



August 12, 2014

FOUNDATION INVESTIGATION AND DESIGN REPORT

**STORMWATER MANAGEMENT PONDS
CONTRACT 1 - HIGHWAY 400 WIDENING FROM
NORTH OF KING ROAD TO SOUTH CANAL ROAD
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P. 2835-02-00**

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GEOCRES NO.: 30M13-204

Report Number: 09-1111-0018-9

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DRAFT REPORT





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PART A

**FOUNDATION INVESTIGATION REPORT
STORMWATER MANAGEMENT PONDS
CONTRACT 1 – HIGHWAY 400 WIDENING FROM NORTH OF
KING ROAD TO SOUTH CANAL ROAD
G.W.P. 2835-02-00**



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the detail design of the widening of Highway 400 from north of King Road to South Canal Road in the Regional Municipality of York, Ontario, including replacement of the 16th Side Road underpass, Lloydtown-Aurora Road underpass, Highway 9 underpass and the southbound and northbound South Canal bridges, culvert extensions and replacements, retaining walls, the widening of high fill embankments and deep cuts, stormwater management ponds, and high mast light poles and sign supports.

The Terms of Reference for the foundation engineering services are outlined in MTO's Request for Proposal, dated May 2008, that forms part of the Consultant's Agreement (No. 2007-E-0002) for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for this project, dated October 2010.

This report addresses the investigation carried out for proposed **stormwater management (SWM) Ponds 6 and 7** within Contract 1. The purpose of this investigation is to establish the subsurface conditions at the location of the proposed SWM ponds based on borehole drilling and geotechnical laboratory testing on selected samples.

2.0 SITE DESCRIPTION

SWM Ponds 6 and 7 are located on the **west side of Highway 400, about 800 m south of Highway 9 and immediately south of South Canal Bank Road, respectively**, in the Regional Municipality of York, Ontario. Agricultural fields are present along the Highway 400 corridor in this area, with commercial facilities generally located near the Highway 9 interchange and South Canal Bank Road.

In general, the topography at and south of the Highway 9 interchange consists of rolling terrain, with the natural ground surface in the vicinity of SWM Pond 6 sloping downward from south to north, from about Elevation 254 m to 248 m.

Immediately to the north of Highway 9, the natural ground surface and Highway 400 descend into the "Holland Marsh" (as described further in Section 4.1), where the ground surface is relatively flat. SWM Pond 7 is located on the south margin of the Holland Marsh, and the existing natural ground surface at the proposed pond location is between about Elevation 220 m and 222 m.

3.0 INVESTIGATION PROCEDURES

The field work for the foundation investigation at SWM Ponds 6 and 7 was carried out in November 2013, at **which time a total of ten boreholes (five boreholes per SWM pond)**, were advanced at the proposed SWM pond sites. The locations of Boreholes SWM6-1 to SWM6-5 and SWM7-1 to SWM7-5 are shown on Drawings 1 and 2 for SWM Ponds 6 and 7, respectively.

The field investigation was carried out using a D-90 track-mounted drill rig, supplied and operated by Walker Drilling Inc. of Utopia, Ontario. The boreholes were advanced using **140 mm outside diameter continuous flight hollow stem augers**. Soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m using a 50 mm outside diameter split-spoon sampler driven by an automatic hammer in accordance with the Standard



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Penetration Test (SPT) procedure (ASTM D1586-08a). The boreholes were advanced to depths ranging from about 6.6 m to 12.8 m below existing ground surface.

The groundwater conditions in the open boreholes were observed during the drilling operations and a piezometer was installed in each of Borehole SWM6-3, SWM7-2 and SWM7-3 to permit monitoring of the water level at those locations. The piezometers consist of 50 mm diameter PVC pipe, with a slotted screen sealed at a selected depth within the boreholes. The borehole and annulus surrounding the piezometer pipe above the screen sand pack was backfilled to the ground surface with bentonite pellets/grout. Piezometer installation details and water level readings are described on the borehole records presented in Appendices A and C for SWM Ponds 6 and 7, respectively. All boreholes in which standpipe piezometers were not installed were backfilled to ground surface with bentonite upon completion, in accordance with Ontario Regulation 903 (as amended).

The field work was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground utilities, directed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's geotechnical laboratory in Mississauga, Ontario where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO LS and/or ASTM standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples.

The borehole locations and the ground surface elevations were surveyed by Callon Dietz, a registered Ontario Land Surveyor. The borehole locations in MTM NAD 83 northing and easting coordinates, and the ground surface elevations referenced to geodetic datum, are summarized below and are shown on Drawings 1 and 2.

Borehole No.	Location (MTM NAD 83)		Ground Surface Elevation (m)	Drilled Depth (m)
	Northing (m)	Easting (m)		
SWM6-1	4,875,803.0	297,338.6	252.6	6.7
SWM6-2	4,875,778.0	297,274.7	252.8	7.6
SWM6-3	4,875,863.0	297,276.7	250.8	12.8
SWM6-4	4,875,900.0	297,284.7	250.0	6.7
SWM6-5	4,875,884.0	297,247.6	250.4	9.8
SWM7-1	4,876,959.0	297,103.1	221.7	6.7
SWM7-2	4,876,916.0	297,050.0	220.7	11.3
SWM7-3	4,876,883.0	297,051.7	224.5	6.6
SWM7-4	4,876,894.0	297,005.9	220.2	6.6
SWM7-5	4,876,969.0	297,052.2	219.7	6.7



4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This 23 km section of Highway 400 traverses, from south to north, the physiographic regions known as the South Slope, Oak Ridges Moraine and Simcoe Lowland (Chapman and Putman, 1984). Along Highway 400, the South Slope is present south of King Road; the Oak Ridge Moraines extends from north of King Road to south of Highway 9; and the Simcoe Lowlands occupy a 4 km wide strip extending from south of Highway 9 to Holland River. SWM Ponds 6 and 7 are located within the Simcoe Lowlands physiographic region.

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

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

4.2 Overview of Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the laboratory tests carried out on selected soil samples, are provided on the borehole records contained in Appendices A and C for SWM Ponds 6 and 7, respectively. The laboratory test results are also shown in Appendices B and D for these SWM Ponds. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In general, the subsoils at the proposed SWM Pond 6 site consist of a deposit of firm to very stiff clayey silt to silty clay containing organics, underlain by a deposit of clayey silt till. At the proposed SWM Pond 7 site, the subsoils generally consist of thin layers of topsoil, peat and surficial clayey silt and silt and sand, underlain by a deposit of clayey silt till. The clayey silt till deposit at both pond sites contains cobbles and boulders at various depths as inferred from grinding of the augers during drilling operations.

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



4.3 SWM Pond 6

4.3.1 Clayey Silt to Silty Clay

A deposit of clayey silt to silty clay was encountered immediately below the ground surface in all of the boreholes advanced at the proposed site for SWM Pond 6. The thickness of the deposit ranges from about 1.4 m to 8.5 m, with the base of the deposit between approximately 251.2 m and 242.3 m as encountered in the boreholes; the deposit base is higher in the south portion of the site, and lower in the central and north portion of the site.

The clayey silt to silty clay contains trace to some sand and trace gravel, as well as rootlets and organic material. The presence of cobbles and/or boulders within this deposit was inferred from grinding of the augers in Borehole SWM6-2. The results of grain size distribution test on seven selected samples from this deposit are shown on Figure B1 in Appendix B.

Atterberg limits tests were completed on eight selected samples of the clayey silt deposit and measured liquid limits ranging from 29 per cent to 39 per cent, plastic limits ranging from 16 per cent to 19 per cent, and plasticity indices ranging from 12 per cent to 20 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B2 in Appendix B. These results confirm that the deposit is a clayey silt to silty clay of low to medium plasticity. The natural water content measured on samples within this deposit ranges from 18 per cent to 27 per cent.

The Standard Penetration Test (SPT) "N" values measured within this deposit range from 6 blows to 34 blows per 0.3 m of penetration, suggesting that the clayey silt to silty clay deposit ranges in consistency from firm to hard; however, the deposit typically has a stiff to very stiff consistency.

4.3.2 Clayey Silt Till

A till deposit was encountered in all of the boreholes at SWM Pond 6, underlying the clayey silt to silty clay deposit. The surface of this deposit was encountered at depths of between 1.4 m and 8.5 m (Elevation 251.2 m to 242.3 m), generally declining from the south to the north end of the pond area. The till was not fully penetrated in any of the boreholes, with the deepest borehole extending to about Elevation 238.0 m.

The till consists of clayey silt with sand to some sand, trace gravel. Cobbles and/or boulders were inferred within this deposit based on grinding of the augers, as noted on the borehole records contained in Appendix A. Grain size distribution test results of five samples from this deposit are shown on Figure B3 in Appendix B.

Atterberg limits tests were completed on five selected samples of the till deposit and measured liquid limits ranging from 20 per cent to 25 per cent, plastic limits ranging from 12 per cent to 15 per cent, and plasticity indices ranging from 9 per cent to 12 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B4 in Appendix B, and confirm that the material is a clayey silt of low plasticity. The natural water content measured on samples within this deposit ranges from 9 per cent to 17 per cent, generally near the plastic limit for this deposit.

The SPT "N" values measured within the clayey silt till range from 12 blows per 0.3 m of penetration to 105 blows per 0.2 m of penetration. The lower SPT "N" values of 12 blows to 21 blows per 0.3 m of penetration were generally measured in the upper 1 m to 2 m of the till deposit in some of the boreholes, and this upper portion of the till has a stiff to very stiff consistency. In general, however, the till has a very stiff to hard consistency.



4.4 SWM Pond 7

4.4.1 Peat

An approximately 0.3 m to 0.4 m thick layer of peat was encountered immediately below the existing ground surface in Boreholes SWM7-3 and SWM7-4.

One SPT “N” value of 6 blows per 0.3 m of penetration was measured in the peat, suggesting a firm consistency.

4.4.2 Clayey Silt

A clayey silt deposit was encountered below the peat in Borehole SWM7-3 (at a depth of 0.3 m), and immediately below the existing ground surface in Boreholes SWM7-1 and SWM7-5. The deposit consists of clayey silt with sand to trace sand, trace to some gravel; it also contains rootlets and organic materials. The deposit ranges in thickness from 1.2 m to 5.5 m, with its base encountered between about 218.9 m and 223.0 m.

Atterberg limits tests were completed on two selected samples of the deposit and measured liquid limits of 16 per cent and 23 per cent, plastic limits of 12 per cent and 14 per cent, and plasticity indices of 4 per cent and 10 per cent. The results of the Atterberg limits tests are shown on a plasticity chart on Figure D1 in Appendix D, and indicate that the material is a clayey silt of low plasticity. The natural water content as measured on two samples of this deposit is approximately 9 per cent and 12 per cent, near the plastic limit for this deposit.

The SPT “N” values measured in the clayey silt deposit range from 3 blows to 24 blows per 0.3 m of penetration, suggesting a variable, soft to very stiff consistency.

4.4.3 Silt and Sand to Sand and Gravel

A thin cohesionless soil deposit was encountered below the peat in Borehole SWM7-4, below the clayey silt in Boreholes SWM7-1 and SWM7-5, and immediately below the existing ground surface in Borehole SWM7-2. The surface of this deposit was encountered at depths of up to 1.4 m (Elevation 218.9 m). The thickness of the deposit ranges from about 0.7 m to 2.0 m, and the deposit base was encountered in the boreholes between Elevation 218.2 m and 219.6 m.

