater and seepage from water within permeable zones of fill or granular soils will need to be managed to prevent surface erosion. Maintenance of slopes and provisions for localized groundwater control are recommended to ensure slope stability is maintained throughout temporary works.

7.4 Dewatering

Dewatering will likely be required to temporarily reduce the groundwater levels in the upper and lower aquifers for the construction of the UTS structure. The groundwater profiles presented on Figures 3S and 3B may be used for conceptual design to assess the groundwater conditions and potential dewatering requirements. It should be noted that the groundwater conditions have been interpreted based on limited groundwater data available for the UTS area; therefore, groundwater monitoring data for the Richmond Hill Centre Station site has been utilized for conceptual design. It is expected that further subsurface investigations will be undertaken at appropriate stages of the project to further assess the soil and groundwater conditions at the site for detail design and construction of the UTS structure, EEB No. 7, EEB No. 8, the fan room and ventilation shaft structures, as well as any other ancillary structures.

Based on the available subsurface investigation information, the hydraulic conductivity of the saturated granular soils within the Recent Granular Deposits/ORMC is anticipated to up to about 2 x10^{-4} m/sec. Given an approximate saturated aquifer thickness of about 5 m, the representative transmissivity of the unconfined aquifer within the Recent Granular Deposits/ORMC in the vicinity of the UTS site is anticipated to be approximately 90 m^2/day. Assuming an aquifer thickness of 15 to 20 metres, the transmissivity of the Upper Granular Deposit is expected to be approximately 260 m^2/day to 350 m^2/day.

The Theis analytical solution was used to estimate the theoretical radius of influence of the proposed dewatering systems, as follows:

$$s(r,t) = \frac{Q}{4\pi T} W\left(\frac{r^2 S}{4Tt}\right)$$

where $s(r,t)$ = Drawdown at radial distance (r) and time (t) after the start of pumping

Q = Pumping rate required per dewatering source to achieve the required drawdown (m^3/day)

T = Aquifer transmissivity (m^2/day)

S = Aquifer storativity (0.1 – assumed for unconfined aquifer conditions, 10^{-4} assumed for confined aquifer conditions)

W = Theis well function

It is assumed that steady state conditions will be achieved after approximately 50 days of pumping. The steady-state groundwater inflow rates to the excavations were calculated using standard analytical solutions for construction dewatering as provided in Powers (2007)[3].

7.4.1 Underground Train Storage Structure

Excavations ranging from depths of about 20 m at the south end to about 24 m at the north end are likely required for construction of the UTS structure. Locally, at Bantry Avenue, excavations to a depth of up to 31 m below the road embankment surface may be required. Excavation in this area may include sloping cuts through the embankment fill as well as supported excavations depending on the design options associated with the Bantry Avenue bridge. The base of the underground storage structure is at about elevation 182.5 m at the south end and about elevation 185 m at the north end. The groundwater pressure level in the upper aquifer varies between elevation 196 m at the south end and about elevation 201 m at the north end. The groundwater pressure level in the lower aquifer is inferred to rise gradually from about elevation 189 m, near the south end of the UTS to about elevation 194 m near the north end of the UTS.

The available information indicates that dewatering for the UTS structure could consist of multi stage eductors, localized vacuum well points and potentially, deep wells to address overall groundwater drawdown and depressurization requirements. In addition, conventional sump pits and pumps will be needed to control seepage from within the Recent Granular Deposits/ORMC and the Upper Granular Deposit. Within the Recent Granular Deposits/ORMC, interbedded cohesive layers may also be found. Dewatering of the last 0.5 m to 1 m of granular soils immediately above the interbedded cohesive layers or above the interface with the underlying Upper Till will be difficult and the eductor systems will likely need to be supplemented with conventional sump pits and pumps and localized use of vacuum and well points. Using the Theis analytical solution as described

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[3] Powers, J.P., Corwin, A.B., Schmall, P.C. and Kaeck, W.E., Construction Dewatering and Groundwater Control, New Methods and Applications, Third Edition, John Wiley & Sons, Inc. 2007.

above, the theoretical radius of influence for the dewatering system is anticipated to be approximately 200 m in the unconfined aquifer within the Recent Granular Deposit/ORMC.

Based on the available subsurface and groundwater information groundwater pressure levels in the Upper Granular Deposit will likely need to be lowered by about 7 m to prevent hydraulic uplift failure of the excavation base. Lowering of the groundwater pressure level will likely require use of multi-stage eductors supplemented with deep wells at relatively close spacing. The theoretical radius of influence may be on the order of 5,000 m in the confined Upper Granular Deposit.

Based on available subsurface investigation information, the steady-state groundwater inflow rate for the dewatering system for the UTS area is anticipated to range between approximately 3,300 m^3/day and 4,000 m^3/day, corresponding to a pumping rate of about 2,300 L/min to about 2,800 L/min over a 24 hour period. During the initial dewatering period, the discharge rate from the dewatering system will be greater that the steady-state rate, due to the volume of water being removed from storage in the overburden aquifer. The dewatering system should be designed and sized accordingly.

Depending on the results of further subsurface investigations and evaluation, it may be necessary to utilize continuous walls with internal dewatering systems in the UTS area to limit dewatering flow rates. If a cut-off wall is installed to a depth sufficient to penetrate at least 50 per cent of the confined Upper Granular Deposit, the dewatering flow rates may be reduced to less than 2,500 m^3/day. The above estimated discharge rates with or without installation of continuous walls within the Upper Granular Deposit to a depth sufficient to penetrate at least 50 per cent of the aquifer is based on dewatering systems for the a typical 150 m long section of the UTS structure and is largely based on the subsurface conditions encountered for the Richmond Hill Centre Station area and the supplementary boreholes 126 and 128. The above estimated discharge rates excludes cumulative impact associated with combined dewatering systems for the entire UTS structure and the adjacent Richmond Hill Centre Station.

7.4.2 Ancillary Structures

Dewatering for construction of the EEB No. 7, EEB No. 8 and the fan room and ventilation shaft structures are likely required. However, the need for dewatering for ancillary structures should be examined pending further investigation and definition of the ancillary structures concept.

7.5 Backfilling

Backfill around and over the UTS structure should consist of well compacted engineered fill, that is free from topsoil or other organic matter, construction rubble and particle sizes greater than 150 mm. The specific properties of the backfill material will vary depending on the structure, surrounding ground conditions and the performance criteria of the fill. Generally, it is recommended that the grain size distribution and plasticity of the backfill around or over the structures be similar to that of the surrounding ground. This is particularly of concern where excavations are made into or through cohesive soils. Granular soils, if used for backfill in such conditions, are likely to become saturated over time and may build up groundwater around the structure, promoting leakage into the permanent structure unless the backfill is provided with drains to water management facilities at lower elevations.

In general, it is considered that the native deposits from the site will likely be suitable for use as backfill material provided the material is sorted, conditioned or protected to maintain water contents within an appropriate range and compacted and placed in accordance with the typical TTC earthwork and backfill specifications. The existing fill materials should not be considered for re-use unless future investigations determine that the physical and environmental chemistry qualities are sufficiently known to justify re-use.

For selected areas, imported granular fill may be required. Imported granular fill materials are generally used for utility bedding and backfill, as road base and subbase, for foundation subgrades, and as backfill behind retaining walls.

8.0 GROUND MOVEMENT

8.1 Deep Excavation Induced Ground Movements

Deep excavations will result in movement of the surrounding ground. Maximum ground movements will generally occur immediately behind the excavation perimeter, reducing with increasing distance from the excavation area. Excavation-induced ground movement is likely to be reduced to nominal values at distances ranging from about equal to the excavation depth to two times the excavation depth, depending on the ground conditions and magnitude of displacements. For construction of the UTS facilities, where the excavation is mainly through dense to very dense Recent Granular Deposit/ORMC and very stiff to hard Upper Till, ground movements are anticipated to attenuate to negligible values (i.e., less than 5 mm) at a distance of about 20 m from the excavation perimeter. In areas where the excavation is through loose to compact Recent Granular Deposit/ORMC, larger ground movements are likely to be observed.

For excavations with relatively flexible temporary support systems such as soldier piles with lagging, the maximum vertical and lateral ground displacement is typically about 0.2 per cent of the excavation depth. In areas of extensive fill or loose Recent Granular Deposit/ORMC, the magnitude of ground displacements may be on the order of 1 per cent of the excavation depth for conventional soldier pile and lagging excavation support with internal horizontal supports or ground anchors. For stiffer temporary support systems, such as secant pile walls, ground displacements are likely to be reduced to about half the magnitude associated with soldier pile with lagging. Actual ground displacements are dependent on the design, construction techniques including dewatering measures utilized and workmanship, as well as the final construction sequence.

In accordance with the TTC Design Manual, a detailed assessment will be required for structures and utilities that are located within the “zone of influence of ground displacements” to ensure the cut and cover construction will not adversely affect nearby existing facilities. A detailed review of the surrounding site use and the existing facilities will need to be undertaken to identify their tolerances of ground displacements.

8.2 Instrumentation and Movement Monitoring

Monitoring is required to assess the effects of each stage of construction on existing facilities. An instrumentation and monitoring program will need to be undertaken based on the facilities identified within the zone of influence. The objectives of the instrumentation and monitoring program are as follows:

- Monitor displacements of the ground, existing structures, infrastructure and utilities for comparison to design estimates;
- Compare vibration and noise levels to confirm that these are within required limits;
- Compare displacement performance of the monitored structures in relation to construction activities;
- Monitor temporary dewatering activities in comparison with Permit to Take Water regulations; and

- Monitor Contractor's compliance with the requirements of the construction contract.

Baseline readings of groundwater levels, building and utility elevations, and structure and utility condition surveys should be completed prior to construction activities taking place.

In principle, it is recommended that the Contractor be responsible for the supply and installation of all instrumentation, as well as undertaking monitoring throughout the construction period for controlling construction means and methods. The Contractor should also be responsible for planning and conducting all construction work in a manner such that ground movement, groundwater lowering, and structural displacement are maintained within clearly specified limits, and, where necessary, undertaking corrective action. For Quality Assurance purposes, independent readings should be taken and interpreted at regular and frequent intervals by a representative appointed by the TTC.

9.0 MANAGEMENT AND DISPOSAL OF SOIL AND GROUNDWATER

Excess material derived from the cut and cover construction work should generally be managed through the following categories:

1) Re-use of existing site material that meet the earthwork specifications as structural backfill, general backfill and landscaping material, where appropriate;

2) Transport of excess materials, that are deemed environmentally compliant, to a suitable facility for use as general fill at a land-based site or to recycling facilities; or

3) Disposal as waste for excess material that cannot be accepted in Categories 1 and 2.

Following further geotechnical and geo-environmental subsurface investigations and monitoring and development of the UTS facilities design, a provisional estimate of the likely volume of excess material that might be classified under each of the above three categories should be carried out.

An earthwork specification for the planned project will need to be prepared to outline the roles, responsibilities, procedures and acceptance criteria for materials management during construction. The Contractor would be typically responsible for the identification, segregation, handling (including stockpiling and transporting) and disposal of excess material that is not considered to be re-usable on-site as fill.

The Contractor should be also be required to manage groundwater and surface water throughout construction in compliance with all the latest and applicable regulations, laws and guidelines for the disposal of excess soil and groundwater.

10.0 FUTURE SUBSURFACE EXPLORATIONS AND TESTING

During subsequent stages of design and planning, additional subsurface information will be required. Based on the available information and conceptual design, additional subsurface explorations and testing should focus on the following key issues:

- The extent, continuity and grain size distribution characteristics of the Recent Granular Deposit/ORMC between elevation 195 m and 205 m should be explored in more detail across the entire UTS site;
- Groundwater pressures within the Recent Granular Deposit/ORMC and Upper Granular Deposit should be better defined between Stations 7+680 and 8+400;
- The extent, continuity and permeability of the Upper Granular Deposit should be investigated using multiple boreholes with observation wells and a minimum of three long-term pumping tests with at least four boreholes located within each section of the underground storage facilities structure extended to approximately elevation 165 m during the next phase of investigation; and
- The vertical extent and continuity of the Upper Till (silty clay to sandy silt till) should be explored in detail between approximately Stations 7+680 and 8+400 to better understand the potential resistance to hydraulic uplift pressures acting on the excavation base and UTS structure.

In particular, at least two future deep boreholes completed in the proposed UTS area should be provided with at least three multiple vibrating wire piezometers in each borehole, with these located between approximately elevation 165 m and 195 m. These piezometers should be sealed within the Recent Granular Deposit/ORMC, the Upper Till and the Upper Granular Deposit to better define the pore water pressure profile in the excavation area.

All future explorations and testing should be carried out in accordance with the TTC standards. Further, because of the importance of groundwater control issues for this UTS project and possible re-use of native soil deposits for earthworks, it is recommended that every soil sample be subjected to laboratory grain size distribution tests, in addition to selected cohesive soil samples being subjected to Atterberg limits testing.

11.0 CLOSURE

This geotechnical report for conceptual design was prepared for the Yonge Subway Extension by Golder Associates Ltd. with input from the project designer, McCormick Rankin Corporation and Hatch Mott MacDonald, on behalf of the Toronto Transit Commission. This report is intended for developing conceptual design of the UTS structure. The information presented in this report is based on existing available data and current project information and is subject to revision as additional site and subsurface ground data is obtained. As the design of the proposed project progresses, the conclusions presented in this report should be updated to reflect additional information and design requirements.

GOLDER ASSOCIATES LTD.

Reza Lackpour

LICENSED PROFESSIONAL ENGINEER
S. J. BOONE
90559738
PROVINCE OF ONTARIO

Reza Lackpour, M.Sc., P.Eng.
Geotechnical Engineer

Storer J. Boone, Ph.D., P.Eng.
Associate

MSWL/SJB/RL/ly/cr

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The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder’s express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client can not rely upon the electronic media versions of Golder’s report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

IMPORTANT INFORMATION AND LIMITATIONS
OF THIS REPORT (cont'd)

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

TABLE I

SUMMARY OF PRELIMINARY SOIL PARAMETERS

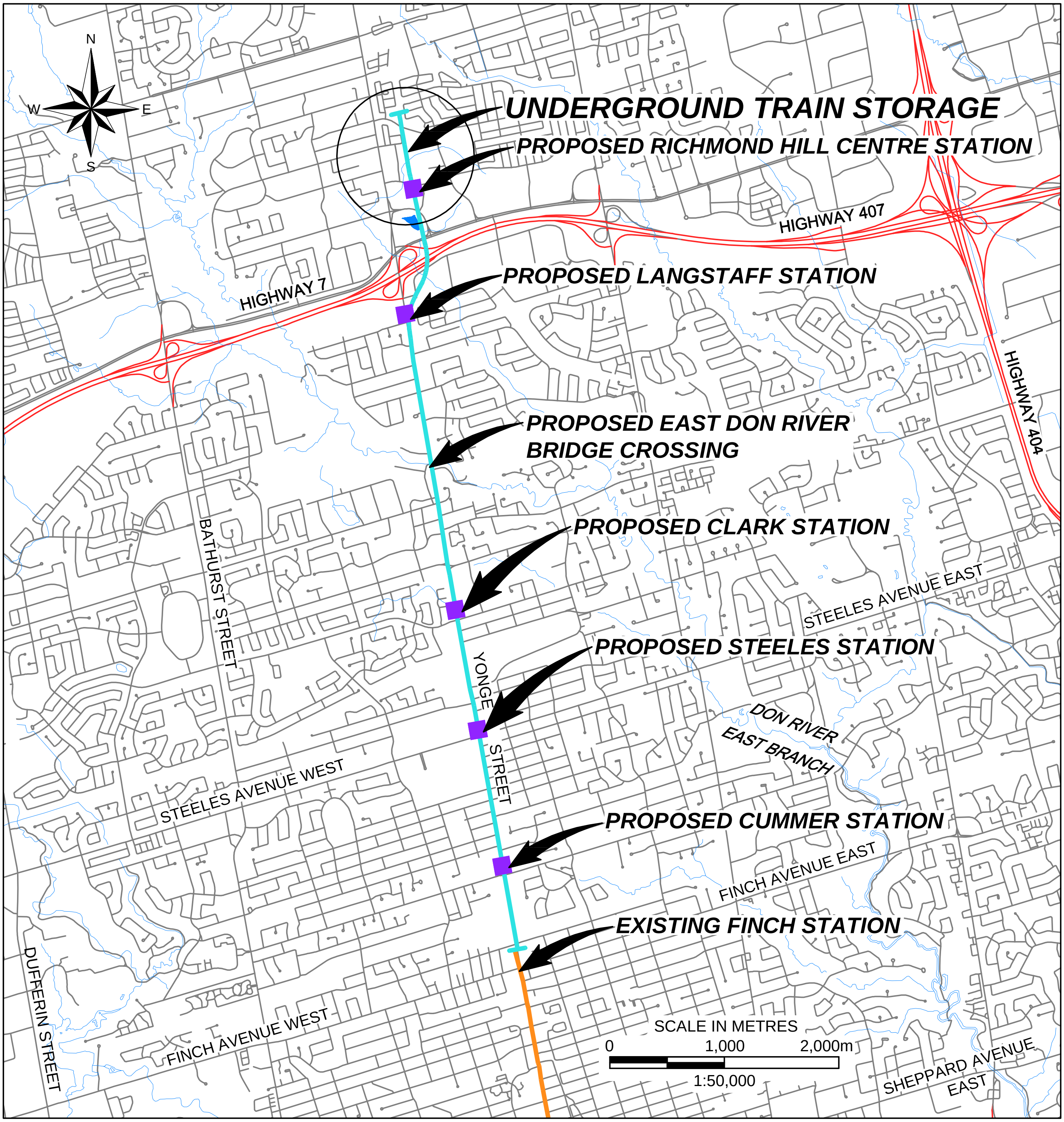
Underground Train Storage
Yonge Subway Extension
Regional Municipality of York, Ontario

LOCATION	STRATUM	BULK UNIT WEIGHT, γ (kN/m^3)	UNDRAINED SHEAR STRENGTH, S_u (kPa)	EFFECTIVE ANGLE OF FRICTION ϕ' (degrees)	COEFFICIENT OF ACTIVE EARTH PRESSURE K_A	COEFFICIENT OF PASSIVE EARTH PRESSURE K_P
Underground Train Storage STA. 7+600 to STA. 8+400	Fill (Type 1)	19.5 to 20.0	30 to 60	26 to 28	0.39 to 0.36	2.6 to 2.8
	Recent Granular deposits (Types 6, 7 and 12)	19.5 to 21.0	-	33 to 38	0.29 to 0.24	3.4 to 4.2
	Upper Till Deposit (Types 11 and 12)	21.0 to 22.0	150 to 250	33 to 35	0.29 to 0.27	3.4 to 3.7

NOTES:

1. Table to be read in conjunction with Golder report titled “Geotechnical Report for Conceptual Design, Yonge Subway Extension, Underground Train Storage, Regional Municipality of York, Ontario”, Report No. 09-1111-6091-3000-R07, dated November 2011, Updated December 2013.

Prepared By: MSWL
Checked By: SJB



LEGEND

- 🟪 STATION SITE
- YONGE SUBWAY EXTENSION PROJECT LIMITS
- EXISTING YONGE SUBWAY LINE

REFERENCE

DRAWING BASED ON CANMAP STREETFILES V2005.4.

NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

ALL LOCATIONS ARE APPROXIMATE.

PROJECT
GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN
YONGE SUBWAY EXTENSION
UNDERGROUND TRAIN STORAGE
REGIONAL MUNICIPALITY OF YORK, ONTARIO

TITLE

SITE LOCATION PLAN

Golder Associates
LONDON, ONTARIO

PROJECT No.		09-1111-6091	FILE No.	0911116091AD001
			SCALE AS SHOWN	REV.
CADD	DCH	Oct. 18/11		
CHECK			**FIGURE 1**	

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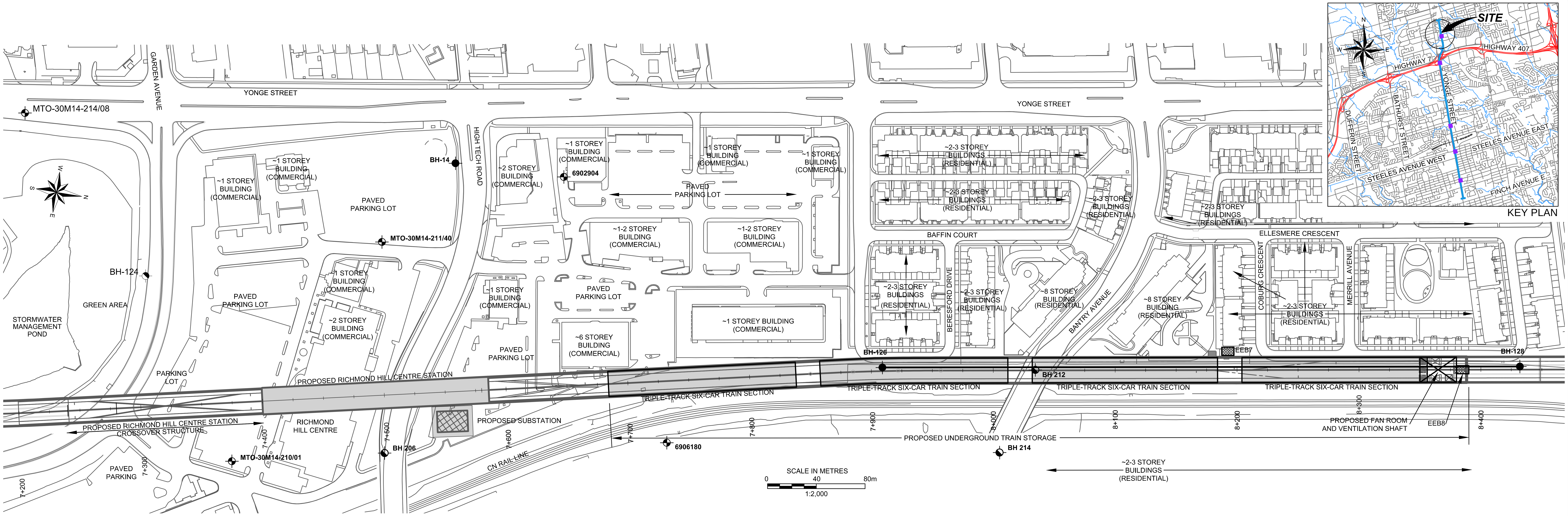


LEGEND

◐ BOREHOLE (SPL CONSULTANTS LTD., 2010)

● BOREHOLE (GOLDER ASSOCIATES LTD., 2009 & 2013)

⊘ BOREHOLE (SOIL PROBE LTD., 1997)

⊕ BOREHOLE OR WELL
(FROM YORK-PEEL-DURHAM-TORONTO-CONSERVATIN AUTHORITIES
MORAINE COALITION [YPDT - CAMC] DATABASE RECORDS:
REVIEWED NOVEMBER 2008)

━ YONGE SUBWAY EXTENSION PROJECT LIMITS

REFERENCE

1) BASE PLAN AND ALIGNMENT PROVIDED IN DIGITAL FORMAT BY McCORMICK RANKIN CORPORATION, HATCH MOTT MACDONALD, YSE TRACK WORK ALIGNMENT, PLAN AND PROFILE DATED FEBRUARY 28, 2011. THE PROFILES ARE APPROXIMATE AND ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY.

2) CANMAP STREETFILES V2005.4.

NOTES

1) THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH THE REPORT TITLED "GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN, YONGE SUBWAY EXTENSION, UNDERGROUND TRAIN STORAGE, REGIONAL MUNICIPALITY OF YORK, ONTARIO"; Report No. 09-1111-6091-3000-R07, dATED nOVEMBER 2011, UPDATED dECEMBER 2013.

2) ALL LOCATIONS ARE APPROXIMATE.

3) SIZE OF BUILDINGS ARE APPROXIMATE AND ARE FOR ILLUSTRATIVE PURPOSES ONLY.

PROJECT
GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN
YONGE SUBWAY EXTENSION
UNDERGROUND TRAIN STORAGE
REGIONAL MUNICIPALITY OF YORK, ONTARIO

TITLE
KEY PLAN AND BOREHOLE LOCATION PLAN
UNDERGROUND TRAIN STORAGE

Golder Associates
LONDON, ONTARIO

PROJECT No.	09-1111-6091		FILE No.	0911116091AD002
			SCALE AS SHOWN	REV.
CADD	DCH\WDF	Oct. 31/13		
CHECK				

FIGURE 2

Drawing File: 0911116091AD002.dwg Dec 19, 2013 - 2:10pm

BOREHOLE MATERIAL SYMBOLS:

1	FILL	7	SANDY SILT/ SAND AND SILT
2	ORGANICS	8	SILT
3	GRAVEL	9	CLAYEY SILT
4	SAND AND GRAVEL/ GRAVELLY SAND	10	CLAY/SILTY CLAY
5	SAND	11	SILTY CLAY TILL / CLAYEY SILT TILL
6	SILTY SAND	12	SANDY SILT TILL/SILTY SAND TILL/ SAND AND SILT TILL
			BEDROCK

NOTES:

1. THIS FIGURE SHOULD BE READ IN CONJUNCTION WITH THE GOLDER REPORT TITLED "GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN, YOUNG SUBWAY EXTENSION, UNDERGROUND TRAIN STORAGE, REGIONAL MUNICIPALITY OF YORK, ONTARIO", REPORT No. 09-1111-6091-3000-R07, DATED NOVEMBER 2011, UPDATED DECEMBER 2013..
2. THE CHARACTERISTICS AND VARIABILITY ANTICIPATED WITHIN THE MAJOR SOIL DEPOSITS ARE DESCRIBED IN THE TEXT OF THIS REPORT. SIGNIFICANT LAYERS, INTERLAYERS AND LENSES WITHIN THE MAJOR DEPOSITS ILLUSTRATED ARE INTERPRETED FROM THE BOREHOLE RECORDS. THE BOUNDARIES ILLUSTRATED ARE INTENDED TO HIGHLIGHT THE VARIABILITY WITHIN THE DEPOSITS, WHICH EXHIBIT GRADUAL TRANSITIONS FROM ONE SOIL TYPE TO ANOTHER. IN ADDITION, LENSES AND INTERLAYERS NOT DETECTED BY THE SUBSURFACE INVESTIGATION WILL BE PRESENT BETWEEN BOREHOLES.
3. THIS INTERPRETED STRATIGRAPHY FIGURE IS A SIMPLIFICATION OF SUBSURFACE CONDITIONS BASED ON GOLDER ASSOCIATES LTD., SPL CONSULTANTS LTD., SOIL PROBE LTD., AND MTO BOREHOLES. DETAILED DESCRIPTIONS OF THE CONDITIONS ENCOUNTERED AT THE BOREHOLE LOCATIONS ARE FOUND ON THE RECORDS OF BOREHOLES CONTAINED IN THE GEOTECHNICAL INVESTIGATION REPORTS LISTED IN SECTION 3 OF THE REPORT REFERENCED ABOVE.
4. THIS FIGURE IS PREPARED FOR CONCEPTUAL DESIGN PURPOSES ONLY.
5. BOREHOLE WIDTH IN PROFILE IS NOT TO SCALE.
6. PROFILES EXTEND IN ORDER OF INCREASING STATIONING ALONG THE CENTRE LINE OF THE YONGE SUBWAY EXTENSION ALIGNMENT.
7. STRUCTURES AND YONGE SUBWAY LINE EXTENSION OUTLINES ARE SHOWN FOR GENERAL ILLUSTRATION PURPOSES ONLY AND DO NOT NECESSARILY INDICATE EXTENTS OF FOUNDATIONS.
8. BOREHOLE MATERIAL SYMBOLS FOR YPDT-CAMC BOREHOLES THAT WERE NOT COMPLETED BY GOLDER ASSOCIATES LTD., SPL CONSULTANTS LTD., SOIL PROBE LTD., OR MTO DO NOT SHOW THE HATCH PATTERNS FOR THE SPECIFIC MATERIAL TYPES SHOWN ABOVE SINCE THERE REMAINS SOME UNCERTAINTY REGARDING MATERIAL CLASSIFICATION. COLOURS ON THESE BOREHOLES ARE INTENDED TO ONLY PROVIDE A GENERAL INDICATION OF REPORTED MATERIAL TYPE.

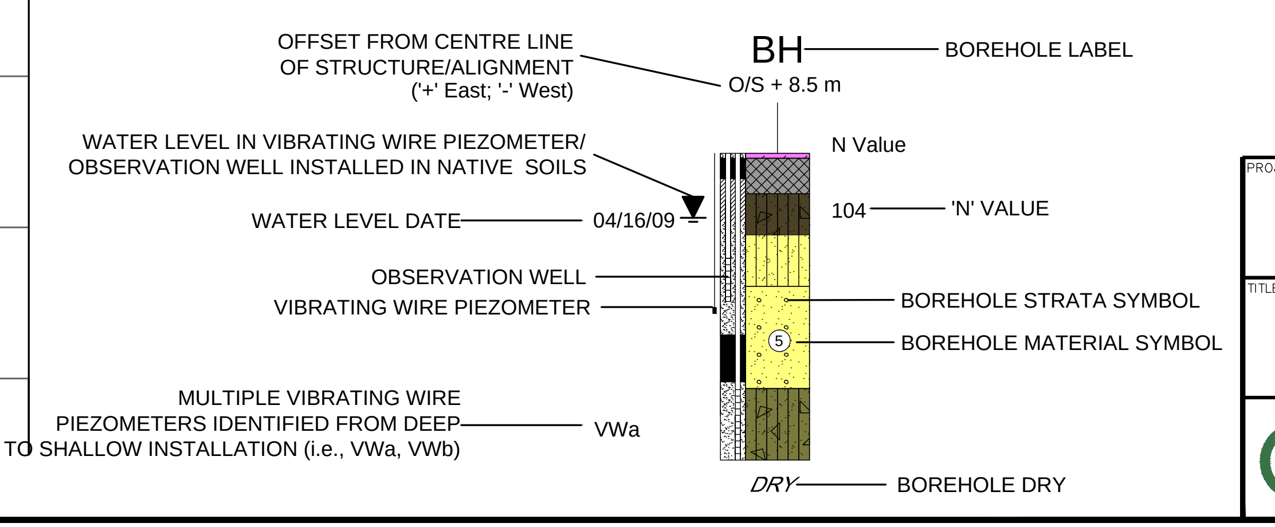
REFERENCES:

1. BASE PLAN AND ALIGNMENT PROVIDED IN DIGITAL FORMAT BY McCORMICK RANKIN CORPORATION, HATCH MOTT MACDONALD, YONGE STREET EXTENSION TRACK WORK ALIGNMENT, PLAN AND PROFILE DATED SEPTEMBER 30, 2010 AND FEBRUARY 28, 2011. THE PROFILES ARE APPROXIMATE AND ARE SHOWN FOR ILLUSTRATION PURPOSES ONLY
2. GEOLOGIC PROFILE DATABASE AS PROVIDED BY YORK-PEEL-DURHAM-TORONTO-CONSERVATION AUTHORITIES MORAINE COALITION [YPDT - CAMC].
3. INTERPRETED GROUNDWATER LEVEL PROFILE BASED ON GROUNDWATER LEVEL DATA PROVIDED ON RECORD OF BOREHOLE SHEETS PREPARED FOR OR BY GOLDER ASSOCIATES LTD., SPL CONSULTANTS LTD., SOIL PROBE LTD., AND MTO.

GENERAL LEGEND:

— — — — INTERPRETED MAJOR DEPOSIT BOUNDARY
— — — — INTERPRETED GROUNDWATER LEVEL

5 0 5 10
SCALE VERTICAL 1:250 METRES
10 0 10 20
SCALE HORIZONTAL 1:500 METRES



PROJECT
GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN
YONGE SUBWAY EXTENSION
UNDERGROUND TRAIN STORAGE
REGION OF YORK, ONTARIO

TITLE
INTERPRETED STRATIGRAPHIC PROFILE
UNDERGROUND TRAIN STORAGE
STA. 7+200 to STA. 7+850

Golder Associates
LONDON, ONTARIO

PROJECT No.	09-1111-6091		FILE No.	0911116091AD003
			SCALE AS SHOWN	REV.
CADD	DCH	Nov. 23/11	**FIGURE 3A**	
CHECK				

BOREHOLE MATERIAL SYMBOLS:

①	FILL
②	ORGANICS
③	GRAVEL
④	SAND AND GRAVEL/ GRAVELLY SAND
⑤	SAND
⑥	SILTY SAND
⑦	SANDY SILT/ SAND AND SILT
⑧	SILT
⑨	CLAYEY SILT
⑩	CLAY/SILTY CLAY
⑪	SILTY CLAY TILL / CLAYEY SILT TILL
⑫	SANDY SILT TILL/SILTY SAND TILL/ SAND AND SILT TILL
	BEDROCK

NOTES:

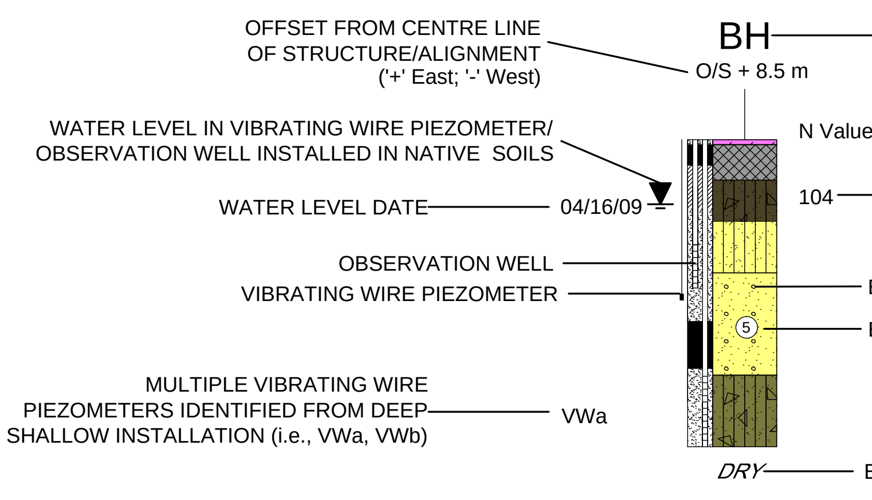
1. THIS FIGURE SHOULD BE READ IN CONJUNCTION WITH THE GOLDER REPORT TITLED "GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN, YOUNG SUBWAY EXTENSION, UNDERGROUND TRAIN STORAGE, REGIONAL MUNICIPALITY OF YORK, ONTARIO", REPORT No. 09-1111-6091-3000-R07, DATED NOVEMBER 2011, UPDATED DECEMBER 2013..
2. THE CHARACTERISTICS AND VARIABILITY ANTICIPATED WITHIN THE MAJOR SOIL DEPOSITS ARE DESCRIBED IN THE TEXT OF THIS REPORT. SIGNIFICANT LAYERS, INTERLAYERS AND LENSES WITHIN THE MAJOR DEPOSITS ILLUSTRATED ARE INTERPRETED FROM THE BOREHOLE RECORDS. THE BOUNDARIES ILLUSTRATED ARE INTENDED TO HIGHLIGHT THE VARIABILITY WITHIN THE DEPOSITS, WHICH EXHIBIT GRADUAL TRANSITIONS FROM ONE SOIL TYPE TO ANOTHER. IN ADDITION, LENSES AND INTERLAYERS NOT DETECTED BY THE SUBSURFACE INVESTIGATION WILL BE PRESENT BETWEEN BOREHOLES.
3. THIS INTERPRETED STRATIGRAPHY FIGURE IS A SIMPLIFICATION OF SUBSURFACE CONDITIONS BASED ON GOLDER ASSOCIATES LTD., SPL CONSULTANTS LTD., SOIL PROBE LTD., AND MTO BOREHOLES. DETAILED DESCRIPTIONS OF THE CONDITIONS ENCOUNTERED AT THE BOREHOLE LOCATIONS ARE FOUND ON THE RECORDS OF BOREHOLES CONTAINED IN THE GEOTECHNICAL INVESTIGATION REPORTS LISTED IN SECTION 3 OF THE REPORT REFERENCED ABOVE.
4. THIS FIGURE IS PREPARED FOR CONCEPTUAL DESIGN PURPOSES ONLY.
5. BOREHOLE WIDTH IN PROFILE IS NOT TO SCALE.
6. PROFILES EXTEND IN ORDER OF INCREASING STATIONING ALONG THE CENTRE LINE OF THE YONGE SUBWAY EXTENSION ALIGNMENT.
7. STRUCTURES AND YONGE SUBWAY LINE EXTENSION OUTLINES ARE SHOWN FOR GENERAL ILLUSTRATION PURPOSES ONLY AND DO NOT NECESSARILY INDICATE EXTENTS OF FOUNDATIONS.
8. BOREHOLE MATERIAL SYMBOLS FOR YPDT-CAMC BOREHOLES THAT WERE NOT COMPLETED BY GOLDER ASSOCIATES LTD., SPL CONSULTANTS LTD., SOIL PROBE LTD., OR MTO DO NOT SHOW THE HATCH PATTERNS FOR THE SPECIFIC MATERIAL TYPES SHOWN ABOVE SINCE THERE REMAINS SOME UNCERTAINTY REGARDING MATERIAL CLASSIFICATION. COLOURS ON THESE BOREHOLES ARE INTENDED TO ONLY PROVIDE A GENERAL INDICATION OF REPORTED MATERIAL TYPE.

REFERENCES:

1. BASE PLAN AND ALIGNMENT PROVIDED IN DIGITAL FORMAT BY McCORMICK RANKIN CORPORATION, HATCH MOTT MACDONALD, YONGE STREET EXTENSION TRACK WORK ALIGNMENT, PLAN AND PROFILE DATED SEPTEMBER 30, 2010 AND FEBRUARY 28, 2011. THE PROFILES ARE APPROXIMATE AND ARE SHOWN FOR ILLUSTRATION PURPOSES ONLY
2. GEOLOGIC PROFILE DATABASE AS PROVIDED BY YORK-PEEL-DURHAM-TORONTO-CONSERVATION AUTHORITIES MORAINE COALITION [YPDT - CAMC].
3. INTERPRETED GROUNDWATER LEVEL PROFILE BASED ON GROUNDWATER LEVEL DATA PROVIDED ON RECORD OF BOREHOLE SHEETS PREPARED FOR OR BY GOLDER ASSOCIATES LTD., SPL CONSULTANTS LTD., SOIL PROBE LTD., AND MTO.