This deposit ranges in composition from silt and sand to silty sand containing trace clay, to sand and gravel. Rootlets, wood fragments and organic material were observed in some of the recovered samples. Grain size distribution test results of two samples from this deposit are shown on Figure D2 in Appendix D. The natural water content measured on samples within this deposit ranges from 8 per cent to 23 per cent.

The SPT “N” values measured within this deposit range from 12 blows to 26 blows per 0.3 m of penetration, indicating a compact relative density.

4.4.4 Clayey Silt Till

A clayey silt till deposit was encountered in all of the boreholes at SWM Pond 7, underlying the clayey silt or silt and sand to sand and gravel deposits. The surface of this deposit was encountered at depths of about 1.1 m to



3.4 m (Elevation 223.0 m to 218.2 m) and it was not fully penetrated in any of the boreholes to depths; the deepest of the boreholes extended to Elevation 209.4 m (a depth of 11.3 m).

The till deposit consists of clayey silt with sand to some sand, trace to some gravel. The presence of cobbles and boulders was inferred at various locations in this deposit based on grinding of the augers, as noted on the borehole records. Grain size distribution testing was completed on eight selected samples, and the results are shown on Figures D3A and D3B in Appendix D.

Atterberg limits tests were completed on nine specimens of the clayey silt till, and measured liquid limits ranging from 18 per cent to 25 per cent, plastic limits ranging from 11 per cent to 13 per cent, and plasticity indices ranging from 6 per cent to 12 per cent. The results of the Atterberg limits tests are shown on a plasticity chart on Figures D4A and D4B in Appendix D; these test results confirm that the till is a clayey silt of low plasticity. The natural water content measured on selected samples of the till ranges from 8 per cent to 12 per cent, near the plastic limit for the material.

The SPT "N" values measured within the clayey silt till deposit range from 14 blows per 0.3 m of penetration to 98 blows per 0.23 m of penetration, suggesting a stiff to hard consistency.

4.5 Groundwater Conditions

The water levels were observed in the open boreholes immediately following completion of drilling, and these observations are recorded on the borehole records contained in Appendices A and C; however, these measured levels are not considered to be representative of the stabilized groundwater levels at the proposed SWM pond sites.

A standpipe piezometer was installed in one borehole at the proposed SWM Pond 6 site, and two boreholes at the proposed SWM Pond 7 site. The water levels measured in the piezometers are shown on the borehole records in Appendices A and C and summarized as follows:

Borehole No.	Date	Water Level Depth (m)	Water Level Elevation (m)
SWM6-3	November 28, 2013	2.1	248.7
	December 9, 2013	2.0	248.8
	January 7, 2014	2.2	248.6
SWM7-2	November 28, 2013	8.1	212.6
	December 9, 2013	8.0	212.7
	January 7, 2014	7.6	213.1
SWM7-3*	November 28, 2013	1.0	223.5
	December 9, 2013	0.9	223.6
	January 7, 2014	0.9	223.6

* Note that Borehole SWM7-3 is located outside of the footprint of the pond, and at a higher ground elevation (upslope) from SWM7-2.



The measurements summarized above are considered to represent the “stabilized” groundwater level at the SWM pond sites in fall/winter conditions. The water level is, however, expected to fluctuate seasonally and in response to changes in precipitation and snow melt, and is expected to be higher during the spring and other periods of heavy precipitation.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Matthew Kelly, P.Eng., and reviewed by Ms. Lisa Coyne, P.Eng., a senior geotechnical engineer and Principal with Golder. Mr. Ty Garde, P.Eng., Golder's Designated MTO Foundations Contact for this project and a Principal with Golder, conducted an independent quality control review of the report.

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PART B

**FOUNDATION DESIGN REPORT
STORMWATER MANAGEMENT PONDS
CONTRACT 1 – HIGHWAY 400 WIDENING FROM NORTH OF
KING ROAD TO SOUTH CANAL ROAD
G.W.P. 2835-02-00**



6.0 DISCUSSION AND ENGINEERING RECOMMENDATION

6.1 General

This section of the report provides geotechnical recommendations for the design of two proposed stormwater management (SWM) ponds within the limits of Contract 1 for this project, designated as SWM Pond 6 and SWM Pond 7. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation at the proposed SWM pond locations. The interpretation and recommendations contained in this report are intended to provide the designers with sufficient information to complete the detail design of the proposed SWM ponds.

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

The following table summarizes the design pond base elevation and approximate maximum cut depth for each of the proposed SWM ponds.

SWM Pond	Design Pond Base Elevation (m)	Maximum Water Level Elevation (m)	Subsurface Conditions at Pond Base	Approximate Maximum Cut Depth (m)
SWM Pond 6	246.0	250.25	Clayey silt till	7.0
SWM Pond 7	219.1	222.3	Clayey silt till	3.5

6.2 Pond Base Stability – Construction and Maintenance Conditions

The design groundwater levels indicated below have been considered in developing the design recommendations for the proposed SWM ponds. These groundwater levels are considered reasonable based on the groundwater levels measured in the piezometers and the potential for higher groundwater levels in spring conditions. At SWM Pond 7, the design groundwater level has been interpolated based on the piezometer measurements from Borehole SWM7-2, located within the footprint of the proposed pond, and SWM7-3, located to the south of the proposed SWM pond footprint, in an area of higher ground. There is an adequate factor of safety against base instability based on the design groundwater level and the proposed pond base elevation at both SWM pond locations, in both shorter-term construction conditions, and longer-term maintenance conditions.

SWM Pond	Pond Base Elevation (m)	Design Groundwater Elevation (m)	Groundwater Level Relative to Pond Base	Potential for Base Instability
SWM Pond 6	246.0	249.0	3.0 m above	No
SWM Pond 7	219.1	221.0	1.9 m above	No



As noted above, at the SWM pond locations the design groundwater level is approximately 1.9 m to 3.0 m above the design pond base elevation. Relatively minor groundwater seepage is anticipated from the relatively low permeability surficial clayey silt and clayey silt till deposits. A higher seepage volume is anticipated where “perched” groundwater may be encountered in surficial silt and sand to sand and gravel deposits on top of the clayey silt till deposit, or from granular interlayers or lenses within the till deposit.

It is anticipated that pumping from properly filtered sumps within the excavation would be adequate to control the groundwater during the construction of the SWM ponds. In future periods where the pond is fully drained for maintenance purposes, no groundwater control measures are expected to be required.

6.3 Pond Liner and Berm Construction Considerations

If site grading and stormwater storage requirements permit, it is recommended that the permanent pool level (i.e., minimum operating water level in each SWM pond) be designed to be close to the groundwater level at each pond location, to minimize the potential for interaction between storm water and groundwater.

Based on the existing topography at the proposed SWM Pond sites, some portions of the pond side slopes will be cut below the existing ground surface, and some portions of the pond side slopes will be constructed as a berm above the existing ground surface. The cut or fill conditions and requirements for pond liners and/or berm treatments are summarized in the following sections.

6.3.1 SWM Pond 6

The pond side slopes will be cut below the existing ground surface through clayey soils. Given the low permeability of the surficial clayey silt to silty clay and the clayey silt till soils, a pond liner is not required at this pond location.

6.3.2 SWM Pond 7

The south side of the pond will be constructed in cut, while the north side and east and west ends will be constructed as a berm above the existing ground surface. The proposed pond base elevation is 219.1 m; cohesionless (silt and sand to sand and gravel) soils were encountered at and below this elevation in Boreholes SWM7-1, SWM7-4 and SWM7-5, overlying low-permeability clayey silt. It is recommended that a “key trench” be subexcavated to or below Elevation 218 m in the clayey silt till, extending over the full footprint of the berm and an additional 1 m in front of the berm toe, along the east, west and north sides of SWM Pond 7. This subexcavation should be replaced with compacted cohesive fill, as described below. Provided that the berm is “keyed” into this subexcavation in the clayey silt till deposit to prevent seepage under the berm, a pond liner is not required at this pond location.

The prepared subgrade for the berm should be inspected by the geotechnical engineer prior to placement of the backfill and the berm fill material, to check that no cohesionless/water-bearing soils are present at the subgrade level. The cohesive material used to backfill the “key trench” and construct the berm should be approved by the geotechnical engineer prior to placement. In this regard, the excavated clayey materials from the site (i.e. the



surficial clayey silt to silty clay, or clayey silt till) would be suitable for reuse for berm construction provided that these materials are at a suitable water content. The approved material should be placed and compacted in accordance with OPSS 501 (*Compacting*). Care should be taken to ensure homogeneity of the constructed berm (i.e. no erodible layers, or permeable cohesionless soil layers).

6.4 Global Stability of Pond Cut Slopes and Berm Slopes

Slope stability analyses were performed using the commercially available program *Slide*, developed by Rocscience Inc., at critical sections for the pond locations to verify that the cut slopes and berms (fill sections) have a global factor of safety equal to or greater than 1.3 under static conditions. This minimum factor of safety is considered appropriate for the proposed SWM pond side slopes on this project, considering the design requirements and the available field and laboratory testing data.

The soil parameters summarized below have been used for stability analyses for both short-term (undrained) and long-term (effective stress) conditions. These parameters were estimated from empirical correlations (CHBDC, 2006) with the borehole and Standard Penetration Test data from the proposed pond sites, as well as consideration of geotechnical laboratory test data from these boreholes and from similar soils along this section of Highway 400:

Soil Deposit	Bulk Unit Weight (kN/m ³)	Undrained Shear Strength (kPa)	Effective Friction Angle
Fill for construction of berms (fill sections at SWM Pond 7)	21	-	32°
Soft to hard clayey silt to silty clay	19	50	26°
Compact silt and sand to sand and gravel	20	-	30°
Stiff to hard clayey silt till	21	75	32°

The piezometric conditions used in the stability analyses are based on the design groundwater levels as discussed above, typical/normal operating water levels, as well as maximum water levels for the ponds, as summarized below:

Pond	Design Groundwater Elevation (m)	Typical Operating Water Level Elevation (m)	Maximum Water Level Elevation (m)
SWM Pond 6	249.0	249.0	250.25
SWM Pond 7	221.0	221.0	222.3

It is understood that the inside slope of the ponds and forebay berm slopes will be oriented at 5 horizontal to 1 vertical (5H:1V) below the normal operating water level, and 3H:1V above the normal operating water level, and that the outside slopes of the perimeter berms will be oriented at 3H:1V. The results of the stability analyses



indicate that a factor of safety of 1.3 or greater is achieved for the global stability of pond side slopes oriented as described above, both under normal operating water levels and high water levels. Examples of the global static stability analyses are included on Figures 1 to 3 for selected typical or critical cross-sections at the proposed pond locations.

Stability analyses were also carried out for the case where the pond is fully drained for future maintenance. Under this “rapid drawdown” condition, the pond water level may be lowered to the base of the pond faster than the groundwater level in the cut slope/berm side slope is able to drain. At SWM Pond 7, the factor of safety against global instability of the pond side slopes remains greater than 1.3 under rapid drawdown conditions. However, under rapid drawdown conditions at SWM Pond 6, the factor of safety against instability approaches 1.0 for slip surfaces that penetrate to a depth of about 1 m below the slope face. This can be mitigated by draining SWM Pond 6 over a period of at least two weeks, to maintain an adequate factor of safety during future maintenance operations where full drainage of the pond is required.

6.5 Surficial Stability and Erosion Protection

The requirements for the design of erosion protection measures for the inlet and outlet storm sewer pipes should be assessed by the hydraulic design engineer. As a minimum, rip-rap treatment for the inlet and outlet of the storm sewer pipes should be consistent with the standard presented in OPSD 810.010 (*Rip-Rap Treatment for Sewer and Culvert Outlets*) Rip-Rap Treatment Type A, and OPSD 810.020 (*Rip-Rap Treatment for Ditch Inlets*). The rip-rap should be placed to above the pipe obvert, in combination with cut-off headwalls if these are adopted. Rip-rap should be provided over the full extent of the side slopes and base grade below and adjacent to the sewer inlet / outlet locations. Protection of the inlet channel against surficial erosion will be required, particularly at SWM Pond 7 where higher velocity and/or more turbulent water flows may occur due to the change in ground surface elevation from Highway 9 toward the Holland Marsh, in the vicinity of this SWM pond. In this regard, the SWM pond inlet channel/area should be lined with river stone or rip-rap protection, placed on a geotextile separator, that extends the full width and up the side slopes of the channel as necessary.

The pond slopes above the operating water level should be vegetated as soon as practicable after construction to minimize the potential for erosion due to surface water run-off, either by placement of topsoil (OPSS 802, *Topsoil*) and pegged sod (OPSS 803, *Sodding*) or seeding (OPSS 804, *Seed and Cover*). Consideration could also be given to protecting the active water line zone (i.e., from the low water level to the high water level) with a minimum 150 mm thick layer of rip-rap meeting Classification R-10 according to OPSS.PROV 1004 (*Aggregates - Miscellaneous*); however, this may not be necessary if appropriate vegetation can be established in this zone.

In addition, a granular drainage blanket may be required to control surficial sloughing of cut slopes through saturated cohesionless soil (sand to silt) zones or layers, if these are encountered within the till deposit during construction. This construction provision is discussed further in Section 6.6 (Construction Considerations).



6.6 Construction Considerations

6.6.1 Excavations for Pond Construction

Permanent and temporary excavations for the pond cuts and any associated drainage structures, where required, will be made through the surficial clayey silt to silty clay and silt and sand to sand and gravel deposits, and into clayey silt till. Cobbles and boulders were encountered or inferred at various depths within the till deposit in some of the boreholes. Conventional excavation equipment is expected to be suitable for construction of the SWM ponds.

Where temporary excavations are required within or adjacent to the proposed SWM ponds for drainage structures, the surficial soils (i.e. firm to very stiff clayey silt to silty clay and water-bearing, compact cohesionless deposits) are considered to be Type 3 soils, while the till is considered to be Type 2 soil according to the *Occupational Health & Safety Act & Regulation (OHSA) for Construction Projects*. As such, temporary open-cut excavations should be completed with side slopes no steeper than 1H:1V. All excavations must be carried out in accordance with the latest edition of the OHSA.

6.6.2 Groundwater Control During Construction

As discussed in Section 6.2, at the locations of SWM ponds the design groundwater level is approximately 1.9 m to 3.0 m above the design pond base elevation. Relatively minor groundwater seepage is anticipated from the low permeability surficial clayey silt to silty clay or clayey silt till deposits. Greater seepage is anticipated from water "perched" in the surficial silt and sand to sand and gravel deposits, or from lenses or interlayers of water-bearing cohesionless soils within or perched on top of the till deposit, although such seepage is anticipated to be of relatively limited duration.

It is recommended that the ponds be excavated and ditches or sub-drains/trenches installed to allow for gravity drainage in advance of reaching the final base grades and side slope orientations, to allow the groundwater to drain and thereby reduce the risk of surficial instability on the side slopes and/or disturbance/softening at the pond base. Consideration could be given to sequencing the excavation to allow construction of the drainage outlet pipes first to provide a passive drainage system for groundwater control during the pond excavation works.

6.6.3 Granular Drainage Blankets on Pond Cut Slopes

Lenses or interlayers of water-bearing cohesionless soils may be encountered within the clayey silt till deposit during excavation of the cut slopes for SWM Pond 6 and/or the south side of SWM Pond 7. A granular drainage blanket may be required to control surficial sloughing of cut slopes through such saturated cohesionless soil zones or layers, where these are encountered.

Determination of the frequency, extent and exact locations of such seepage zones from the limited borehole data obtained as part of this investigation is not possible. Therefore, an observational approach is recommended, involving examination of the cut slopes during and following construction to identify any areas of water-bearing cohesionless soils, with a granular drainage blanket placed on the pond cut slopes where lenses or layers or water-bearing cohesionless soils are observed, to minimize surficial sloughing and/or erosion.



To provide an effective filter and drainage medium, the drainage blanket should be comprised of a minimum thickness of 600 mm of OPSS.PROV 1004 granular sheeting material, or OPSS.PROV 1010 Granular A or Granular B Type II material.

6.6.4 SWM Pond 6 Maintenance After Construction

As discussed in Section 6.4, special procedures will apply at SWM Pond 6 if it is required to be fully drained for maintenance or cleaning in the future. In order to maintain an adequate factor of safety against global instability of the pond side slopes, the pond should be drained over a minimum period of two weeks.

7.0 CLOSURE

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

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MWK/SMM/LCC/TJG/sm

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- Occupational Health and Safety Act and Regulations, Construction Projects (O.Reg 213/91), 2011.

Ontario Provincial Standard Specifications (OPSS)

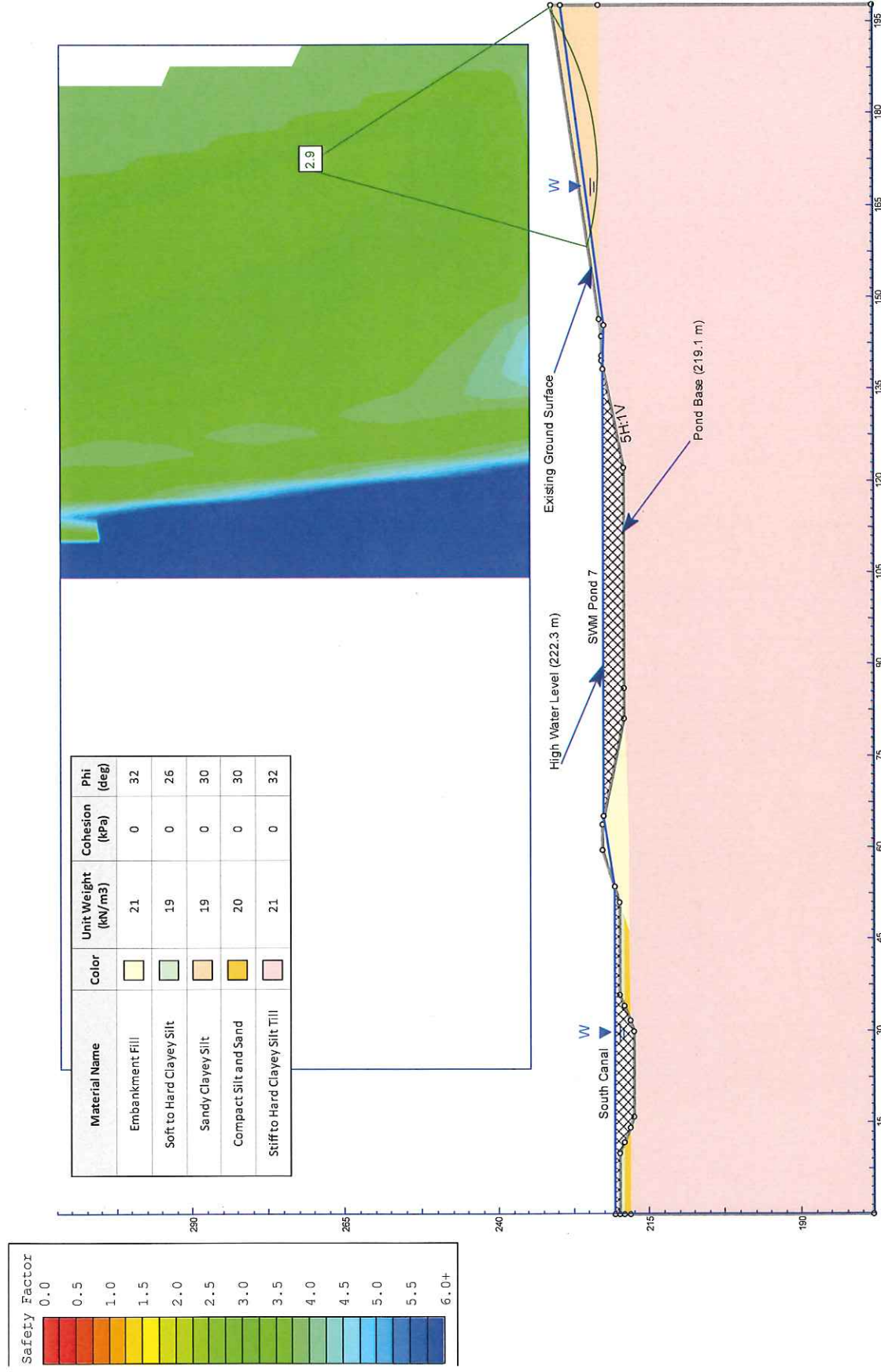
OPSS 501	Construction Specification for Compacting
OPSS 802	Construction Specification for Topsoil
OPSS 803	Construction Specification for Sodding
OPSS 804	Construction Specification for Seed and Cover
OPSS.PROV 1004	Material Specification for Aggregates - Miscellaneous
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario Provincial Standard Drawings (OPSD)

OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
OPSD 810.020	General Rip-Rap Layout for Ditch Inlets

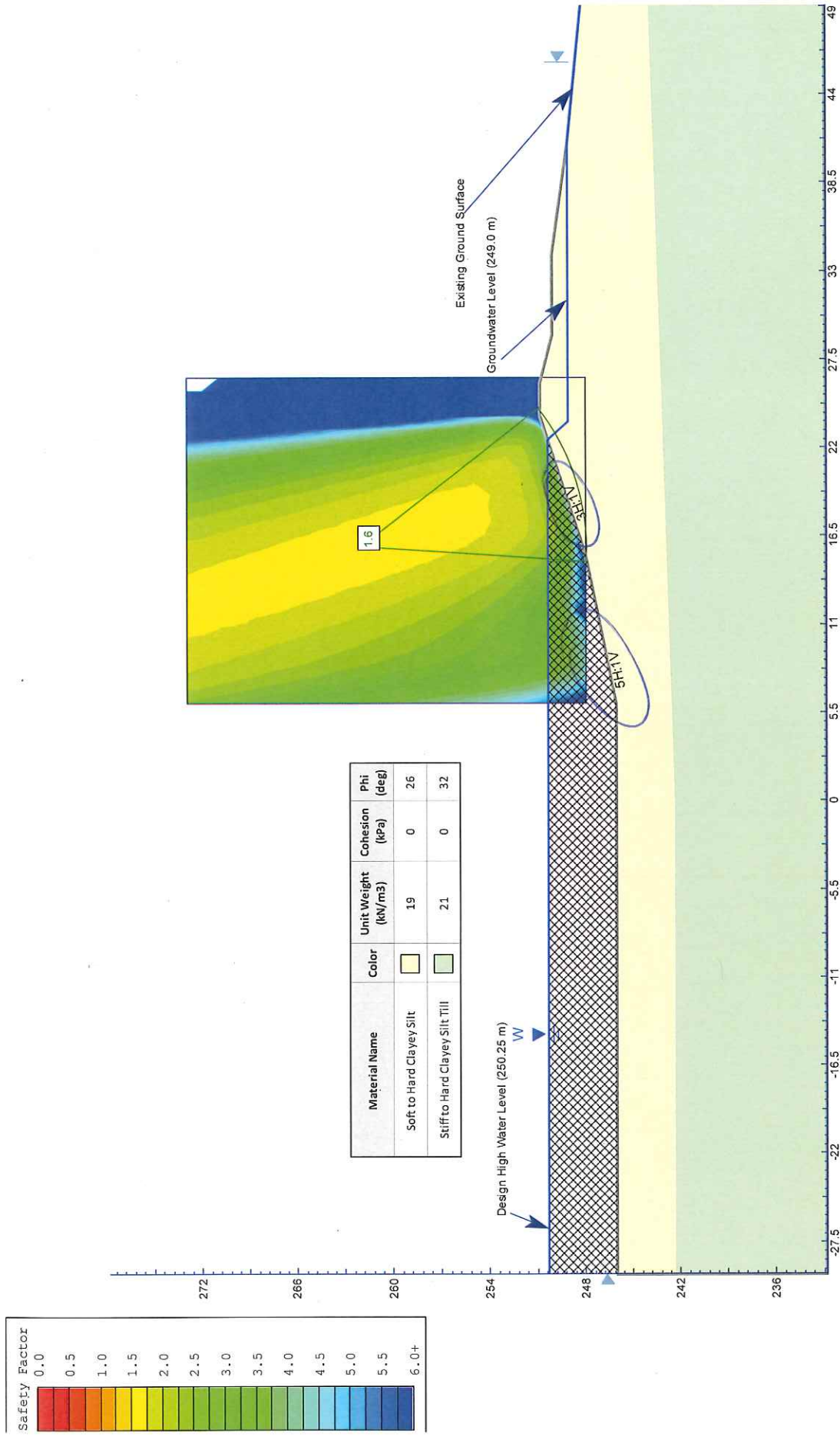
Stormwater Management Pond 7 Cut Slope Stability