GENERAL LEGEND:

- — — — INTERPRETED MAJOR DEPOSIT BOUNDARY
- — — — INTERPRETED GROUNDWATER LEVEL



5 0 5 10
SCALE VERTICAL 1:250 METRES

10 0 10 20
SCALE HORIZONTAL 1:500 METRES

PROJECT
GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN
YONGE SUBWAY EXTENSION
UNDERGROUND TRAIN STORAGE
REGION OF YORK, ONTARIO

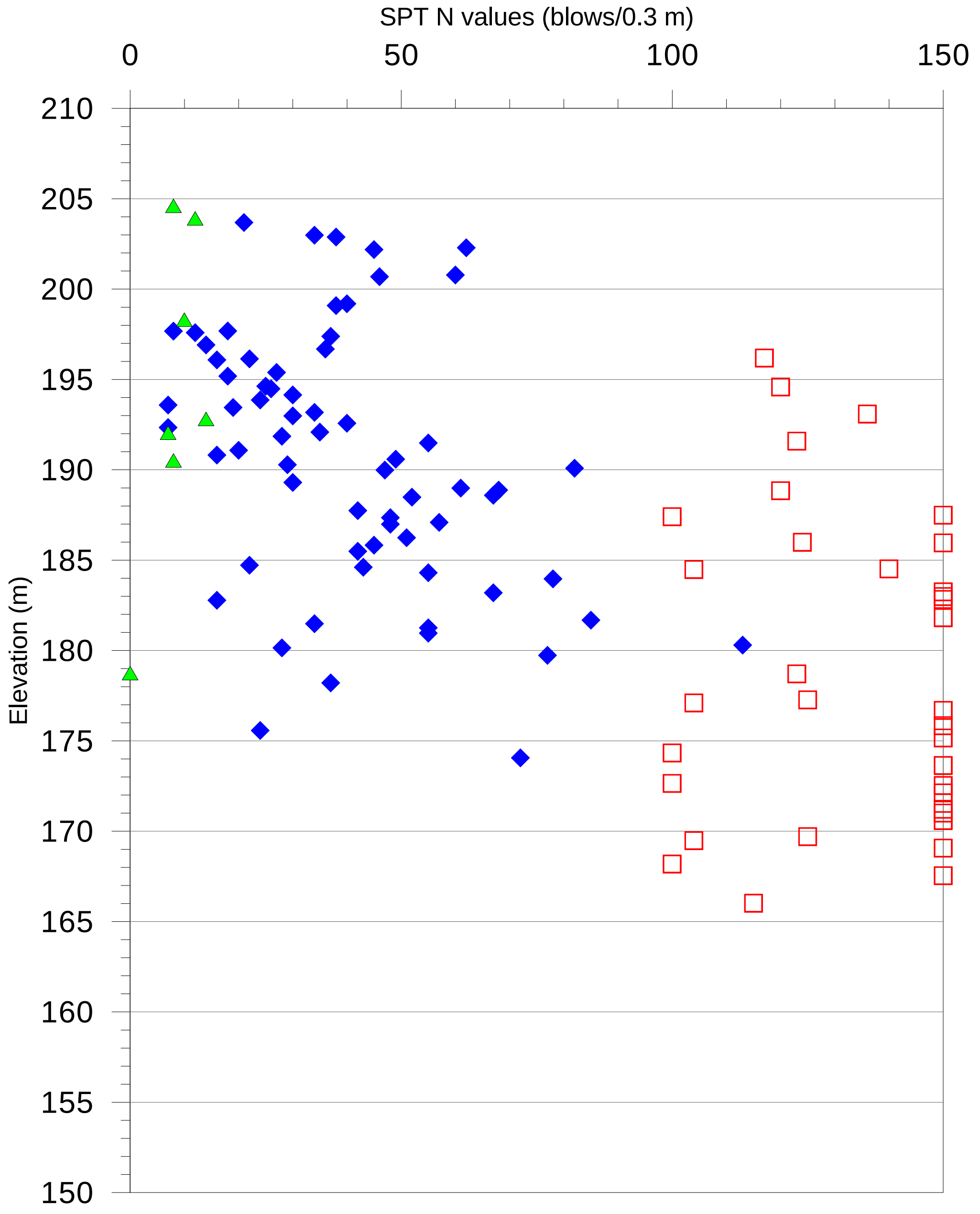
TITLE
INTERPRETED STRATIGRAPHIC PROFILE
UNDERGROUND TRAIN STORAGE
STA. 7+850 to STA. 8+400

Golder Associates
LONDON, ONTARIO

PROJECT No.	09–1111–6091		FILE No.	0911116091AD003
			SCALE AS SHOWN	REV.
CADD	DCH	Nov. 23/11		
CHECK				

FIGURE 3B

UNDERGROUND TRAIN STORAGE
STA. 7+200 TO STA. 8+400



LEGEND:

◆ MEASURED "N" VALUE FOR 0.3 m OF PENETRATION.

□ "N" VALUES EXTRAPOLATED FOR 0.3 m OF PENETRATION UP TO A MAXIMUM THRESHOLD OF 150 BLOWS.
"N" VALUES LIMITED AT 150 BLOWS ARE ACTUALLY GREATER THAN THIS THRESHOLD VALUE.

▲ MEASURED "N" VALUE FOR 0.3 m OF PENETRATION FOR BOREHOLE 14 BETWEEN ELEVATION 177.5 m AND ELEVATION 179 m, BOREHOLE 124 BETWEEN ELEVATION 189 m AND ELEVATION 193 m, BOREHOLE 206 ABOVE ELEVATION 197.5 m, BOREHOLE 212 ABOVE ELEVATION 203.5 m, AND BOREHOLE 214 ABOVE ELEVATION 204 m.

NOTES:

1. THIS FIGURE SHOULD BE READ IN CONJUNCTION WITH THE REPORT TITLED "GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN, YONGE SUBWAY EXTENSION, UNDERGROUND TRAIN STORAGE, REGIONAL MUNICIPALITY OF YORK, ONTARIO".

2. DATA SHOWN EXCLUDES FILL MATERIALS.

PROJECT GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN
YONGE SUBWAY EXTENSION
UNDERGROUND TRAIN STORAGE
REGIONAL MUNICIPALITY OF YORK, ONTARIO

TITLE

SPT-N DISTRIBUTION VERSUS ELEVATION

Golder Associates
LONDON, ONTARIO

PROJECT No.	09-1111-6091	FILE No.	0911116091-3000-R07004	
		SCALE	AS SHOWN	REV. 2
DRAWN	SL	Oct. 18/11		
CHECK			**FIGURE 4**	

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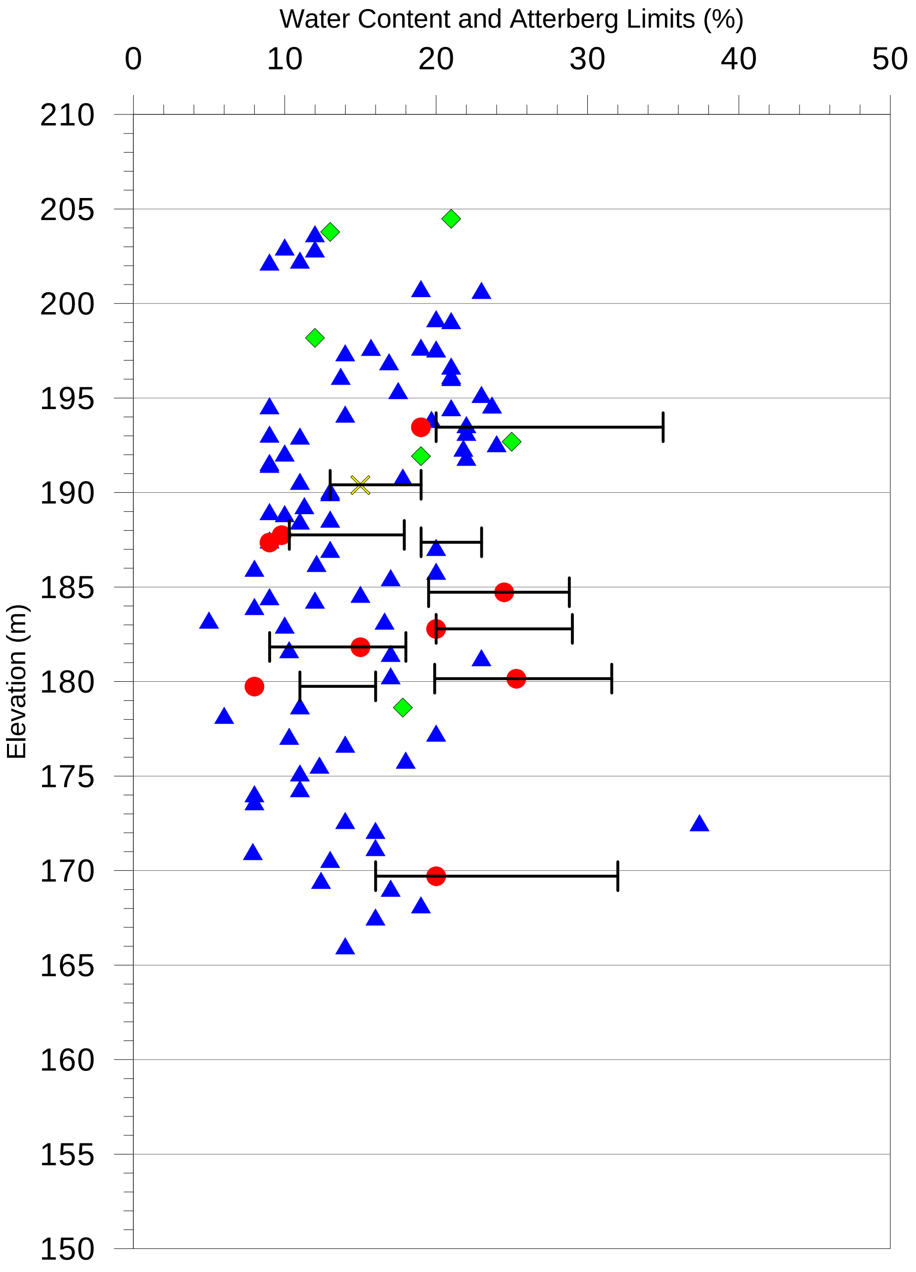
UNDERGROUND TRAIN STORAGE
STA. 7+200 TO STA. 8+400



LEGEND:

▲ WATER CONTENT (%)

● WATER CONTENT WITH ASSOCIATED ATTERBERG LIMITS (%)

◆ WATER CONTENT FOR BOREHOLE 14 BETWEEN ELEVATION 177.5 m AND ELEVATION 179 m, BOREHOLE 124 BETWEEN ELEVATION 189 m AND ELEVATION 193 m, BOREHOLE 206 ABOVE ELEVATION 197.5 m, BOREHOLE 212 ABOVE ELEVATION 203.5 m AND BOREHOLE 214 ABOVE ELEVATION 204 m (%)

✕ WATER CONTENT WITH ASSOCIATED ATTERBERG LIMITS FOR BOREHOLE 124 BETWEEN ELEVATION 189 m AND ELEVATION 193 m (%)

⊢⊣ ATTERBERG LIMITS (%)

NOTES:

1. THIS FIGURE SHOULD BE READ IN CONJUNCTION WITH THE REPORT TITLED "GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN, YONGE SUBWAY EXTENSION, UNDERGROUND TRAIN STORAGE, REGIONAL MUNICIPALITY OF YORK, ONTARIO".

2. DATA SHOWN EXCLUDES FILL MATERIALS.

PROJECT GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN
YONGE SUBWAY EXTENSION
UNDERGROUND TRAIN STORAGE
REGIONAL MUNICIPALITY OF YORK, ONTARIO

TITLE

WATER CONTENT AND ATTERBERG LIMITS
DISTRIBUTION VERSUS ELEVATION

Golder Associates
LONDON, ONTARIO

PROJECT No.	09-1111-6091		FILE No.	0911116091-3000-R07005
			SCALE AS SHOWN	REV. 1
DRAWN	SL	Oct. 18/11		
CHECK			**FIGURE 5**	

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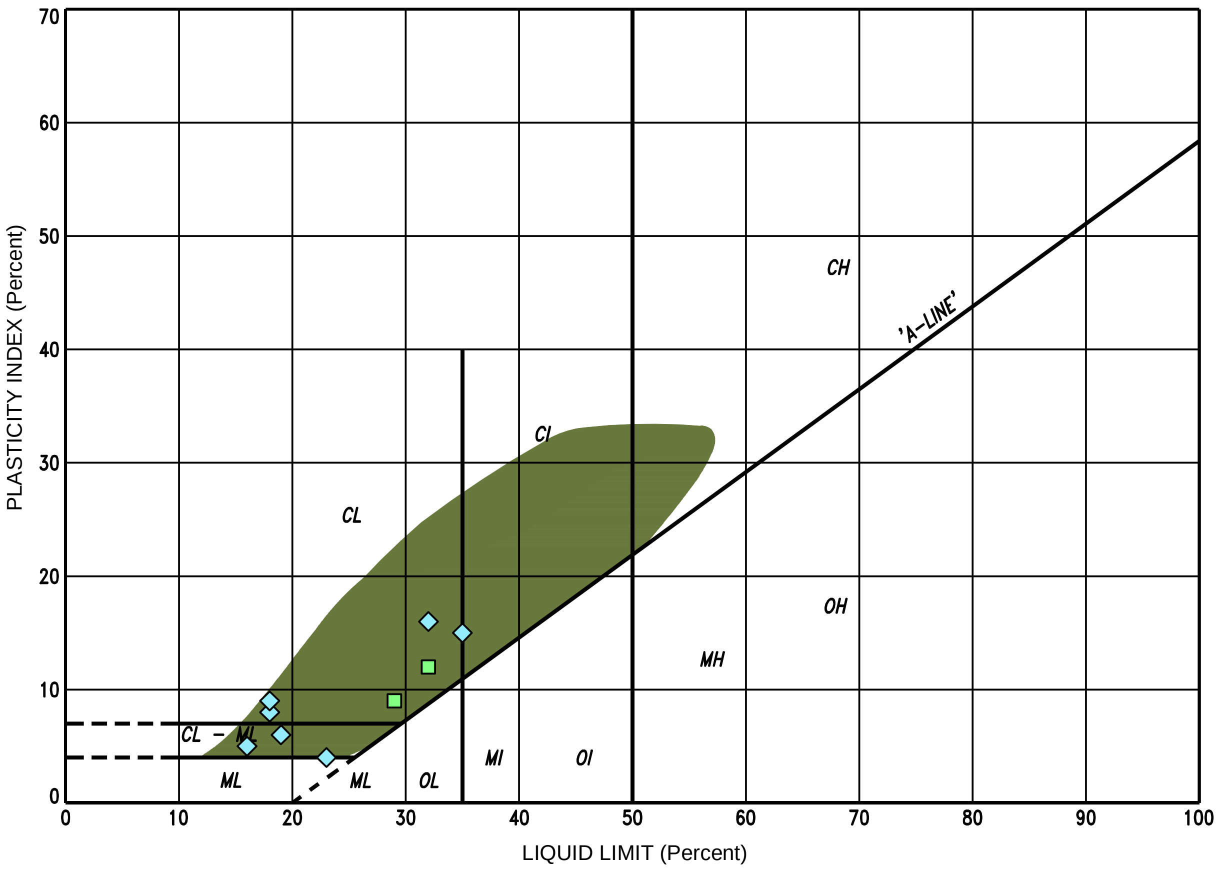
PLASTICITY CHART
CLAYEY SILT/CLAY/SILTY CLAY/SILTY CLAY TILL/ CLAYEY SILT TILL (TYPES 9,10 and 11)

FIGURE 6



LEGEND:

- ● TYPE 9 (CLAYEY SILT)
- 🟩 TYPE 10 (CLAY/SILTY CLAY)
- ◇ TYPE 11 (SILTY CLAY TILL/ CLAYEY SILT TILL)

NOTES:

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE REPORT TITLED "GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN, YONGE SUBWAY EXTENSION, UNDERGROUND TRAIN STORAGE, REGIONAL MUNICIPALITY OF YORK, ONTARIO".
2. THE RESULTS SHOWN ON THIS FIGURE INCORPORATE LABORATORY TESTING CARRIED OUT FROM BOREHOLES LOCATED WITHIN THE UNDERGROUND TRAIN STORAGE ALIGNMENT ONLY.
3. THE PLASTICITY ENVELOPE IS BASED ON A TYPICAL RANGE OF TEST RESULTS FROM THE YONGE SUBWAY EXTENSION PROJECT AND PREVIOUS TTC PROJECTS FOR TYPE 9, 10, AND 11 MATERIALS. FOR SAMPLE SPECIFIC RESULTS AND INFORMATION, REFER TO THE GEOTECHNICAL DATA RESULTS REFERENCED IN SECTION 3 OF THE REPORT IDENTIFIED ABOVE.

DATE:	Sept. 25/11
PROJECT:	09-1111-6091
INPUT:	DCH
CHECKED:	

Golder Associates
LONDON, ONTARIO

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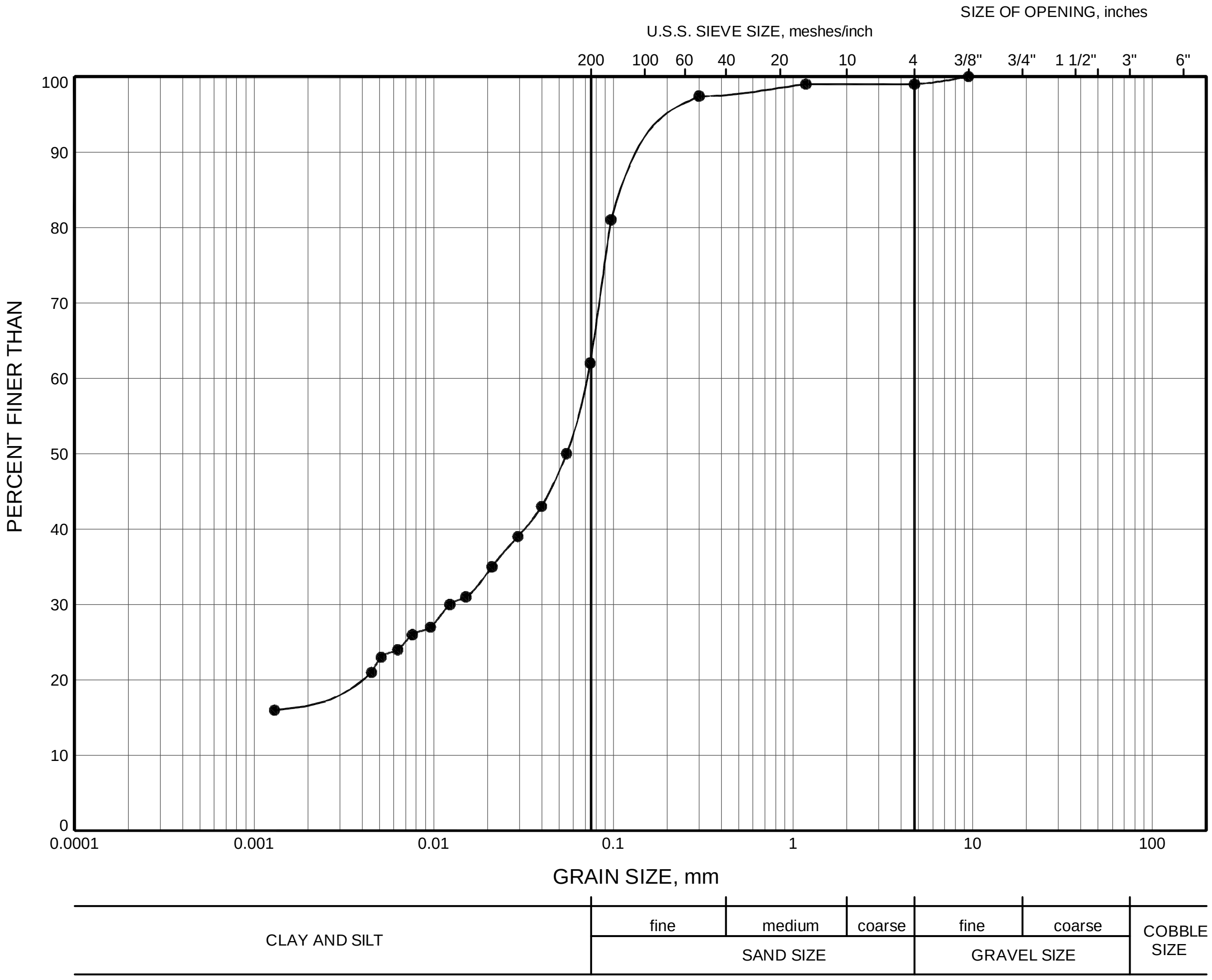
GRAIN SIZE DISTRIBUTION
FILL (TYPE 1)

FIGURE 7



NOTES:

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE REPORT TITLED "GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN, YONGE SUBWAY EXTENSION, UNDERGROUND TRAIN STORAGE, REGIONAL MUNICIPALITY OF YORK, ONTARIO".
2. THE SIZE OF THE SAMPLES USED DURING THE FIELD INVESTIGATION WORK LIMITS THE MAXIMUM RETRIEVED PARTICLE SIZE TO ABOUT 35 MM DIAMETER.
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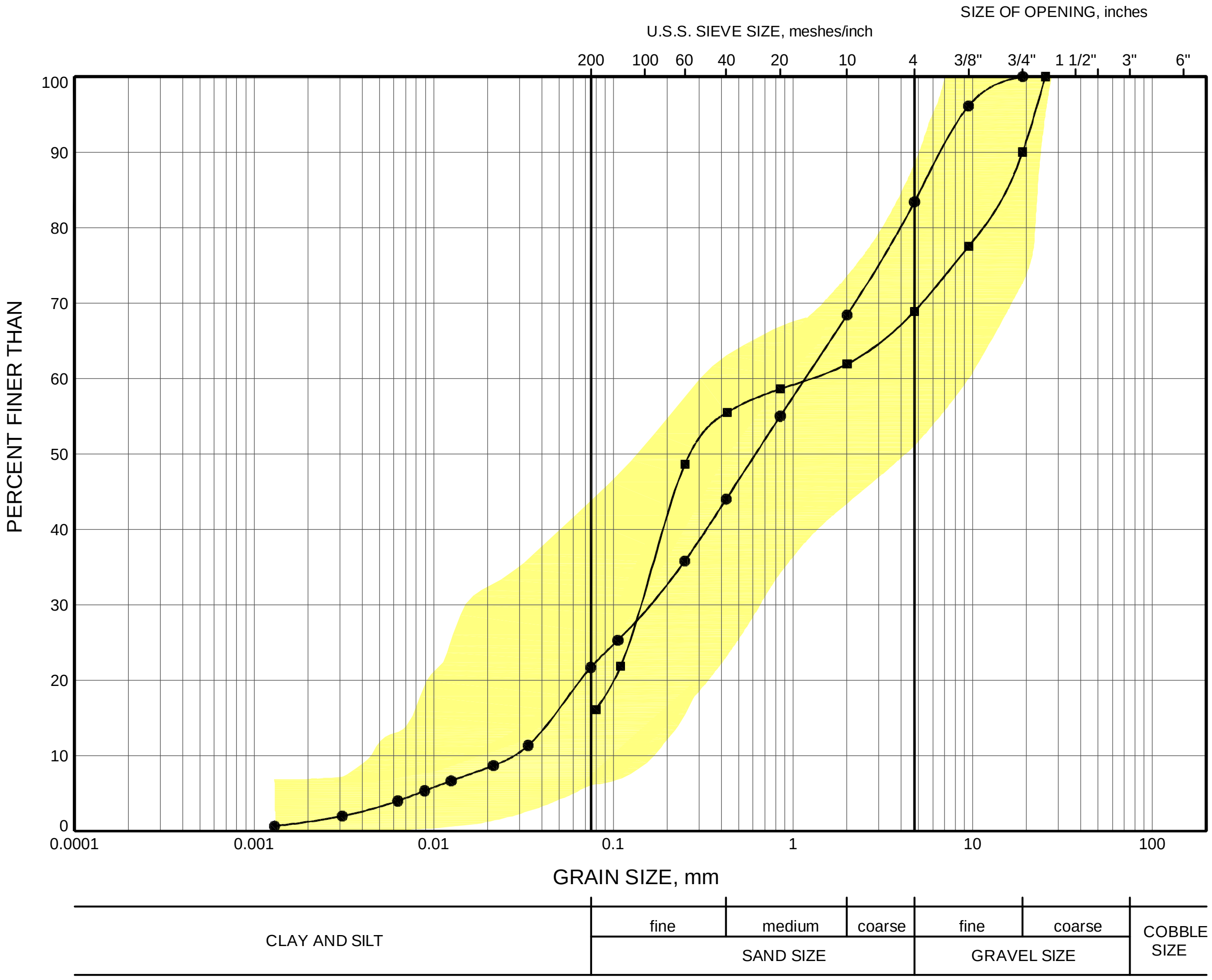
GRAIN SIZE DISTRIBUTION
SAND AND GRAVEL/GRAVELLY SAND (TYPE 4)

FIGURE 8



NOTES:

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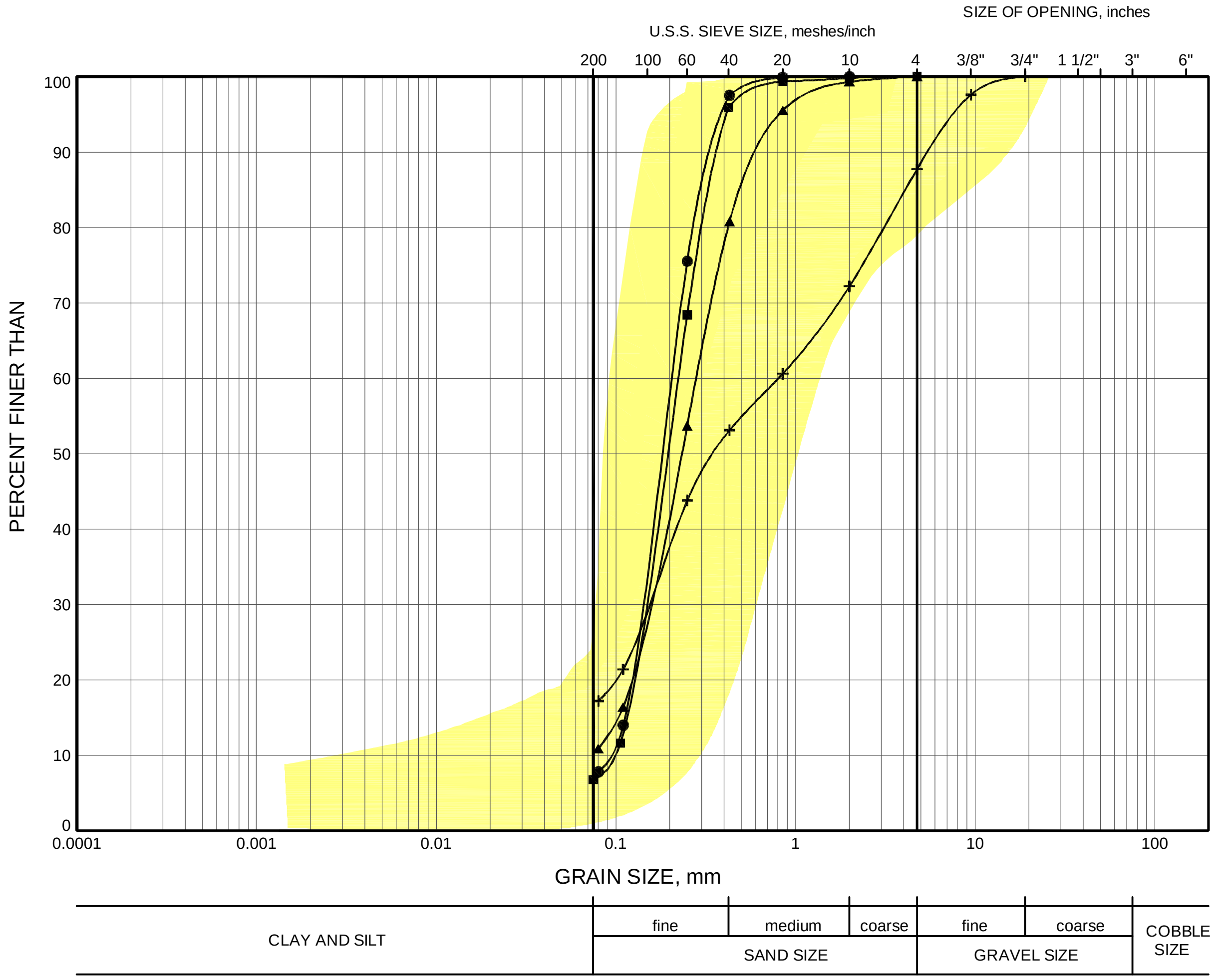
GRAIN SIZE DISTRIBUTION
SAND (TYPE 5)

FIGURE 9



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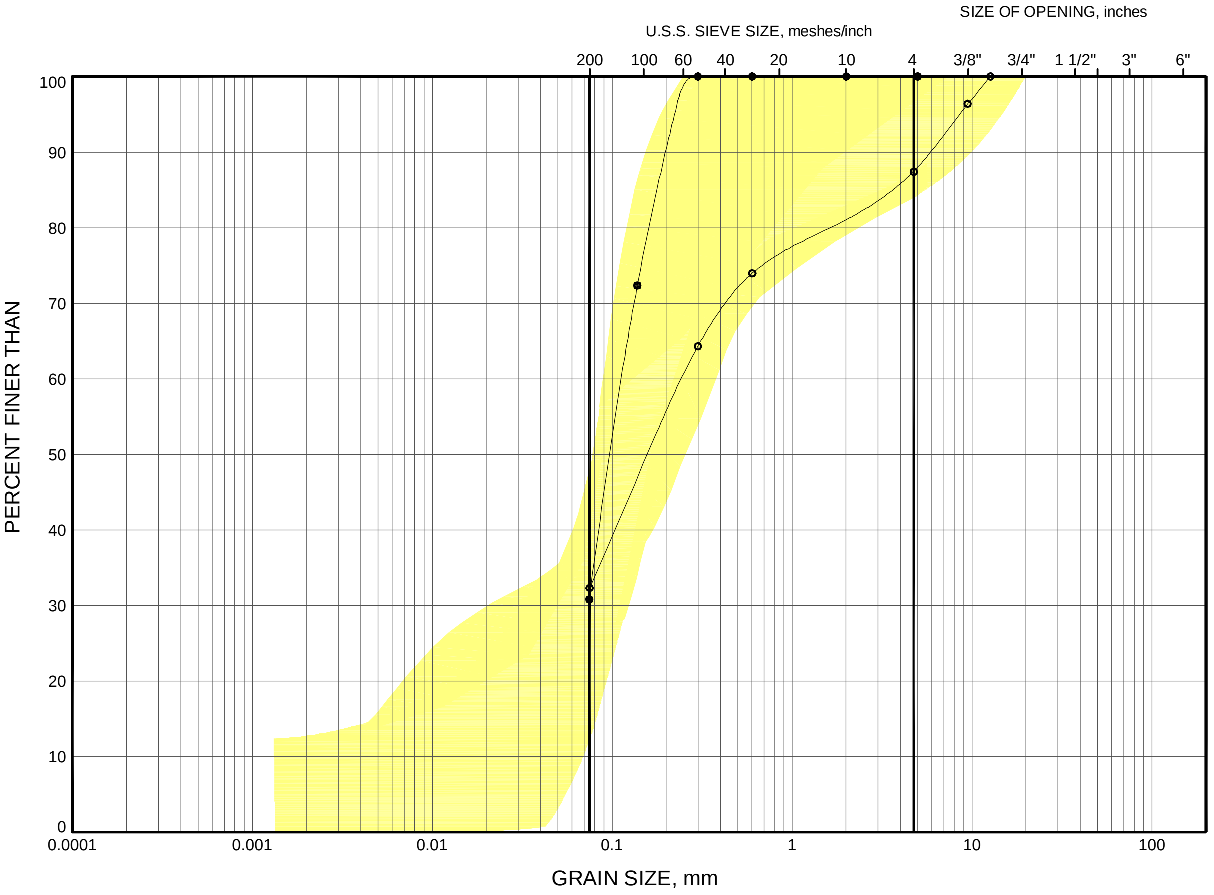
GRAIN SIZE DISTRIBUTION
SILTY SAND (TYPE 6)

FIGURE 10



CLAY AND SILT	fine	medium	coarse	fine	coarse	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

NOTES:

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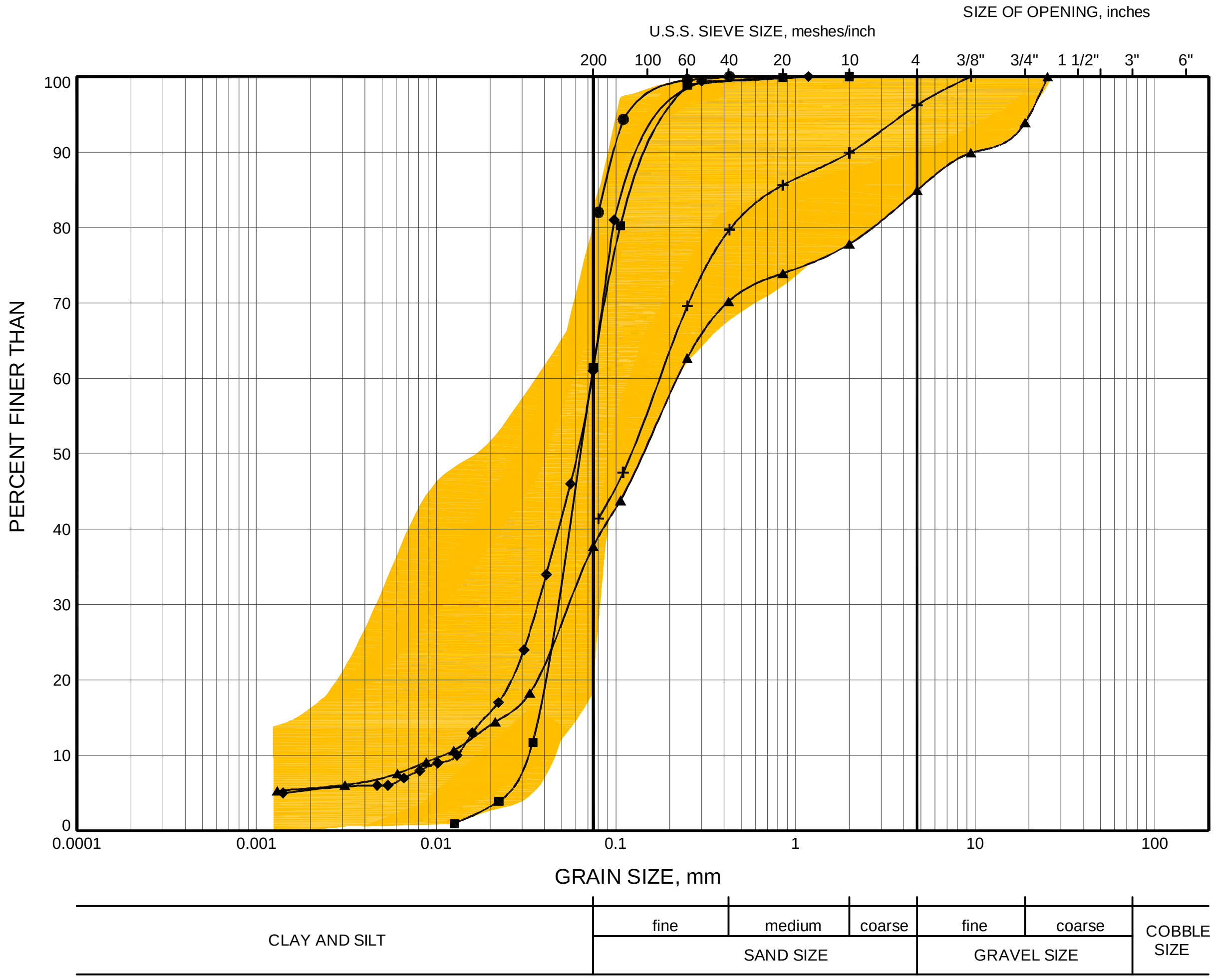
GRAIN SIZE DISTRIBUTION
SANDY SILT/SAND AND SILT (TYPE 7)

FIGURE 11



NOTES:

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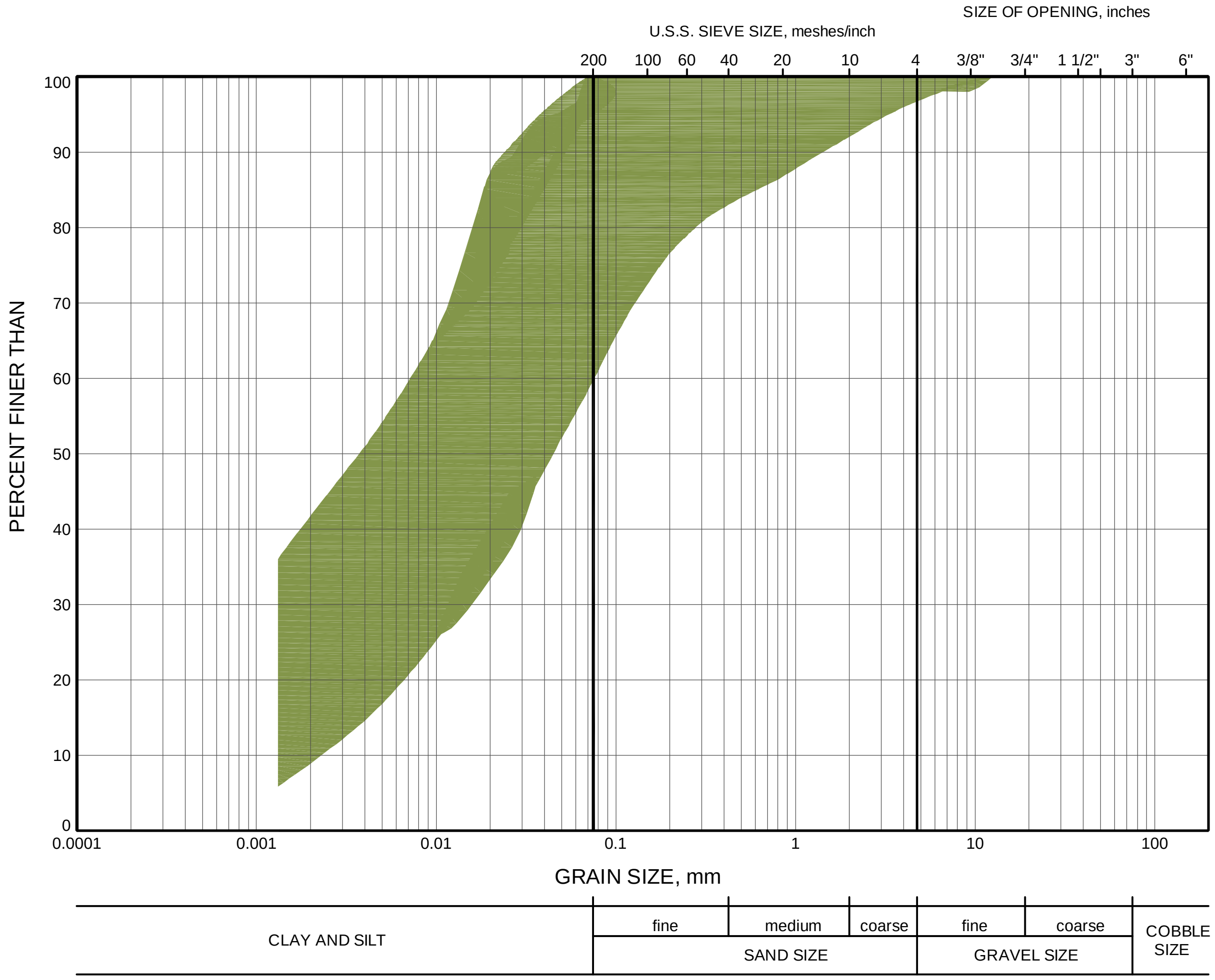
GRAIN SIZE DISTRIBUTION
CLAYEY SILT (TYPE 9)

FIGURE 12



NOTES:

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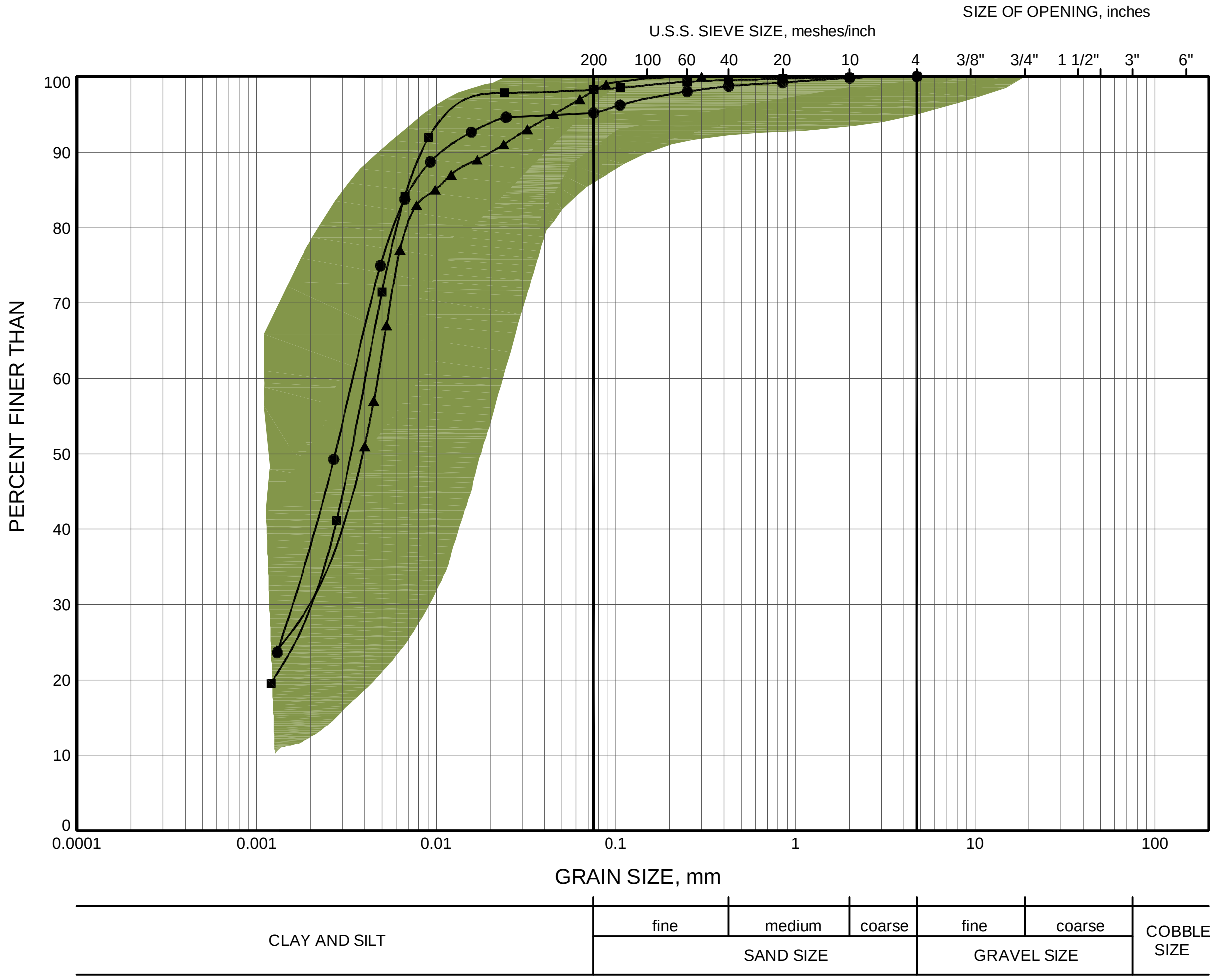
GRAIN SIZE DISTRIBUTION
CLAY/SILTY CLAY (TYPE 10)

FIGURE 13



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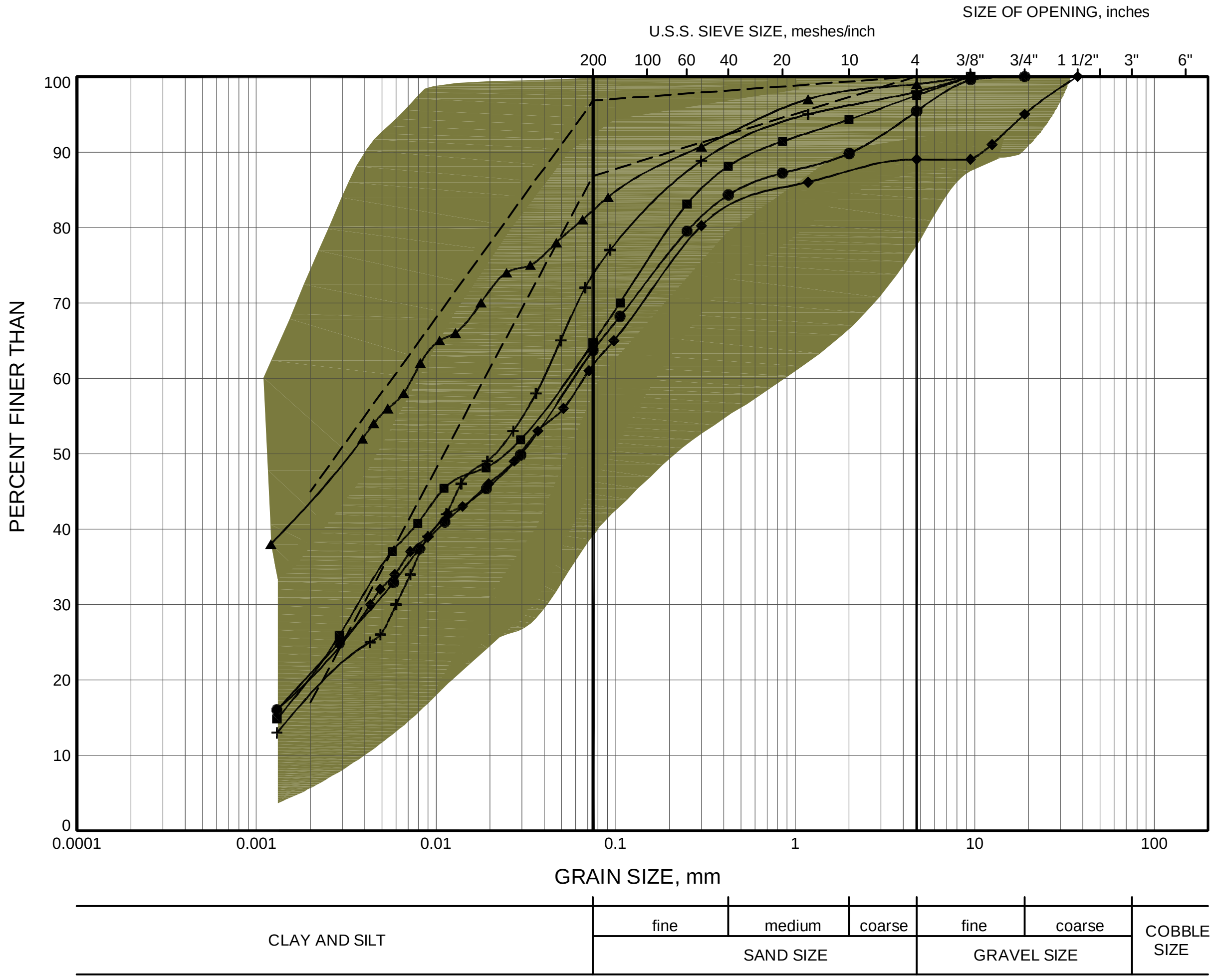
GRAIN SIZE DISTRIBUTION
SILTY CLAY TILL/CLAYEY SILT TILL (TYPE 11)

FIGURE 14



NOTES:

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3. DASHED LINES DENOTE GRAIN SIZE DISTRIBUTION DATA REPORTED FOR MTO BOREHOLES. GRAIN SIZE DISTRIBUTION TESTING CARRIED OUT FOR MTO BOREHOLES INCLUDED THREE TO FOUR SIEVES AND THEREFORE, ARE NOT REPRESENTATIVE OF COMPLETE DISTRIBUTIONS AND ARE ONLY RELEVANT AT THE DISCRETE INFLECTION POINTS ON THE PLOT.