Figure 2



Stormwater Management Pond 6 Cut Slope Stability

Figure 1



Stormwater Management Pond 7 Embankment Fill Slope Stability

Figure 3





APPENDIX A

Borehole Records – SWM Pond 6



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes: 1

2

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

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



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils Consistency

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


IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

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

PROJECT 09-1111-0018		RECORD OF BOREHOLE No SWM6-1				SHEET 1 OF 1		METRIC				
W.P. 2835-02-00		LOCATION N 4875803.0 ; E 297338.6				ORIGINATED BY BM						
DIST Central HWY 400		BOREHOLE TYPE 140 mm O.D. Continuous Flight Hollow Stem Augers				COMPILED BY MAS/AV						
DATUM Geodetic		DATE November 14, 2013				CHECKED BY SMM/LCC						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa		WATER CONTENT (%)		
252.6	GROUND SURFACE											
0.0	CLAYEY SILT, trace to some sand, trace gravel, containing rootlets Stiff Brown Moist to wet		1	SS	9							
251.2			2	SS	13							
1.4	CLAYEY SILT with sand, trace gravel (TILL) Stiff to hard Brown to grey Moist		3	SS	12							
	Auger grinding at a depth of 2.4 m Possible cobbles		4	SS	35							
			5	SS	27							
	Auger grinding at a depth of 4.0 m Possible cobbles		6	SS	43							
			7	SS	103/0.28							
245.9			8	SS	105/0.20							
6.7	END OF BOREHOLE SPLIT-SPOON REFUSAL NOTE: 1. Water level in open borehole at a depth of 6.2 m below ground surface (Elev. 246.4 m) upon completion of drilling.											

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RECORD OF BOREHOLE No SWM6-2 SHEET 1 OF 1
METRIC

PROJECT 09-1111-0018
 W.P. 2835-02-00 LOCATION N 4875778.0 ; E 297274.7 ORIGINATED BY BM
 DIST Central HWY 400 BOREHOLE TYPE 140 mm O.D. Continuous Flight Hollow Stem Augers COMPILED BY MAS/AV
 DATUM Geodetic DATE November 13, 2013 CHECKED BY SMM/LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)
								20	40	60			
252.8	GROUND SURFACE												
0.0	CLAYEY SILT, trace sand, trace gravel, containing rootlets Stiff to very stiff Brown Moist to wet Auger grinding, possible cobbles at 1.1 m		1	SS	8		252					0 0 58 42	
			2	SS	17								
			3	SS	12		251						
250.6													
2.2	CLAYEY SILT with sand, trace gravel (TILL) Very stiff to hard Brown becoming grey below a depth of 6.1 m Moist Auger grinding at depths of 2.3 m and 3.5 m Possible cobbles		4	SS	16		250						
			5	SS	24								
			6	SS	19		249					3 26 47 24	
			7	SS	32		248						
			8	SS	25		247						
							246						
245.2	END OF BOREHOLE SPLIT-SPOON REFUSAL		9	SS	*								
7.6	NOTES: 1. Water level in open borehole at a depth of 3.0 m below ground surface (Elev. 249.8 m) upon completion of drilling. * SPLIT-SPOON Sampler Bouncing.												

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RECORD OF BOREHOLE No SWM6-3 SHEET 1 OF 2
METRIC

PROJECT 09-1111-0018

W.P. 2835-02-00

LOCATION N 4875863.0 ; E 297276.7

ORIGINATED BY BM

DIST Central HWY 400

BOREHOLE TYPE 140 mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY MAS/AV

DATUM Geodetic

DATE November 13, 2013

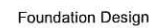
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SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
250.8 0.0	GROUND SURFACE CLAYEY SILT, trace sand, containing rootlets to a depth of 0.8 m Stiff to very stiff Brown becoming grey below a depth of 6.1 m Moist to wet		1	SS	14		250						
			2	SS	15								
			3	SS	17		249						0 1 72 27
			4	SS	21		248						
			5	SS	22		247						
			6	SS	20		246						
			7	SS	22		245						
			8	SS	29		244						0 1 65 34
			9	SS	24		243						
242.3 8.5	CLAYEY SILT, some sand, trace gravel (TILL) Hard Grey Wet		10	SS	40		242						
			11	SS	37		240						5 15 46 34
			12	SS	85		238						
238.0 12.8	END OF BOREHOLE												

Continued Next Page

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


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METRIC

CHECKED BY SMM/LCC

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

PROJECT 09-1111-0018			RECORD OF BOREHOLE No SWM6-4			SHEET 1 OF 1			METRIC					
W.P. 2835-02-00			LOCATION N 4875900.0 ; E 297284.7			ORIGINATED BY BM								
DIST Central HWY 400			BOREHOLE TYPE 140 mm O.D. Continuous Flight Hollow Stem Augers			COMPILED BY MAS/AV								
DATUM Geodetic			DATE November 12, 2013			CHECKED BY SMM/LCC								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
250.0	GROUND SURFACE							20 40 60 80 100						
0.0	CLAYEY SILT, some sand, containing rootlets Stiff to very stiff Dark brown Moist to wet		1	SS	10									
			2	SS	25									
248.6														
1.5	CLAYEY SILT Very stiff to hard Brown becoming grey below a depth of 4.9 m Moist to wet		3	SS	27									
			4	SS	36									
			5	SS	27									
			6	SS	18									
		7	SS	24										
244.4														
5.6	CLAYEY SILT, some sand, trace gravel (TILL) Very stiff Grey Wet													
243.3			8	SS	21									
6.7	END OF BOREHOLE													
	NOTE: 1. Open borehole dry upon completion of drilling.													

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PROJECT 09-1111-0018		RECORD OF BOREHOLE No SWM6-5		SHEET 1 OF 1		METRIC							
W.P. 2835-02-00		LOCATION N 4875884.0 ; E 297247.6		ORIGINATED BY BM									
DIST Central HWY 400		BOREHOLE TYPE 140 mm O.D. Continuous Flight Hollow Stem Augers		COMPILED BY MAS/AV									
DATUM Geodetic		DATE November 12, 2013		CHECKED BY SMM/LCC									
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
250.4	GROUND SURFACE						20 40 60 80 100						
0.0	CLAYEY SILT to SILTY CLAY, trace sand, trace gravel, containing rootlets Firm to very stiff Brown Moist to wet		1	SS	6								1 1 51 47
249.0			2	SS	23								
1.5	CLAYEY SILT, trace sand Stiff to hard Brown becoming grey below a depth of 5.0 m Moist		3	SS	15								
			4	SS	11								
			5	SS	10								
			6	SS	24								0 0 65 35
			7	SS	34								
244.8													
5.6	CLAYEY SILT with sand, trace to some gravel (TILL) Hard Grey Moist to wet		8	SS	41								
			9	SS	42								15 21 46 18
	Auger grinding at a depth of 8.2 m Possible cobbles or boulder												
240.7			10	SS	65								
9.8	END OF BOREHOLE												
	NOTE: 1. Water level in open borehole at a depth of 7.6 m below ground surface (Elev. 242.8 m) upon completion of drilling.												



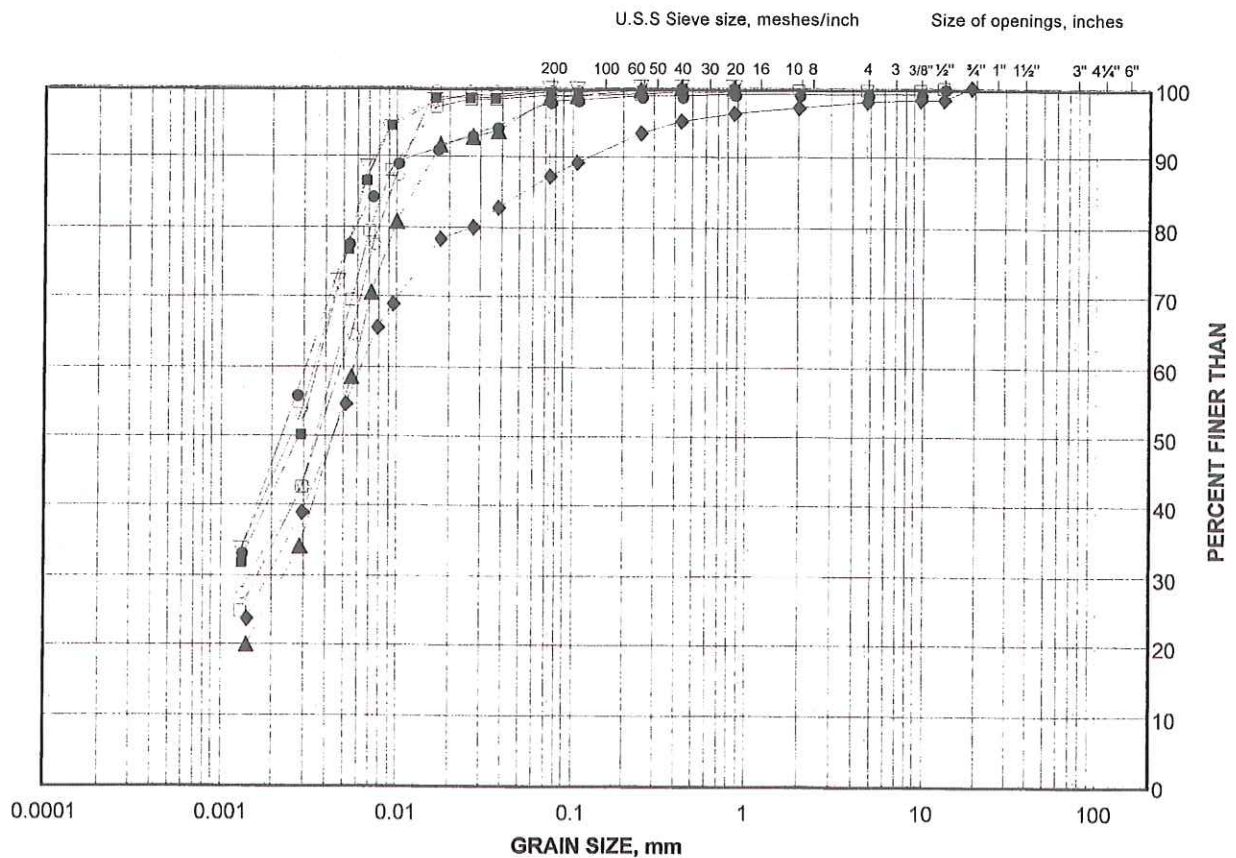
APPENDIX B

Laboratory Test Results – SWM Pond 6

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay

FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SWM6-5	2	249.3
■	SWM6-2	2	251.7
◆	SWM6-1	2	251.5
▲	SWM6-3	3	249.0
▽	SWM6-4	5	246.7
○	SWM6-5	6	246.3
□	SWM6-3	8	244.4