4. THE GRAIN SIZE DISTRIBUTION ENVELOPE IS BASED ON A TYPICAL RANGE OF TEST RESULTS FROM THE YONGE SUBWAY EXTENSION PROJECT AND PREVIOUS TTC PROJECTS. FOR SAMPLE SPECIFIC RESULTS AND INFORMATION, REFER TO THE GEOTECHNICAL DATA REPORTS REFERENCED IN SECTION 3 OF THE REPORT IDENTIFIED ABOVE.

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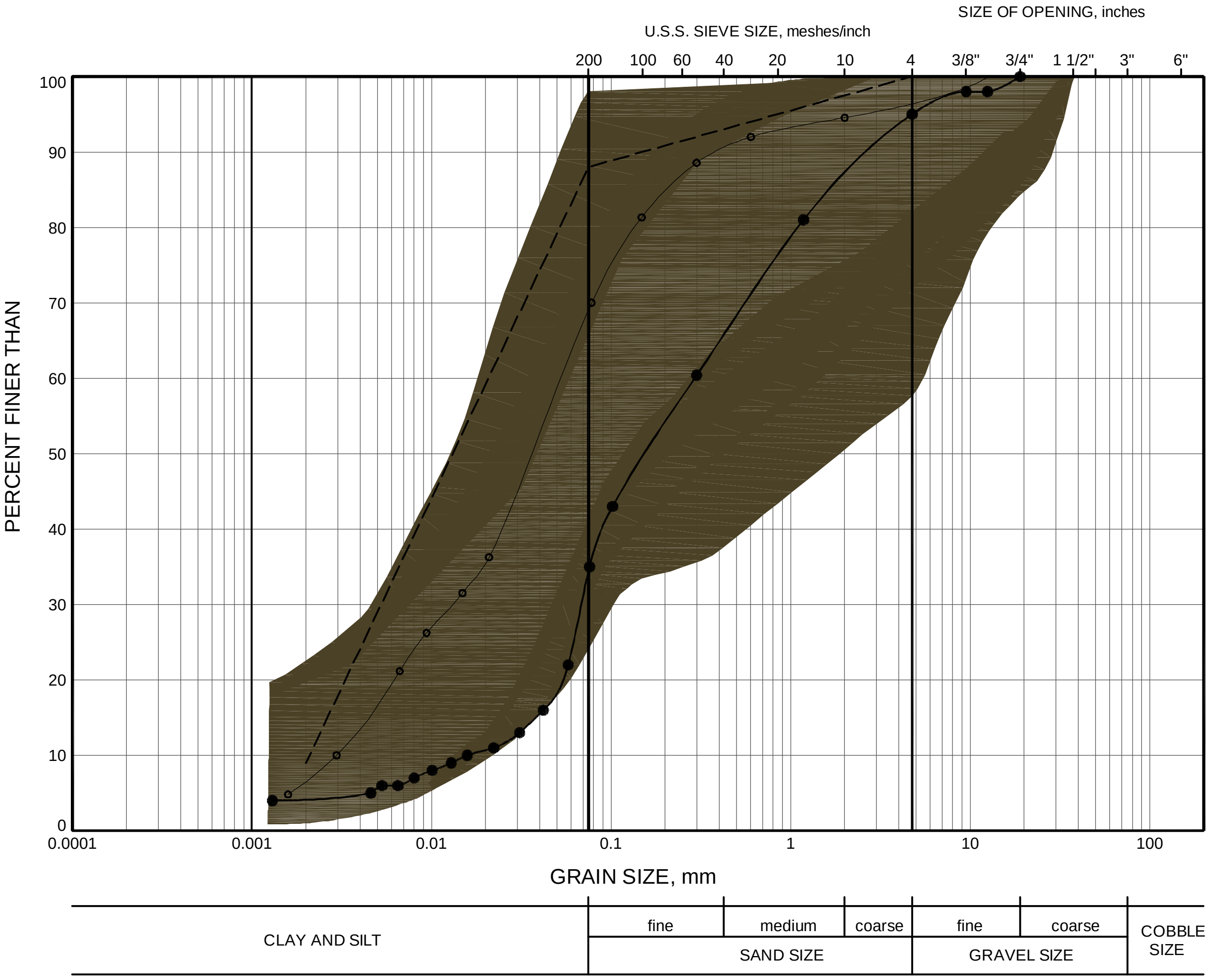
GRAIN SIZE DISTRIBUTION
SANDY SILT TILL/SILTY SAND TILL/SAND AND SILT TILL (TYPE 12)

FIGURE 15



NOTES:

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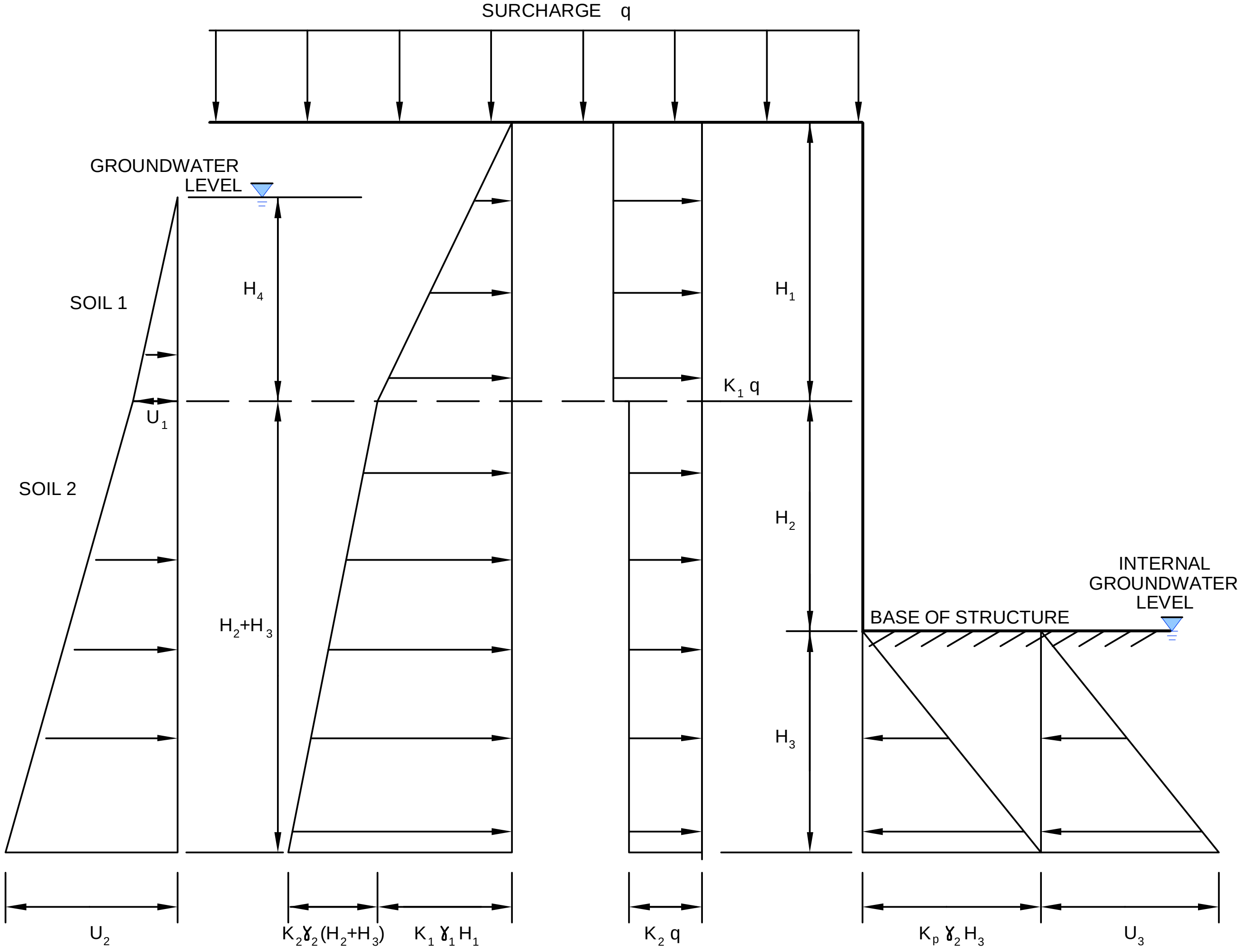
EARTH PRESSURE DIAGRAM FOR TEMPORARY STRUCTURES SUPPORTED USING SOIL ANCHORS FOR LAYERED STRATIGRAPHIC PROFILE

FIGURE 16



γ_1 = BULK UNIT WEIGHT OF SOIL 1

γ_2 = BULK UNIT WEIGHT OF SOIL 2

K_1 = EARTH PRESSURE COEFFICIENT OF SOIL 1

K_2 = EARTH PRESSURE COEFFICIENT OF SOIL 2

K_p = CONVENTIONAL PASSIVE EARTH PRESSURE COEFFICIENT OF SOIL 2

U_1 = PORE WATER PRESSURE IN SOIL 1

U_2 = PORE WATER PRESSURE IN SOIL 2

U_3 = PORE WATER PRESSURE IN SOIL 2 ON INTERIOR OF EXCAVATION AND UNLESS FULL DEWATERING IS PROVIDED OUTSIDE OF CONTINUOUS WALL SYSTEMS, U_3 MUST EQUAL U_2 AT THE BOTTOM ELEVATION OF THE WALL PENETRATION

H_1 = THICKNESS OF SOIL 1

H_2 = THICKNESS OF SOIL 2

H_3 = DEPTH OF EMBEDMENT FROM BASE OF STRUCTURE

H_4 = DEPTH OF GROUNDWATER IN SOIL 1 FROM BASE OF LAYER

NOTE: THIS FIGURE SHOULD BE READ IN CONJUNCTION WITH THE REPORT TITLED "GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN, YONGE SUBWAY EXTENSION, UNDERGROUND TRAIN STORAGE, REGIONAL MUNICIPALITY OF YORK, ONTARIO".

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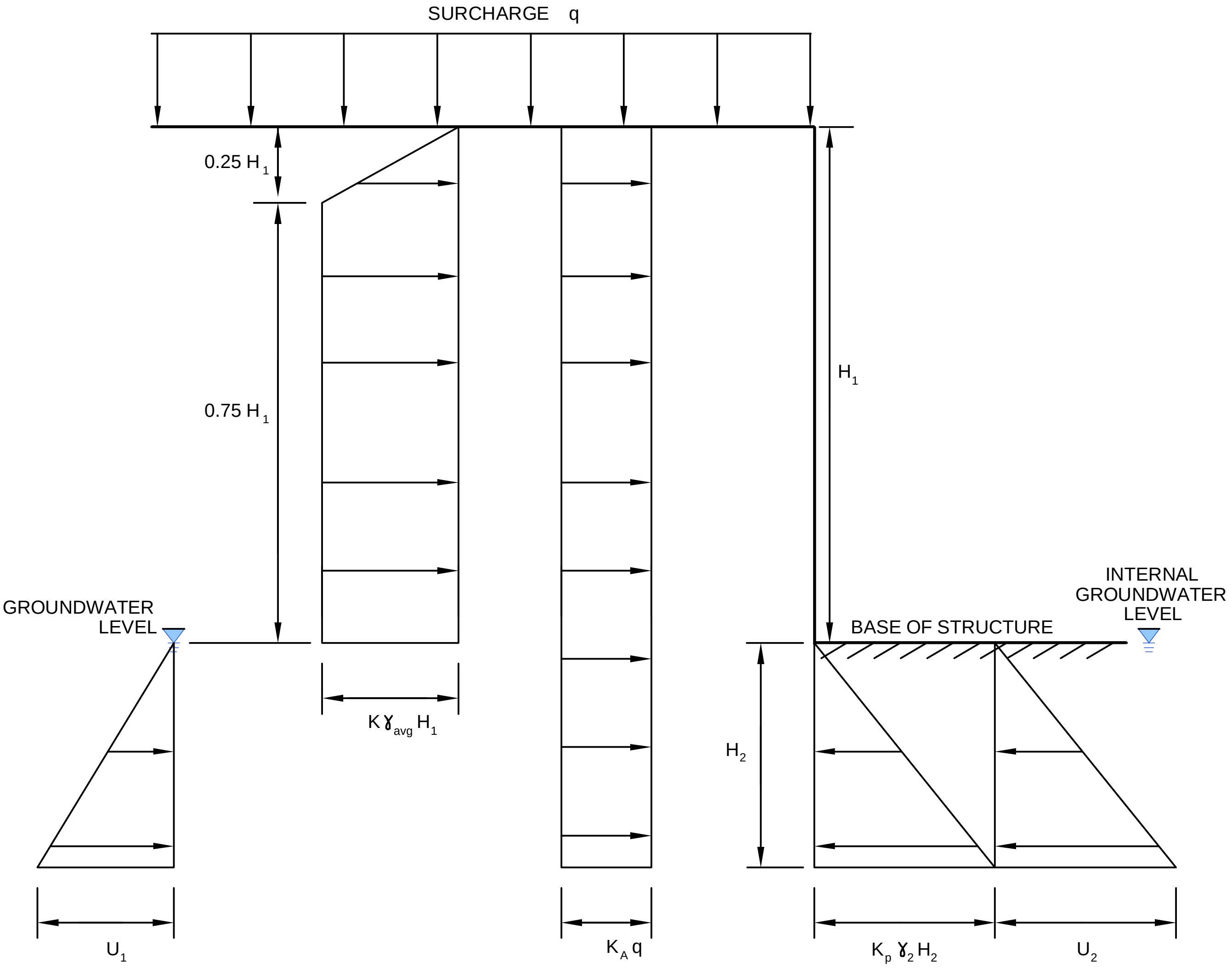
EARTH PRESSURE DIAGRAM FOR FULLY DEWATERED TEMPORARY STRUCTURES SUPPORTED USING INTERNAL STRUTS FOR LAYERED STRATIGRAPHIC PROFILE

FIGURE 17



γ_{avg} = AVERAGE BULK UNIT WEIGHT OF SOILS ABOVE EXCAVATION BASE

K = 0.25, APPARENT EARTH PRESSURE COEFFICIENT OF SOIL

K_p = CONVENTIONAL PASSIVE EARTH PRESSURE COEFFICIENT OF SOIL

K_A = CONVENTIONAL ACTIVE EARTH PRESSURE COEFFICIENT OF SOIL

U_1 AND U_2 SHALL BE CALCULATED BASED ON THE ACHIEVED GROUNDWATER LEVEL DURING DEWATERING

H_1 = DEPTH OF EXCAVATION FROM GROUND SURFACE

H_2 = DEPTH OF EMBEDMENT FROM BASE OF STRUCTURE

NOTE: THIS FIGURE SHOULD BE READ IN CONJUNCTION WITH THE REPORT TITLED "GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN, YONGE SUBWAY EXTENSION, UNDERGROUND TRAIN STORAGE, REGIONAL MUNICIPALITY OF YORK, ONTARIO".

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solutions@golder.com
www.golder.com

Golder Associates Ltd.
309 Exeter Road, Unit #1
London, Ontario, N6L 1C1
Canada
T: +1 (519) 652 0099

January 2014

SUPPLEMENTARY GEOTECHNICAL DATA REPORT

Yonge Subway Extension
Underground Train Storage
Regional Municipality of York, Ontario

Submitted to:

Mr. Kent Barber, P.Eng.
McCormick Rankin Corporation, a member of MMM Group Limited
300 - 2655 North Sheridan Way
Mississauga, Ontario
L5K 2P8

REPORT

Report Number: 09-1111-6091-6000-R01

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FIGURES

APPENDICES

1.0 INTRODUCTION

Golder Associates Ltd. (“Golder”) was retained by MMM Group Limited (MMM) to assist in the completion of a geotechnical investigation to supplement the subsurface data for the Toronto Transit Commission (TTC) for the proposed subway extension connecting the existing Finch Station at Yonge Street to Highway 407 and Richmond Hill Centre in Toronto, Ontario.

The purpose of the supplementary investigation for this project is to provide supplemental factual data at the proposed station locations and tunnel sections of the subway alignment. Data reports associated with previous investigations carried out for the subway extension project are listed below for reference purposes:

- “Geo-Engineering Factual Data Report, Conceptual Design Investigation, Yonge Subway Extension (Version 2), Contract Y85-10”, SPL Consultants Ltd., November 15, 2010.
- “Geotechnical Data Report, York Rapid Transit Plan, Yonge Subway Extension, Regional Municipality of York, Ontario”, Golder Associates Ltd., January 2009.

The supplementary investigation summarized in this report was undertaken in the area of the planned Underground Train Storage (UTS) facility at the north end of the subway extension. Two boreholes were completed and these were numbered 126 and 128, consistent with a prior listing of boreholes completed under separate investigation phases. Borehole 127 was not drilled for this phase.

2.0 PROJECT AND SITE DESCRIPTION

The location of the project is illustrated on Figures 1 and 2. It is proposed that the existing Yonge Subway will be extended from the present Finch Station terminus in Toronto northward to just past Highway 407 in Richmond Hill. The alignment is planned to be about 7 kilometres long and will include up to six stations. The stations may be located in the following general areas (south to north):

- Cummer/Drewry Station;
- Steeles Station;
- Clark Station;
- Royal Orchard Station;
- Longbridge/Langstaff Station;
- Richmond Hill Centre (RHC) Station; and
- Underground Train Storage facility.

3.0 INVESTIGATION PROCEDURES

3.1 General

The supplementary drilling and sampling for the Yonge Subway Extension UTS facility was carried out between May 14 and 23, 2013, during which time two boreholes, 126 and 128, were advanced to depths of between 33.68 metres (m) and 35.64 m below ground surface, respectively. Additional groundwater sampling, groundwater level measurements, and rising head tests were conducted in July and September, 2013. These boreholes are shown in plan on Figure 1.

The as-drilled borehole positions are referenced to MTM NAD 83 UTM 17 northing and easting coordinates and the ground surface elevations are referenced to geodetic datum; these coordinates are summarized below and are also included in the Record of Borehole Sheets that follow the text of this report.

Borehole Number	Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
126	Near Beresford Drive	4855836.4	626342.6	206.56	33.68
128	Near Coburg Crescent	4856350.3	626246.0	209.05	35.64

3.2 Field Investigation

3.2.1 Geotechnical

The borehole investigation and well installations were carried out using truck-mounted drilling equipment, supplied and operated by At-Cost Drilling of Gormley, Ontario. The borehole investigation was carried out using both 125 millimetre (mm) diameter continuous flight solid stem augers and a 75 mm / 125 mm diameter tricone bit for rotary drilling. Soil samples were obtained at intervals of 0.76 m for the top 5 m, and at intervals of 1.5 m for the remaining depth of the boreholes, using a 50 mm outside diameter split-spoon sampler driven by an automatic hammer, and performed in accordance with the standard penetration test (SPT) as described in the TTC Document “Geotechnical Investigation – Direction for Conducting Site Investigations (Version 5)” and applicable standards. The SPT “N” values referenced in this report represent the number of blows of a 63.5 kg hammer free-falling 760 mm required to drive the standard sampler 300 mm into the ground after having first penetrated 150 mm.

Two groundwater observation wells were installed at each borehole location at two different depths. In each case, the shallow groundwater observation well was installed in a separate, un-sampled borehole immediately adjacent to the sampled borehole. The observation wells typically consists of a 3.0 m long, 50 mm diameter slotted screen installed within a filter sand pack and solid-wall riser pipe to the surface. The boreholes were terminated within the granular deposits at the designated levels and backfilled above the sand pack to the ground surface with bentonite pellets and protective casings were installed at all locations. Following installation of the deeper well screens the surrounding granular soils caved into the boreholes, limiting the ability to seal these wells immediately above the screened zones. Installation details are shown on the Record of Borehole sheets.

The field work was supervised throughout by a member of Golder's technical staff, who located the boreholes in the field, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Markham geotechnical laboratory where the samples underwent further visual examination and laboratory testing. Classification tests (water content determinations, Atterberg limit tests and grain size distribution analyses) were carried out on selected soil samples (see Appendix A for results). All of the laboratory tests were carried out to applicable ASTM Standards.

3.2.2 In-situ Hydraulic Conductivity Testing

In-situ hydraulic conductivity testing (rising head tests) was completed on all four monitoring wells installed at the site to determine the hydraulic conductivity of the overburden soils (within the vicinity of the screened and intervals bound by the sand-pack or caved granular soils). For each test, standing water within the well was removed rapidly using a submersible pump and the water level recovery was monitored by an automated water level recorder as well as manually. The results of the rising head tests are summarized in Appendix B and further discussed in Section 4.8.1.

3.2.3 Geo-Environmental

During drilling, soil samples were obtained at regular depth intervals and were logged in the field noting subsurface conditions including soil type, colour and texture, moisture condition and visual evidence of contamination (if any). Details of the condition encountered in the boreholes are presented on the Record of Borehole Sheets following the text of the report.

3.2.3.1 Filed Monitoring

A portion of each soil sample collected from boreholes 126 and 128 was placed in laboratory supplied glass jars for potential chemical analysis, where the testing was required, and the reminder of the sample was placed in a sealed bag, which was subsequently screened for combustible vapours using a Gastechtor, Model 1238 ME, operated in the methane gas elimination mode and calibrated to hexane gas standards. The combustible gas concentration was recorded as parts per million by volume (ppm). The headspace screening results are presented on the Record of Borehole Sheets.

3.2.3.2 Groundwater Quality Testing

Groundwater samples were collected from two of the monitoring wells (one shallow well and one deep well) installed at the site for chemical analysis. Prior to sample collection, the monitoring wells were purged in order to obtain representative samples of groundwater quality. The samples were subsequently submitted to Maxxam Analytical Laboratories in Mississauga for analysis. Laboratory certificate of analysis for the groundwater quality samples are provided in Appendix C.

3.2.3.3 Soil Environmental Quality Testing

In order to characterize the chemical quality of the subsurface material, two soil samples from each borehole were collected and submitted to AGAT Analytical Laboratories in Mississauga for testing of metals and inorganics (O. Reg. 153(511)). The laboratory test results are included in Appendix D. No visual or olfactory evidence of environmental impact was encountered during this investigation.

4.0 SUBSURFACE CONDITIONS ENCOUNTERED DURING INVESTIGATION

An initial investigation was carried out by Golder Associates Ltd. (2009) to provide data for the Transit Project Assessment Process for the Yonge Subway Extension Environmental Assessment. A supplementary geotechnical investigation was carried out by SPL Consultants Ltd. (2010) to provide conceptual design information along Yonge Street between the Canadian National Rail tracks and High Tech Road between approximately Stations 3+300 and 7+400. Subsequent to the conceptual design report issued by Golder in 2011 for the UTS, additional investigations were carried out by Golder in 2013 to better define subsurface conditions in the northern areas of the UTS and these are summarized in this report.

Soils encountered in the boreholes completed by Golder Associates Ltd. (2009) and SPL Consultants Ltd. (2010) were classified in accordance with the TTC Geotechnical Standards, Version 5, Parts A to E including associated appendices in effect at the time the Yonge Subway extension conceptual design phase was initiated. While the soil types and groupings have changed since that time, the previous system has been retained for this report for consistency with earlier reports. Under this system, the soil types described on the Record of Borehole sheets and the laboratory test results included in this report are given twelve different classifications and graphic symbols (Types 1 through 12), which are consistent with the range of soil deposits anticipated to be encountered for subway construction in the Greater Toronto Area.

The classification system generally utilized is listed below:

- Fill (Type 1)
- Organics (Type 2)
- Gravel to Sand and Gravel (Types 3 and 4)
- Sand to Silty Sand (Types 5 and 6)
- Sandy Silt to Silt (Types 7 and 8)
- Clayey Silt to Clay (Types 9 and 10)
- Clayey Silt Till to Silty Clay Till (Type 11)
- Sandy Silt Till to Silty Sand Till (Type 12)

Note that Deposit Types 11 and 12 are interpreted as glacial till deposits on the basis of their heterogeneous structure, the relatively broad grain size distribution and the documented local geology. It is noted that Type 3 was not encountered in the boreholes advanced during this investigation. The results of the laboratory tests are provided in Appendix A. A brief discussion of the materials encountered in the boreholes advanced during this investigation is provided in the subsections that follow.

The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations. Bedrock was not encountered in any of the boreholes.

4.1 Topsoil (Type 2)

A layer of topsoil approximately 100 to 200 mm thick was encountered at the ground surface in boreholes 126 and 128, which were drilled on the grass covered areas between the roadways and nearby rail tracks. Materials designated as topsoil in this report were classified solely based on visual and textural evidence. Testing of organic content or for other nutrients was not carried out. Therefore, the use of materials classified as topsoil cannot be relied upon for support and growth of landscaping vegetation.

4.2 Fill (Type 1)

Fill material was encountered underlying the topsoil at both borehole locations. The fill extended to depths of approximately 3.7 m and 2.2 m below ground surface, corresponding to base elevations of approximately 202.8 and 206.8 m at the locations of boreholes 126 and 128, respectively. The fill material consisted primarily of brown clayey silt to silty clay containing variable proportions of sand, gravel, and organic matter (roots, topsoil, etc.). Oxidation stains were observed on some of the samples obtained within the fill material.

The measured SPT ‘N’ values in the fill material ranged from 3 to 14 blows per 0.3 m of penetration, indicating a soft to stiff consistency. Measured water contents obtained from the fill samples were between about 10 and 16 per cent.

4.3 Sand and Gravel (Type 4)

Based on the drilling activities and field observation of the return fluid during drilling borehole 126, it was inferred that a layer of sand and gravel is present between approximately elevations 183.7 and 184.3 m. This layer was not sampled and the sample attempted upon observing the field drilling behaviours recovered silty sand (described below).

4.4 Sand to Silty Sand (Types 5 and 6)

Layers of brown to grey silty sand (Type 6) containing trace to some gravel were encountered in borehole 126 between approximate elevations of 196.4 and 197.9 m, 183.2 and 183.7 m, 179.6 and 180.6 m, and 175.3 and 176.7 m, with the thicknesses ranging from about 0.5 m to 1.5 m. Standard Penetration Test ‘N’ values measured in the silty sand ranged from 38 blows per 0.3 m to 50 blows per 0.08 m of penetration, indicating a relative density of dense to very dense. Measured natural water contents of the samples of these layers varied from 11 to 21 per cent.

A layer of brown to grey sand (Type 5) containing some silt was encountered in borehole 126 between approximately elevations 194.8 and 196.4 m for a total thickness of about 1.6 m. One SPT ‘N’ value of 66 blows per 0.3 m of penetration was measured in this layer, corresponding to very dense relative density. The measured natural water content of one sample of this layer was about 18 per cent.

4.5 Sandy Silt / Sand and Silt to Silt (Types 7 and 8)

Brown to grey sandy silt to sand and silt layers (Type 7) containing trace amounts of gravel and clay were encountered in borehole 126 between approximate elevations of 197.9 and 201.6 m, 193.5 and 194.8 m, 178.1 and 179.6 m, and 173.7 and 175.3 m, with the thicknesses ranging from about 1.3 m to 3.7 m. The measured SPT 'N' values within the sandy silt to sand and silt layers generally ranged from 87 blows per 0.28 m of penetration to 76 blows per 0.15 m of penetration, corresponding to very dense relative density. Three SPT 'N' values ranging between 9 and 17 blows per 0.3 m of penetration were encountered between approximately elevations 198.7 and 201.6 m, corresponding to loose to compact relative density. The measured natural water content of samples obtained from the sandy silt to sand and silt layers ranged from approximately 10 to 16 per cent. Laboratory test data for a grain size distribution test carried out on one sample of the sand and silt material is provided in Appendix A

Layers of grey silt (Type 8) containing trace to some sand and some clay were encountered in borehole 126 between approximate elevations of 191.7 and 193.5 m, 176.7 and 178.1 m, and at the bottom of the borehole between elevations 172.9 and 173.7 m. In borehole 128, silt was encountered between the elevations of about 195.8 and 198.8 m. These silt layers ranged in thickness between approximately 1.4 and 3 m, though the silt at the bottom of borehole 126 was not fully penetrated. The measured SPT 'N' values in the silt layers ranged between 24 blows per 0.3 m of penetration to 90 blows per 0.15 m of penetration, indicating a compact to very dense relative density. The measured natural water content of the silt material ranged between 17 and 22 per cent. Laboratory test data for grain size distribution tests carried out on three samples from the silt material are provided in Appendix A.

4.6 Clayey Silt to Silty Clay (Types 9 and 10)

Layers of grey clayey silt to silty clay containing trace amounts of sand and gravel were encountered in both boreholes. At some locations the clayey silt to silty clay contained seams of sand, silt and sand, and/or silt. In borehole 126, soil Types 9 and 10 were encountered between the approximate elevations of 188.8 and 190.3 m, and 184.3 and 187.2 m. These soil types were encountered in greater proportion in borehole 128 between the approximate elevations of 198.8 and 200.4 m and from 188.2 to the bottom of the borehole at elevation 173.4 m. The measured SPT 'N' values in these cohesive deposits ranged from 15 blows per 0.3 m of penetration to 90 blows per 0.28 m of penetration, indicating a stiff to hard consistency.

The measured natural water contents obtained from selected samples of the cohesive deposit were between 17 and 25 per cent. Atterberg limits testing carried out on five samples of the cohesive deposit measured liquid limits ranging from approximately 20 to 29 per cent, plastic limits ranging from approximately 15 to 18 per cent and plasticity indices ranging from approximately 5 to 12 per cent, indicating that these soils can be characterized as low to medium plasticity. Laboratory test data for grain size distribution and Atterberg limits of these soils are provided in Appendix A.

4.7 Clayey Silt Till to Silty Clay Till (Type 11)

A cohesive glacial till deposit, consisting of brown to grey silty clay to clayey silt containing varying proportions of sand and gravel, was encountered in both borehole. This cohesive till is differentiated from those materials classified as clayey silt to silty clay/clay (Types 9 and 10) on account of the more massive and heterogeneous structure and the presence of embedded angular coarse sand and fine gravel. In borehole 126 the cohesive till layers were encountered between the approximate elevations of 201.6 and 202.8 m, 190.3 and 191.7 m, 187.2 and 188.8 m, and between 180.6 and 183.2 m. Cohesive glacial till was encountered in borehole 128 between the approximate elevations of 200.4 and 206.8 m, and 188.2 and 195.8 m.

The measured SPT ‘N’ values generally ranged between 12 and 59 blows per 0.3 m of penetration, indicating a stiff to hard consistency. A total of four SPT ‘N’ values of 5 and 9 blows per 0.3 m of penetration were measured in borehole 126 between approximately elevations 201.6 m and 202.8 m, and/or in borehole 128 at about elevations 195.1 m and 206.5 m, indicating a firm to stiff consistency.

Measured natural water contents on selected samples of the clayey silt to silty clay till typically ranged from 6 to 16 per cent. Atterberg limits testing carried out on five samples of the cohesive till deposit measured liquid limits ranging from approximately 14 to 23 per cent, plastic limits ranging from approximately 10 to 13 per cent and plasticity indices ranging from approximately 4 to 10 per cent, indicating that these soils can be characterized as low to medium plasticity. Laboratory test data for grain size distribution and Atterberg limits of the cohesive till deposit are provided in Appendix A.

4.8 Groundwater Conditions

A total of four groundwater monitoring wells, two monitoring wells at each borehole location, were installed during the current supplemental investigation at the site. The groundwater level was measured in these monitoring wells between July 3, 2013 and September 30, 2013, with additional measurement at the location of monitoring well 126B on May 24, 2013. Details of the monitoring well installations as well as the groundwater levels measured in the monitoring wells are shown in the Record of Borehole sheets.

A summary of the groundwater levels measured in the monitoring wells during the above noted period is presented in the table below. Groundwater levels at the site are expected to fluctuate seasonally and are expected to rise during wet periods of the year.

Monitoring Well	Ground Surface Elevation (m)	Groundwater Level Depth (m)	Groundwater Level Elevation (m)	Stratum at Well Screen	Monitoring Period
126A	206.56	14.86 to 14.97	191.59 to 191.70	Silt to silty sand	July 3, 2013 to September 30, 2013
126B	206.54	10.02 to 10.11	196.43 to 196.52	Silt to sand	May 24, 2013 to September 30, 2013
128A	209.05	14.64 to 15.60	193.45 to 194.41	Clayey silt to silty clay	July 3, 2013 to September 30, 2013
128B	208.99	7.92 to 8.17	200.82 to 201.07	Silt	July 3, 2013 to September 30, 2013

4.8.1 In-situ Hydraulic Conductivity Test Results

The results of the rising head tests, which were carried out in the monitoring wells installed in boreholes 126 and 128 are presented in Appendix B and the calculated hydraulic conductivity values are summarized in the table below. It is noted that the calculated hydraulic conductivity values are only representative of the general soil mass between the top and bottom elevations of the sand-pack around the well screen or caved materials and for a limited distance within the soil deposit. The calculated hydraulic conductivity values should only be considered as an indicator of the overall hydraulic properties within these zones and not a definitive measure of hydraulic behaviour in specific layers within the zone affected by the well screen, sand pack, and caved materials. Layers of coarse material within this zone may unduly influence such tests. For final design and prior to construction, field pumping tests should be conducted in any areas in which dewatering or groundwater flow issues may be critical.

Monitoring Well	Depth to Base of Well (m)	Elevation of Base of Well (m)	Calculated Hydraulic Conductivity (cm/s)
126A	33.38	173.18	$<1x10^{-6}$
126B	14.33	192.21	$5x10^{-4}$
128A	34.75	174.30	$1x10^{-5}$
128B	13.26	195.73	$2x10^{-4}$

We trust this report provided the information required. However, should you have any questions, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

S. J. BOONE
90559733

Reza Lackpour

Storer J. Boone, Ph.D., P.Eng.
Associate

Reza Lackpour, M.Sc., P.Eng.