Project Number: 09-1111-0018

Checked By: *Woyce*

Golder Associates

Date: 30-Jul-14

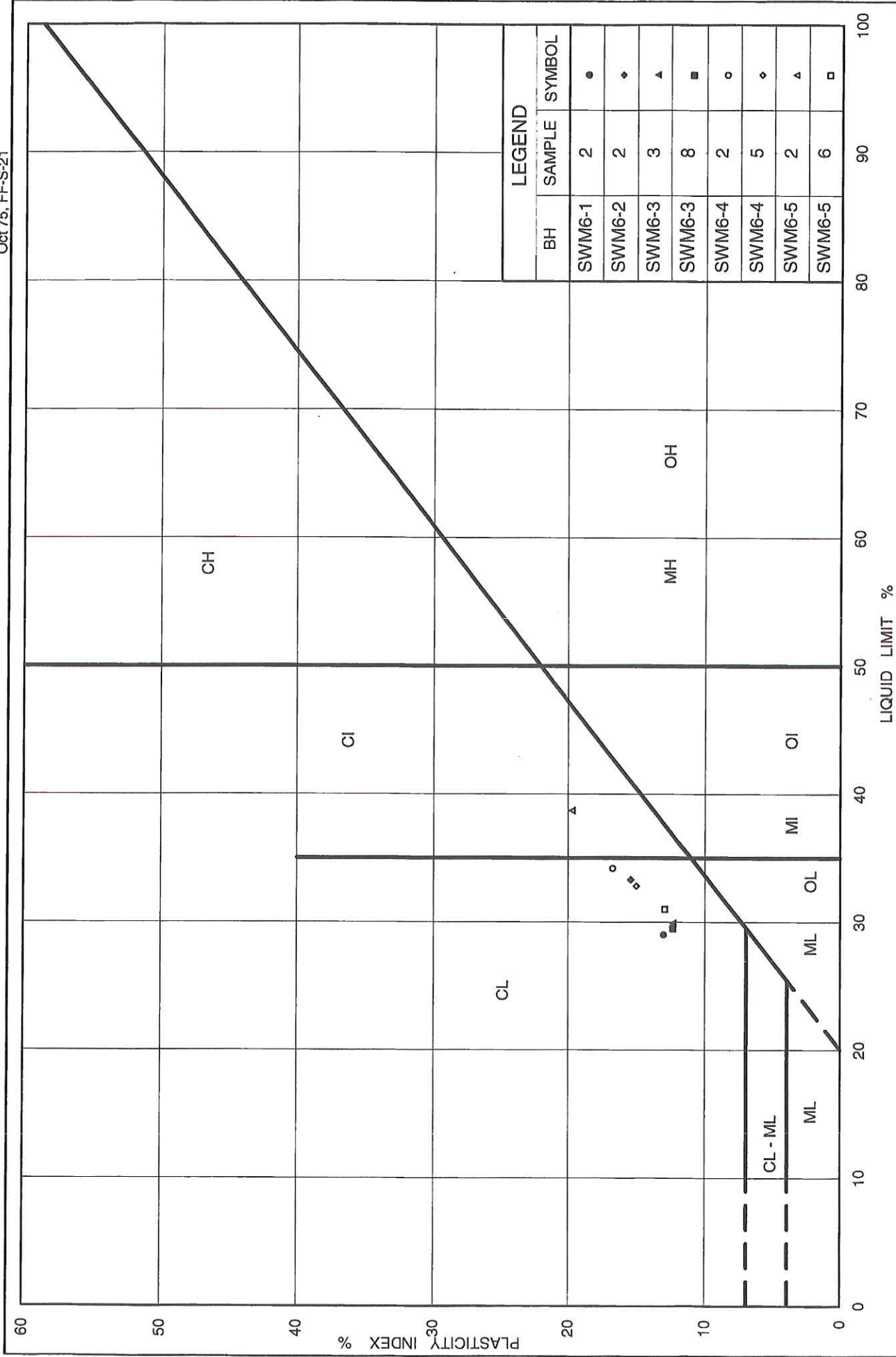


Figure No. B2

PLASTICITY CHART Clayey Silt to Silty Clay

Ministry of Transportation



Project No. 09-1111-0018

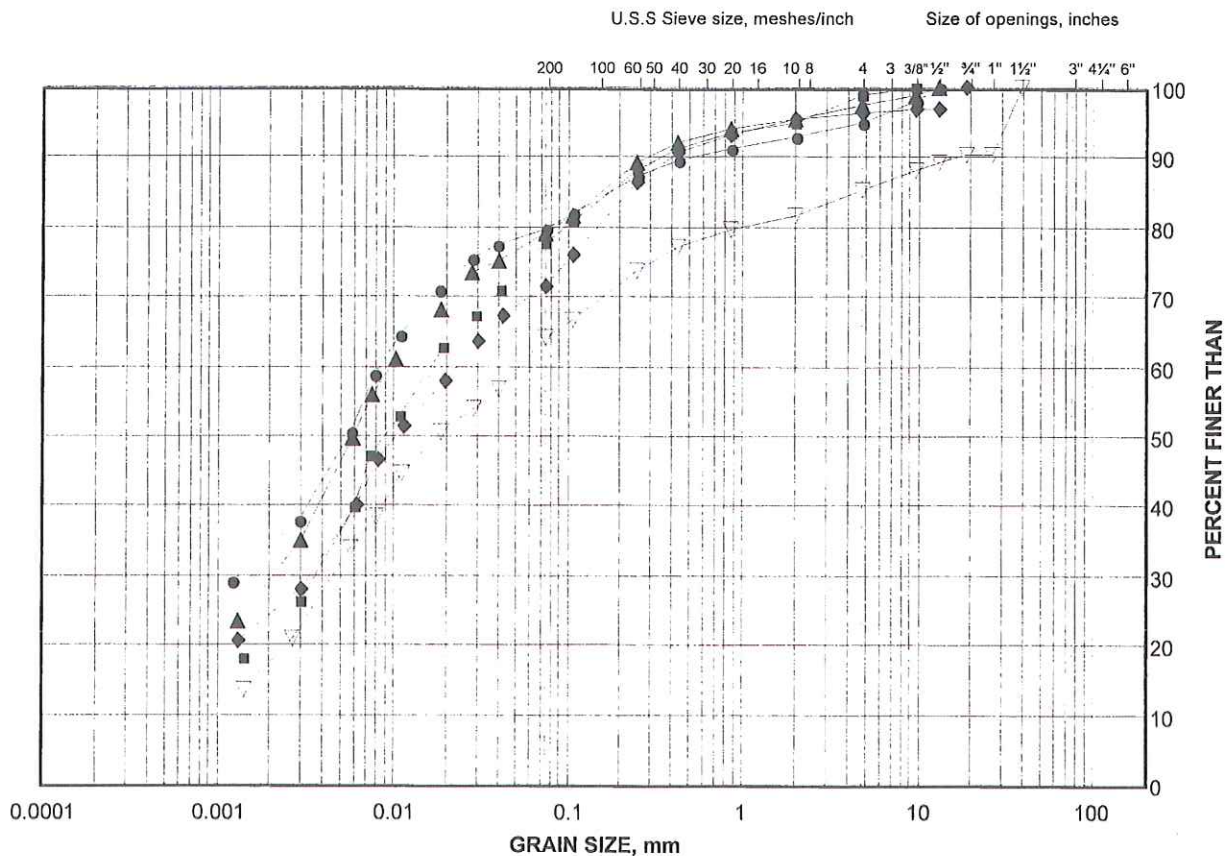
Checked By: *Woy*

Ontario

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt Till

FIGURE B3



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

LEGEND

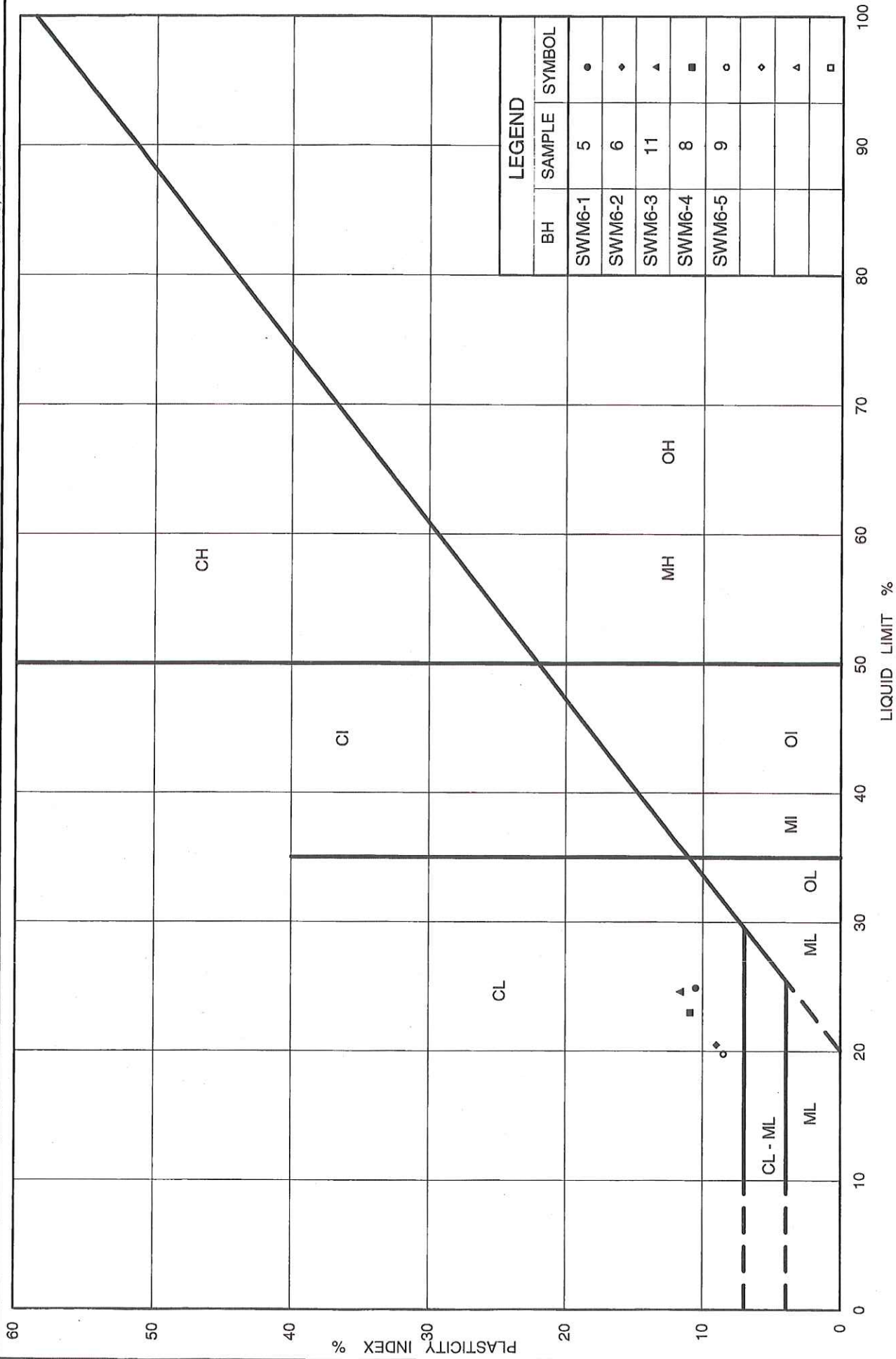
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SWM6-3	11	239.8
■	SWM6-1	5	249.3
◆	SWM6-2	6	248.7
▲	SWM6-4	8	243.6
▼	SWM6-5	9	242.5