SJB/RL/cr

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IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

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Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT (cont'd)

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split spoon 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) Cohesionless Soils

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

(b) Cohesive Soils

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

IV. SOIL TESTS

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

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

LIST OF SYMBOLS

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

I. General

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p/\sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan 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

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

PROJECT: 09-1111-6091 (6000)

RECORD OF BOREHOLE: BH 126

SHEET 1 OF 4

LOCATION: N 4855836.4 ;E 626342.6

BORING DATE: May 17, 2013 - May 23, 2013

DATUM: Geodetic

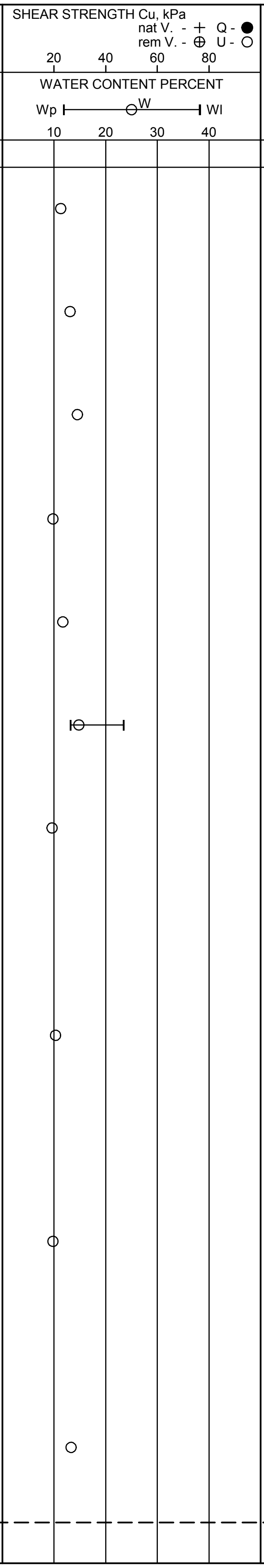
SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

Toronto Transit Commission

BORING METHOD: Power Auger, 125 mm Solid Stem Augers

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	206.56
TOPSOIL	0.00
Firm to stiff, brown SILTY CLAY, sandy to some sand, trace to some gravel, oxidation stains, rootlets, decomposed organic matter, sand seams; FILL (CL)	0.10
Firm to stiff, brown SILTY CLAY, sandy to some sand, trace gravel; TILL (CL)	202.83 3.73
Loose to compact, moist to wet, brown SAND and SILT, trace gravel, trace clay, pockets of silty clay, stratified; (ML/SP)	201.63 4.93
Dense, wet,brown SILTY FINE SAND, trace gravel, stratified; (SM)	197.87 8.69

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ORGANIC VAPOUR READINGS (ppm) ⊕ / % LEL Methane □	ADDITIONAL LAB. TESTING
1	SS	10	ND	
2	SS	7	⊕	
3	SS	14	⊕	
4	SS	13	⊕	
5	SS	7	ND	
6	SS	5	⊕	MH
7	SS	9	ND	
8	SS	14	⊕	
9	SS	17	⊕	MH
10	SS	38	⊕	



PIEZOMETER OR STANDPIPE INSTALLATION

Well B **Stick-up 0.73m**

Well A **Stick-up 0.77m**

Grout

Grout

Bentonite

DEPTH SCALE METRES: 0 – 10

CONTINUED NEXT PAGE

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: RA

CHECKED: RL

PROJECT: 09-1111-6091 (6000)

RECORD OF BOREHOLE: BH 126

SHEET 2 OF 4

LOCATION: N 4855836.4 ;E 626342.6

BORING DATE: May 17, 2013 - May 23, 2013

DATUM: Geodetic

SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

Toronto Transit Commission

--- CONTINUED FROM PREVIOUS PAGE ---

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ORGANIC VAPOUR READINGS	ADDITIONAL LAB. TESTING
10	Power Auger		196.43					
		Very dense, wet, brown to grey, fine to medium SAND, some silt, oxidation stain stratified; (SP)	10.13					
11				11	SS	66	ND	
	Mud Rotary 110 mm Tricone Bit		194.83					
		Very dense, wet, brown SANDY SILT, trace gravel; (SM)	11.73					
12				12	SS	50/ 125mm	⊕	
13			193.45					
		Very dense, wet, grey SILT, some clay, trace sand; (ML)	13.11					
14				13	SS	98/ 275mm	⊕	MH
			191.70					
15		Hard, grey SILTY CLAY, sandy, trace gravel; TILL (CL)	14.86					
				14	SS	50	⊕	MH
16			190.25					
		Hard, grey CLAYEY SILT, trace sand, silty sand seams; (ML)	16.31					
17				15	SS	84	⊕	
			188.81					
		Hard, grey, CLAYEY SILT, sandy, some gravel; TILL (MC)	17.75					
18				16	SS	59	⊕	
19			187.21					
		Very stiff, grey SILTY CLAY to CLAYEY SILT, trace sand, trace gravel, sand seams; (CL-ML)	19.35					
20				17	SS	25		

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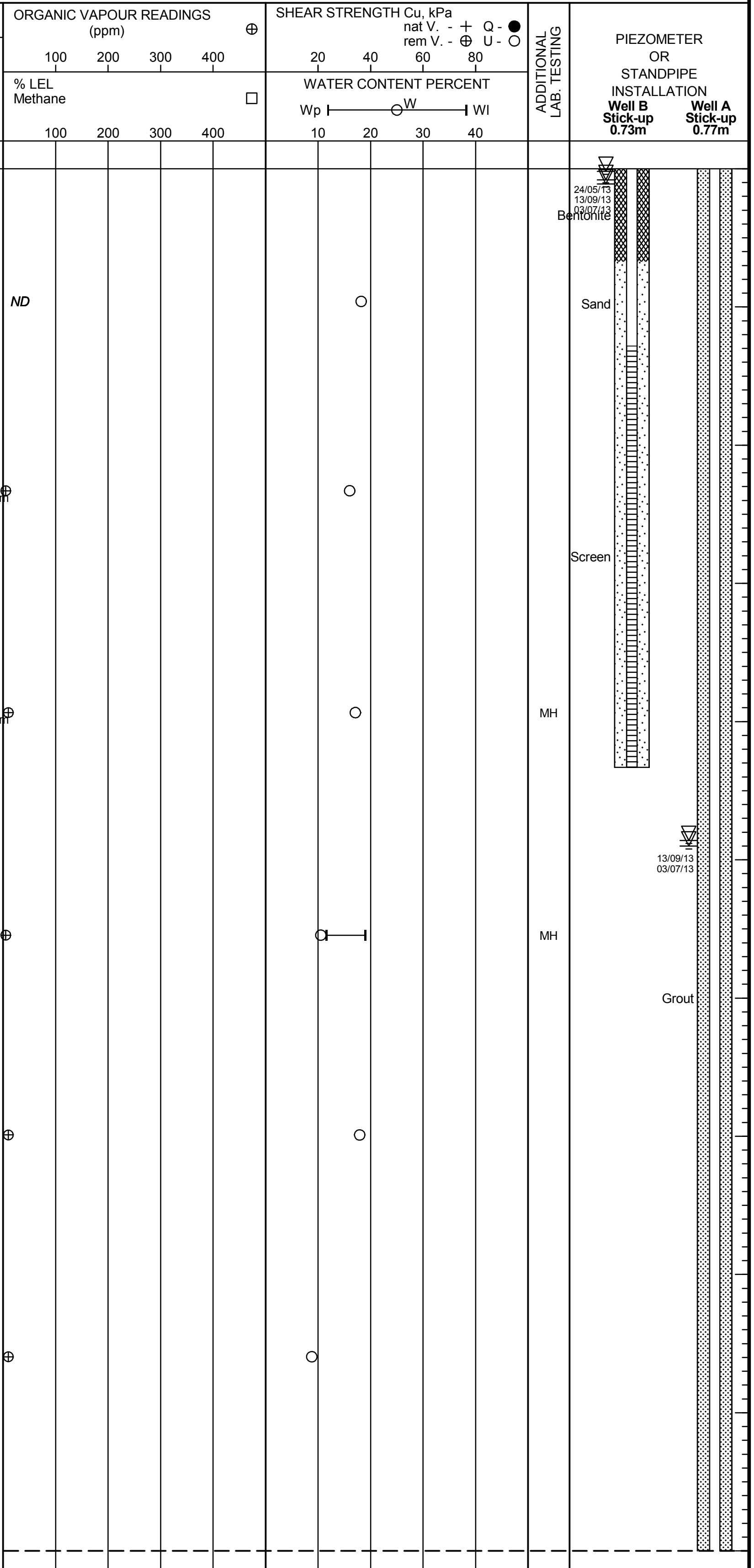


DEPTH SCALE

1 : 50

Golder Associates

LOGGED: RA

CHECKED: RL

PROJECT: 09-1111-6091 (6000)

RECORD OF BOREHOLE: BH 126

SHEET 3 OF 4

LOCATION: N 4855836.4 ;E 626342.6

BORING DATE: May 17, 2013 - May 23, 2013

DATUM: Geodetic

SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

Toronto Transit Commission

ORGANIC VAPOUR READINGS (ppm) ⊕ 100 200 300 400; % LEL Methane □ 100 200 300 400

SHEAR STRENGTH Cu, kPa nat V. - + Q - ● rem V. - ⊕ U - ○ 20 40 60 80

WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40

PIEZOMETER OR STANDPIPE INSTALLATION: **Well B Stick-up 0.73m**, **Well A Stick-up 0.77m**

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ORGANIC VAPOUR READINGS	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
20	Mud Rotary 110 mm Tricone Bit	Very stiff, grey SILTY CLAY to CLAYEY SILT, trace sand, trace gravel, sand seams; (CL-ML)		17	SS	25	*ND*	MH	
21				18	SS	22	*ND*		
22		Wet, grey SAND AND GRAVEL, inferred from drilling; (SP/GP)	184.31 22.25						Grout
23		Very dense, wet, grey SILTY SAND, some gravel; (SM)	183.70 22.86	19A	SS	58	*ND*		
		Hard, grey CLAYEY SILT and SAND, trace gravel; TILL (CL-ML)	183.19 23.37	19B			*ND*		
24				20	SS	50	*ND*	MH	
25									Bentonite
26		Dense, wet, grey SILTY SAND, some gravel; (SM)	180.58 25.98	21	SS	42	⊕		
27		Very dense, wet, grey SAND and SILT, stratified; (SP/ML)	179.59 26.97	22	SS	87/ 275mm	⊕		
28									Caved Material
		Very dense, wet, grey SILT, some clay, trace sand; (ML)	178.06 28.50	23	SS	50/ 100mm	*ND*	MH	
29			176.66 29.90						
30		*CONTINUED NEXT PAGE*							

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: RA

CHECKED: RL

PROJECT: 09-1111-6091 (6000)

RECORD OF BOREHOLE: BH 126

SHEET 4 OF 4

LOCATION: N 4855836.4 ;E 626342.6

BORING DATE: May 17, 2013 - May 23, 2013

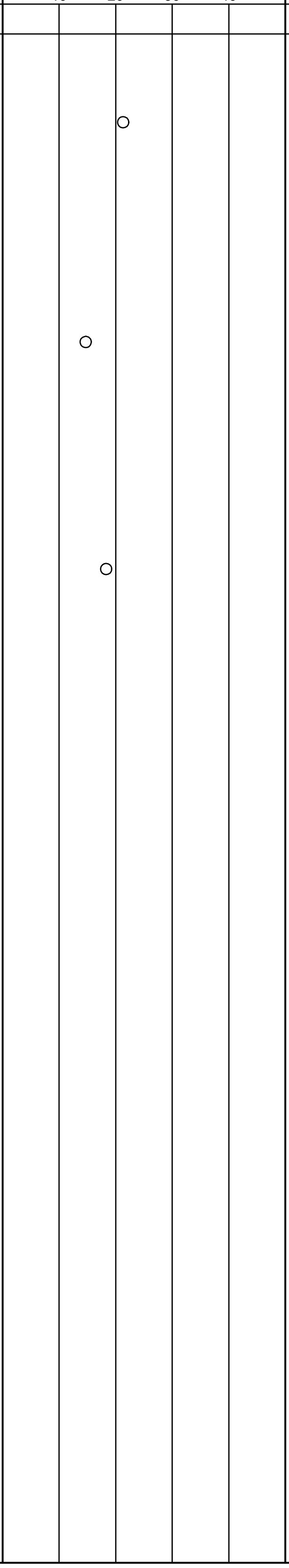
DATUM: Geodetic

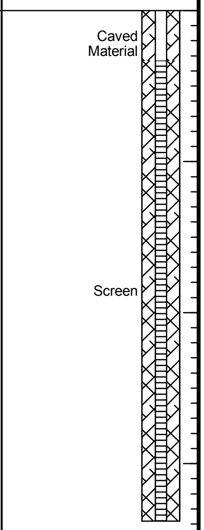
SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

Toronto Transit Commission

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	ORGANIC VAPOUR READINGS (ppm) ⊕ / % LEL Methane ☐	SHEAR STRENGTH Cu, kPa nat V. - + Q - ● rem V. - ⊕ U - ○ / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION Well B Stick-up 0.73m Well A Stick-up 0.77m
		--- *CONTINUED FROM PREVIOUS PAGE* ---									
30	Mud Rotary 110 mm Tricone Bit	Very dense, wet, grey SILTY SAND, stratified; (SM)									Caved Material
					24	SS	50/ 75mm	ND			
31				175.32 31.24							
		Very dense, wet, grey SANDY SILT, trace gravel; (ML)									Screen
32					25	SS	76/ 150mm	ND			
				173.72 32.84							
33		Very dense, wet, grey SILT, some sand; (ML)									
				172.88	26	SS	90/ 150mm	ND			
		END OF BOREHOLE		33.68							

Scale values: ORGANIC VAPOUR READINGS 100 200 300 400; % LEL Methane 100 200 300 400; SHEAR STRENGTH 20 40 60 80; WATER CONTENT PERCENT 10 20 30 40. Depth scale 30 to 40.





NOTES:

1. A 50 mm diameter deep monitoring well (A) was installed at a depth of 33.38m below ground surface in the completed borehole.

2. A 50 mm diameter shallow monitoring well (B) was installed at a depth of 14.33m below ground surface in a new borehole (N 4855834.3; E 626343.1) adjacent to the completed borehole.

Water level measurements:
Monitoring Well A
(Ground surface elevation 206.56m)

Date	Depth	Elevation
03/07/2013	14.90m	191.66m
13/09/2013	14.86m	191.70m
30/09/2013	14.97m	191.59m

Monitoring Well B
(Ground surface elevation 206.54m)

Date	Depth	Elevation
24/05/2013	10.02m	196.52m
03/07/2013	10.11m	196.43m
13/09/2013	10.08m	196.46m
30/09/2013	10.08m	196.46m

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: RA
CHECKED: RL

PROJECT: 09-1111-6091 (6000)

RECORD OF BOREHOLE: BH 128

SHEET 1 OF 4

LOCATION: N 4856350.3 ;E 626246.0

BORING DATE: May 14, 2013 - May 16, 2013

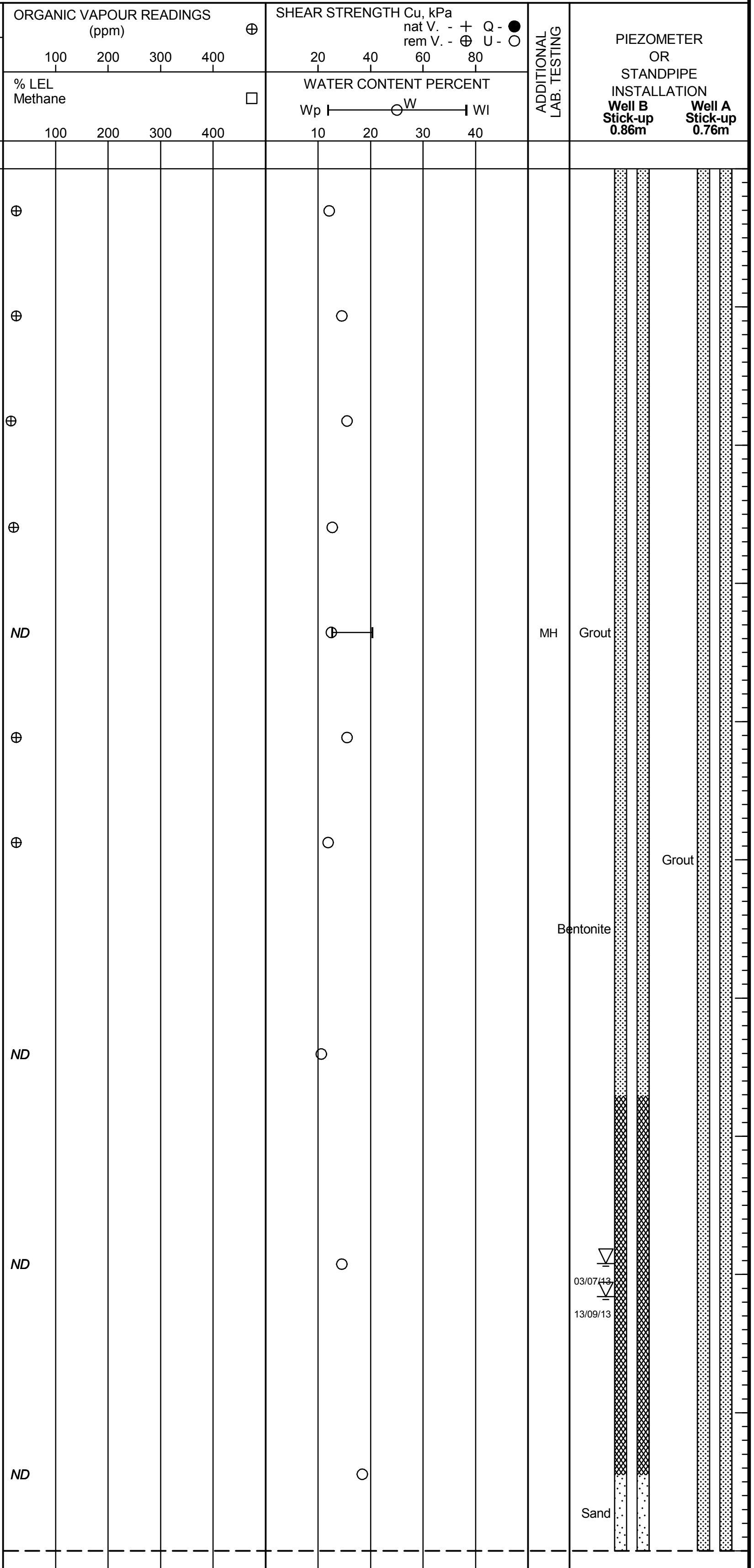
DATUM: Geodetic

SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

Toronto Transit Commission

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
		GROUND SURFACE	209.05
0	Power Auger 125 mm Solid Stem Augers	TOPSOIL	0.00
		Soft to stiff, brown SILTY CLAY to CLAYEY SILT, sandy to some sand, trace gravel, rootlets; FILL (CL-ML)	208.85 0.20
2	Mud Rotary 75 mm Tricone Bit	Stiff, grey SILTY CLAY, sandy to some sand, some gravel, rootlets, mottled, oxidation stains from about 3.8m to 4.5m depth; TILL (CL)	206.84 2.21
		Stiff to hard, brown to grey SILTY CLAY, sandy to trace sand, trace to some gravel, oxidation stains; TILL (CL)	204.55 4.50
		Very stiff, grey SILTY CLAY, trace sand; (CL)	200.36 8.69
10		*CONTINUED NEXT PAGE*	

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ORGANIC VAPOUR READINGS	ADDITIONAL LAB. TESTING
1	SS	11	⊕	
2	SS	11	⊕	
3	SS	3	⊕	
4	SS	9	⊕	
5	SS	12	ND	MH
6	SS	14	⊕	
7	SS	20	⊕	
8	SS	43	ND	
9	SS	15	ND	
10	SS	20	ND	



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: RA
CHECKED: RL

MIS-TTC BHS 001 0911116091.GPJ GAL-MISS.GDT 31/10/13 DATA INPUT:

PROJECT: 09-1111-6091 (6000)

RECORD OF BOREHOLE: BH 128

SHEET 2 OF 4

LOCATION: N 4856350.3 ;E 626246.0

BORING DATE: May 14, 2013 - May 16, 2013

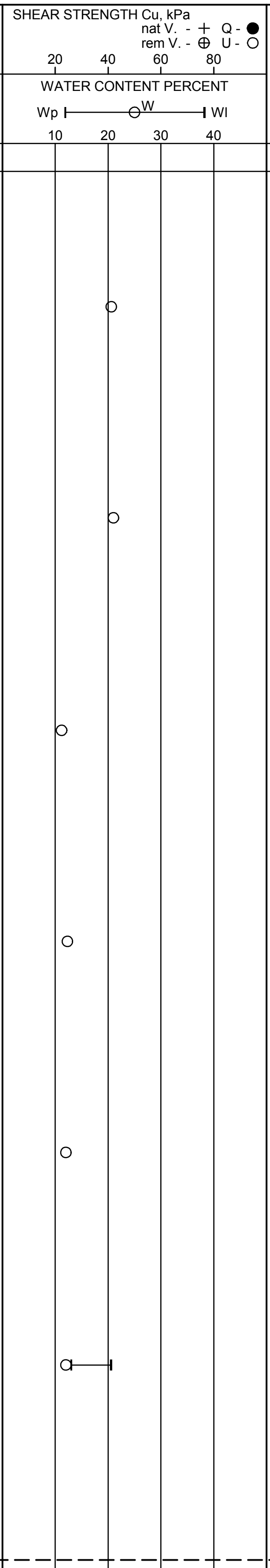
DATUM: Geodetic

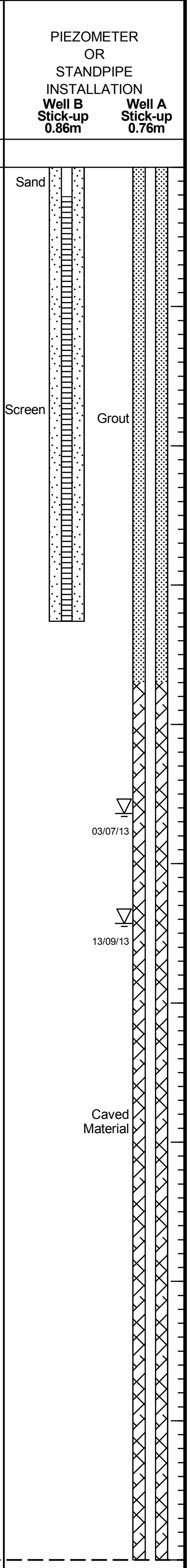
SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

Toronto Transit Commission

BORING METHOD: Mud Rotary, 75 mm Tricone Bit

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ORGANIC VAPOUR READINGS (ppm) / % LEL Methane	ADDITIONAL LAB. TESTING
	--- *CONTINUED FROM PREVIOUS PAGE* ---						
10	Compact to dense, wet, grey SILT, trace sand, stratified; (ML)	198.84 10.21					
11			11	SS	40	*ND*	
12			12	SS	24	*ND*	MH
13	Stiff to hard, grey SILTY CLAY, sandy to trace sand, trace to some gravel; TILL (CL)	195.79 13.26					
14			13	SS	9	*ND*	
15			14	SS	34	*ND*	
16							
17			15	SS	28	*ND*	
18			16	SS	46	*ND*	MH
19							
20			17	SS	40		
	CONTINUED NEXT PAGE						





DEPTH SCALE
1 : 50

Golder Associates

LOGGED: RA
CHECKED: RL

PROJECT: 09-1111-6091 (6000)

RECORD OF BOREHOLE: BH 128

SHEET 3 OF 4

LOCATION: N 4856350.3 ;E 626246.0

BORING DATE: May 14, 2013 - May 16, 2013

DATUM: Geodetic

SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

Toronto Transit Commission

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ORGANIC VAPOUR READINGS (ppm) ⊕ / % LEL Methane ☐	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION Well B Stick-up 0.86m / Well A Stick-up 0.76m
		--- *CONTINUED FROM PREVIOUS PAGE* ---							
20	Mud Rotary 75 mm Tricone Bit	Stiff to hard, grey SILTY CLAY, sandy to trace sand, trace to some gravel; TILL (CL)		17	SS	40	*ND*		
21		Stiff to hard, grey SILTY CLAY, trace sand, trace gravel, sand seams, silt and fine sand seams at about 26.1m; (CL)	188.17 20.88						
				18	SS	34	*ND*		
23				19	SS	18	*ND*		
24				20	SS	15	*ND*	MH	
25									Caved Material
26				21	SS	82/275mm	*ND*		
27		Very stiff to hard, grey CLAYEY SILT, trace sand, trace gravel; (CL-ML)	182.15 26.90						
				22	SS	77	⊕	MH	
29				23	SS	42	*ND*		
30		*CONTINUED NEXT PAGE*							

SHEAR STRENGTH Cu, kPa nat V. - + Q - ● rem V. - ⊕ U - ○ (20, 40, 60, 80)

WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (10, 20, 30, 40)

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: RA

CHECKED: RL

PROJECT: 09-1111-6091 (6000)

RECORD OF BOREHOLE: BH 128

SHEET 4 OF 4

LOCATION: N 4856350.3 ;E 626246.0

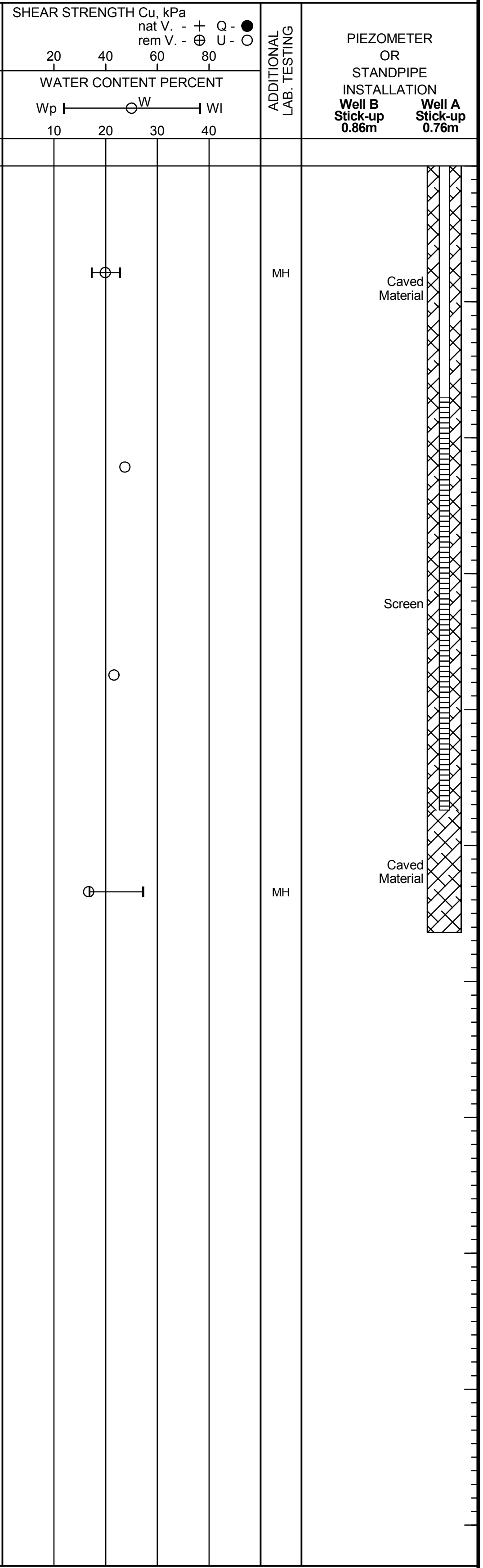
BORING DATE: May 14, 2013 - May 16, 2013

DATUM: Geodetic

SAMPLER HAMMER, 63.5 kg; DROP, 760 mm

Toronto Transit Commission

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ORGANIC VAPOUR READINGS (ppm) / % LEL Methane	ADDITIONAL LAB. TESTING
	--- *CONTINUED FROM PREVIOUS PAGE* ---						
Mud Rotary 75 mm Tricone Bit	Very stiff to hard, grey CLAYEY SILT, trace sand, trace gravel; (CL-ML)	177.50 31.55	24	SS	17	*ND*	MH
	Hard, grey SILTY CLAY, trace sand, silt and sand seam at about 32.2m to 32.3m depth; (CL)	175.98 33.07	25	SS	83/ 275mm	*ND*	
	Hard, grey CLAYEY SILT, trace sand, occassional silt seams; (CL-ML)	174.46 34.59	26	SS	90/ 275mm	*ND*	
	Hard, grey SILTY CLAY, trace sand; (CL)	173.41 35.64	27	SS	67	*ND*	MH
	END OF BOREHOLE						



NOTES:

1. A 50 mm diameter deep monitoring well (A) was installed at a depth of 34.75m below ground surface in the completed borehole.

2. A 50 mm diameter shallow monitoring well (B) was installed at a depth of 13.26m below ground surface in a new borehole (N 4856348.8; E 626246.1) adjacent to the completed borehole.

Water level measurements:
Monitoring Well A
(Ground surface elevation 209.05m)

Date	Depth	Elevation
03/07/2013	14.64m	194.41m
13/09/2013	15.43m	193.62m
30/09/2013	15.60m	193.45m

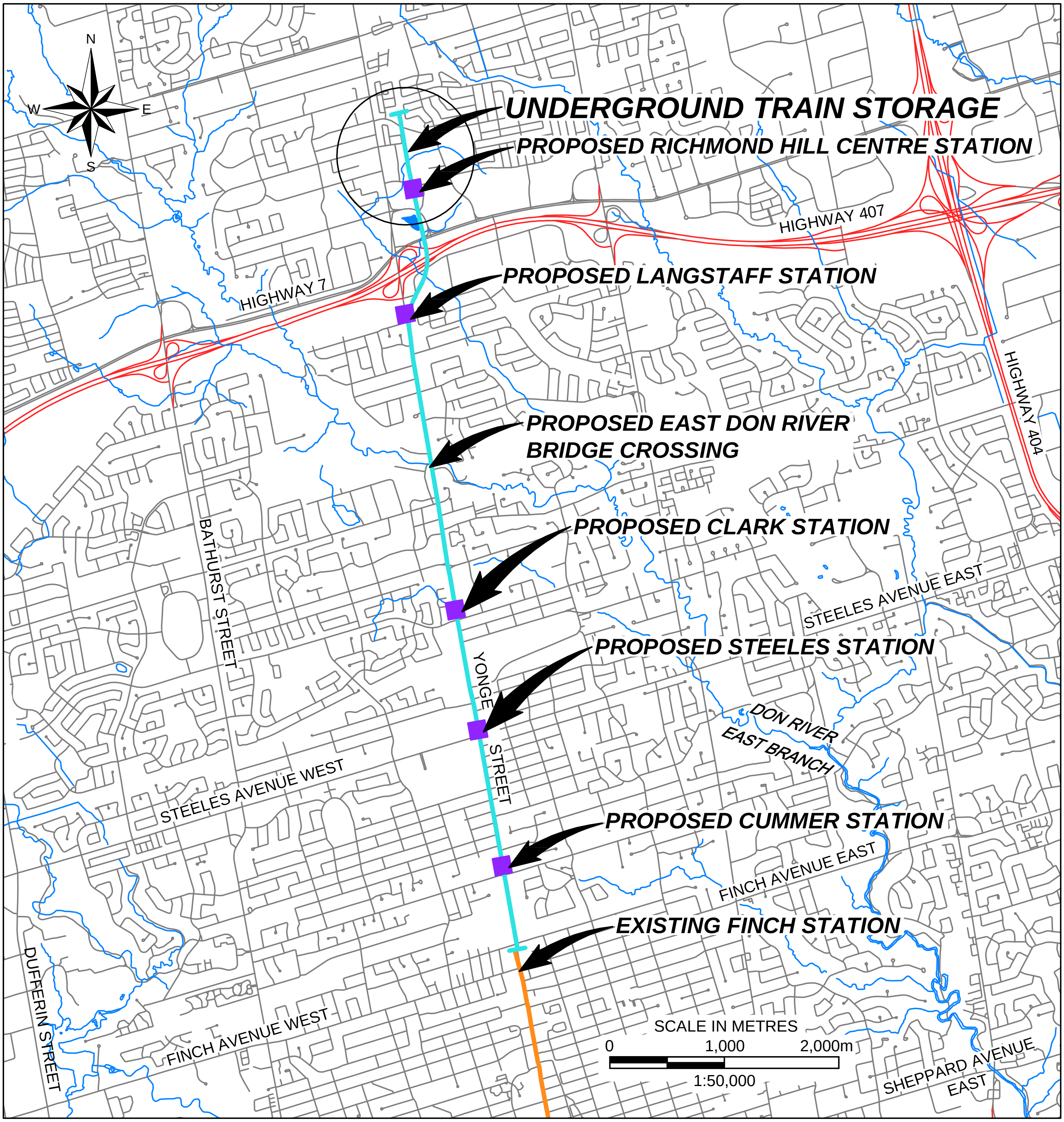
Monitoring Well B
(Ground surface elevation 208.99m)

Date	Depth	Elevation
03/07/2013	7.92m	201.07m
13/09/2013	8.16m	200.83m
30/09/2013	8.17m	200.82m

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: RA
CHECKED: RL



LEGEND

🟪	STATION SITE
⊢⊣	YONGE SUBWAY EXTENSION PROJECT LIMITS
—	EXISTING YONGE SUBWAY LINE

REFERENCE

DRAWING BASED ON CANMAP STREETFILES V2005.4.

NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

ALL LOCATIONS ARE APPROXIMATE.

PROJECT

SUPPLEMENTARY GEOTECHNICAL DATA REPORT
YONGE SUBWAY EXTENSION
UNDERGROUND TRAIN STORAGE
REGIONAL MUNICIPALITY OF YORK, ONTARIO

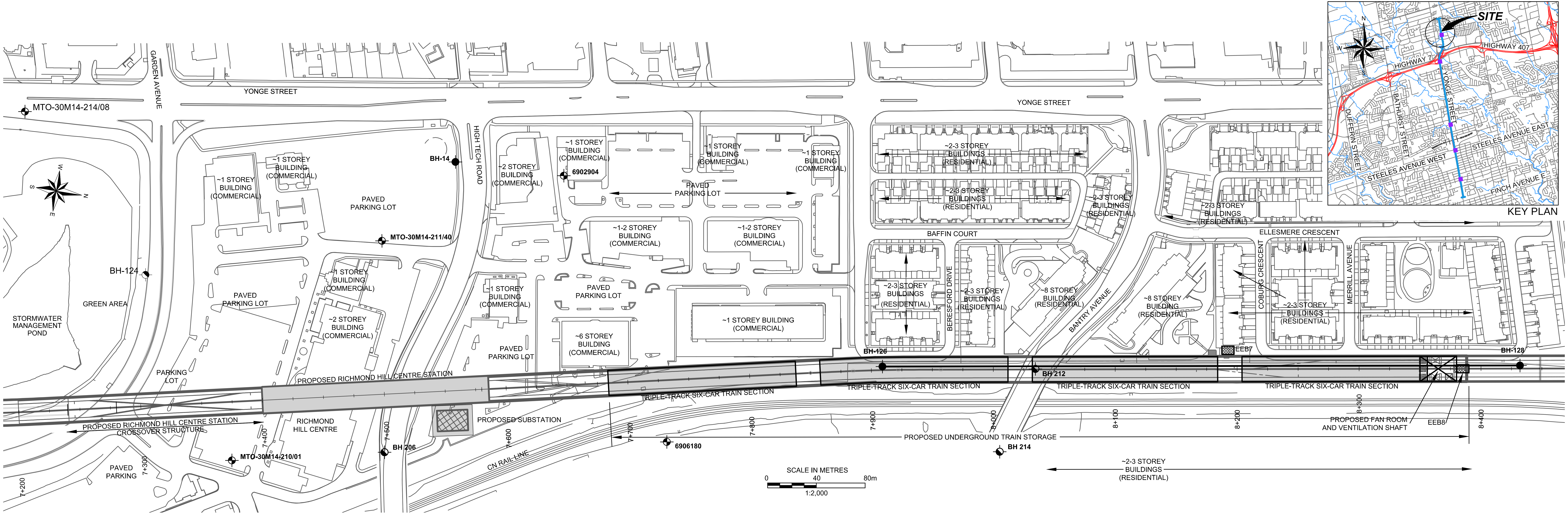
TITLE

SITE LOCATION PLAN

Golder Associates
LONDON, ONTARIO

PROJECT No.		09-1111-6091	FILE No.	0911116091AJ001
			SCALE AS SHOWN	REV.
CADD	DCH	Jan. 14/14	FIGURE 1	
CHECK				

Drawing file: 0911116091AJ001.dwg Jan 17, 2014 – 8:13am



LEGEND

◐ BOREHOLE (SPL CONSULTANTS LTD., 2010)

● BOREHOLE (GOLDER ASSOCIATES LTD., 2009 & 2013)

◑ BOREHOLE (SOIL PROBE LTD., 1997)

⊕ BOREHOLE OR WELL
(FROM YORK-PEEL-DURHAM-TORONTO-CONSERVATIN AUTHORITIES
MORAINE COALITION [YPDT - CAMC] DATABASE RECORDS:
REVIEWED NOVEMBER 2008)

YONGE SUBWAY EXTENSION PROJECT LIMITS

REFERENCE

1) BASE PLAN AND ALIGNMENT PROVIDED IN DIGITAL FORMAT BY McCORMICK RANKIN CORPORATION, HATCH MOTT MACDONALD, YSE TRACK WORK ALIGNMENT, PLAN AND PROFILE DATED FEBRUARY 28, 2011. THE PROFILES ARE APPROXIMATE AND ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY.

2) CANMAP STREETFILES V2005.4.

NOTES

1) THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH THE REPORT TITLED "GEOTECHNICAL REPORT FOR CONCEPTUAL DESIGN, YONGE SUBWAY EXTENSION, UNDERGROUND TRAIN STORAGE, REGIONAL MUNICIPALITY OF YORK, ONTARIO"; Report No. 09-1111-6091-3000-R07, dATED nOVEMBER 2011, UPDATED dECEMBER 2013.

2) ALL LOCATIONS ARE APPROXIMATE.

3) SIZE OF BUILDINGS ARE APPROXIMATE AND ARE FOR ILLUSTRATIVE PURPOSES ONLY.