Project Number: 09-1111-0018

Checked By: *[Signature]*

Golder Associates

Date: 30-Jul-14



PLASTICITY CHART Clayey Silt Till

Figure No. B4
Project No. 09-1111-0018
Checked By: *Maye*

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APPENDIX C

Borehole Records – SWM Pond 7

PROJECT 09-1111-0018		RECORD OF BOREHOLE No SWM7-1				SHEET 1 OF 1		METRIC								
W.P. 2835-02-00		LOCATION N 4876959.0 ; E 297103.1				ORIGINATED BY OS										
DIST Central HWY 400		BOREHOLE TYPE 140 mm O.D. Continuous Flight Hollow Stem Augers				COMPILED BY MWK/AV										
DATUM Geodetic		DATE November 19, 2013				CHECKED BY SMM/LCC										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
221.7	GROUND SURFACE							20	40	60	80	100				
0.0	CLAYEY SILT, trace to some sand, trace gravel, containing organic material Soft to stiff Brown with oxidation staining Moist to wet		1	SS	3											
220.3			2	SS	9											
1.4	SILT and SAND, some gravel, trace to some clay Compact Brown becoming grey below a depth of 2.3 m Moist		3	SS	16											
			4	SS	12											
218.3			5A	SS	15											
3.4	CLAYEY SILT with sand, trace gravel (TILL) Very stiff to hard Grey Moist to wet		5B													
			6	SS	23											
			7	SS	26											
215.0			8	SS	43											
6.7	END OF BOREHOLE															
NOTES:																
1. Water level measured inside augers at a depth of 5.5 m below ground surface (Elev. 216.2 m) upon completion of drilling.																
2. Borehole caved at a depth of 3.0 m below ground surface (Elev. 218.7 m) after removal of augers.																

PROJECT 09-1111-0018			RECORD OF BOREHOLE No SWM7-2			SHEET 1 OF 1			METRIC		
W.P. 2835-02-00			LOCATION N 4876916.0 ; E 297050.0			ORIGINATED BY OS					
DIST Central HWY 400			BOREHOLE TYPE 140 mm O.D. Continuous Flight Hollow Stem Augers			COMPILED BY MWK/AV					
DATUM Geodetic			DATE November 19/20, 2013			CHECKED BY SMM/LCC					
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES	20 40 60 80 100	20 40 60 80 100		
220.7	GROUND SURFACE										
0.0	Silty SAND, containing roots and organic material Compact Brown and black Wet		1	SS	26						
219.6			2A	SS	5						
1.1	CLAYEY SILT with sand, trace gravel (TILL) Stiff to hard Brown becoming grey below a depth of 2.6 m with oxidation staining between depths of 1.1 m and 2.4 m Moist to wet		2B								
			3	SS	21						
			4	SS	14						
			5	SS	16						
			6	SS	17						
			7	SS	18						
			8	SS	28						
			9	SS	65						
			10	SS	75						
			11	SS	63						
209.4	END OF BOREHOLE										
11.3	NOTES: 1. Water level measured at a depth of 8.5 m below ground surface (Elev. 212.2 m) upon completion of drilling. 2. Water level measurements in standpipe piezometer: Date Depth (m) Elev. (m) 28/11/13 8.1 212.6 09/12/13 8.0 212.7 07/01/14 7.6 213.1										



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

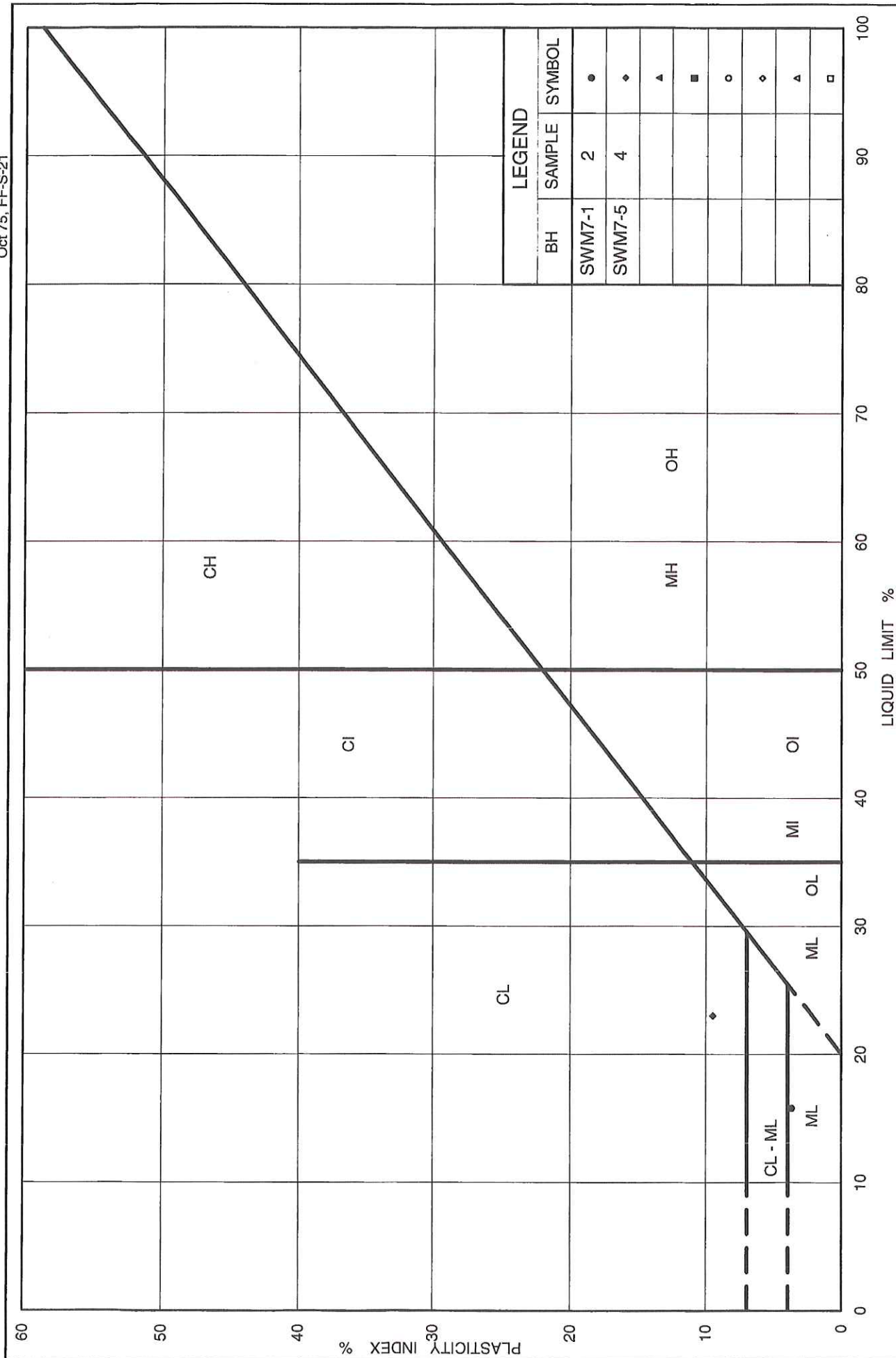
PROJECT 09-1111-0018		RECORD OF BOREHOLE No SWM7-4		SHEET 1 OF 1		METRIC							
W.P. 2835-02-00		LOCATION N 4876894.0 ; E 297005.9		ORIGINATED BY OS									
DIST Central HWY 400		BOREHOLE TYPE 140 mm O.D. Continuous Flight Hollow Stem Augers		COMPILED BY MWK/AV									
DATUM Geodetic		DATE November 20, 2013		CHECKED BY SMM/LCC									
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa		WATER CONTENT (%)			
220.2	GROUND SURFACE						20 40 60 80 100						
0.0	PEAT (Fibrous)		1A	SS	6								
219.8	Firm		1B										
0.4	Black												
	Wet												
219.0	SAND and GRAVEL, Compact		2	SS	23								
1.2	Yellow												
	Moist												
	CLAYEY SILT, with sand, trace gravel (TILL)		3	SS	63								
	Very stiff to hard												
	Brown becoming grey below a depth of 3.2 m with oxidation staining between depths of 1.2 m and 3.1 m		4	SS	102								1 21 52 26
	Moist												
	Augers grinding at a depth of 2.0 m		5	SS	25								
	Possible cobbles and/or boulder												
			6	SS	58								2 24 50 24
			7	SS	58								
			8	SS	62								
213.7	END OF BOREHOLE												
6.6	NOTES:												
	1. Water level measured inside augers at a depth of 5.3 m below ground surface (Elev. 214.9 m) upon completion of drilling.												
	2. Borehole caved at a depth of 5.6 m below ground surface (Elev. 214.6 m) after removal of augers.												

PROJECT 09-1111-0018		RECORD OF BOREHOLE No SWM7-5		SHEET 1 OF 1		METRIC						
W.P. 2835-02-00		LOCATION N 4876969.0 ; E 297052.2		ORIGINATED BY OS								
DIST Central HWY 400		BOREHOLE TYPE 140 mm O.D. Continuous Flight Hollow Stem Augers		COMPILED BY MWK/AV								
DATUM Geodetic		DATE November 19, 2013		CHECKED BY SMM/LCC								
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES					
219.7	GROUND SURFACE											
0.0	CLAYEY SILT, trace gravel, some sand, containing roots and organic material		1	SS	3							
218.9	Soft Black Wet		2A	SS	15							
0.8	SILT and SAND, trace to some clay, containing wood fragments and rootlets		2B									
218.2	Compact Brown Wet to moist		3	SS	13							
1.5	CLAYEY SILT with sand, trace to some gravel (TILL)		4	SS	14							
	Stiff to hard		5	SS	20							
	Brown becoming grey below a depth of 2.3 m		6	SS	23							
	Moist		7	SS	24							
	Augers grinding at a depth of 5.5 m		8	SS	61							
	Possible cobbles and/or boulder											
213.0	END OF BOREHOLE											
6.7	NOTES:											
	1. Borehole dry upon completion of drilling.											
	2. Borehole caved at a depth of 4.7 m below ground surface (Elev. 215.0 m) upon completion of drilling.											



APPENDIX D

Laboratory Test Results – SWM Pond 7



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PLASTICITY CHART Clayey Silt

Figure No. D1

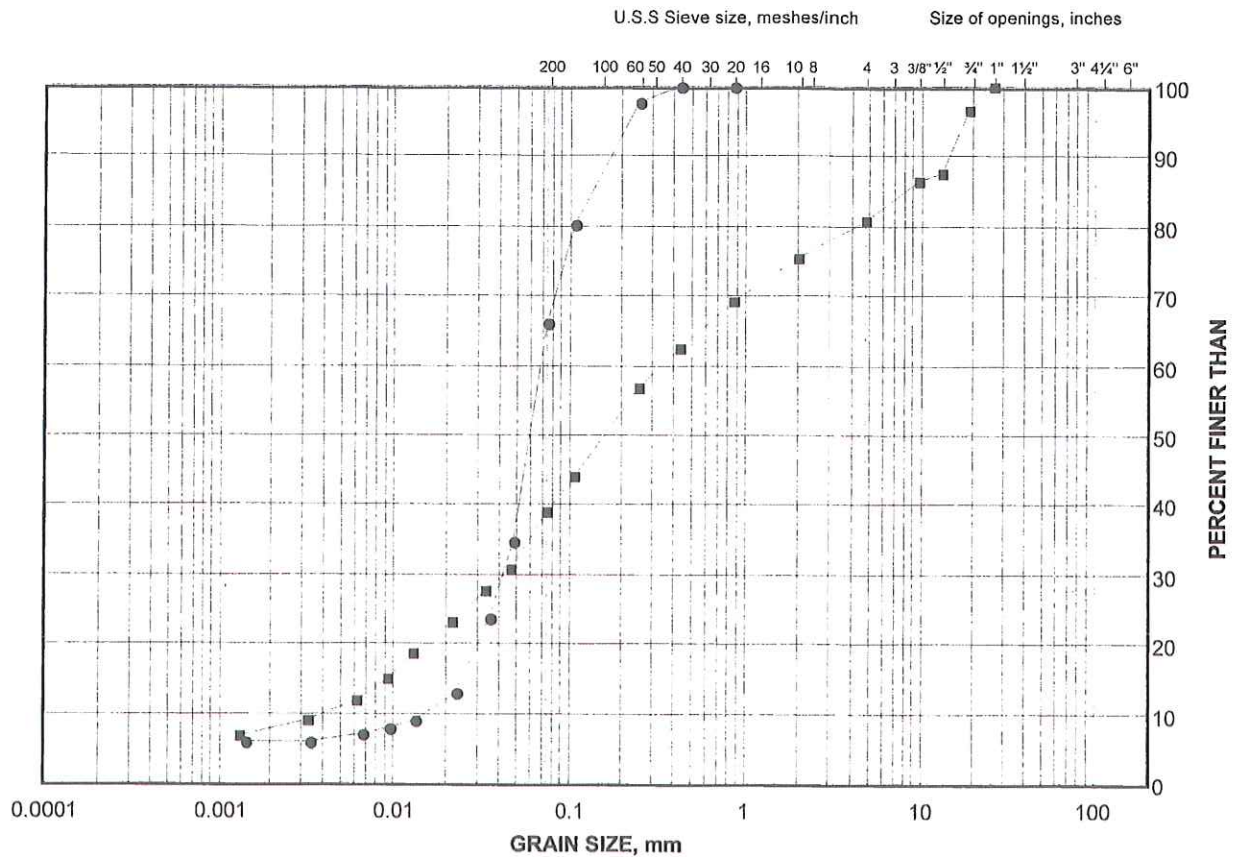
Project No. 09-1111-0018

Checked By: *Wong*

GRAIN SIZE DISTRIBUTION TEST RESULTS

Silt and Sand

FIGURE D2



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SWM7-5	2B	218.7
■	SWM7-1	4	219.1

Project Number: 09-1111-0018

Checked By: *[Signature]*

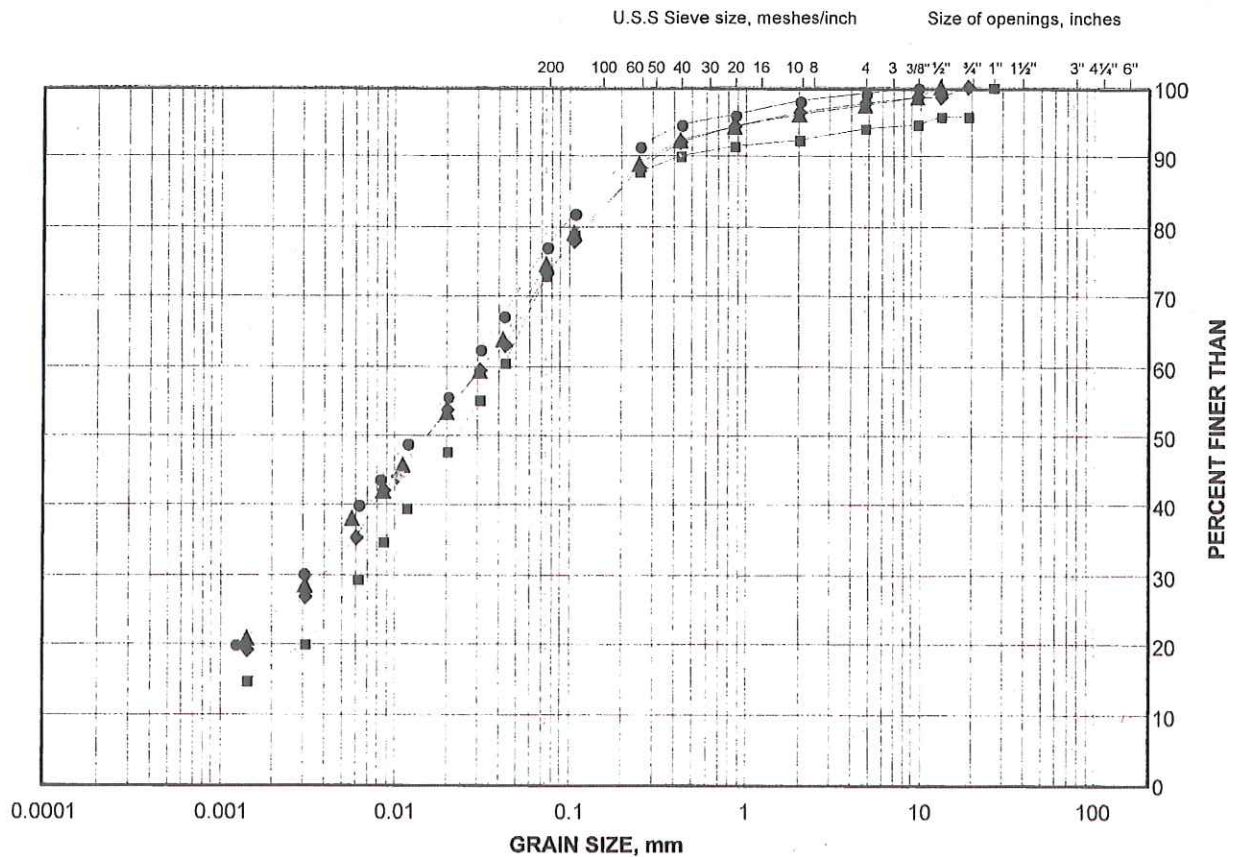
Golder Associates

Date: 30-Jul-14

GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIGURE D3A



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SWM7-4	4	217.8
■	SWM7-3	4	222.0
◆	SWM7-2	4	218.2
▲	SWM7-4	6	216.2