PROJECT
SUPPLEMENTARY GEOTECHNICAL DATA REPORT
YONGE SUBWAY EXTENSION
UNDERGROUND TRAIN STORAGE
REGIONAL MUNICIPALITY OF YORK, ONTARIO

TITLE

KEY PLAN AND BOREHOLE LOCATION PLAN UNDERGROUND TRAIN STORAGE

Golder Associates
LONDON, ONTARIO

PROJECT No.	09–1111–6091	FILE No.	0911116091AJ002
		SCALE	AS SHOWN
CADD	DCH\WDF	Jan. 14/14	REV.
CHECK			

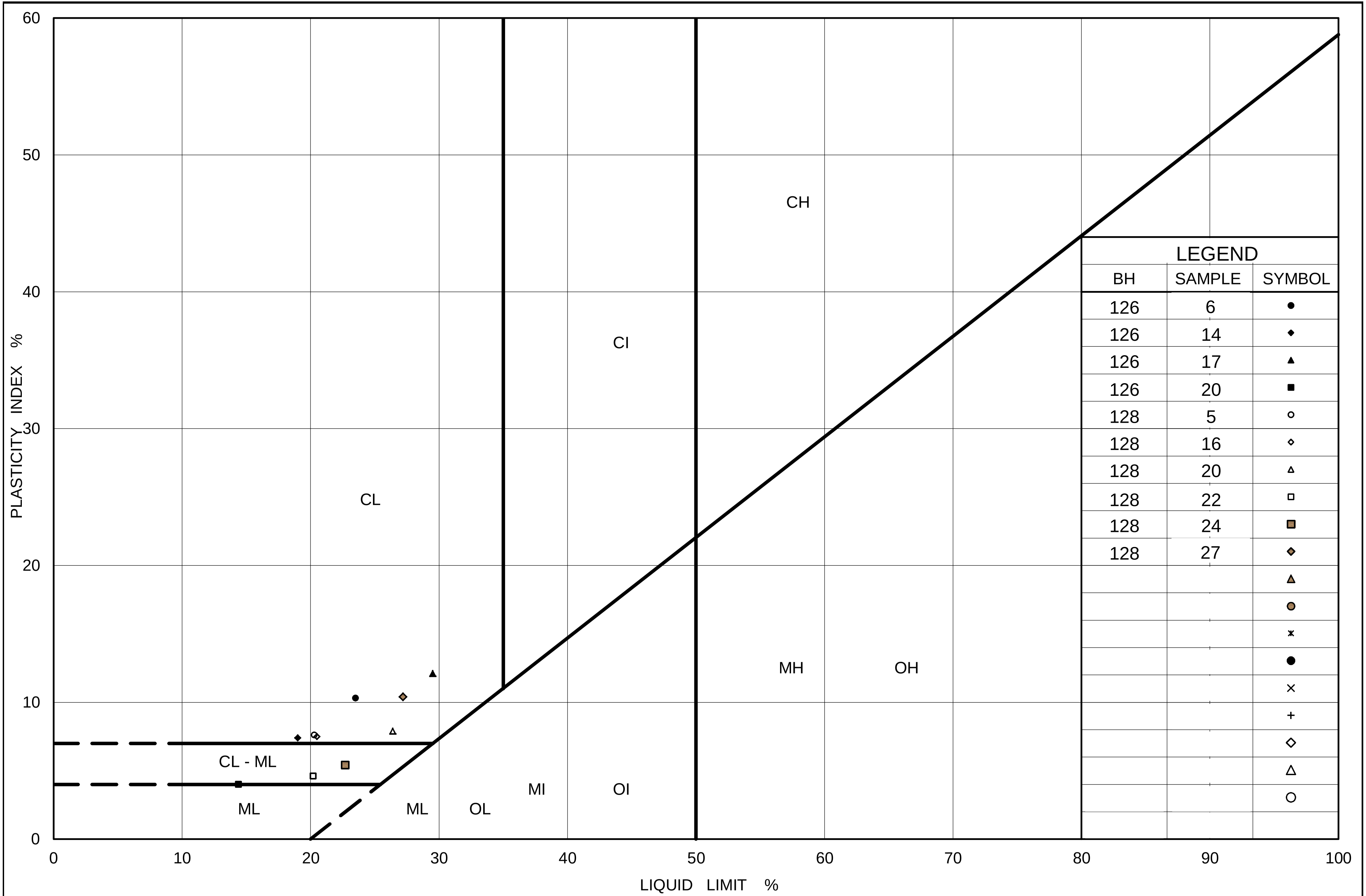
FIGURE 2

Drawing file: 0911116091AJ002.dwg Jan 17, 2014 – 8:16am

APPENDIX A

Geotechnical Laboratory Test Results

Oct 75, FF-S-21



BH	SAMPLE	SYMBOL
126	6	●
126	14	◆
126	17	▲
126	20	■
128	5	○
128	16	◇
128	20	△
128	22	□
128	24	■
128	27	◆
		▲
		●
		×
		●
		×
		+
		◇
		△
		○

Golder Associates

PLASTICITY CHART

FIGURE A1

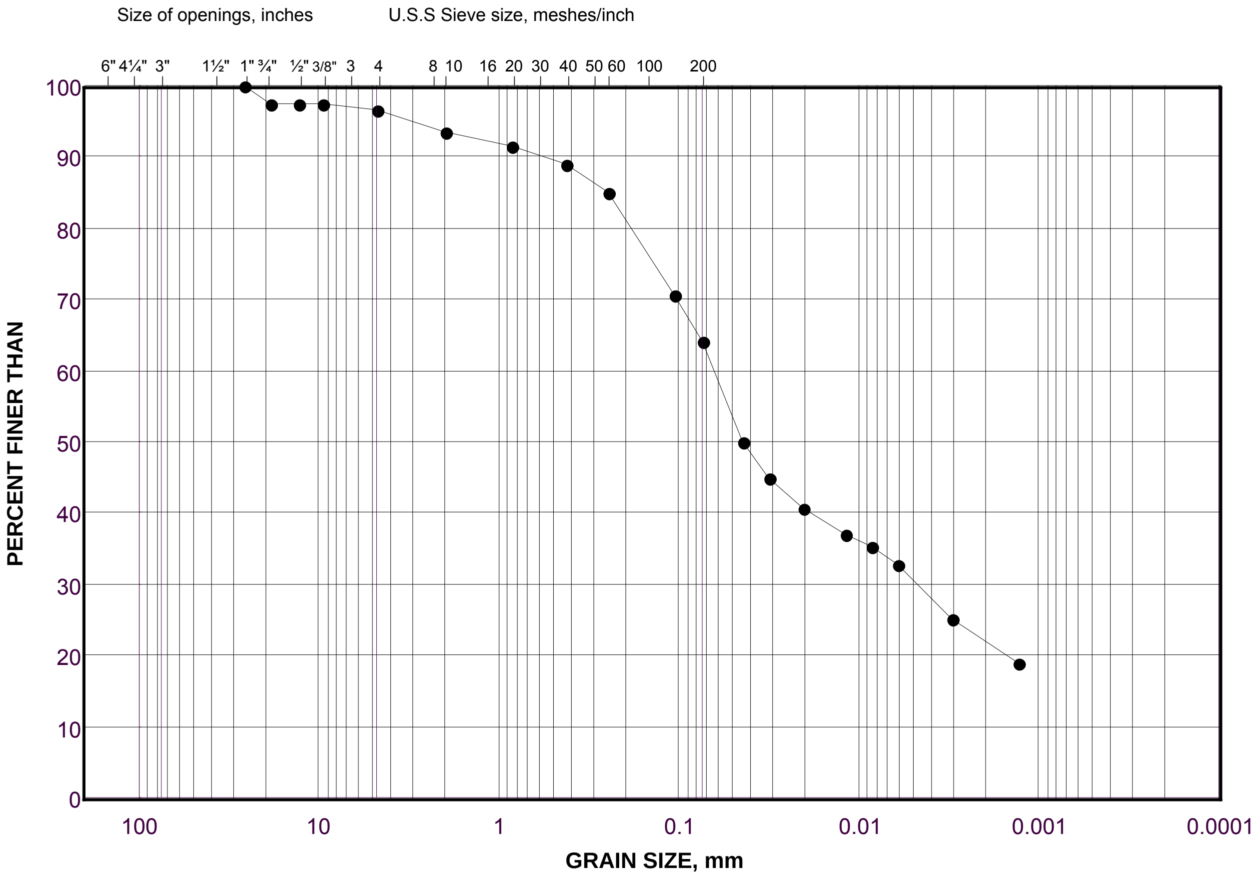
Project No. 09-1111-6091 6000

Checked By:

FIGURE A1

GRAIN SIZE DISTRIBUTION

FIGURE A2



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	126	6	3.81 - 4.42

Project Number: 09-1111-6091 (6000)

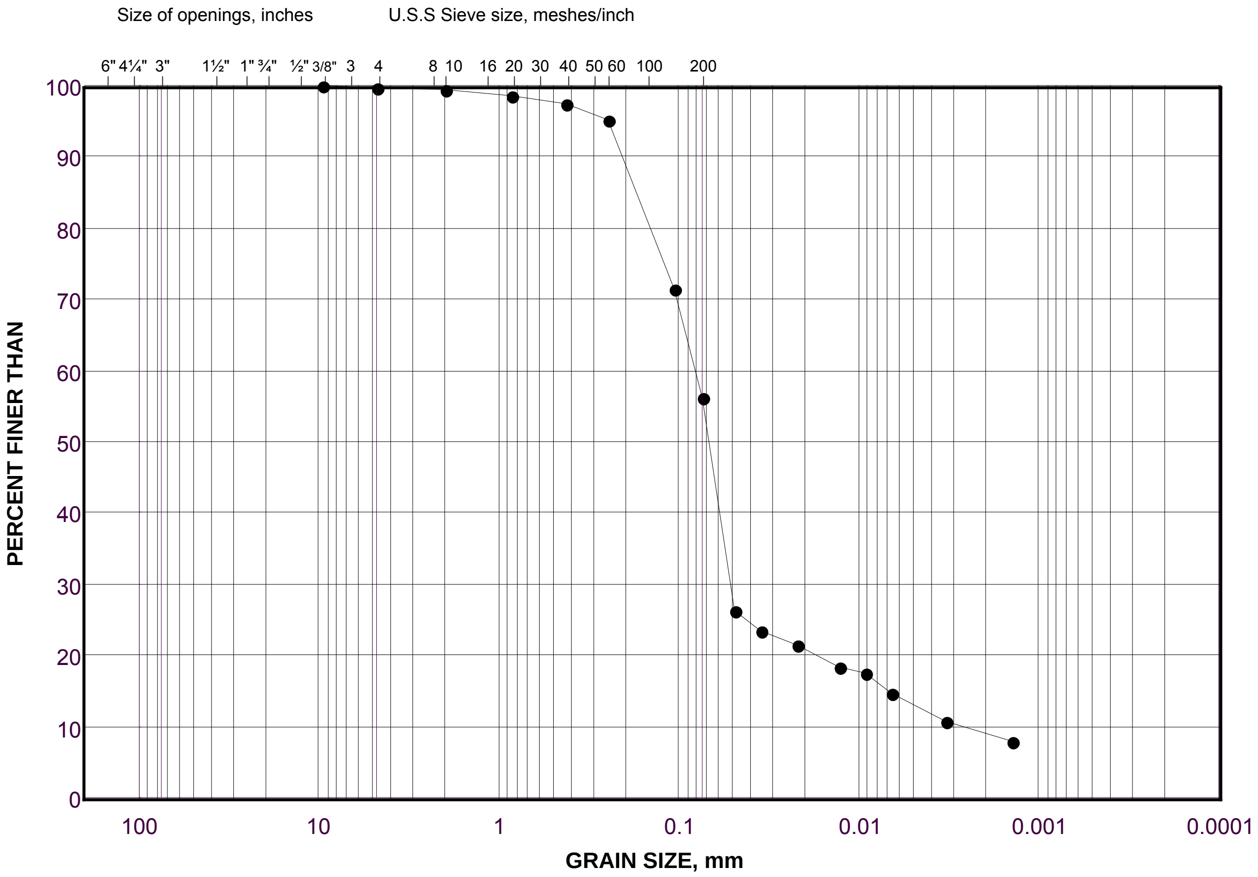
Checked By: ____________________

Golder Associates

Date: 11-Jun-13

GRAIN SIZE DISTRIBUTION

FIGURE A3



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	126	9	7.62 - 8.23

Project Number: 09-1111-6091 (6000)

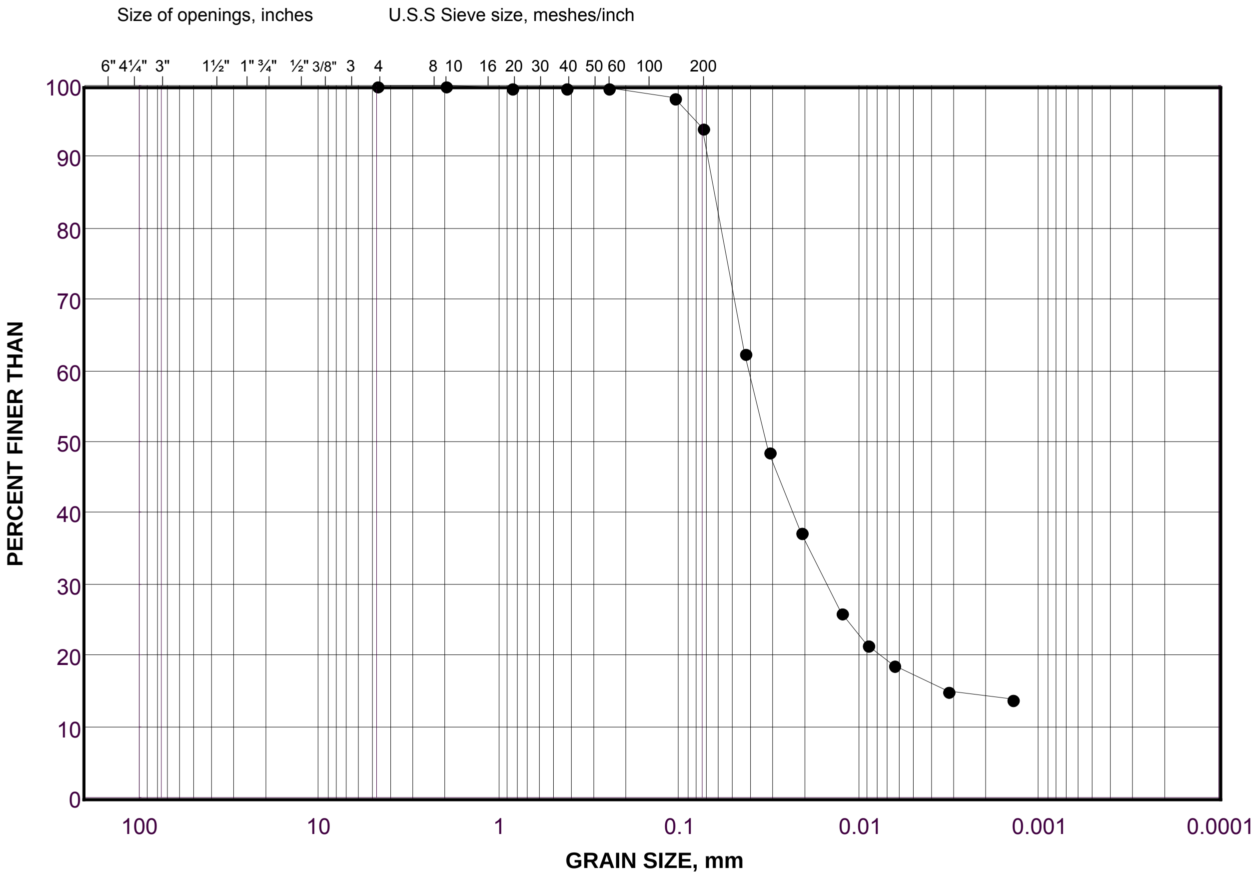
Checked By: ______________________

Golder Associates

Date: 11-Jun-13

GRAIN SIZE DISTRIBUTION

FIGURE A4



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	126	13	13.72 - 14.14

Project Number: 09-1111-6091 (6000)

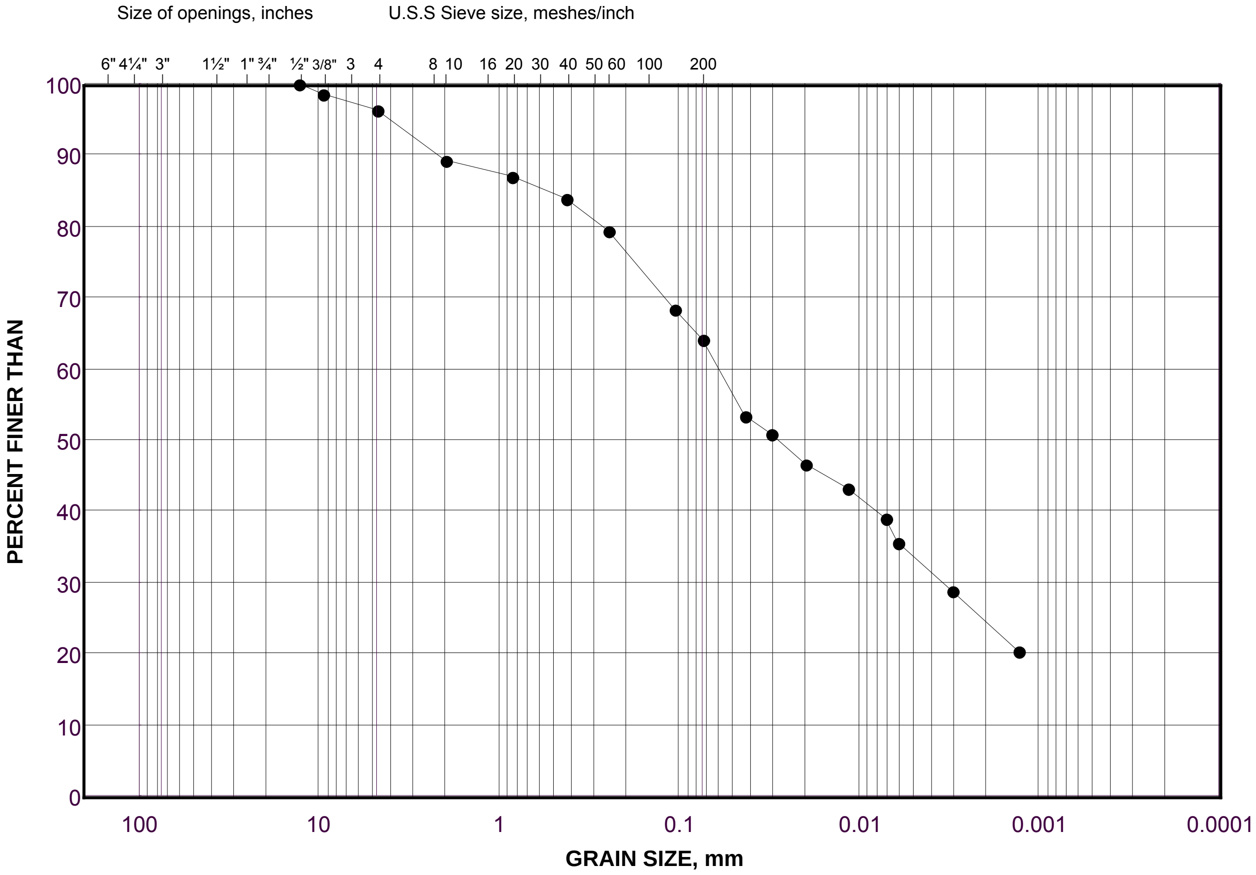
Checked By: ____________________

Golder Associates

Date: 11-Jun-13

GRAIN SIZE DISTRIBUTION

FIGURE A5



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	126	14	15.24 - 15.85

Project Number: 09-1111-6091 (6000)

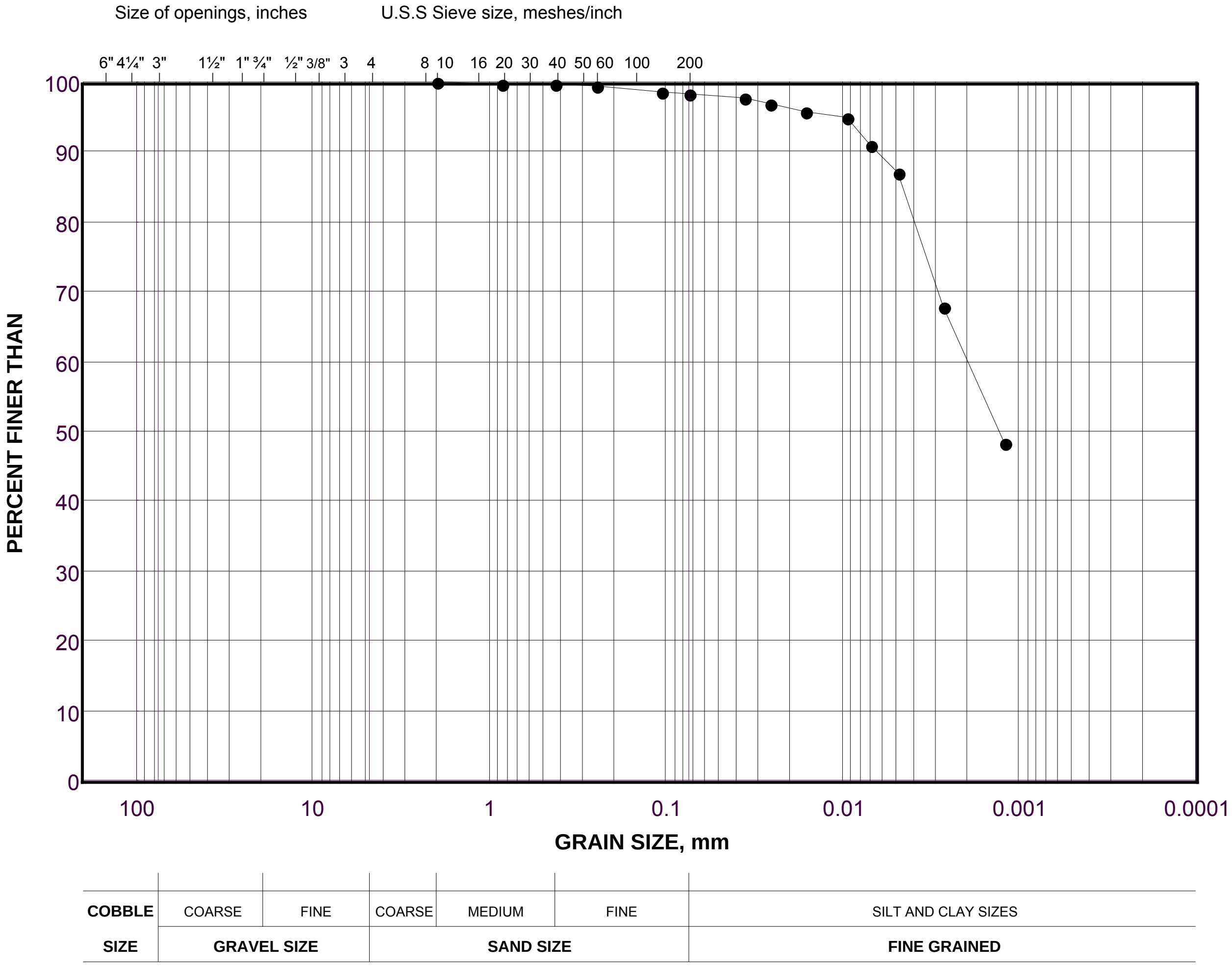
Checked By: ____________________

Golder Associates

Date: 11-Jun-13

GRAIN SIZE DISTRIBUTION

FIGURE A6



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	126	17	19.81 - 20.42

Project Number: 09-1111-6091 (6000)

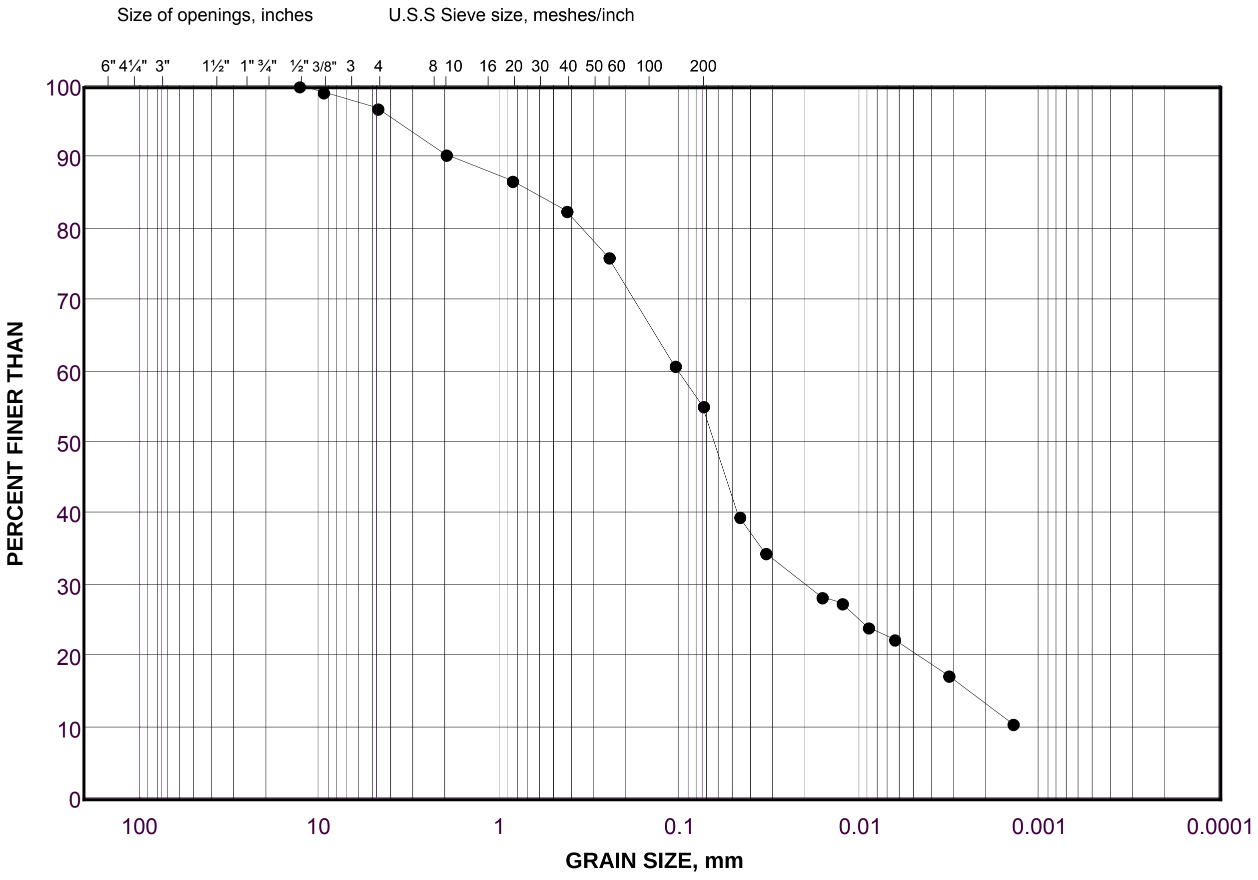
Checked By: ______________________

Golder Associates

Date: 11-Jun-13

GRAIN SIZE DISTRIBUTION

FIGURE A7



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	126	20	24.38 - 24.99

Project Number: 09-1111-6091 (6000)

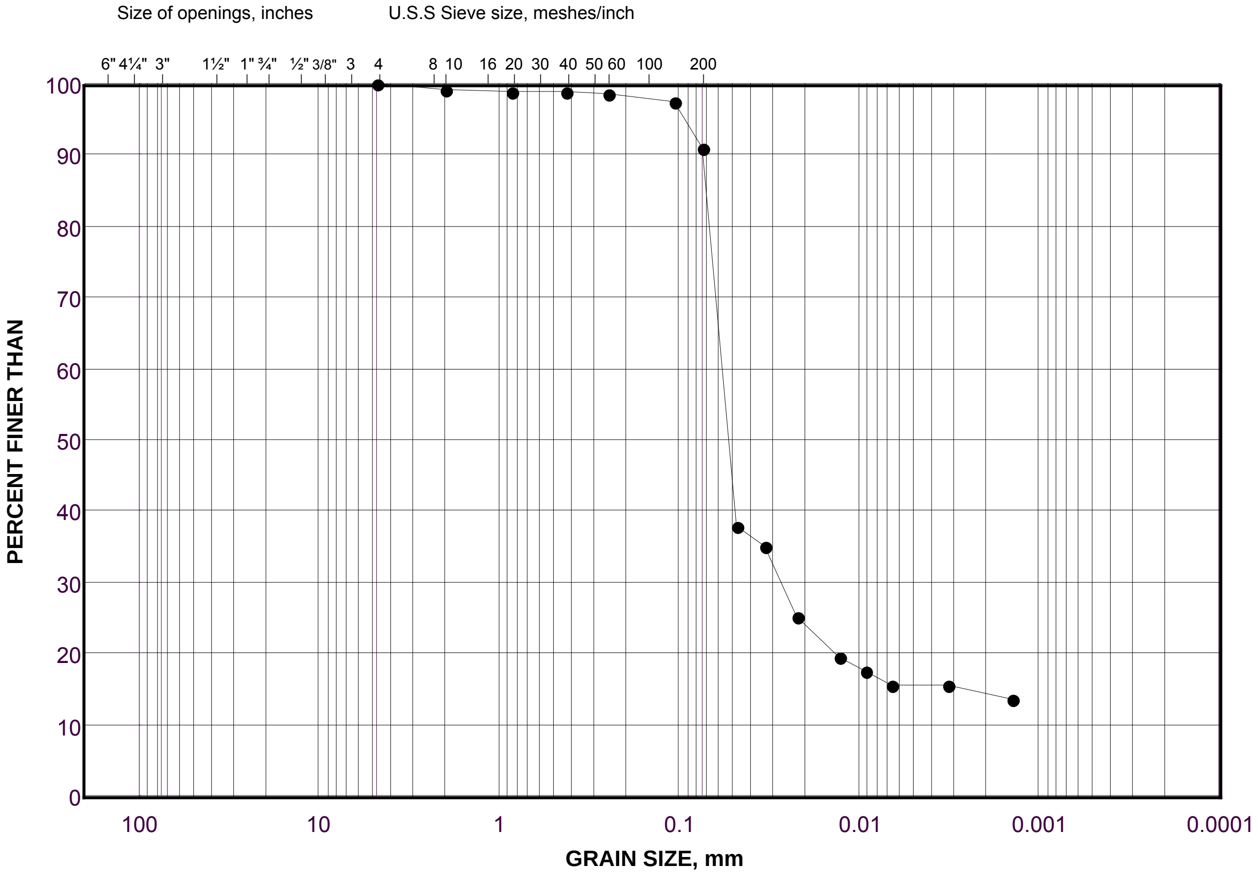
Checked By: ____________________

Golder Associates

Date: 11-Jun-13

GRAIN SIZE DISTRIBUTION

FIGURE A8



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	126	23	28.96 - 29.57

Project Number: 09-1111-6091 (6000)

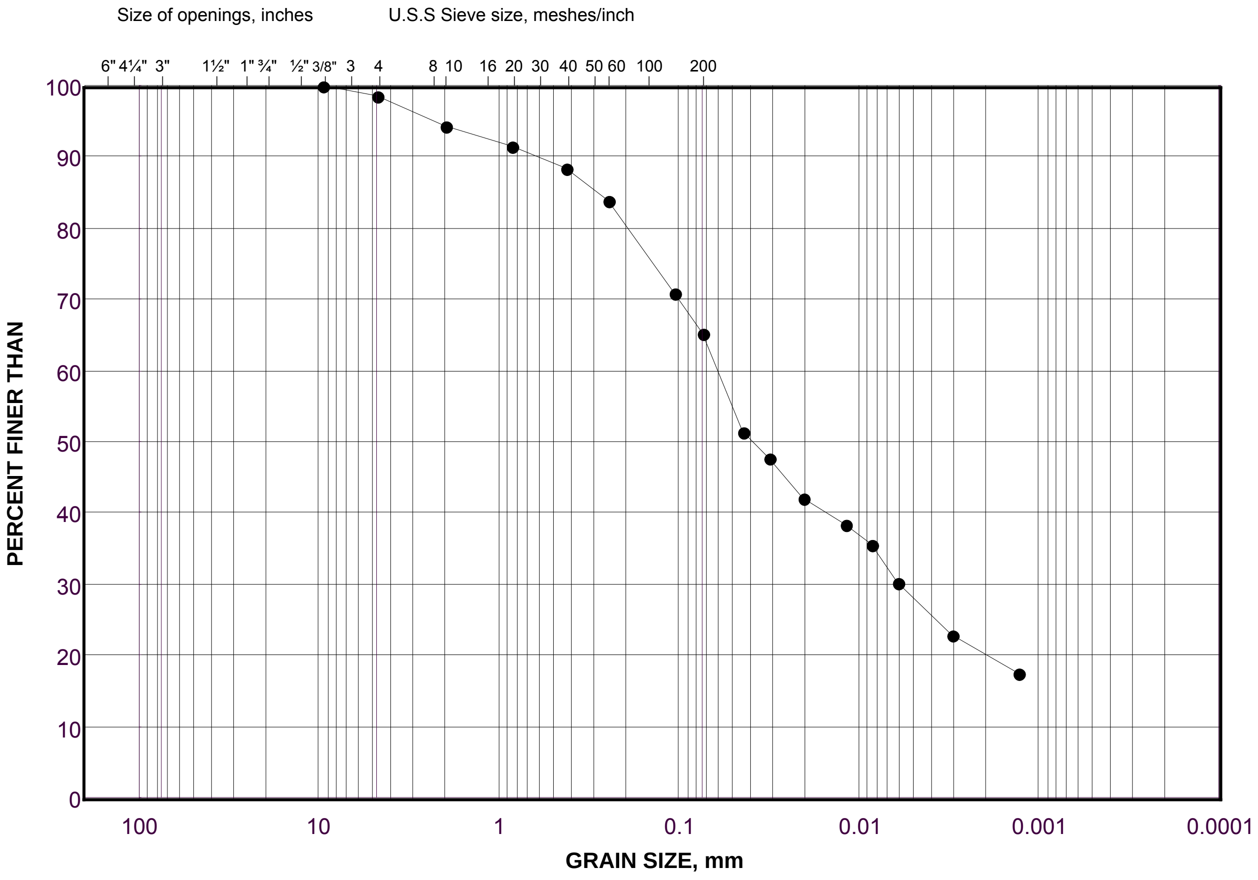
Checked By: ______________________

Golder Associates

Date: 11-Jun-13

GRAIN SIZE DISTRIBUTION

FIGURE A9



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	128	5	3.05 - 3.66

Project Number: 09-1111-6091 (6000)

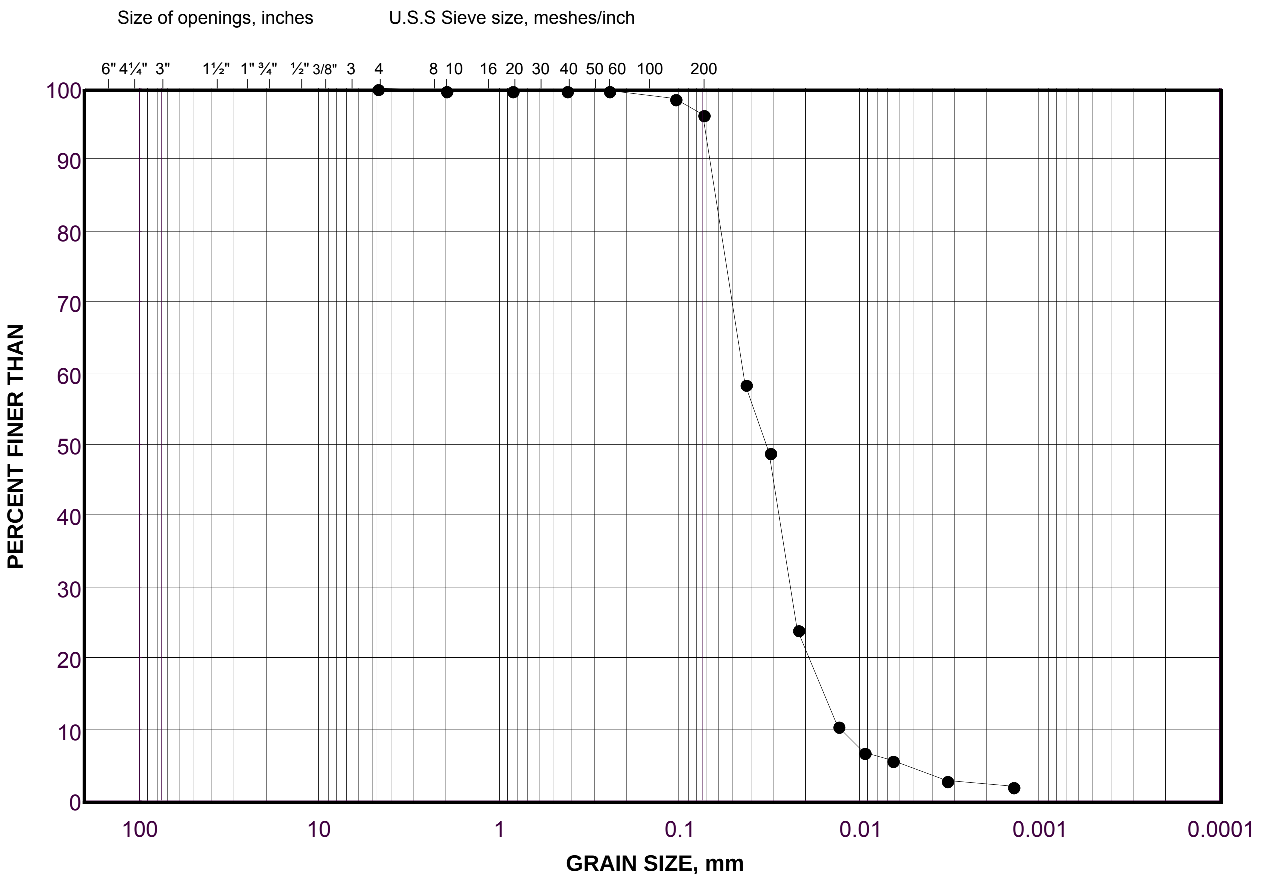
Checked By: ____________________

Golder Associates

Date: 11-Jun-13

GRAIN SIZE DISTRIBUTION

FIGURE A10



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	128	12	12.19 - 12.80

Project Number: 09-1111-6091 (6000)

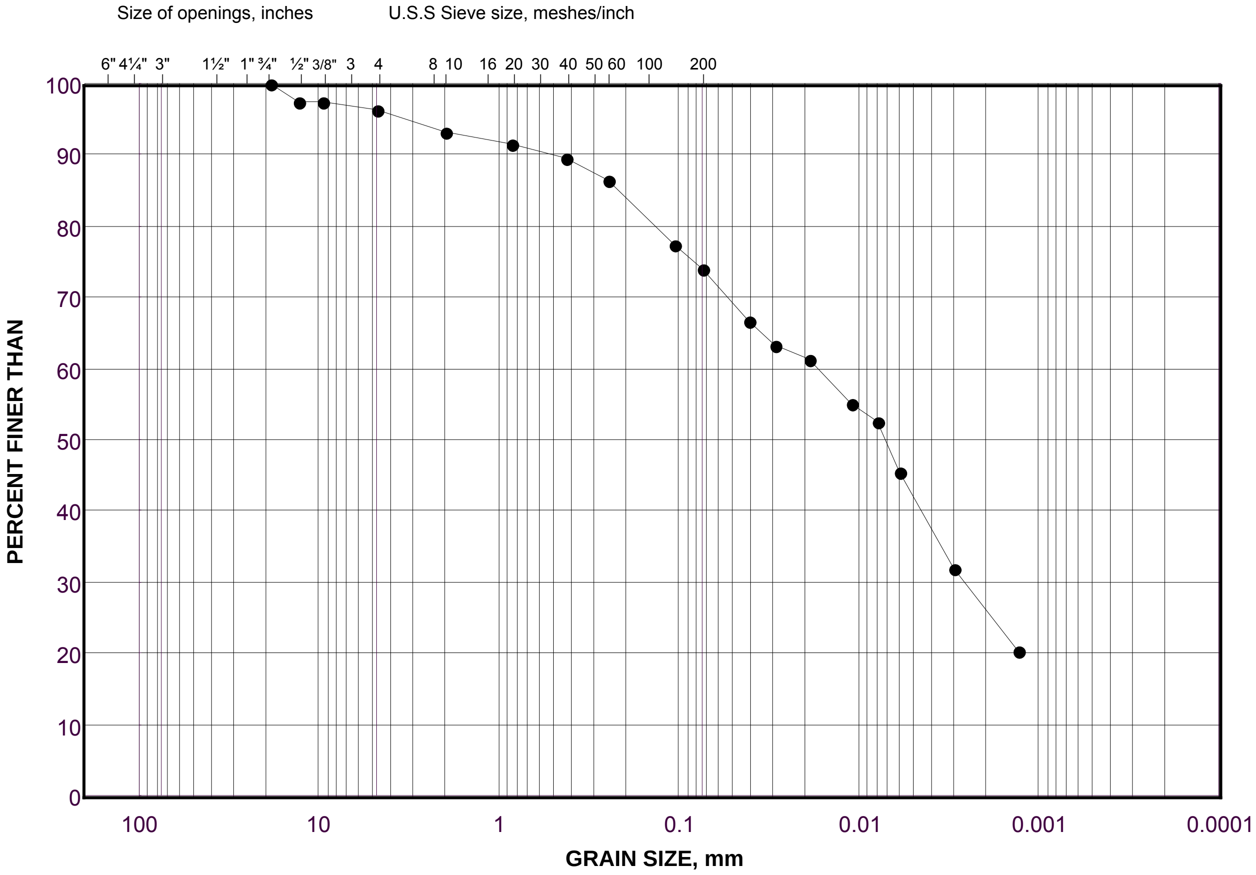
Checked By: ______________________

Golder Associates

Date: 11-Jun-13

GRAIN SIZE DISTRIBUTION

FIGURE A11



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	128	16	18.29 - 18.90

Project Number: 09-1111-6091 (6000)

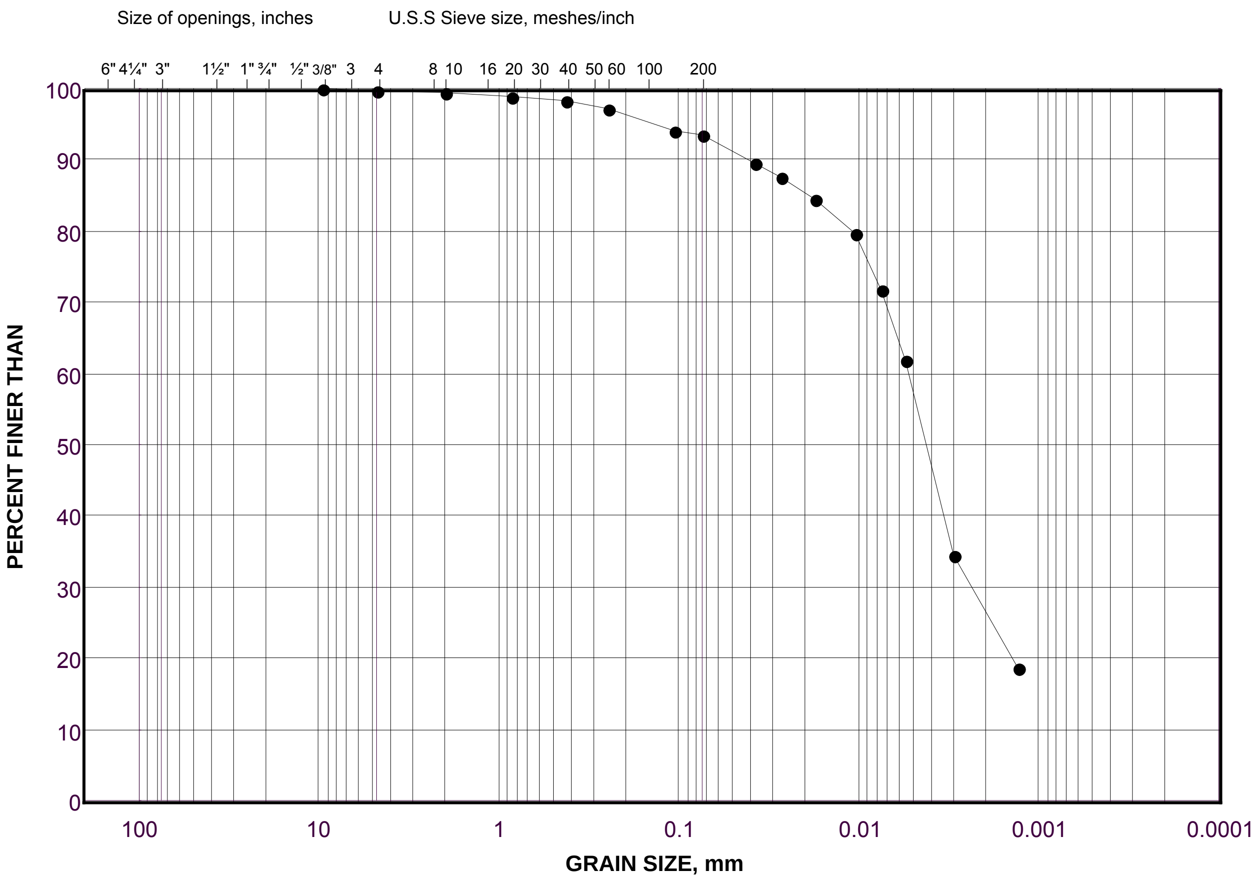
Checked By: ______________________

Golder Associates

Date: 11-Jun-13

GRAIN SIZE DISTRIBUTION

FIGURE A12



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	128	20	24.38 - 24.99

Project Number: 09-1111-6091 (6000)

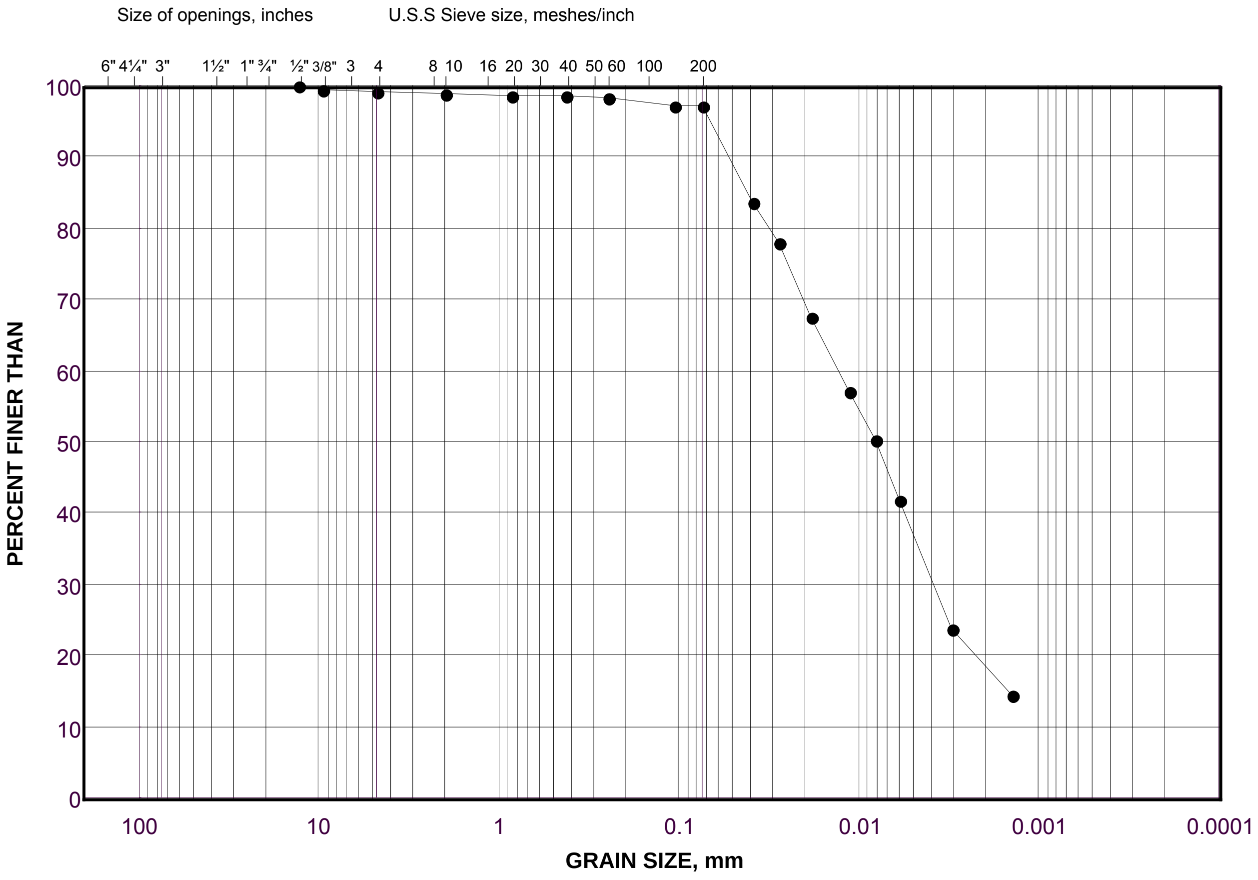
Checked By: ______________________

Golder Associates

Date: 11-Jun-13

GRAIN SIZE DISTRIBUTION

FIGURE A13



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	128	22	27.43 - 28.04

Project Number: 09-1111-6091 (6000)

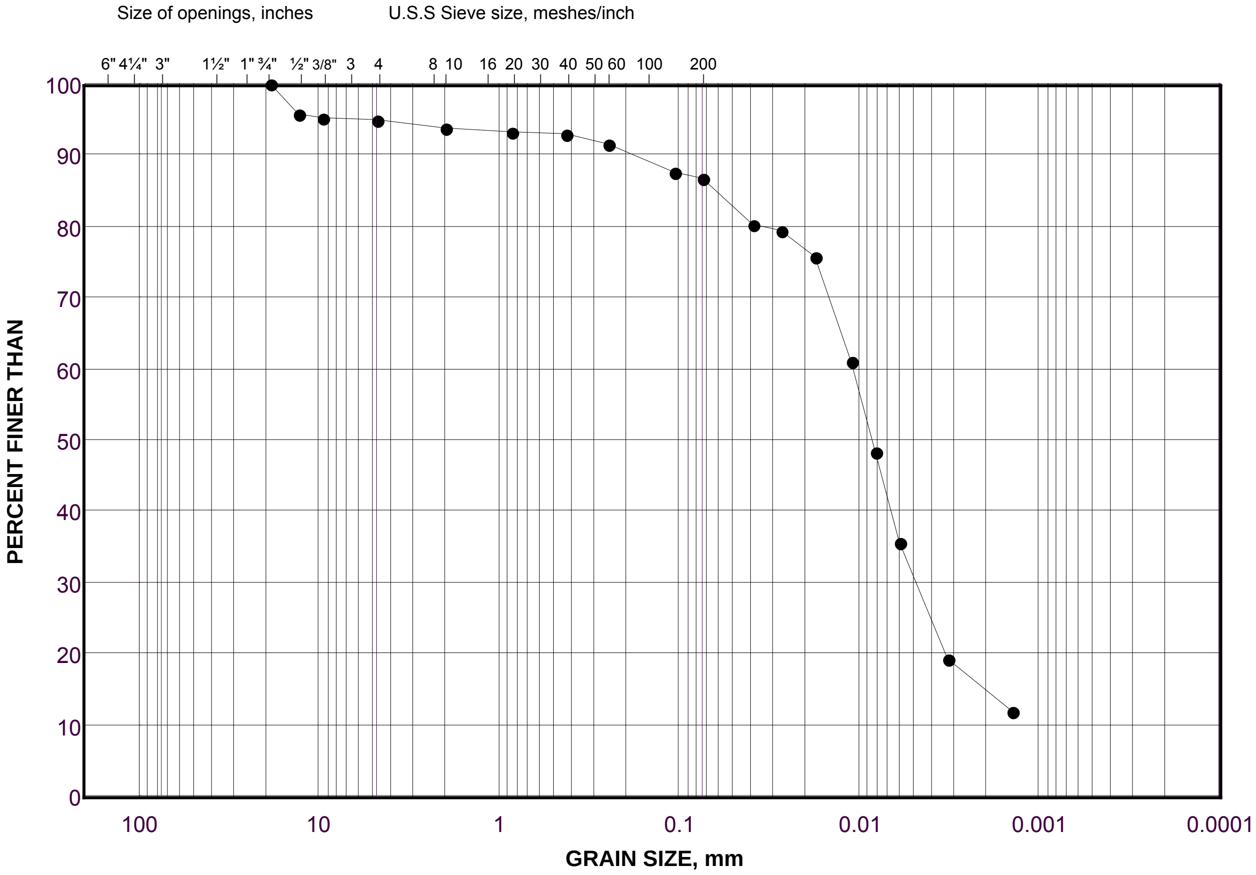
Checked By: ______________________

Golder Associates

Date: 11-Jun-13

GRAIN SIZE DISTRIBUTION

FIGURE A14



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	128	24	30.48 - 31.09

Project Number: 09-1111-6091 (6000)

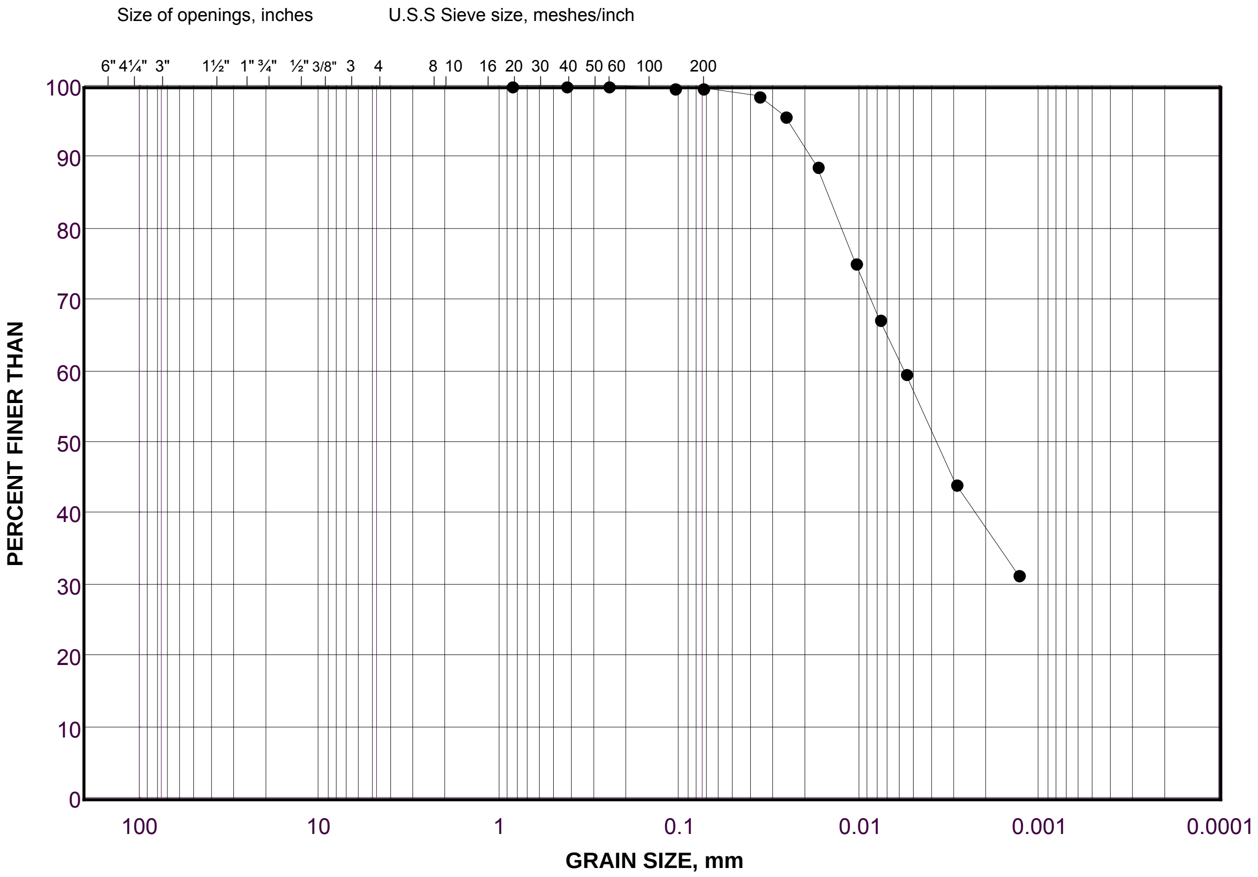
Checked By: ____________________

Golder Associates

Date: 11-Jun-13

GRAIN SIZE DISTRIBUTION

FIGURE A15



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	128	27	35.05 - 35.66

Project Number: 09-1111-6091 (6000)

Checked By: ________________________

Golder Associates

Date: 11-Jun-13

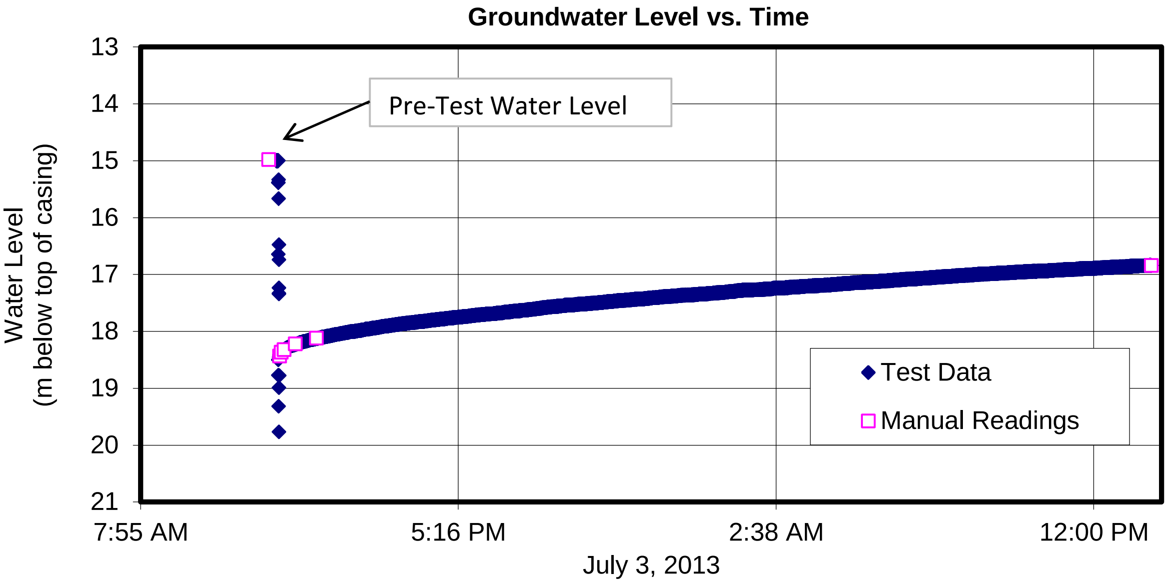
APPENDIX B

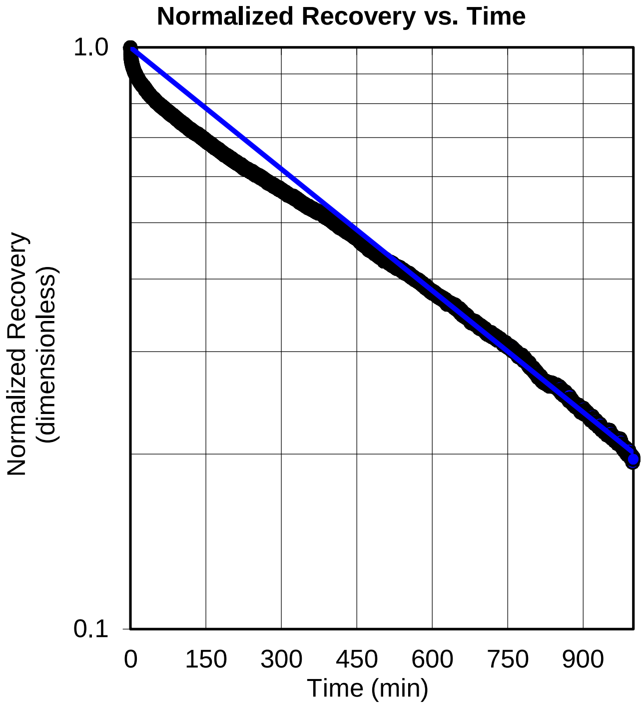
In Situ Permeability Test Results

In-Situ Hydraulic Conductivity Test Report

Borehole BH126 A

FIGURE B1





Sand Pack Interval (below ground surface)

29.7 m to 33.4 m

Time Lag (T_o) = 620 min

Sand Pack Length (L) = 3.65 m

Well Radius (r) = 0.025 m

Hole Radius (R) = 0.055 m

Soil Type

Sandy Silt

Hvorslev Analysis

Hydraulic Conductivity (K) = $\frac{(r^2)\ \ln(^L/_R)}{2T_0L}$ = **< 1.E-06 cm/s**

DATE: July 2013

PROJECT: 09-1111-6091

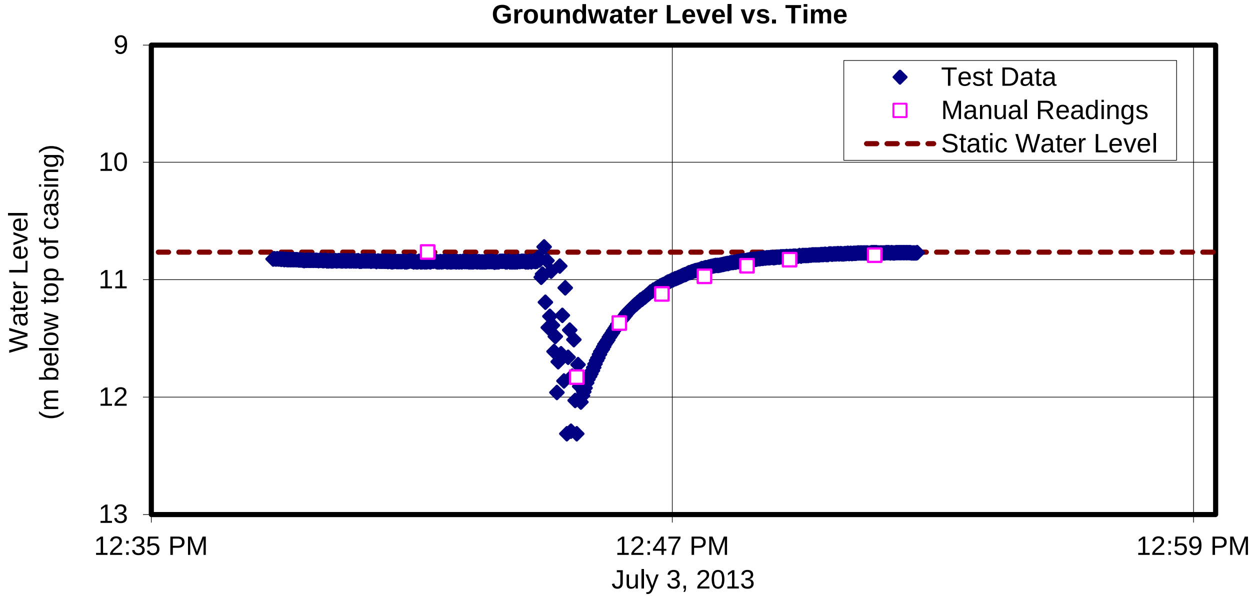
DESIGN: JB

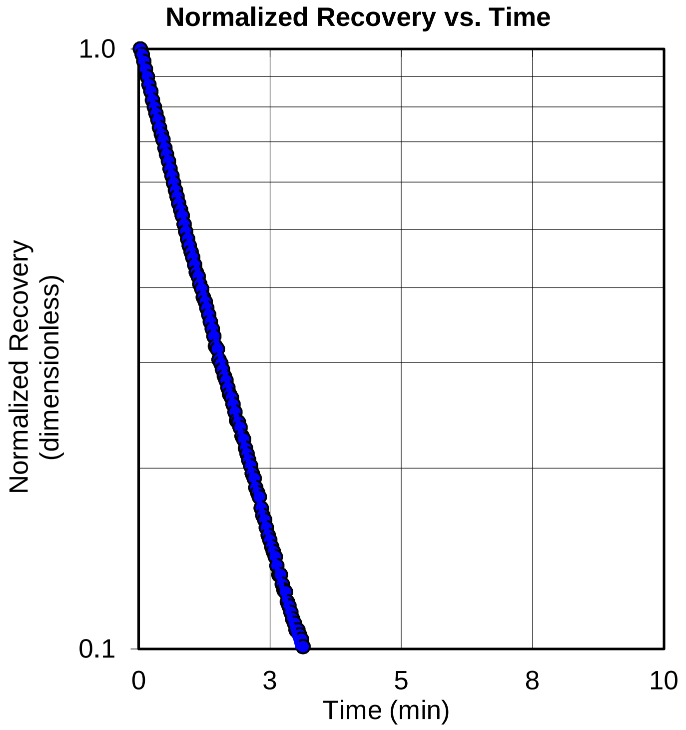
CHECK: SMD

In-Situ Hydraulic Conductivity Test Report

Borehole BH126 B

FIGURE B2





Sand Pack Interval (below ground surface)

10.7 m to 14.3 m

Time Lag (T_o) = 1.3 min

Sand Pack Length (L) = 3.65 m

Well Radius (r) = 0.025 m

Hole Radius (R) = 0.055 m

Soil Type

Sandy Silt

Hvorslev Analysis

Hydraulic Conductivity (K) = $\frac{(r^2)\ln({}^{L}/_{R})}{2T_0L}$ = **5.E-04 cm/s**

DATE: July 2013

PROJECT: 09-1111-6091

Golder Associates

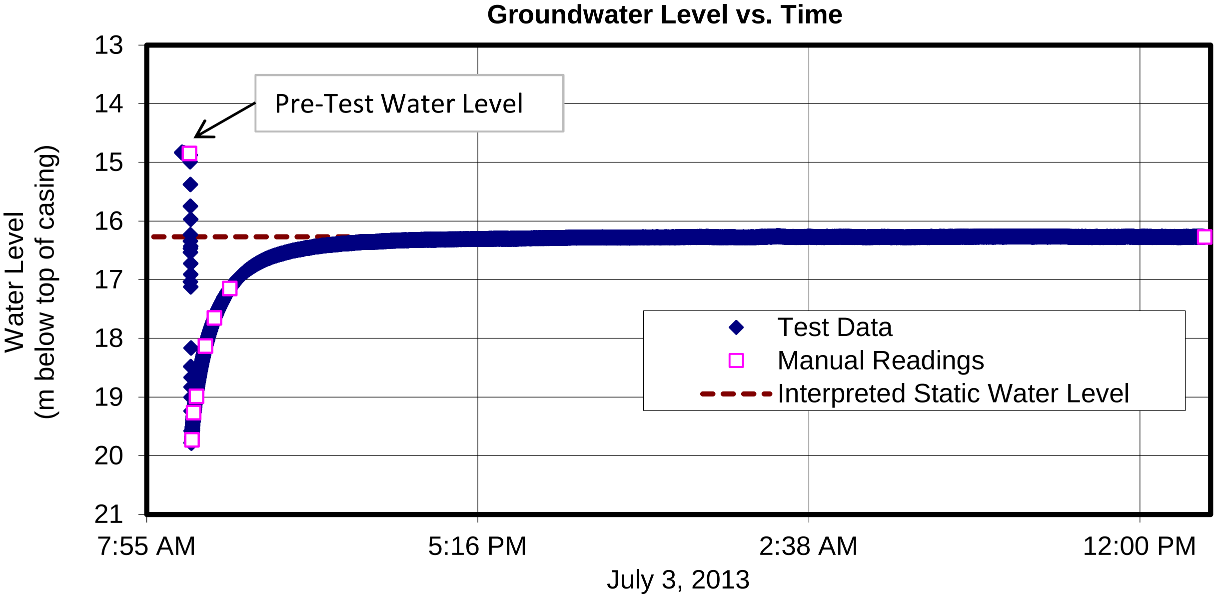
DESIGN: JB

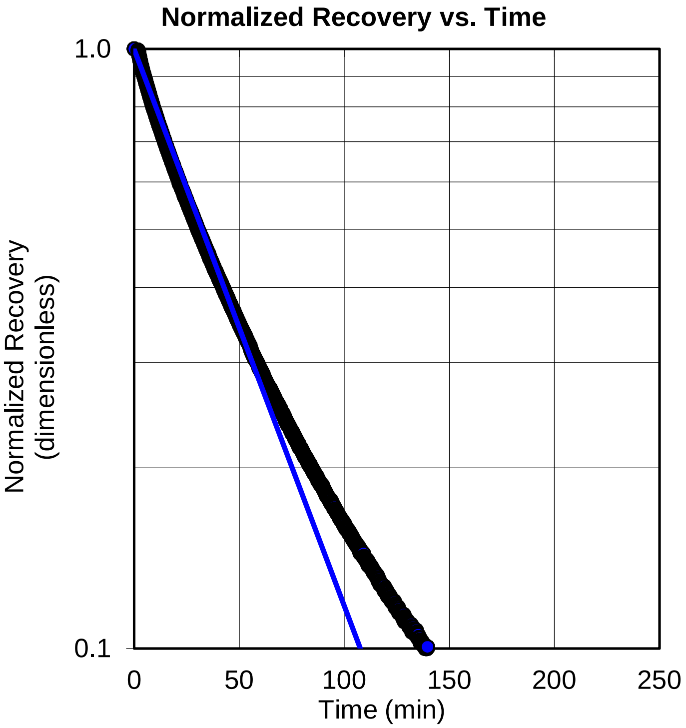
CHECK: SMD

In-Situ Hydraulic Conductivity Test Report

Borehole BH128 A

FIGURE B3





Sand Pack Interval (below ground surface)

31.1 m to 34.8 m

Time Lag (T_o) = 46.5 min

Sand Pack Length (L) = 3.65 m

Well Radius (r) = 0.025 m

Hole Radius (R) = 0.055 m

Soil Type

Silty Clay

Hvorslev Analysis

Hydraulic Conductivity (K) = $\frac{(r^2)\ln(^{L}/_{R})}{2T_0L}$ = **1.E-05 cm/s**

DATE: July 2013

PROJECT: 09-1111-6091

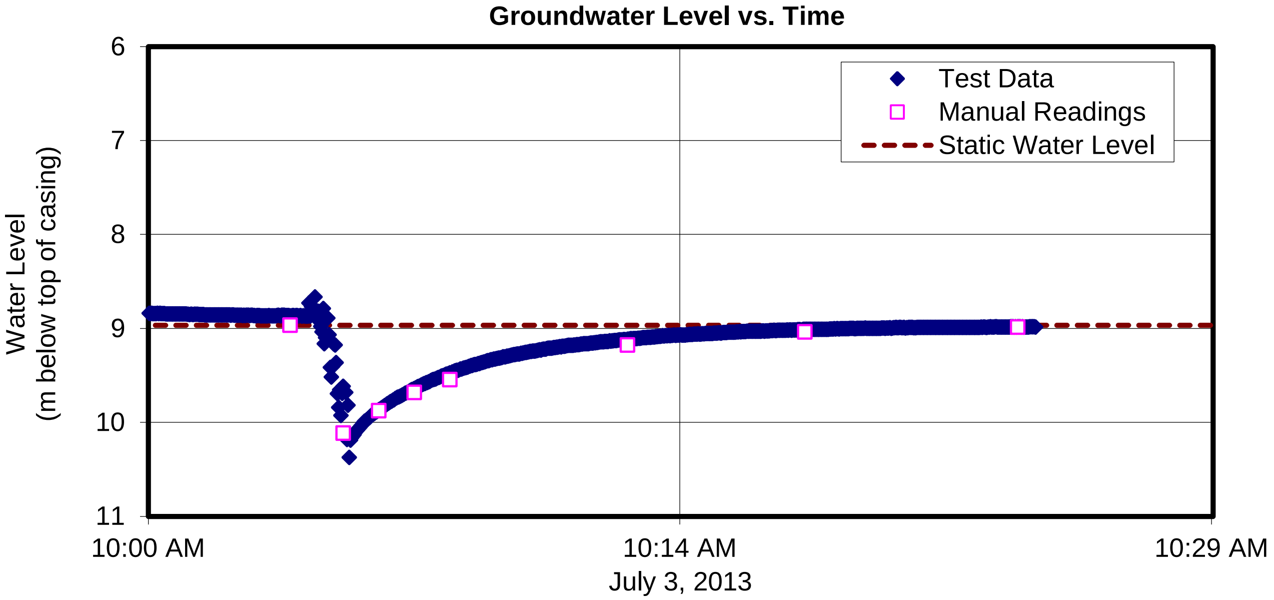
DESIGN: JB

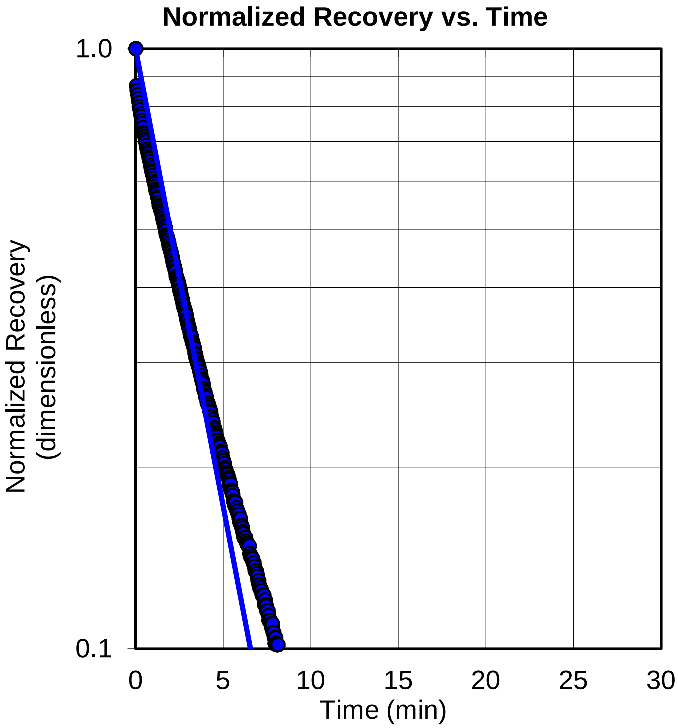
CHECK: SMD

In-Situ Hydraulic Conductivity Test Report

Borehole BH128 B

FIGURE B4





Sand Pack Interval (below ground surface)

9.4 m to 13.3 m

Time Lag (T_o) = 2.8 min

Sand Pack Length (L) = 3.9 m

Well Radius (r) = 0.025 m

Hole Radius (R) = 0.055 m

Soil Type

Silt and Fine Sand

Hvorslev Analysis

$$\textbf{Hydraulic Conductivity (K)} = \frac{(r^2)\ \ln(^L/_R)}{2T_0L} = \mathbf{2.E\text{-}04\ \ cm/s}$$

DATE: July 2013

PROJECT: 09-1111-6091

Golder Associates

DESIGN: JB

CHECK: SMD

APPENDIX C

Water Quality Test Results (Certificates of Analysis - Maxxam Analytical)

Maxxam

Success Through Science®

Your Project #: 09-1111-6091
Site#: 09-1111-6091
Your C.O.C. #: 43784401, 437844-01-01

Attention: Reza Lackpour
Golder Associates Ltd
140 Renfrew Dr
Suite 110
Markham, ON
L3R 6B3

Report Date: 2013/10/02

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B3G2546
Received: 2013/09/25, 12:25

Sample Matrix: Water
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Alkalinity	2	N/A	2013/09/27	CAM SOP-00448	SM 2320B
Carbonate, Bicarbonate and Hydroxide	1	N/A	2013/09/27	CAM SOP-00102	APHA 4500-CO2 D
Carbonate, Bicarbonate and Hydroxide	1	N/A	2013/09/30	CAM SOP-00102	APHA 4500-CO2 D
Chloride by Automated Colourimetry	2	N/A	2013/09/27	CAM SOP-00463	EPA 325.2
Conductivity	2	N/A	2013/09/27	CAM SOP-00414	SM 2510
Dissolved Organic Carbon (DOC)	2	N/A	2013/09/26	CAM SOP-00446	SM 5310 B
Hardness (calculated as CaCO3)	2	N/A	2013/10/02	CAM SOP 00102	SM 2340 B
Dissolved Metals by ICPMS	2	N/A	2013/10/01	CAM SOP-00447	EPA 6020
Ion Balance (% Difference)	2	N/A	2013/10/02		
Anion and Cation Sum	2	N/A	2013/10/02		
Total Ammonia-N	2	N/A	2013/10/02	CAM SOP-00441	US GS I-2522-90
Nitrate (NO3) and Nitrite (NO2) in Water (1)	2	N/A	2013/09/27	CAM SOP-00440	SM 4500 NO3I/NO2B
pH	2	N/A	2013/09/27	CAM SOP-00413	SM 4500H+ B
Orthophosphate	2	N/A	2013/09/27	CAM SOP-00461	EPA 365.1
Sat. pH and Langelier Index (@ 20C)	2	N/A	2013/10/02		
Sat. pH and Langelier Index (@ 4C)	2	N/A	2013/10/02		
Sulphate by Automated Colourimetry	2	N/A	2013/09/27	CAM SOP-00464	EPA 375.4
Total Dissolved Solids (TDS calc)	2	N/A	2013/10/02		

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

(1) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Antonella Brasil, Project Manager
Email: ABrasil@maxxam.ca
Phone# (905) 817-5817

==

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.

Total cover pages: 1

RESULTS OF ANALYSES OF WATER

Maxxam ID		TF2054		TF2055		
Sampling Date		2013/09/25 09:30		2013/09/25 10:30		
	Units	**BH128A**	**QC Batch**	**BH126B**	**RDL**	**QC Batch**
Calculated Parameters						
Anion Sum	me/L	4.11	3361956	9.44	N/A	3361956
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	180	3363338	190	1.0	3363338
Calculated TDS	mg/L	220	3361959	540	1.0	3361959
Carb. Alkalinity (calc. as CaCO3)	mg/L	2.6	3363338	1.9	1.0	3363338
Cation Sum	me/L	4.01	3361956	9.21	N/A	3361956
Hardness (CaCO3)	mg/L	110	3362918	300	1.0	3362918
Ion Balance (% Difference)	%	1.26	3361955	1.26	N/A	3361955
Langelier Index (@ 20C)	N/A	0.437	3361957	0.819		3361957
Langelier Index (@ 4C)	N/A	0.187	3361958	0.571		3361958
Saturation pH (@ 20C)	N/A	7.75	3361957	7.22		3361957
Saturation pH (@ 4C)	N/A	8.00	3361958	7.47		3361958
Inorganics						
Total Ammonia-N	mg/L	0.93	3366236	0.16	0.050	3366236
Conductivity	umho/cm	390	3365238	970	1.0	3364341
Dissolved Organic Carbon	mg/L	2.2	3364536	1.1	0.20	3364162
Orthophosphate (P)	mg/L	0.013	3365249	<0.010	0.010	3365249
pH	pH	8.19	3365239	8.04		3364340
Dissolved Sulphate (SO4)	mg/L	8	3365250	110	1	3365250
Alkalinity (Total as CaCO3)	mg/L	180	3365237	190	1.0	3364335
Dissolved Chloride (Cl)	mg/L	10	3365248	120	1	3365248
Nitrite (N)	mg/L	<0.010	3365230	<0.010	0.010	3365728
Nitrate (N)	mg/L	<0.10	3365230	0.83	0.10	3365728
Nitrate + Nitrite	mg/L	<0.10	3365230	0.83	0.10	3365728

N/A = Not Applicable
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		TF2054	TF2055		
Sampling Date		2013/09/25 09:30	2013/09/25 10:30		
	Units	**BH128A**	**BH126B**	**RDL**	**QC Batch**
Metals					
Dissolved Aluminum (Al)	ug/L	98	41	5.0	3369883
Dissolved Antimony (Sb)	ug/L	0.77	<0.50	0.50	3369883
Dissolved Arsenic (As)	ug/L	10	<1.0	1.0	3369883
Dissolved Barium (Ba)	ug/L	96	96	2.0	3369883
Dissolved Beryllium (Be)	ug/L	<0.50	<0.50	0.50	3369883
Dissolved Boron (B)	ug/L	170	50	10	3369883
Dissolved Cadmium (Cd)	ug/L	<0.10	<0.10	0.10	3369883
Dissolved Calcium (Ca)	ug/L	24000	94000	200	3369883
Dissolved Chromium (Cr)	ug/L	<5.0	<5.0	5.0	3369883
Dissolved Cobalt (Co)	ug/L	9.3	1.5	0.50	3369883
Dissolved Copper (Cu)	ug/L	<1.0	<1.0	1.0	3369883
Dissolved Iron (Fe)	ug/L	<100	<100	100	3369883
Dissolved Lead (Pb)	ug/L	<0.50	<0.50	0.50	3369883
Dissolved Magnesium (Mg)	ug/L	13000	16000	50	3369883
Dissolved Manganese (Mn)	ug/L	40	27	2.0	3369883
Dissolved Molybdenum (Mo)	ug/L	8.7	1.3	0.50	3369883
Dissolved Nickel (Ni)	ug/L	1.9	<1.0	1.0	3369883
Dissolved Phosphorus (P)	ug/L	<100	<100	100	3369883
Dissolved Potassium (K)	ug/L	1300	1700	200	3369883
Dissolved Selenium (Se)	ug/L	<2.0	<2.0	2.0	3369883
Dissolved Silicon (Si)	ug/L	6600	5900	50	3369883
Dissolved Silver (Ag)	ug/L	0.17	0.19	0.10	3369883
Dissolved Sodium (Na)	ug/L	38000	72000	100	3369883
Dissolved Strontium (Sr)	ug/L	410	220	1.0	3369883
Dissolved Thallium (Tl)	ug/L	<0.050	<0.050	0.050	3369883
Dissolved Titanium (Ti)	ug/L	5.5	<5.0	5.0	3369883
Dissolved Uranium (U)	ug/L	1.9	1.2	0.10	3369883
Dissolved Vanadium (V)	ug/L	3.9	1.2	0.50	3369883
Dissolved Zinc (Zn)	ug/L	<5.0	<5.0	5.0	3369883

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Test Summary

Maxxam ID TF2054
Sample ID BH128A
Matrix Water

Collected 2013/09/25
Shipped
Received 2013/09/25

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	3365237	N/A	2013/09/27	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	3363338	N/A	2013/09/30	Automated Statchk
Chloride by Automated Colourimetry	AC	3365248	N/A	2013/09/27	Alina Dobreanu
Conductivity	COND	3365238	N/A	2013/09/27	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	3364536	N/A	2013/09/26	Anastasia Hamanov
Hardness (calculated as CaCO3)		3362918	N/A	2013/10/02	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	3369883	N/A	2013/10/01	Prempal Bhatti
Ion Balance (% Difference)	CALC	3361955	N/A	2013/10/02	Automated Statchk
Anion and Cation Sum	CALC	3361956	N/A	2013/10/02	Automated Statchk
Total Ammonia-N	LACH/NH4	3366236	N/A	2013/10/02	Anastasia Hamanov
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	3365230	N/A	2013/09/27	Sandeep Singh
pH	PH	3365239	N/A	2013/09/27	Surinder Rai
Orthophosphate	AC	3365249	N/A	2013/09/27	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	3361957	N/A	2013/10/02	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	3361958	N/A	2013/10/02	Automated Statchk
Sulphate by Automated Colourimetry	AC	3365250	N/A	2013/09/27	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	3361959	N/A	2013/10/02	Automated Statchk

Maxxam ID TF2055
Sample ID BH126B
Matrix Water

Collected 2013/09/25
Shipped
Received 2013/09/25

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	3364335	N/A	2013/09/27	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	3363338	N/A	2013/09/27	Automated Statchk
Chloride by Automated Colourimetry	AC	3365248	N/A	2013/09/27	Alina Dobreanu
Conductivity	COND	3364341	N/A	2013/09/27	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	3364162	N/A	2013/09/26	Anastasia Hamanov
Hardness (calculated as CaCO3)		3362918	N/A	2013/10/02	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	3369883	N/A	2013/10/01	Prempal Bhatti
Ion Balance (% Difference)	CALC	3361955	N/A	2013/10/02	Automated Statchk
Anion and Cation Sum	CALC	3361956	N/A	2013/10/02	Automated Statchk
Total Ammonia-N	LACH/NH4	3366236	N/A	2013/10/02	Anastasia Hamanov

Test Summary

Nitrate (NO3) and Nitrite (NO2) in Water	LACH	3365728	N/A	2013/09/27	Sandeep Singh
pH	PH	3364340	N/A	2013/09/27	Surinder Rai
Orthophosphate	AC	3365249	N/A	2013/09/27	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	3361957	N/A	2013/10/02	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	3361958	N/A	2013/10/02	Automated Statchk
Sulphate by Automated Colourimetry	AC	3365250	N/A	2013/09/27	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	3361959	N/A	2013/10/02	Automated Statchk

Package 1	6.3°C

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

GENERAL COMMENTS

Sample TF2054-01: DOC and Ammonia: Sample(s) were submitted with sediment levels >1cm. Analysis performed with client's consent.

Sample TF2055-01: DOC, Ammonia, Alkalinity, Chloride, Conductivity, Nitrite/Nitrate, pH, Phosphate, Sulphate: Sample(s) were submitted with sediment levels >1cm. Analysis performed with client's consent.

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
3364162	Dissolved Organic Carbon	2013/09/26	102	80 - 120	101	80 - 120	<0.20	mg/L	NC	20		
3364335	Alkalinity (Total as CaCO3)	2013/09/27					<1.0	mg/L	1.1	25	94	85 - 115
3364341	Conductivity	2013/09/27			101	85 - 115	<1.0	umho/cm	0.1	25		
3364536	Dissolved Organic Carbon	2013/09/26	101	80 - 120	100	80 - 120	<0.20	mg/L	NC	20		
3365230	Nitrite (N)	2013/09/27	101	80 - 120	99	85 - 115	<0.010	mg/L	NC	25		
3365230	Nitrate (N)	2013/09/27	NC	80 - 120	98	85 - 115	<0.10	mg/L	4.0	25		
3365237	Alkalinity (Total as CaCO3)	2013/09/27					<1.0	mg/L	0.9	25	96	85 - 115
3365238	Conductivity	2013/09/27			101	85 - 115	<1.0	umho/cm	0.3	25		
3365248	Dissolved Chloride (Cl)	2013/09/27	NC	80 - 120	103	80 - 120	<1	mg/L	0.2	20		
3365249	Orthophosphate (P)	2013/09/27	111	75 - 125	98	80 - 120	<0.010	mg/L	NC	25		
3365250	Dissolved Sulphate (SO4)	2013/09/27	NC	75 - 125	103	80 - 120	<1	mg/L	0.2	20		
3365728	Nitrite (N)	2013/09/27	101	80 - 120	104	85 - 115	<0.010	mg/L	NC	25		
3365728	Nitrate (N)	2013/09/27	102	80 - 120	105	85 - 115	<0.10	mg/L	NC	25		
3366236	Total Ammonia-N	2013/10/02	104	80 - 120	104	85 - 115	<0.050	mg/L	NC	20		
3369883	Dissolved Aluminum (Al)	2013/10/01	106	80 - 120	99	80 - 120	<5.0	ug/L				
3369883	Dissolved Antimony (Sb)	2013/10/01	109	80 - 120	98	80 - 120	<0.50	ug/L				
3369883	Dissolved Arsenic (As)	2013/10/01	103	80 - 120	96	80 - 120	<1.0	ug/L				
3369883	Dissolved Barium (Ba)	2013/10/01	NC	80 - 120	98	80 - 120	<2.0	ug/L				
3369883	Dissolved Beryllium (Be)	2013/10/01	105	80 - 120	101	80 - 120	<0.50	ug/L				
3369883	Dissolved Boron (B)	2013/10/01	106	80 - 120	105	80 - 120	<10	ug/L				
3369883	Dissolved Cadmium (Cd)	2013/10/01	103	80 - 120	99	80 - 120	<0.10	ug/L				
3369883	Dissolved Calcium (Ca)	2013/10/01	NC	80 - 120	98	80 - 120	<200	ug/L				
3369883	Dissolved Chromium (Cr)	2013/10/01	101	80 - 120	96	80 - 120	<5.0	ug/L				
3369883	Dissolved Cobalt (Co)	2013/10/01	99	80 - 120	96	80 - 120	<0.50	ug/L				
3369883	Dissolved Copper (Cu)	2013/10/01	92	80 - 120	96	80 - 120	<1.0	ug/L				
3369883	Dissolved Iron (Fe)	2013/10/01	98	80 - 120	95	80 - 120	<100	ug/L				
3369883	Dissolved Lead (Pb)	2013/10/01	95	80 - 120	97	80 - 120	<0.50	ug/L	NC	20		
3369883	Dissolved Magnesium (Mg)	2013/10/01	NC	80 - 120	98	80 - 120	77, RDL=50	ug/L				
3369883	Dissolved Manganese (Mn)	2013/10/01	NC	80 - 120	98	80 - 120	<2.0	ug/L				
3369883	Dissolved Molybdenum (Mo)	2013/10/01	110	80 - 120	97	80 - 120	<0.50	ug/L				
3369883	Dissolved Nickel (Ni)	2013/10/01	94	80 - 120	95	80 - 120	<1.0	ug/L				
3369883	Dissolved Phosphorus (P)	2013/10/01	104	80 - 120	95	80 - 120	<100	ug/L				
3369883	Dissolved Potassium (K)	2013/10/01	104	80 - 120	97	80 - 120	<200	ug/L				
3369883	Dissolved Selenium (Se)	2013/10/01	87	80 - 120	98	80 - 120	<2.0	ug/L				
3369883	Dissolved Silicon (Si)	2013/10/01	NC	80 - 120	98	80 - 120	<50	ug/L				
3369883	Dissolved Silver (Ag)	2013/10/01	72 (1)	80 - 120	95	80 - 120	0.11, RDL=0.10	ug/L				
3369883	Dissolved Sodium (Na)	2013/10/01	NC	80 - 120	99	80 - 120	<100	ug/L				
3369883	Dissolved Strontium (Sr)	2013/10/01	NC	80 - 120	99	80 - 120	<1.0	ug/L				
3369883	Dissolved Thallium (Tl)	2013/10/01	95	80 - 120	98	80 - 120	<0.050	ug/L				
3369883	Dissolved Titanium (Ti)	2013/10/01	105	80 - 120	94	80 - 120	<5.0	ug/L				

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
3369883	Dissolved Uranium (U)	2013/10/01	100	80 - 120	98	80 - 120	<0.10	ug/L				
3369883	Dissolved Vanadium (V)	2013/10/01	105	80 - 120	97	80 - 120	<0.50	ug/L				
3369883	Dissolved Zinc (Zn)	2013/10/01	93	80 - 120	97	80 - 120	<5.0	ug/L				

N/A = Not Applicable

RDL = Reportable Detection Limit

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

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

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

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 not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

Validation Signature Page

Maxxam Job #: B3G2546

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

Cristina Carriere

Cristina Carriere, Scientific Services

==

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

IMMEDIATE TEST

Maxxam Analytics International Corporation o/a Maxxam Analytics
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5779 www.maxxam.ca

CHAIN OF CUSTODY RECORD

Page 1 of 1

INVOICE INFORMATION:

Company Name: #1326 Golder Associates Ltd
Contact Name: ~~Steve~~ ~~Josip Balaban~~ Central Accounting
Address: 6925 Century Ave Suite 100 1111
Mississauga ON L5N 7K2
Phone: (905)567-4444 Fax: (905)567-6561
Email: Maxxam@golder.com, jennifer_lee@golder.com

REPORT INFORMATION (if differs from invoice):

Company Name: Golder Associates
Contact Name: Reza Lackpour
Address: 140 Renfew Drive, Suite 110
Markham
Phone: 905 475 2625 Ext: 6049 Fax:
Email: reza_lackpour@golder.com

PROJECT INFORMATION:

Quotation #: B24075
P.O. #:
Project #: 09-1111-6091
Project Name:
Site #:
Sampled By: JB

Laboratory Use Only:

MAXXAM JOB #:
BOTTLE ORDER #: 437844
CHAIN OF CUSTODY #: C#437844-01-01
PROJECT MANAGER: Antonella Brasil

Regulation 153 (2011)

☐ Table 1 ☐ Res/Park ☐ Medium/Fine
☐ Table 2 ☐ Ind/Comm ☐ Coarse
☐ Table 3 ☐ Agri/Other ☐ For RSC
☐ Table ___

Other Regulations

☐ CCME ☐ Sanitary Sewer Bylaw
☐ Reg. 558 ☐ Storm Sewer Bylaw
☐ MISA Municipality ______
☐ PWQO
☐ Other ______

SPECIAL INSTRUCTIONS

Include Criteria on Certificate of Analysis (Y/N)? ___

Note: For MOE regulated drinking water samples - please use the Drinking Water Chain of Custody Form

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

ANALYSIS REQUESTED (Please be specific)

25-Sep-13 12:25
Antonella Brasil
B3G2546
NNA ENV-634

TURNAROUND TIME (TAT) REQUIRED:

PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS

Regular (Standard) TAT: ☑
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details

Job Specific Rush TAT (if applies to entire submission)
Date Required: ______ Time Required: ______ ☐
Rush Confirmation Number: ______ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Regulated Drinking Water ? (Y / N)	Metals Field Filtered ? (Y / N)	RCAp - Comprehensive										# of Bottles	Comments
1		BH128A	Sept 25/13	9:30	GW	N	Y	✓										4	
2		BH126B	Sept 25/13	10:30	GW	N	Y	✓										4	
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			

*RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time:	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time:	# Jars Used and Not Submitted
J. Balaban	13/09/25	12:25	CHRISTINA KHAWA	2013/09/25	12:25	

Laboratory Use Only

Time Sensitive
Temperature (°C) on Receipt: 6/7/6°C
Custody Seal Present: Yes ☐ No ✓
Intact

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

Your Project #: 09-1111-6091
Site#: 09-1111-6091
Your C.O.C. #: 27204419, 272044-191-01

Attention: Reza Lackpour
Golder Associates Ltd
140 Renfrew Dr
Suite 110
Markham, ON
L3R 6B3

Report Date: 2013/10/07

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B3G6616
Received: 2013/10/01, 13:15

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
1,3-Dichloropropene Sum	1	N/A	2013/10/07	CAM SOP-00226	EPA 8260
Petroleum Hydro. CCME F1 & BTEX in Water	1	N/A	2013/10/05	CAM SOP-00315	CCME CWS
Petroleum Hydrocarbons F2-F4 in Water	1	2013/10/05	2013/10/06	CAM SOP-00316	CCME Hydrocarbons
Polychlorinated Biphenyl in Water	1	2013/10/02	2013/10/03	CAM SOP-00309	SW846 8082
Volatile Organic Compounds in Water	1	N/A	2013/10/04	CAM SOP 00228	EPA 8260 modified

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Antonella Brasil, Project Manager
Email: ABrasil@maxxam.ca
Phone# (905) 817-5817

==
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.

Total cover pages: 1

VOLATILE ORGANICS BY GC/MS (WATER)

Maxxam ID		TH4403		
Sampling Date		2013/09/30 14:55		
	Units	**BH126B**	**RDL**	**QC Batch**
Calculated Parameters				
1,3-Dichloropropene (cis+trans)	ug/L	<0.50	0.50	3371186
Volatile Organics				
Acetone (2-Propanone)	ug/L	<10	10	3372460
Benzene	ug/L	<0.20	0.20	3372460
Bromodichloromethane	ug/L	<0.50	0.50	3372460
Bromoform	ug/L	<1.0	1.0	3372460
Bromomethane	ug/L	<0.50	0.50	3372460
Carbon Tetrachloride	ug/L	<0.20	0.20	3372460
Chlorobenzene	ug/L	<0.20	0.20	3372460
Chloroform	ug/L	<0.20	0.20	3372460
Dibromochloromethane	ug/L	<0.50	0.50	3372460
1,2-Dichlorobenzene	ug/L	<0.50	0.50	3372460
1,3-Dichlorobenzene	ug/L	<0.50	0.50	3372460
1,4-Dichlorobenzene	ug/L	<0.50	0.50	3372460
Dichlorodifluoromethane (FREON 12)	ug/L	<1.0	1.0	3372460
1,1-Dichloroethane	ug/L	<0.20	0.20	3372460
1,2-Dichloroethane	ug/L	<0.50	0.50	3372460
1,1-Dichloroethylene	ug/L	<0.20	0.20	3372460
cis-1,2-Dichloroethylene	ug/L	<0.50	0.50	3372460
trans-1,2-Dichloroethylene	ug/L	<0.50	0.50	3372460
1,2-Dichloropropane	ug/L	<0.20	0.20	3372460
cis-1,3-Dichloropropene	ug/L	<0.30	0.30	3372460
trans-1,3-Dichloropropene	ug/L	<0.40	0.40	3372460
Ethylbenzene	ug/L	<0.20	0.20	3372460
Ethylene Dibromide	ug/L	<0.20	0.20	3372460
Hexane	ug/L	<1.0	1.0	3372460
Methylene Chloride(Dichloromethane)	ug/L	<2.0	2.0	3372460
Methyl Isobutyl Ketone	ug/L	<5.0	5.0	3372460
Methyl Ethyl Ketone (2-Butanone)	ug/L	<10	10	3372460
Methyl t-butyl ether (MTBE)	ug/L	<0.50	0.50	3372460
Styrene	ug/L	<0.50	0.50	3372460
1,1,1,2-Tetrachloroethane	ug/L	<0.50	0.50	3372460
1,1,2,2-Tetrachloroethane	ug/L	<0.50	0.50	3372460
Tetrachloroethylene	ug/L	<0.20	0.20	3372460
Toluene	ug/L	<0.20	0.20	3372460

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B3G6616
Report Date: 2013/10/07

Golder Associates Ltd
Client Project #: 09-1111-6091

Sampler Initials: GR

VOLATILE ORGANICS BY GC/MS (WATER)

Maxxam ID		TH4403		
Sampling Date		2013/09/30 14:55		
	Units	**BH126B**	**RDL**	**QC Batch**
1,1,1-Trichloroethane	ug/L	<0.20	0.20	3372460
1,1,2-Trichloroethane	ug/L	<0.50	0.50	3372460
Trichloroethylene	ug/L	<0.20	0.20	3372460
Vinyl Chloride	ug/L	<0.20	0.20	3372460
p+m-Xylene	ug/L	<0.20	0.20	3372460
o-Xylene	ug/L	<0.20	0.20	3372460
Xylene (Total)	ug/L	<0.20	0.20	3372460
Trichlorofluoromethane (FREON 11)	ug/L	<0.50	0.50	3372460
Surrogate Recovery (%)				
4-Bromofluorobenzene	%	94		3372460
D4-1,2-Dichloroethane	%	116		3372460
D8-Toluene	%	95		3372460

PETROLEUM HYDROCARBONS (CCME)

Maxxam ID		TH4403		
Sampling Date		2013/09/30 14:55		
	Units	**BH126B**	**RDL**	**QC Batch**
BTEX & F1 Hydrocarbons				
F1 (C6-C10)	ug/L	<25	25	3375636
F1 (C6-C10) - BTEX	ug/L	<25	25	3375636
F2-F4 Hydrocarbons				
F2 (C10-C16 Hydrocarbons)	ug/L	<100	100	3375673
F3 (C16-C34 Hydrocarbons)	ug/L	<200	200	3375673
F4 (C34-C50 Hydrocarbons)	ug/L	<200	200	3375673
Reached Baseline at C50	ug/L	YES		3375673
Surrogate Recovery (%)				
1,4-Difluorobenzene	%	105		3375636
4-Bromofluorobenzene	%	98		3375636
D10-Ethylbenzene	%	92		3375636
D4-1,2-Dichloroethane	%	98		3375636
o-Terphenyl	%	92		3375673

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

POLYCHLORINATED BIPHENYLS BY GC-ECD (WATER)

Maxxam ID		TH4403	TH4403		
Sampling Date		2013/09/30 14:55	2013/09/30 14:55		
	Units	**BH126B**	**BH126B Lab-Dup**	**RDL**	**QC Batch**
PCBs					
Aroclor 1242	ug/L	<0.05	<0.05	0.05	3371968
Aroclor 1248	ug/L	<0.05	<0.05	0.05	3371968
Aroclor 1254	ug/L	<0.05	<0.05	0.05	3371968
Aroclor 1260	ug/L	<0.05	<0.05	0.05	3371968
Total PCB	ug/L	<0.05	<0.05	0.05	3371968
Surrogate Recovery (%)					
Decachlorobiphenyl	%	66	67		3371968

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Test Summary

Maxxam ID TH4403
Sample ID BH126B
Matrix Water

Collected 2013/09/30
Shipped
Received 2013/10/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
1,3-Dichloropropene Sum	CALC	3371186	N/A	2013/10/07	Automated Statchk
Petroleum Hydro. CCME F1 & BTEX in Wat	HSGC/MSFD	3375636	N/A	2013/10/05	Yang Yu
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	3375673	2013/10/05	2013/10/06	Biljana Lazovic
Polychlorinated Biphenyl in Water	GC/ECD	3371968	2013/10/02	2013/10/03	Sarah Huang
Volatile Organic Compounds in Water	GC/MS	3372460	N/A	2013/10/04	Nalini Ramballack

Maxxam ID TH4403 Dup
Sample ID BH126B
Matrix Water

Collected 2013/09/30
Shipped
Received 2013/10/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Polychlorinated Biphenyl in Water	GC/ECD	3371968	2013/10/02	2013/10/03	Sarah Huang

Package 1	2.7°C

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

GENERAL COMMENTS

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**
3371968	Decachlorobiphenyl	2013/10/03	70	60 - 130	60	60 - 130	64	%		
3371968	Aroclor 1260	2013/10/03	87	60 - 130	65	60 - 130	<0.05	ug/L	NC	30
3371968	Total PCB	2013/10/03	87	60 - 130	65	60 - 130	<0.05	ug/L	NC	40
3371968	Aroclor 1242	2013/10/03					<0.05	ug/L	NC	30
3371968	Aroclor 1248	2013/10/03					<0.05	ug/L	NC	30
3371968	Aroclor 1254	2013/10/03					<0.05	ug/L	NC	30
3372460	4-Bromofluorobenzene	2013/10/04	100	70 - 130	100	70 - 130	93	%		
3372460	D4-1,2-Dichloroethane	2013/10/04	106	70 - 130	106	70 - 130	107	%		
3372460	D8-Toluene	2013/10/04	106	70 - 130	106	70 - 130	96	%		
3372460	Acetone (2-Propanone)	2013/10/05	116	60 - 140	111	60 - 140	<10	ug/L	NC	30
3372460	Benzene	2013/10/05	100	70 - 130	107	70 - 130	<0.20	ug/L	NC	30
3372460	Bromodichloromethane	2013/10/05	104	70 - 130	112	70 - 130	<0.50	ug/L	NC	30
3372460	Bromoform	2013/10/05	103	70 - 130	108	70 - 130	<1.0	ug/L	NC	30
3372460	Bromomethane	2013/10/05	86	60 - 140	102	60 - 140	<0.50	ug/L	NC	30
3372460	Carbon Tetrachloride	2013/10/05	110	70 - 130	118	70 - 130	<0.20	ug/L	NC	30
3372460	Chlorobenzene	2013/10/05	98	70 - 130	104	70 - 130	<0.20	ug/L	NC	30
3372460	Chloroform	2013/10/05	100	70 - 130	107	70 - 130	<0.20	ug/L	NC	30
3372460	Dibromochloromethane	2013/10/05	102	70 - 130	109	70 - 130	<0.50	ug/L	NC	30
3372460	1,2-Dichlorobenzene	2013/10/05	103	70 - 130	109	70 - 130	<0.50	ug/L	NC	30
3372460	1,3-Dichlorobenzene	2013/10/05	98	70 - 130	103	70 - 130	<0.50	ug/L	NC	30
3372460	1,4-Dichlorobenzene	2013/10/05	96	70 - 130	102	70 - 130	<0.50	ug/L	NC	30
3372460	Dichlorodifluoromethane (FREON 12)	2013/10/05	67	60 - 140	86	60 - 140	<1.0	ug/L	NC	30
3372460	1,1-Dichloroethane	2013/10/05	100	70 - 130	107	70 - 130	<0.20	ug/L	NC	30
3372460	1,2-Dichloroethane	2013/10/05	105	70 - 130	112	70 - 130	<0.50	ug/L	NC	30
3372460	1,1-Dichloroethylene	2013/10/05	103	70 - 130	113	70 - 130	<0.20	ug/L	NC	30
3372460	cis-1,2-Dichloroethylene	2013/10/05	NC	70 - 130	102	70 - 130	<0.50	ug/L	5.4	30
3372460	trans-1,2-Dichloroethylene	2013/10/05	98	70 - 130	106	70 - 130	<0.50	ug/L	NC	30
3372460	1,2-Dichloropropane	2013/10/05	100	70 - 130	107	70 - 130	<0.20	ug/L	NC	30
3372460	cis-1,3-Dichloropropene	2013/10/05	81	70 - 130	95	70 - 130	<0.30	ug/L	NC	30
3372460	trans-1,3-Dichloropropene	2013/10/05	94	70 - 130	114	70 - 130	<0.40	ug/L	NC	30
3372460	Ethylbenzene	2013/10/05	94	70 - 130	101	70 - 130	<0.20	ug/L	NC	30
3372460	Ethylene Dibromide	2013/10/05	100	70 - 130	109	70 - 130	<0.20	ug/L	NC	30
3372460	Hexane	2013/10/05	96	70 - 130	107	70 - 130	<1.0	ug/L	NC	30
3372460	Methylene Chloride(Dichloromethane)	2013/10/05	110	70 - 130	117	70 - 130	<2.0	ug/L	NC	30
3372460	Methyl Isobutyl Ketone	2013/10/05	102	70 - 130	106	70 - 130	<5.0	ug/L	NC	30
3372460	Methyl Ethyl Ketone (2-Butanone)	2013/10/05	103	60 - 140	103	60 - 140	<10	ug/L	NC	30
3372460	Methyl t-butyl ether (MTBE)	2013/10/05	93	70 - 130	100	70 - 130	<0.50	ug/L	NC	30
3372460	Styrene	2013/10/05	101	70 - 130	110	70 - 130	<0.50	ug/L	NC	30
3372460	1,1,1,2-Tetrachloroethane	2013/10/05	105	70 - 130	112	70 - 130	<0.50	ug/L	NC	30
3372460	1,1,2,2-Tetrachloroethane	2013/10/05	102	70 - 130	109	70 - 130	<0.50	ug/L	NC	30

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**
3372460	Tetrachloroethylene	2013/10/05	103	70 - 130	110	70 - 130	<0.20	ug/L	NC	30
3372460	Toluene	2013/10/05	97	70 - 130	103	70 - 130	<0.20	ug/L	NC	30
3372460	1,1,1-Trichloroethane	2013/10/05	106	70 - 130	114	70 - 130	<0.20	ug/L	NC	30
3372460	1,1,2-Trichloroethane	2013/10/05	104	70 - 130	111	70 - 130	<0.50	ug/L	NC	30
3372460	Trichloroethylene	2013/10/05	NC	70 - 130	107	70 - 130	<0.20	ug/L	4.1	30
3372460	Vinyl Chloride	2013/10/05	87	70 - 130	100	70 - 130	<0.20	ug/L	2.9	30
3372460	p+m-Xylene	2013/10/05	95	70 - 130	104	70 - 130	<0.20	ug/L	NC	30
3372460	o-Xylene	2013/10/05	91	70 - 130	99	70 - 130	<0.20	ug/L	NC	30
3372460	Trichlorofluoromethane (FREON 11)	2013/10/05	100	70 - 130	110	70 - 130	<0.50	ug/L	NC	30
3372460	Xylene (Total)	2013/10/05					<0.20	ug/L	NC	30
3375636	1,4-Difluorobenzene	2013/10/05	108	70 - 130	102	70 - 130	105	%		
3375636	4-Bromofluorobenzene	2013/10/05	100	70 - 130	97	70 - 130	101	%		
3375636	D10-Ethylbenzene	2013/10/05	94	70 - 130	91	70 - 130	94	%		
3375636	D4-1,2-Dichloroethane	2013/10/05	96	70 - 130	97	70 - 130	102	%		
3375636	F1 (C6-C10)	2013/10/05	90	70 - 130	96	60 - 140	<25	ug/L	NC	30
3375636	F1 (C6-C10) - BTEX	2013/10/05					<25	ug/L	NC	30
3375673	o-Terphenyl	2013/10/06	99	50 - 130	105	50 - 130	96	%		
3375673	F2 (C10-C16 Hydrocarbons)	2013/10/06	111	50 - 130	110	70 - 130	<100	ug/L	NC	30
3375673	F3 (C16-C34 Hydrocarbons)	2013/10/06	106	50 - 130	106	70 - 130	<200	ug/L	NC	30
3375673	F4 (C34-C50 Hydrocarbons)	2013/10/06	102	50 - 130	103	70 - 130	<200	ug/L	NC	30

N/A = Not Applicable

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

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.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

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 not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

Validation Signature Page

Maxxam Job #: B3G6616

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

C. Ancker

Charles Ancker, B.Sc., M.Sc., C.Chem, Senior Analyst

Eva P

Eva Pranjic

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

M. Riskallah

Medhat Riskallah, Manager, Hydrocarbon Department

==

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Maxxam IMMEDIATE TEST Maxxam Analytics International Corporation o/a Maxxam Analytics
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5779 www.maxxam.ca

CHAIN OF CUSTO

1-Oct-13 13:15
Antonella Brasil
B3G6616
CK1 ENV-837

Page 1 of 1

INVOICE INFORMATION:

Company Name: #1326 Golder Associates Ltd
Contact Name: Central Acct: ~~1112, 1113, 1151~~ 1111
Address: 6925 Century Ave Suite 100 ~~2390 Argentia Rd~~
Mississauga ON L5N 5Z7
jennifer-lee@golder.com
Phone: (905)567-4444 Fax: (905)567-6561
Email: maxxam@golder.com, ~~amber_moreira@golder.com~~

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name: Gillian Roos
Address:
Phone: Fax:
Email: gillian-roos@golder.com

PROJECT INFORMATION:

Quotation #: B24075
P.O. #:
Project #: 09-1111-6091 (6000)
Project Name:
Site #: 09-1111-6091
Sampled By: CWC

Only:

BOTTLE ORDER #: 272044

CHAIN OF COUSTODY #: C#272044-191-01

PROJECT MANAGER: MATHURA THIRUKKUMARA

Regulation 153 (2011)

☐ Table 1 ☐ Res/Park ☐ Medium/Fine
☐ Table 2 ☐ Ind/Comm ☐ Coarse
☐ Table 3 ☐ Agri/Other
☐ Table ___ ☐ **For RSC**

Other Regulations

☐ CCME ☐ Sanitary Sewer Bylaw
☐ Reg. 558 ☐ Storm Sewer Bylaw
☐ MISA Municipality ___
☐ PWQO
☐ Other ___

SPECIAL INSTRUCTIONS

Include Criteria on Certificate of Analysis (Y/N)? ___

Note: For MOE regulated drinking water samples - please use the Drinking Water Chain of Custody Form

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

ANALYSIS REQUESTED (Please be specific):

TURNAROUND TIME (TAT) REQUIRED:

PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS

Regular (Standard) TAT: ☑
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: ___ Time Required: ___ ☐
Rush Confirmation Number: ___ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Regulated Drinking Water ? (Y / N)	Metals Field Filtered ? (Y / N)	PCBS	PHCS	VOCS								# of Bottles	Comments
1		BH126B	30Sept13	14:55	GW	N	/	✓	✓	✓								10	slightly cloudy
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			

*RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time:	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time:	# Jars Used and Not Submitted
Clara Chai	2013/10/01	13:15	JENNIFER MCCARTHY	2013/10/01	13:15.	

Laboratory Use Only

Time Sensitive	Temperature (°C) on Receipt	Custody Seal	Yes	No
	0|3|5°C	Present		✓
		Intact		

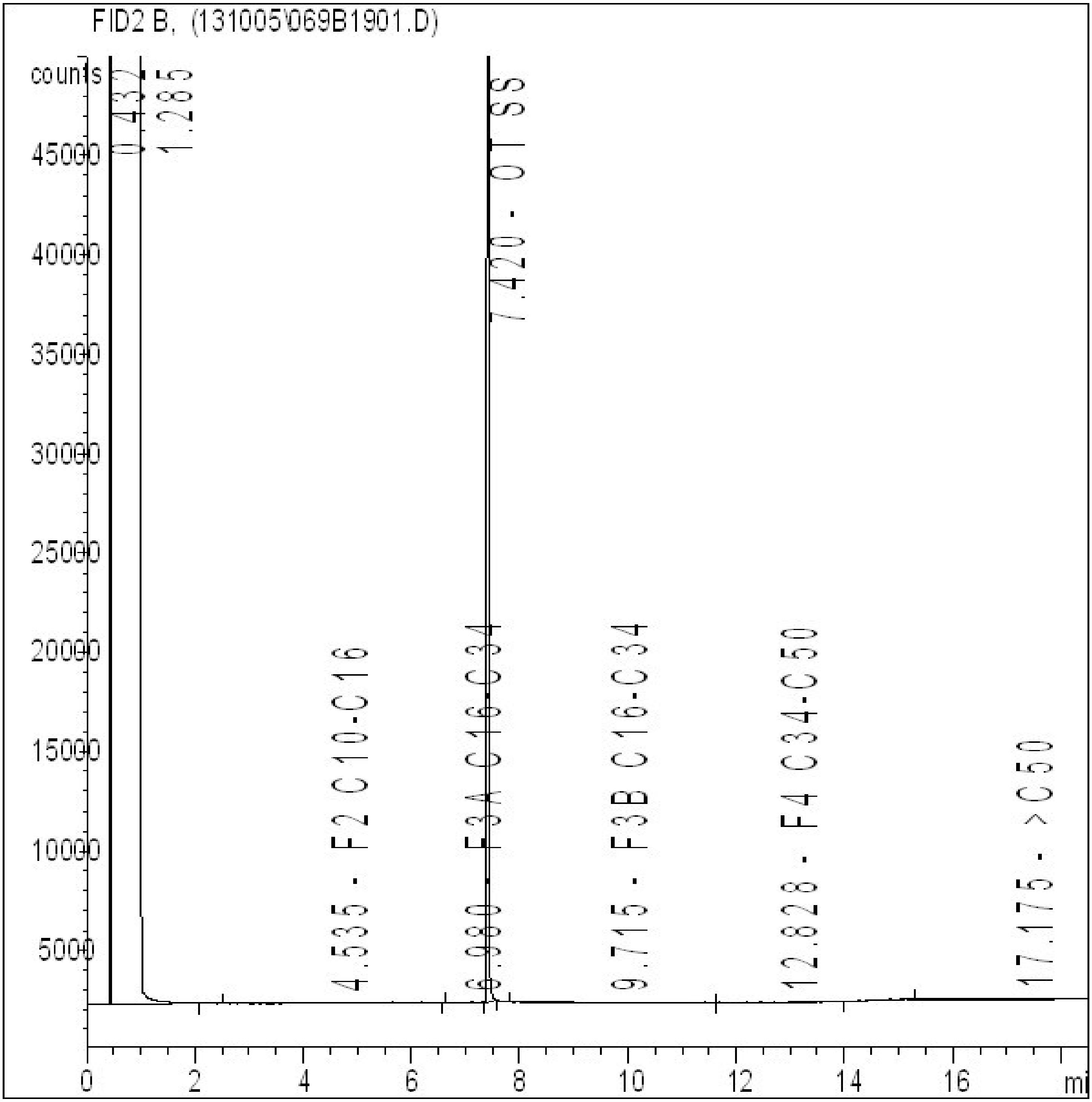
* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

Golder Associates Ltd
Report Date: 2013/10/07 Client Project #: 09-1111-6091
Maxxam Job #: B3G6616
Maxxam Sample: TH4403 Client ID: BH126B

Petroleum Hydrocarbons F2-F4 in Water Chromatogram



Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

Your Project #: 09-1111-6091
Site#: 09-1111-6091
Your C.O.C. #: 43812401, 438124-01-01

Attention: Reza Lackpour
Golder Associates Ltd
140 Renfrew Dr
Suite 110
Markham, ON
L3R 6B3

Report Date: 2013/10/10

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B3G6084
Received: 2013/10/01, 09:00

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Sewer Use By-Law Semivolatile Organics	1	2013/10/02	2013/10/02	EPA 8270, CAM SOP 00301	GC/MS
Biochemical Oxygen Demand (BOD)	1	N/A	2013/10/07	CAM SOP-00427	APHA 5210B
Chromium (VI) in Water	1	N/A	2013/10/04	CAM SOP-00436	EPA 7199
Total Cyanide	1	2013/10/04	2013/10/04	CAM SOP-00457	Ontario MOE CN-E3015
Fluoride	1	2013/10/03	2013/10/04	CAM SOP-00449	APHA 4500FC
Mercury in Water by CVAA	1	2013/10/07	2013/10/08	CAM SOP-00453	SW-846 7470A
Total Metals Analysis by ICPMS	1	N/A	2013/10/09	CAM SOP-00447	EPA 6020
E.coli, (CFU/100mL)	1	N/A	2013/10/01	CAM SOP-00552	MOE LSB E3371
Total Nonylphenol in Liquids by HPLC	1	2013/10/04	2013/10/08	CAM SOP-00313	In-house Method
Nonylphenol Ethoxylates in Liquids: HPLC	1	2013/10/04	2013/10/08	CAM SOP-00313	In-house Method
Animal and Vegetable Oil & Grease	1	N/A	2013/10/03	CAM SOP-00326	SM 5520 B
Total Oil and Grease	1	2013/10/03	2013/10/03	CAM SOP-00326	EPA 1664A
OC Pesticides (Selected) & PCB (1)	1	2013/10/02	2013/10/03	CAM SOP-00307	SW846 8081,8082
OC Pesticides Summed Parameters	1	N/A	2013/10/02	CAM SOP-00307	SW846 8081, 8082
pH	1	N/A	2013/10/04	CAM SOP-00413	SM 4500H+ B
Phenols (4AAP)	1	N/A	2013/10/03	CAM SOP-00444	MOE ROPHEN-E3179
Total Kjeldahl Nitrogen in Water	1	2013/10/03	2013/10/04	CAM SOP-00454	EPA 351.2 Rev 2
Total PAH's (2)	1	N/A	2013/10/03	CAM SOP - 00301	EPA 8270
TPH (Heavy Oil) (3)	1	2013/10/03	2013/10/03	CAM SOP-00326	SM 5520F
Total Suspended Solids	1	N/A	2013/10/03	CAM SOP-00428	SM 2540D
Volatile Organic Compounds in Water	1	N/A	2013/10/04	CAM SOP-00226	EPA 8260 modified

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

(1) Chlordane (Total) = Alpha Chlordane + Gamma Chlordane
(2) Total PAHs include only those PAHs specified in the sewer use by-by-law.
(3) Note: TPH (Heavy Oil) is equivalent to Mineral / Synthetic Oil & Grease

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Antonella Brasil, Project Manager
Email: ABrasil@maxxam.ca
Phone# (905) 817-5817

==

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.

Total cover pages: 2

Maxxam Job #: B3G6084
Report Date: 2013/10/10

Golder Associates Ltd
Client Project #: 09-1111-6091

Sampler Initials: CWI

RESULTS OF ANALYSES OF WATER

Maxxam ID		TH2108		
Sampling Date		2013/09/30 14:55		
	Units	**BH126B**	**RDL**	**QC Batch**
Calculated Parameters				
Total Animal/Vegetable Oil and Grease	mg/L	<0.50	0.50	3370061
Inorganics				
Total BOD	mg/L	<2.0	2.0	3370771
Fluoride (F-)	mg/L	0.21	0.10	3374008
Total Kjeldahl Nitrogen (TKN)	mg/L	0.37	0.10	3373070
pH	pH	7.99		3374009
Phenols-4AAP	mg/L	<0.0010	0.0010	3372293
Total Suspended Solids	mg/L	170	10	3373066
Total Cyanide (CN)	mg/L	<0.0050	0.0050	3374116
Miscellaneous Parameters				
Nonylphenol (Total)	mg/L	<0.001	0.001	3374752
Petroleum Hydrocarbons				
Total Oil & Grease	mg/L	<0.50	0.50	3372388
Total Oil & Grease Mineral/Synthetic	mg/L	<0.50	0.50	3372391

NONYL PHENOL AND NONYL PHENOL ETHOXYLATE (WATER)

Maxxam ID		TH2108	TH2108		
Sampling Date		2013/09/30 14:55	2013/09/30 14:55		
	Units	**BH126B**	**BH126B Lab-Dup**	**RDL**	**QC Batch**
Miscellaneous Parameters					
Nonylphenol Ethoxylate (Total)	mg/L	<0.005	<0.005	0.005	3374758

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		TH2108	TH2108		
Sampling Date		2013/09/30 14:55	2013/09/30 14:55		
	Units	**BH126B**	**BH126B Lab-Dup**	**RDL**	**QC Batch**
Metals					
Chromium (VI)	ug/L	0.75		0.50	3373354
Mercury (Hg)	mg/L	<0.00010	<0.00010	0.00010	3376902
Total Aluminum (Al)	ug/L	1800		5.0	3379313
Total Antimony (Sb)	ug/L	<0.50		0.50	3379313
Total Arsenic (As)	ug/L	<1.0		1.0	3379313
Total Cadmium (Cd)	ug/L	<0.10		0.10	3379313
Total Chromium (Cr)	ug/L	<5.0		5.0	3379313
Total Cobalt (Co)	ug/L	1.1		0.50	3379313
Total Copper (Cu)	ug/L	3.7		1.0	3379313
Total Lead (Pb)	ug/L	1.4		0.50	3379313
Total Manganese (Mn)	ug/L	71		2.0	3379313
Total Molybdenum (Mo)	ug/L	1.2		0.50	3379313
Total Nickel (Ni)	ug/L	2.7		1.0	3379313
Total Phosphorus (P)	ug/L	110		100	3379313
Total Selenium (Se)	ug/L	<2.0		2.0	3379313
Total Silver (Ag)	ug/L	<0.10		0.10	3379313
Total Tin (Sn)	ug/L	2.4		1.0	3379313
Total Titanium (Ti)	ug/L	98		5.0	3379313
Total Zinc (Zn)	ug/L	10		5.0	3379313

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B3G6084
Report Date: 2013/10/10

Golder Associates Ltd
Client Project #: 09-1111-6091

Sampler Initials: CWI

SEMI-VOLATILE ORGANICS BY GC-MS (WATER)

Maxxam ID		TH2108		
Sampling Date		2013/09/30 14:55		
	Units	**BH126B**	**RDL**	**QC Batch**
Semivolatile Organics				
Di-N-butyl phthalate	ug/L	<2	2	3370793
Bis(2-ethylhexyl)phthalate	ug/L	<2	2	3370793
3,3'-Dichlorobenzidine	ug/L	<0.8	0.8	3370793
Pentachlorophenol	ug/L	<1	1	3370793
Phenanthrene	ug/L	<0.2	0.2	3370793
Anthracene	ug/L	<0.2	0.2	3370793
Fluoranthene	ug/L	<0.2	0.2	3370793
Pyrene	ug/L	<0.2	0.2	3370793
Benzo(a)anthracene	ug/L	<0.2	0.2	3370793
Chrysene	ug/L	<0.2	0.2	3370793
Benzo(b/j)fluoranthene	ug/L	<0.2	0.2	3370793
Benzo(k)fluoranthene	ug/L	<0.2	0.2	3370793
Benzo(a)pyrene	ug/L	<0.2	0.2	3370793
Indeno(1,2,3-cd)pyrene	ug/L	<0.2	0.2	3370793
Dibenz(a,h)anthracene	ug/L	<0.2	0.2	3370793
Benzo(g,h,i)perylene	ug/L	<0.2	0.2	3370793
Dibenzo(a,i)pyrene	ug/L	<0.2	0.2	3370793
Benzo(e)pyrene	ug/L	<0.2	0.2	3370793
Perylene	ug/L	<0.2	0.2	3370793
Dibenzo(a,j) acridine	ug/L	<0.4	0.4	3370793
7H-Dibenzo(c,g) Carbazole	ug/L	<0.4	0.4	3370793
1,6-Dinitropyrene	ug/L	<0.4	0.4	3370793
1,3-Dinitropyrene	ug/L	<0.4	0.4	3370793
1,8-Dinitropyrene	ug/L	<0.4	0.4	3370793
Calculated Parameters				
Total PAHs (18 PAHs)	ug/L	<1	1	3370073
Surrogate Recovery (%)				
2,4,6-Tribromophenol	%	64		3370793
2-Fluorobiphenyl	%	59		3370793
D14-Terphenyl (FS)	%	92		3370793
D5-Nitrobenzene	%	69		3370793
D8-Acenaphthylene	%	71		3370793

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

VOLATILE ORGANICS BY GC/MS (WATER)

Maxxam ID		TH2108		
Sampling Date		2013/09/30 14:55		
	Units	**BH126B**	**RDL**	**QC Batch**
Volatile Organics				
Benzene	ug/L	<0.10	0.10	3372187
Chloroform	ug/L	<0.10	0.10	3372187
1,2-Dichlorobenzene	ug/L	<0.20	0.20	3372187
1,4-Dichlorobenzene	ug/L	<0.20	0.20	3372187
cis-1,2-Dichloroethylene	ug/L	<0.10	0.10	3372187
trans-1,3-Dichloropropene	ug/L	<0.20	0.20	3372187
Ethylbenzene	ug/L	<0.10	0.10	3372187
Methylene Chloride(Dichloromethane)	ug/L	<0.50	0.50	3372187
1,1,2,2-Tetrachloroethane	ug/L	<0.20	0.20	3372187
Tetrachloroethylene	ug/L	<0.10	0.10	3372187
Toluene	ug/L	<0.20	0.20	3372187
Trichloroethylene	ug/L	<0.10	0.10	3372187
p+m-Xylene	ug/L	<0.10	0.10	3372187
o-Xylene	ug/L	<0.10	0.10	3372187
Xylene (Total)	ug/L	<0.10	0.10	3372187
Surrogate Recovery (%)				
4-Bromofluorobenzene	%	94		3372187
D4-1,2-Dichloroethane	%	102		3372187
D8-Toluene	%	96		3372187

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ORGANOCHLORINATED PESTICIDES BY GC-ECD (WATER)

Maxxam ID		TH2108		
Sampling Date		2013/09/30 14:55		
	Units	**BH126B**	**RDL**	**QC Batch**
Calculated Parameters				
Aldrin + Dieldrin	ug/L	<0.005	0.005	3369462
Chlordane (Total)	ug/L	<0.005	0.005	3369462
o,p-DDT + p,p-DDT	ug/L	<0.005	0.005	3369462
Total PCB	ug/L	<0.05	0.05	3369462
Pesticides & Herbicides				
Aldrin	ug/L	<0.005	0.005	3372343
Dieldrin	ug/L	<0.005	0.005	3372343
a-Chlordane	ug/L	<0.005	0.005	3372343
g-Chlordane	ug/L	<0.005	0.005	3372343
o,p-DDT	ug/L	<0.005	0.005	3372343
p,p-DDT	ug/L	<0.005	0.005	3372343
Lindane	ug/L	<0.003	0.003	3372343
Hexachlorobenzene	ug/L	<0.005	0.005	3372343
Mirex	ug/L	<0.005	0.005	3372343
Surrogate Recovery (%)				
2,4,5,6-Tetrachloro-m-xylene	%	91		3372343
Decachlorobiphenyl	%	120		3372343

MICROBIOLOGY (WATER)

Maxxam ID		TH2108		
Sampling Date		2013/09/30 14:55		
	Units	**BH126B**	**RDL**	**QC Batch**
Microbiological				
Escherichia coli	CFU/100mL	180	10	3370236

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Test Summary

Maxxam ID TH2108
Sample ID BH126B
Matrix Water

Collected 2013/09/30
Shipped
Received 2013/10/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Sewer Use By-Law Semivolatile Organics	GC/MS	3370793	2013/10/02	2013/10/02	Kathy Horvat
Biochemical Oxygen Demand (BOD)	BOD	3370771	N/A	2013/10/07	Hemang Trivedi
Chromium (VI) in Water	IC	3373354	N/A	2013/10/04	Sally Coughlin
Total Cyanide	TECH/CN	3374116	2013/10/04	2013/10/04	Xuanhong Qiu
Fluoride	F	3374008	2013/10/03	2013/10/04	Surinder Rai
Mercury in Water by CVAA	CVAA	3376902	2013/10/07	2013/10/08	Magdalena Carlos
Total Metals Analysis by ICPMS	ICP/MS	3379313	N/A	2013/10/09	Hua Ren
E.coli, (CFU/100mL)	PL	3370236	N/A	2013/10/01	Sirimathie Aluthwala
Total Nonylphenol in Liquids by HPLC	LC/FLU	3374752	2013/10/04	2013/10/08	Marian Godax
Nonylphenol Ethoxylates in Liquids: HPLC	LC/FLU	3374758	2013/10/04	2013/10/08	Marian Godax
Animal and Vegetable Oil & Grease	BAL	3370061	N/A	2013/10/03	Automated Statchk
Total Oil and Grease	BAL	3372388	2013/10/03	2013/10/03	Amjad Mir
OC Pesticides (Selected) & PCB	GC/ECD	3372343	2013/10/02	2013/10/03	Joy Zhang
OC Pesticides Summed Parameters	CALC	3369462	N/A	2013/10/02	Automated Statchk
pH	PH	3374009	N/A	2013/10/04	Surinder Rai
Phenols (4AAP)	TECH/PHEN	3372293	N/A	2013/10/03	Bramdeo Motiram
Total Kjeldahl Nitrogen in Water	AC	3373070	2013/10/03	2013/10/04	Chandra Nandlal
Total PAH's	CALC	3370073	N/A	2013/10/03	Automated Statchk
TPH (Heavy Oil)	BAL	3372391	2013/10/03	2013/10/03	Amjad Mir
Total Suspended Solids	SLDS	3373066	N/A	2013/10/03	Malik Kai Morgan John
Volatile Organic Compounds in Water	P&T/MS	3372187	N/A	2013/10/04	Blair Gannon

Maxxam ID TH2108 Dup
Sample ID BH126B
Matrix Water

Collected 2013/09/30
Shipped
Received 2013/10/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Mercury in Water by CVAA	CVAA	3376902	2013/10/07	2013/10/08	Magdalena Carlos
Nonylphenol Ethoxylates in Liquids: HPLC	LC/FLU	3374758	2013/10/04	2013/10/08	Marian Godax

Package 1	7.0°C

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

GENERAL COMMENTS

Sample TH2108-01: Total/Dissolved Chromium < Hexavalent Chromium: Both values fall within acceptable RPD limits for duplicates and are likely equivalent.

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
3370771	Total BOD	2013/10/07					<2.0	mg/L	NC	25	104	85 - 115
3370793	2,4,6-Tribromophenol	2013/10/02	82	10 - 130	86	10 - 130	71	%				
3370793	2-Fluorobiphenyl	2013/10/02	57	30 - 130	54	30 - 130	52	%				
3370793	D14-Terphenyl (FS)	2013/10/02	93	30 - 130	98	30 - 130	101	%				
3370793	D5-Nitrobenzene	2013/10/02	75	30 - 130	77	30 - 130	71	%				
3370793	D8-Acenaphthylene	2013/10/02	65	30 - 130	62	30 - 130	55	%				
3370793	Di-N-butyl phthalate	2013/10/03	90	30 - 130	87	30 - 130	<2	ug/L	NC	40		
3370793	Bis(2-ethylhexyl)phthalate	2013/10/03	93	30 - 130	95	30 - 130	<2	ug/L	NC	40		
3370793	3,3'-Dichlorobenzidine	2013/10/03	78	30 - 130	97	30 - 130	<0.8	ug/L	NC	40		
3370793	Pentachlorophenol	2013/10/03	35	30 - 130	59	30 - 130	<1	ug/L	NC	40		
3370793	Phenanthrene	2013/10/03	95	30 - 130	98	30 - 130	<0.2	ug/L	NC	40		
3370793	Anthracene	2013/10/03	94	30 - 130	99	30 - 130	<0.2	ug/L	NC	40		
3370793	Fluoranthene	2013/10/03	86	30 - 130	91	30 - 130	<0.2	ug/L	NC	40		
3370793	Pyrene	2013/10/03	89	30 - 130	92	30 - 130	<0.2	ug/L	NC	40		
3370793	Benzo(a)anthracene	2013/10/03	105	30 - 130	108	30 - 130	<0.2	ug/L	NC	40		
3370793	Chrysene	2013/10/03	111	30 - 130	115	30 - 130	<0.2	ug/L	NC	40		
3370793	Benzo(b/j)fluoranthene	2013/10/03	95	30 - 130	98	30 - 130	<0.2	ug/L	NC	40		
3370793	Benzo(k)fluoranthene	2013/10/03	101	30 - 130	105	30 - 130	<0.2	ug/L	NC	40		
3370793	Benzo(a)pyrene	2013/10/03	91	30 - 130	94	30 - 130	<0.2	ug/L	NC	40		
3370793	Indeno(1,2,3-cd)pyrene	2013/10/03	93	30 - 130	96	30 - 130	<0.2	ug/L	NC	40		
3370793	Dibenz(a,h)anthracene	2013/10/03	92	30 - 130	92	30 - 130	<0.2	ug/L	NC	40		
3370793	Benzo(g,h,i)perylene	2013/10/03	95	30 - 130	94	30 - 130	<0.2	ug/L	NC	40		
3370793	Dibenzo(a,i)pyrene	2013/10/03	86	N/A	78	30 - 130	<0.2	ug/L	NC	40		
3370793	Benzo(e)pyrene	2013/10/03	102	30 - 130	105	30 - 130	<0.2	ug/L	NC	40		
3370793	Perylene	2013/10/03	99	30 - 130	102	30 - 130	<0.2	ug/L	NC	40		
3370793	Dibenzo(a,j) acridine	2013/10/03	101	30 - 130	73	30 - 130	<0.4	ug/L	NC	40		
3370793	7H-Dibenzo(c,g) Carbazole	2013/10/03	95	30 - 130	101	30 - 130	<0.4	ug/L	NC	40		
3370793	1,6-Dinitropyrene	2013/10/03	95	30 - 130	99	30 - 130	<0.4	ug/L	NC	40		
3370793	1,3-Dinitropyrene	2013/10/03	95	30 - 130	104	30 - 130	<0.4	ug/L	NC	40		
3370793	1,8-Dinitropyrene	2013/10/03	92	30 - 130	99	30 - 130	<0.4	ug/L	NC	40		
3372187	4-Bromofluorobenzene	2013/10/04	102	70 - 130	105	70 - 130	95	%				
3372187	D4-1,2-Dichloroethane	2013/10/04	99	70 - 130	100	70 - 130	102	%				
3372187	D8-Toluene	2013/10/04	100	70 - 130	102	70 - 130	96	%				
3372187	Benzene	2013/10/04	98	70 - 130	99	70 - 130	<0.10	ug/L	NC	30		
3372187	Chloroform	2013/10/04	97	70 - 130	97	70 - 130	<0.10	ug/L				
3372187	1,2-Dichlorobenzene	2013/10/04	101	70 - 130	101	70 - 130	<0.20	ug/L				
3372187	1,4-Dichlorobenzene	2013/10/04	99	70 - 130	99	70 - 130	<0.20	ug/L				
3372187	cis-1,2-Dichloroethylene	2013/10/04	90	70 - 130	99	70 - 130	<0.10	ug/L				
3372187	trans-1,3-Dichloropropene	2013/10/04	105	70 - 130	108	70 - 130	<0.20	ug/L				
3372187	Ethylbenzene	2013/10/04	99	70 - 130	102	70 - 130	<0.10	ug/L	NC	30		

Golder Associates Ltd

Maxxam Job #: B3G6084
Report Date: 2013/10/10

Client Project #: 09-1111-6091

Sampler Initials: CWI

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
3372187	Methylene Chloride(Dichloromethane)	2013/10/04	106	70 - 130	107	70 - 130	<0.50	ug/L				
3372187	1,1,2,2-Tetrachloroethane	2013/10/04	99	70 - 130	103	70 - 130	<0.20	ug/L				
3372187	Tetrachloroethylene	2013/10/04	103	70 - 130	104	70 - 130	<0.10	ug/L				
3372187	Toluene	2013/10/04	96	70 - 130	97	70 - 130	<0.20	ug/L	NC	30		
3372187	Trichloroethylene	2013/10/04	100	70 - 130	100	70 - 130	<0.10	ug/L				
3372187	p+m-Xylene	2013/10/04	102	70 - 130	104	70 - 130	<0.10	ug/L	NC	30		
3372187	o-Xylene	2013/10/04	100	70 - 130	103	70 - 130	<0.10	ug/L	NC	30		
3372187	Xylene (Total)	2013/10/04					<0.10	ug/L	NC	30		
3372293	Phenols-4AAP	2013/10/03	92	80 - 120	109	85 - 115	<0.0010	mg/L	NC	25		
3372343	2,4,5,6-Tetrachloro-m-xylene	2013/10/03	105	50 - 130	91	50 - 130	91	%				
3372343	Decachlorobiphenyl	2013/10/03	65	50 - 130	129	50 - 130	123	%				
3372343	Aldrin	2013/10/03	92	50 - 130	92	50 - 130	<0.005	ug/L	NC	30		
3372343	Dieldrin	2013/10/03	108	50 - 130	112	50 - 130	<0.005	ug/L	NC	30		
3372343	a-Chlordane	2013/10/03	100	50 - 130	101	50 - 130	<0.005	ug/L	NC	30		
3372343	g-Chlordane	2013/10/03	104	50 - 130	105	50 - 130	<0.005	ug/L	NC	30		
3372343	o,p-DDT	2013/10/03	100	50 - 130	93	50 - 130	<0.005	ug/L	NC	30		
3372343	p,p-DDT	2013/10/03	104	50 - 130	86	50 - 130	<0.005	ug/L	NC	30		
3372343	Lindane	2013/10/03	94	50 - 130	98	50 - 130	<0.003	ug/L	NC	30		
3372343	Hexachlorobenzene	2013/10/03	94	50 - 130	91	50 - 130	<0.005	ug/L	NC	30		
3372343	Mirex	2013/10/03	74	30 - 130	97	30 - 130	<0.005	ug/L	NC	40		
3372388	Total Oil & Grease	2013/10/03			93	85 - 115	<0.50	mg/L	4.2	25		
3372391	Total Oil & Grease Mineral/Synthetic	2013/10/03			92	85 - 115	<0.50	mg/L	2.7	25		
3373066	Total Suspended Solids	2013/10/03					<10	mg/L	NC	25	97	85 - 115
3373070	Total Kjeldahl Nitrogen (TKN)	2013/10/04	NC	80 - 120	110	80 - 120	0.14, RDL=0.10	mg/L	9.2	20	112	N/A
3373354	Chromium (VI)	2013/10/04	98	80 - 120	98	80 - 120	<0.50	ug/L	NC	20		
3374008	Fluoride (F-)	2013/10/04	110	80 - 120	103	80 - 120	<0.10	mg/L	NC	20		
3374116	Total Cyanide (CN)	2013/10/04	100	80 - 120	97	80 - 120	<0.0050	mg/L	NC	20		
3374752	Nonylphenol (Total)	2013/10/08	76	50 - 130	93	50 - 130	<0.001	mg/L	NC	40		
3374758	Nonylphenol Ethoxylate (Total)	2013/10/08	71	50 - 130	81	50 - 130	<0.005	mg/L	NC	40		
3376902	Mercury (Hg)	2013/10/08	105	80 - 120	100	80 - 120	<0.00010	mg/L	NC	20		
3379313	Total Aluminum (Al)	2013/10/09	NC	80 - 120	103	80 - 120	<5.0	ug/L				
3379313	Total Antimony (Sb)	2013/10/09	105	80 - 120	106	80 - 120	<0.50	ug/L				
3379313	Total Arsenic (As)	2013/10/09	104	80 - 120	102	80 - 120	<1.0	ug/L				
3379313	Total Cadmium (Cd)	2013/10/09	102	80 - 120	106	80 - 120	<0.10	ug/L				
3379313	Total Chromium (Cr)	2013/10/09	102	80 - 120	103	80 - 120	<5.0	ug/L				
3379313	Total Cobalt (Co)	2013/10/09	103	80 - 120	104	80 - 120	<0.50	ug/L				
3379313	Total Copper (Cu)	2013/10/09	102	80 - 120	101	80 - 120	<1.0	ug/L				
3379313	Total Lead (Pb)	2013/10/09	101	80 - 120	102	80 - 120	<0.50	ug/L	NC	20		
3379313	Total Manganese (Mn)	2013/10/09	103	80 - 120	105	80 - 120	<2.0	ug/L				
3379313	Total Molybdenum (Mo)	2013/10/09	105	80 - 120	107	80 - 120	<0.50	ug/L				

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
3379313	Total Nickel (Ni)	2013/10/09	103	80 - 120	103	80 - 120	<1.0	ug/L				
3379313	Total Phosphorus (P)	2013/10/09	101	80 - 120	104	80 - 120	<100	ug/L				
3379313	Total Selenium (Se)	2013/10/09	103	80 - 120	104	80 - 120	<2.0	ug/L				
3379313	Total Silver (Ag)	2013/10/09	103	80 - 120	106	80 - 120	<0.10	ug/L				
3379313	Total Tin (Sn)	2013/10/09	104	80 - 120	105	80 - 120	<1.0	ug/L				
3379313	Total Titanium (Ti)	2013/10/09	109	80 - 120	102	80 - 120	<5.0	ug/L				
3379313	Total Zinc (Zn)	2013/10/09	104	80 - 120	103	80 - 120	<5.0	ug/L				

N/A = Not Applicable

RDL = Reportable Detection Limit

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

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

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

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.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

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 not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

Validation Signature Page

Maxxam Job #: B3G6084

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

Eva P

Eva Pranjic

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

Floyd Mayede

Floyd Mayede, Senior Analyst

Mahmudul Khan, GC Analysts

Robert Macaulay

Robert Macaulay, Senior Analyst

Validation Signature Page

Maxxam Job #: B3G6084

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

Sirimathie Aluthwala, Campobello Micro

==

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 MICRO Maxxam Analytics International Corporation o/a Maxxam Analytics

6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5779 www.maxxam.ca

CHAIN OF CUSTO

1-Oct-13 09:00
Antonella Brasil
B3G6084
AKP ENV-836

Page 1 of 1

nly:

INVOICE INFORMATION:

Company Name: #1326 Golder Associates Ltd
Contact Name: Central Accounting: 1111
Address: 6925 Century Ave Suite 100
Mississauga ON L5N 7K2
Phone: (905)567-4444 Fax: (905)567-6561
Email: Jennifer_lee@golder.com, maxxam@golder.com, si

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name: Gillian Roos
Address:
Phone: (905)567-6100 x1727 Fax:
Email: gillian_roos@golder.com

PROJECT INFORMATION:

Quotation #: B24075
P.O. #:
Project #: 09-1111-6091(6000)
Project Name:
Site #: 09-1111-0691
Sampled By: CWI

BOTTLE ORDER #: 438124

CHAIN OF CUSTODY #: C#438124-01-01

PROJECT MANAGER: Antonella Brasil

Regulation 153 (2011)

☐ Table 1 ☐ Res/Park ☐ Medium/Fine
☐ Table 2 ☐ Ind/Comm ☐ Coarse
☐ Table 3 ☐ Agri/Other
☐ Table ___ ☐ **For RSC**

Other Regulations

☐ CCME ☐ Sanitary Sewer Bylaw
☐ Reg. 558 ☐ Storm Sewer Bylaw
☐ MISA Municipality ___
☐ PWQO
☐ Other ___

SPECIAL INSTRUCTIONS

Include Criteria on Certificate of Analysis (Y/N)? ___

Note: For MOE regulated drinking water samples - please use the Drinking Water Chain of Custody Form

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

ANALYSIS REQUESTED (Please be specific):

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Regulated Drinking Water ? (Y / N)	Metals Field Filtered ? (Y / N)	Toronto Storm Sewer Bylaw	Fluoride	Total Kjeldahl Nitrogen in Water	Animal and Vegetable Oil & Grease							# of Bottles	Comments
1		BH126B	30Sept13	14:55	GW	N	/	✓	✓	✓	✓							19	slightly cloudy
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			

TURNAROUND TIME (TAT) REQUIRED:

PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS

Regular (Standard) TAT: ☑

(will be applied if Rush TAT is not specified):

Standard TAT = 5-7 Working days for most tests.

Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission) ☐

Date Required: ___ Time Required: ___

Rush Confirmation Number: ___ *(call lab for #)*

*RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time:	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time:	# Jars Used and Not Submitted
Clara Chan	2013/10/1	9:00am	ASAD BHATTI	2013/10/01	09:00	

Laboratory Use Only

Time Sensitive	Temperature (ºC) on Receipt	Custody Seal	Yes	No
	8/7/6°C	Present		✓
		Intact		✓

White: Maxxam Yellow: Client

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

Maxxam Analytics International Corporation o/a Maxxam Analytics

APPENDIX D

Chemical Laboratory Test Results (Certificates of Anaylsis - AGAT)

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: GOLDER ASSOCIATES LTD
140 RENFREW DR. SUITE 110
MARKHAM, ON L3R6B3
(905) 475-5591

ATTENTION TO: Hammad Din

PROJECT NO:

AGAT WORK ORDER: 13T717934

SOIL ANALYSIS REVIEWED BY: Anthony Dapaah, PhD (Chem), Inorganic Lab Manager

DATE REPORTED: May 30, 2013

PAGES (INCLUDING COVER): 4

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2013-05-22

DATE REPORTED: 2013-05-30

			SAMPLE DESCRIPTION:	BH 126 SA6	BH 126 SA10
			SAMPLE TYPE:	Soil	Soil
			DATE SAMPLED:	5/17/2013	5/17/2013
Parameter	Unit	G / S	RDL	4375828	4375829
Antimony	µg/g	1.3	0.8	<0.8	<0.8
Arsenic	µg/g	18	1	2	<1
Barium	µg/g	220	2	53	9
Beryllium	µg/g	2.5	0.5	<0.5	<0.5
Boron	µg/g	36	5	7	<5
Boron (Hot Water Soluble)	µg/g	NA	0.10	0.11	<0.10
Cadmium	µg/g	1.2	0.5	<0.5	<0.5
Chromium	µg/g	70	2	13	4
Cobalt	µg/g	21	0.5	4.7	1.2
Copper	µg/g	92	1	11	3
Lead	µg/g	120	1	6	2
Molybdenum	µg/g	2	0.5	<0.5	<0.5
Nickel	µg/g	82	1	7	<1
Selenium	µg/g	1.5	0.4	<0.4	<0.4
Silver	µg/g	0.5	0.2	<0.2	<0.2
Thallium	µg/g	1	0.4	<0.4	<0.4
Uranium	µg/g	2.5	0.5	<0.5	<0.5
Vanadium	µg/g	86	1	19	8
Zinc	µg/g	290	5	25	7
Chromium VI	µg/g	0.66	0.2	<0.2	<0.2
Cyanide	µg/g	0.051	0.040	<0.040	<0.040
Mercury	µg/g	0.27	0.10	<0.10	<0.10
Electrical Conductivity (2:1)	mS/cm	0.57	0.005	0.263	0.100
Sodium Adsorption Ratio	NA	2.4	NA	0.370	0.536
pH, 2:1 CaCl2 Extraction	pH Units		NA	7.78	8.16

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T1(ALL) - Current

4375828-4375829 EC & SAR were determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio.

Certified By:

Quality Assurance

CLIENT NAME: GOLDER ASSOCIATES LTD

AGAT WORK ORDER: 13T717934

PROJECT NO:

ATTENTION TO: Hammad Din

Soil Analysis

RPT Date: May 30, 2013			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
O. Reg. 153(511) - Metals & Inorganics (Soil)															
Antimony	1		< 0.8	< 0.8	0.0%	< 0.8	100%	70%	130%	81%	80%	120%	77%	70%	130%
Arsenic	1		2	2	0.0%	< 1	107%	70%	130%	98%	80%	120%	104%	70%	130%
Barium	1		14	14	0.0%	< 2	103%	70%	130%	99%	80%	120%	99%	70%	130%
Beryllium	1		< 0.5	< 0.5	0.0%	< 0.5	107%	70%	130%	111%	80%	120%	112%	70%	130%
Boron	1		5	5	0.0%	< 5	100%	70%	130%	111%	80%	120%	118%	70%	130%
Boron (Hot Water Soluble)	1		0.25	0.26	5.5%	< 0.10	96%	60%	140%	94%	70%	130%	101%	60%	140%
Cadmium	1		< 0.5	< 0.5	0.0%	< 0.5	99%	70%	130%	112%	80%	120%	104%	70%	130%
Chromium	1		5	5	0.0%	< 2	96%	70%	130%	101%	80%	120%	108%	70%	130%
Cobalt	1		1.8	1.9	5.4%	< 0.5	100%	70%	130%	100%	80%	120%	103%	70%	130%
Copper	1		4	4	0.0%	< 1	97%	70%	130%	104%	80%	120%	106%	70%	130%
Lead	1		2	2	0.0%	< 1	105%	70%	130%	105%	80%	120%	101%	70%	130%
Molybdenum	1		< 0.5	< 0.5	0.0%	< 0.5	104%	70%	130%	102%	80%	120%	108%	70%	130%
Nickel	1		< 1	< 1	0.0%	< 1	102%	70%	130%	101%	80%	120%	99%	70%	130%
Selenium	1		< 0.4	< 0.4	0.0%	< 0.4	98%	70%	130%	100%	80%	120%	107%	70%	130%
Silver	1		< 0.2	< 0.2	0.0%	< 0.2	88%	70%	130%	97%	80%	120%	101%	70%	130%
Thallium	1		< 0.4	< 0.4	0.0%	< 0.4	97%	70%	130%	102%	80%	120%	101%	70%	130%
Uranium	1		< 0.5	< 0.5	0.0%	< 0.5	104%	70%	130%	102%	80%	120%	102%	70%	130%
Vanadium	1		6	7	15.4%	< 1	99%	70%	130%	101%	80%	120%	105%	70%	130%
Zinc	1		9	9	0.0%	< 5	102%	70%	130%	108%	80%	120%	105%	70%	130%
Chromium VI	1		< 0.2	< 0.2	0.0%	< 0.2	93%	70%	130%	92%	80%	120%	95%	70%	130%
Cyanide	1		< 0.040	< 0.040	0.0%	< 0.040	108%	70%	130%	105%	80%	120%	119%	70%	130%
Mercury	1		< 0.10	< 0.10	0.0%	< 0.10	108%	70%	130%	99%	80%	120%	85%	70%	130%
Electrical Conductivity (2:1)	1		0.260	0.262	0.8%	< 0.005	97%	90%	110%	NA			NA		
Sodium Adsorption Ratio	1		1.22	1.23	0.9%	NA	NA			NA			NA		
pH, 2:1 CaCl2 Extraction	1		7.90	7.91	0.1%	NA	97%	90%	110%	NA			NA		

Certified By:

Method Summary

CLIENT NAME: GOLDER ASSOCIATES LTD
AGAT WORK ORDER: 13T717934
PROJECT NO:
ATTENTION TO: Hammad Din

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Antimony	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Barium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron (Hot Water Soluble)	MET-93-6104	EPA SW 846 6010C; MSA, Part 3, Ch.21	ICP/OES
Cadmium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Copper	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Lead	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Nickel	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Selenium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Silver	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Thallium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Uranium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Zinc	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium VI	INOR-93-6029	SM 3500 B; MSA Part 3, Ch. 25	SPECTROPHOTOMETER
Cyanide	INOR-93-6052	MOE CN-3015 & E 3009 A;SM 4500 CN	TECHNICON AUTO ANALYZER
Mercury	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES
pH, 2:1 CaCl2 Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER

AGAT Laboratories

↳ BLK

5835 Coopers Avenue
Mississauga, ON
L4Z 1Y2
www.agatlabs.com · webearth.agatlabs.com

P: 905.712.5100 · F: 905.712.5122 · TF: 800.856.6261

Laboratory Use Only
Arrival Temperature: 3.7/4.8/5.1
AGAT WO #: 13T710934
Lab Temperature:
Notes:

Chain of Custody Record

Client Information

Company: Golder.Markham
Contact: N.Din
Address:
Phone:
Fax:
Project:
PO: 09-1111-6091-6270
AGAT Quotation #: ⊘

Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements

☒ Regulation 153/04 *(reg. 511 Amend.)*
Table 1 *Indicate one*
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture *(check one)*
☐ Coarse ☐ Fine

☐ Sewer Use
Region *Indicate one*
☐ Sanitary
☐ Storm

☐ Regulation 558
☐ CCME
☐ Other *(specify)*
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*

Regular TAT
☒ 5 to 7 Working Days

Rush TAT (please provide prior notification)
Rush Surcharges Apply
☐ 3 Working Days
☐ 2 Working Days
☐ 1 Working Day

OR

Date Required (Rush surcharges may apply):

**TAT is exclusive of weekends and statutory holidays*

Invoice To

Same: Yes ☐ No ☐
Company:
Contact:
Address:

Is this a drinking water sample?
(potable water intended for human consumption)
☐ Yes ☐ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition?**
☐ Yes ☐ No

Legend Matrix

GW	Ground Water	**O**	Oil
SW	Surface Water	**P**	Paint
SD	Sediment	**S**	Soil

Report Information – reports to be sent to:

1. Name: N. Din
Email:
2. Name: Reza Lalyour
Email:

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ FOC ☐ Cr+6- ☐ SAR ☐ NO_3/NO_2 ☐ N- Total ☐ Hg ☐ pH	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2	VOC: ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use	pH								
BH126/SA6	May 17/13		Soil	1		X															X								
BH126/SA10	↓		↓	1		X															X								

Samples Relinquished By (Print Name and Sign): N. Din	Date/Time May 22/13	Samples Received By (Print Name and Sign):	Date/Time May 23
Samples Relinquished By (Print Name and Sign):	Date/Time May 23/13	Samples Received By (Print Name and Sign):	Date/Time 9:55

Pink Copy - Client
Yellow Copy - AGAT
White Copy- AGAT

Page 1 of 1

Nº: 194816

Document ID: DIV-78-1511.007

Date Issued: July 23, 2012

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: GOLDER ASSOCIATES LTD
140 RENFREW DR. SUITE 110
MARKHAM, ON L3R6B3
(905) 475-5591

ATTENTION TO: Hammad Din

PROJECT NO: 09-1111-6091

AGAT WORK ORDER: 13T716824

SOIL ANALYSIS REVIEWED BY: Elizabeth Polakowska, MSc (Animal Sci), PhD (Agri Sci), Inorganic Lab Supervisor

DATE REPORTED: May 27, 2013

PAGES (INCLUDING COVER): 4

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Certificate of Analysis

AGAT WORK ORDER: 13T716824
PROJECT NO: 09-1111-6091

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CANADA L4Z 1Y2
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CLIENT NAME: GOLDER ASSOCIATES LTD

ATTENTION TO: Hammad Din

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2013-05-17

DATE REPORTED: 2013-05-27

			SAMPLE DESCRIPTION:	128/7	128/10
			SAMPLE TYPE:	Soil	Soil
			DATE SAMPLED:	5/14/2013	5/14/2013
Parameter	Unit	G / S	RDL	4361134	4361135
Antimony	µg/g	1.3	0.8	<0.8	<0.8
Arsenic	µg/g	18	1	2	3
Barium	µg/g	220	2	87	69
Beryllium	µg/g	2.5	0.5	0.6	<0.5
Boron	µg/g	36	5	7	8
Boron (Hot Water Soluble)	µg/g	NA	0.10	0.31	0.12
Cadmium	µg/g	1.2	0.5	<0.5	<0.5
Chromium	µg/g	70	2	20	20
Cobalt	µg/g	21	0.5	8.6	8.8
Copper	µg/g	92	1	13	22
Lead	µg/g	120	1	8	8
Molybdenum	µg/g	2	0.5	<0.5	<0.5
Nickel	µg/g	82	1	15	17
Selenium	µg/g	1.5	0.4	<0.4	<0.4
Silver	µg/g	0.5	0.2	<0.2	<0.2
Thallium	µg/g	1	0.4	<0.4	<0.4
Uranium	µg/g	2.5	0.5	0.5	0.6
Vanadium	µg/g	86	1	26	25
Zinc	µg/g	290	5	42	41
Chromium VI	µg/g	0.66	0.2	<0.2	<0.2
Cyanide	µg/g	0.051	0.040	<0.040	<0.040
Mercury	µg/g	0.27	0.10	<0.10	<0.10
Electrical Conductivity (2:1)	mS/cm	0.57	0.005	0.173	0.257
Sodium Adsorption Ratio	NA	2.4	NA	0.671	0.124
pH, 2:1 CaCl2 Extraction	pH Units		NA	7.67	7.90

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T1(ALL) - Current

4361134-4361135 EC & SAR were determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio.

Certified By: Elizabeth Rolakowska

Quality Assurance

CLIENT NAME: GOLDER ASSOCIATES LTD
AGAT WORK ORDER: 13T716824
PROJECT NO: 09-1111-6091
ATTENTION TO: Hammad Din

Soil Analysis

RPT Date: May 27, 2013			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
O. Reg. 153(511) - Metals & Inorganics (Soil)															
Antimony	1		< 0.8	< 0.8	0.0%	< 0.8	101%	70%	130%	90%	80%	120%	80%	70%	130%
Arsenic	1		5	5	0.0%	< 1	105%	70%	130%	109%	80%	120%	103%	70%	130%
Barium	1		102	101	1.0%	< 2	100%	70%	130%	104%	80%	120%	93%	70%	130%
Beryllium	1		0.7	0.7	0.0%	< 0.5	88%	70%	130%	116%	80%	120%	109%	70%	130%
Boron	1		11	11	0.0%	< 5	80%	70%	130%	115%	80%	120%	107%	70%	130%
Boron (Hot Water Soluble)	1		<0.10	<0.10	0.0%	< 0.10	107%	60%	140%	108%	70%	130%	130%	60%	140%
Cadmium	1		< 0.5	< 0.5	0.0%	< 0.5	97%	70%	130%	117%	80%	120%	102%	70%	130%
Chromium	1		24	23	4.3%	< 2	93%	70%	130%	115%	80%	120%	107%	70%	130%
Cobalt	1		12.4	12.2	1.6%	< 0.5	99%	70%	130%	114%	80%	120%	103%	70%	130%
Copper	1		26	27	3.8%	< 1	96%	70%	130%	120%	80%	120%	99%	70%	130%
Lead	1		9	10	10.5%	< 1	102%	70%	130%	111%	80%	120%	98%	70%	130%
Molybdenum	1		0.7	0.7	0.0%	< 0.5	101%	70%	130%	114%	80%	120%	108%	70%	130%
Nickel	1		25	25	0.0%	< 1	98%	70%	130%	117%	80%	120%	102%	70%	130%
Selenium	1		< 0.4	< 0.4	0.0%	< 0.4	86%	70%	130%	114%	80%	120%	103%	70%	130%
Silver	1		< 0.2	< 0.2	0.0%	< 0.2	86%	70%	130%	119%	80%	120%	105%	70%	130%
Thallium	1		< 0.4	< 0.4	0.0%	< 0.4	94%	70%	130%	110%	80%	120%	96%	70%	130%
Uranium	1		0.7	0.7	0.0%	< 0.5	100%	70%	130%	112%	80%	120%	101%	70%	130%
Vanadium	1		29	29	0.0%	< 1	97%	70%	130%	111%	80%	120%	106%	70%	130%
Zinc	1		63	62	1.6%	< 5	102%	70%	130%	118%	80%	120%	105%	70%	130%
Chromium VI	1		< 0.2	< 0.2	0.0%	< 0.2	96%	70%	130%	93%	80%	120%	96%	70%	130%
Cyanide	1		< 0.040	< 0.040	0.0%	< 0.040	102%	70%	130%	106%	80%	120%	108%	70%	130%
Mercury	1		< 0.10	< 0.10	0.0%	< 0.10	111%	70%	130%	102%	80%	120%	102%	70%	130%
Electrical Conductivity (2:1)	1		0.203	0.203	0.0%	< 0.005	95%	90%	110%	NA			NA		
Sodium Adsorption Ratio	1		0.293	0.294	0.2%	NA	NA			NA			NA		
pH, 2:1 CaCl2 Extraction	1		8.23	8.26	0.4%	NA	102%	90%	110%	NA			NA		

Comments: NA signifies Not Applicable.

Certified By: Elizabeth Polakowska

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CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
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Method Summary

CLIENT NAME: GOLDER ASSOCIATES LTD
PROJECT NO: 09-1111-6091

AGAT WORK ORDER: 13T716824
ATTENTION TO: Hammad Din

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Antimony	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Barium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron (Hot Water Soluble)	MET-93-6104	EPA SW 846 6010C; MSA, Part 3, Ch.21	ICP/OES
Cadmium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Copper	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Lead	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Nickel	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Selenium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Silver	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Thallium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Uranium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Zinc	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium VI	INOR-93-6029	SM 3500 B; MSA Part 3, Ch. 25	SPECTROPHOTOMETER
Cyanide	INOR-93-6052	MOE CN-3015 & E 3009 A;SM 4500 CN	TECHNICON AUTO ANALYZER
Mercury	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES
pH, 2:1 CaCl2 Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER

AGAT Laboratories

5835 Coopers Avenue
Mississauga, ON
L4Z 1Y2
www.agatlabs.com · webearth.agatlabs.com

Chain of Custody Record

P: 905.712.5100 · F: 905.712.5122 · TF: 800.856.6261

Laboratory Use Only
Arrival Temperature: 37/22/2.1
AGAT WO #:
Lab Temperature: 13T716824
Notes:

Client Information

Company: Golder
Contact: H.Din
Address: 110- 140 Renfrew Drive
Markham
Phone: 905-475-5591 Fax:
Project: PO: 09- 1111-6091
AGAT Quotation #:

Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements

☒ Regulation 153/04 (reg. 511 Amend.)
Table 1 Indicate one
☐ Ind/Com
☒ Res/Park
☐ Agriculture
Soil Texture *(check one)*
☒ Coarse ☐ Fine

☐ Sewer Use
Region Indicate one
☐ Sanitary
☐ Storm

☐ Regulation 558
☐ CCME
☐ Other *(specify)*
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*

Regular TAT
☒ 5 to 7 Working Days

Rush TAT (please provide prior notification)
Rush Surcharges Apply
☐ 3 Working Days
☐ 2 Working Days
☐ 1 Working Day

OR

Date Required (Rush surcharges may apply):

**TAT is exclusive of weekends and statutory holidays*

Invoice To

Same: Yes ☐ No ☐
Company: Go
Contact:
Address:

Is this a drinking water sample?
(potable water intended for human consumption)
☐ Yes ☐ No
If "Yes", please use the
Drinking Water Chain of Custody Form

Is this submission for a **Record of Site Condition?**
☐ Yes ☐ No

Legend Matrix

GW	Ground Water	**O**	Oil
SW	Surface Water	**P**	Paint
SD	Sediment	**S**	Soil

Report Information – reports to be sent to:

1. Name: Hammad D.N
Email: hammad.din@gmail.com
2. Name:
Email:

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ FOC ☐ Cr+6- ☐ SAR ☐ NO_3/NO_2 ☐ N- Total ☐ Hg ☐ pH	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2	VOC: ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use	pH							
128/7	May 14/13		Soil	1		X															X							
128/10	↓		Soil	1		X															X							

Samples Relinquished By (Print Name and Sign): H.Din
Date/Time: May 17/13
Samples Received By (Print Name and Sign):
Date/Time: may 17/13 1:40
Samples Relinquished By (Print Name and Sign):
Date/Time
Samples Received By (Print Name and Sign):
Date/Time: 5:00

Pink Copy - Client
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Nº: 194814

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
309 Exeter Road, Unit #1
London, Ontario, N6L 1C1
Canada
T: +1 (519) 652 0099