Project Number: 09-1111-0018

Checked By: *Woyce*

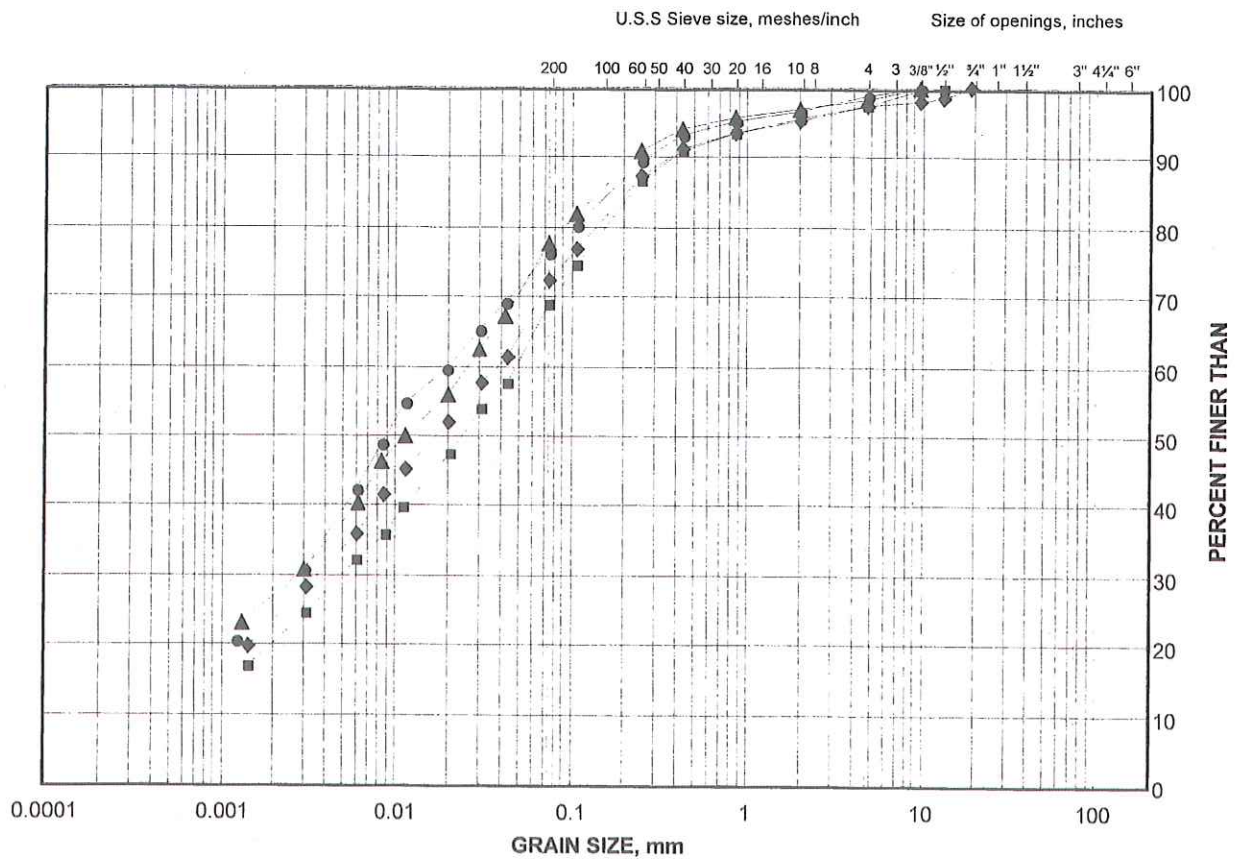
Golder Associates

Date: 30-Jul-14

GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIGURE D3B



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

LEGEND

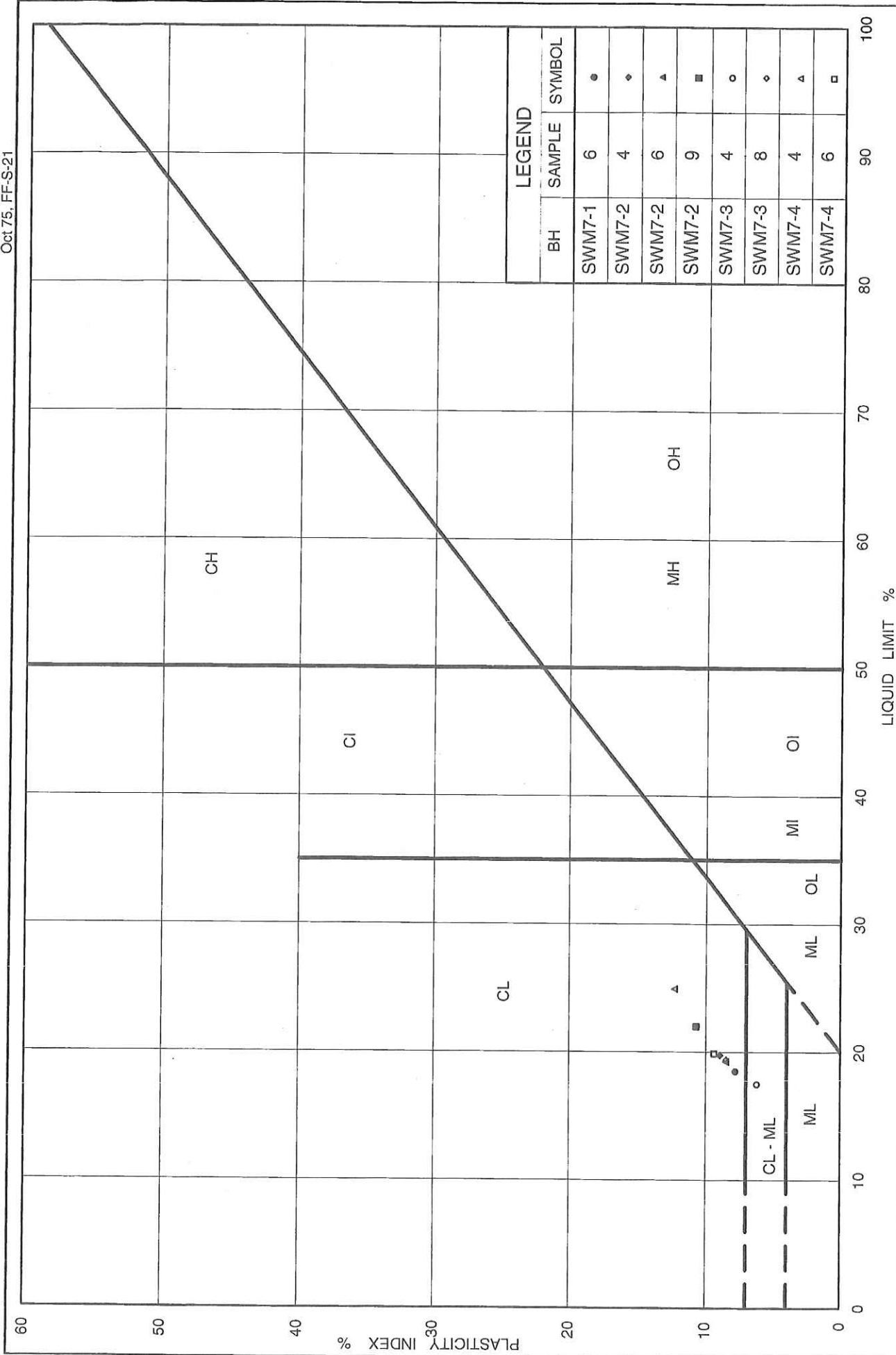
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	SWM7-5	6	215.6
■	SWM7-1	6	217.6
◆	SWM7-3	8	218.1
▲	SWM7-2	9	212.8

Project Number: 09-1111-0018

Checked By: *May*

Golder Associates

Date: 30-Jul-14



PLASTICITY CHART Clayey Silt Till

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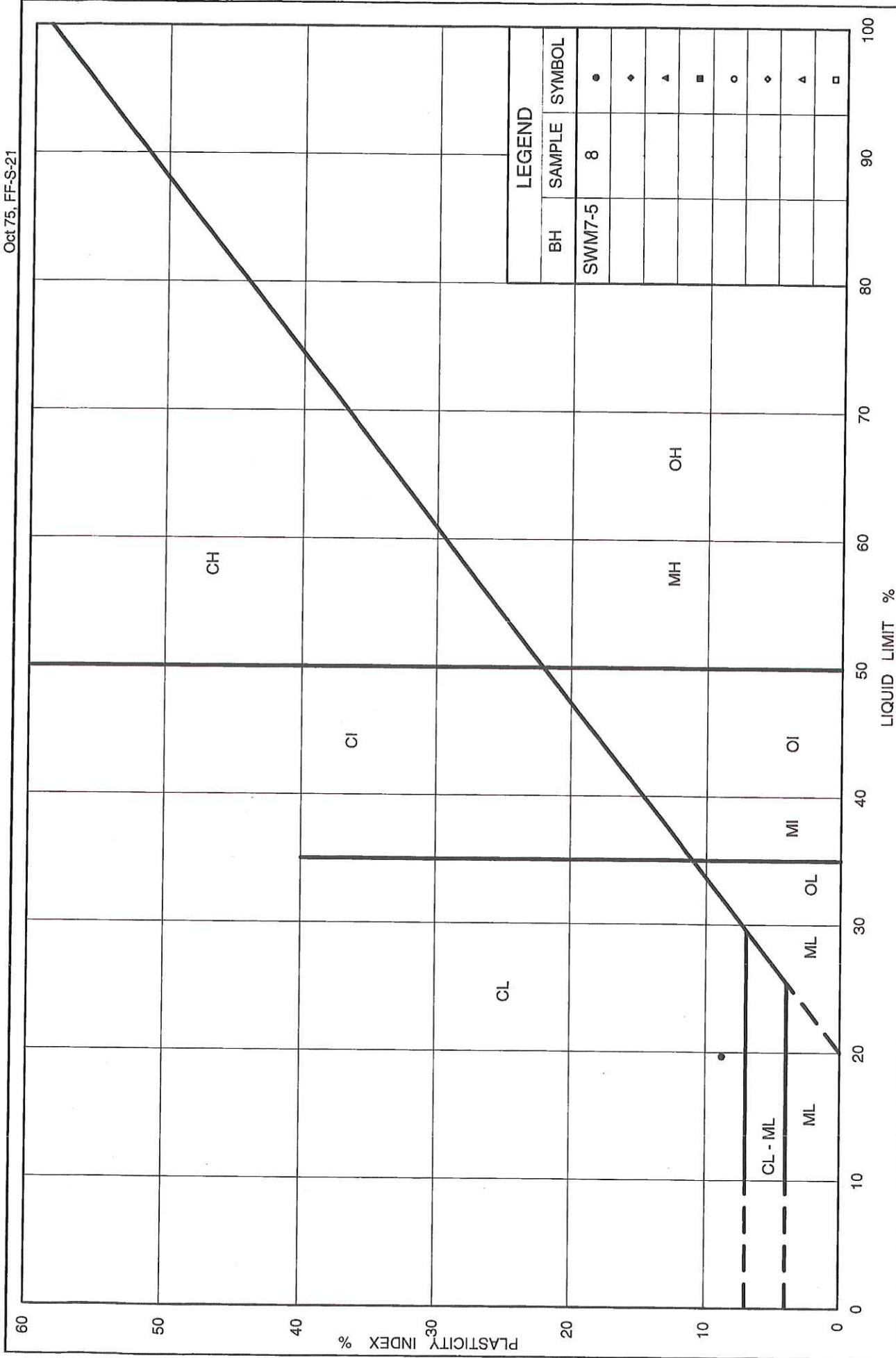
Figure No. D4A

Project No. 09-1111-0018

Checked By: *Wey*



Ontario



PLASTICITY CHART Clayey Silt Till

Figure No. D4B

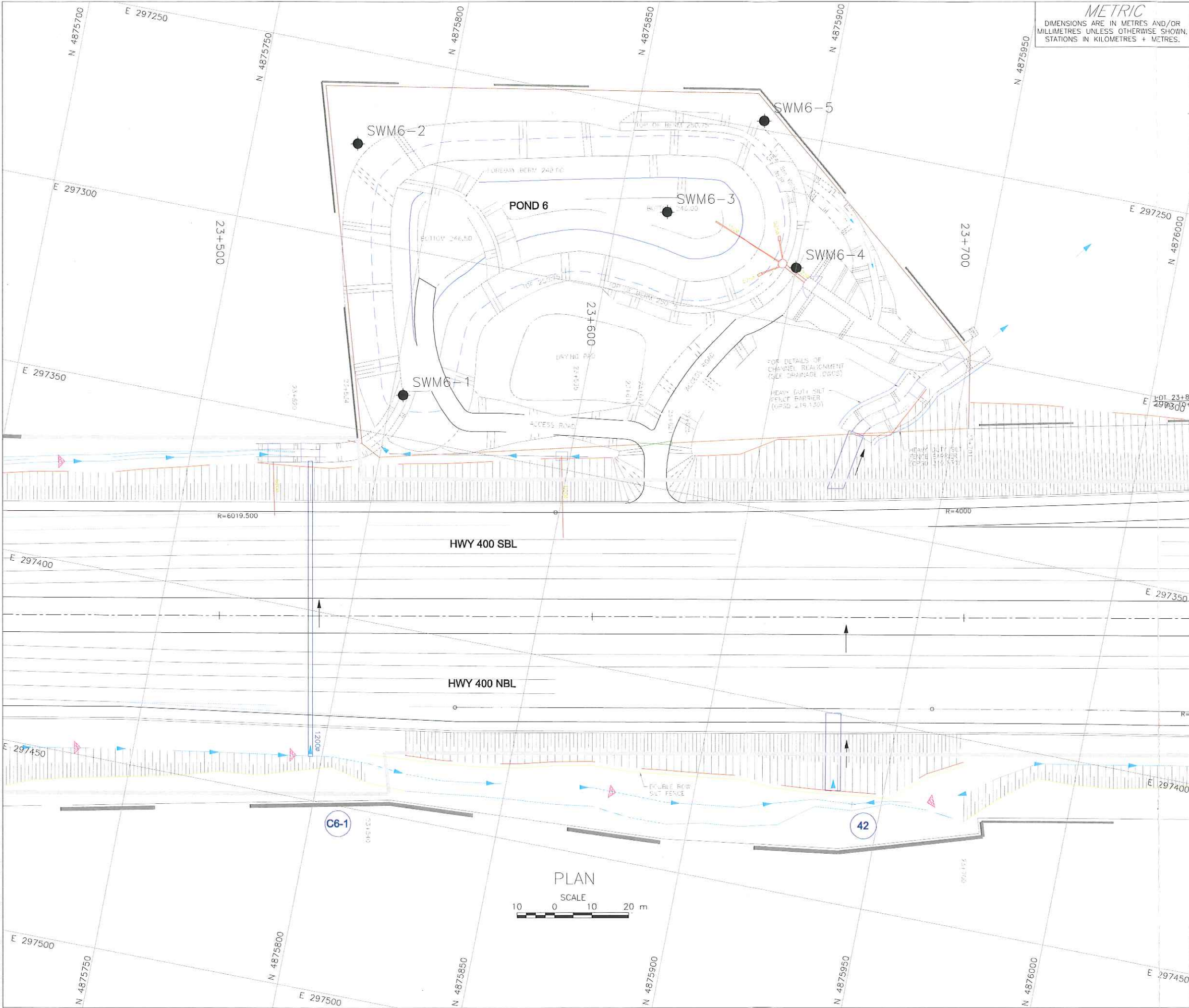
Project No. 09-1111-0018

Checked By: *Mary*

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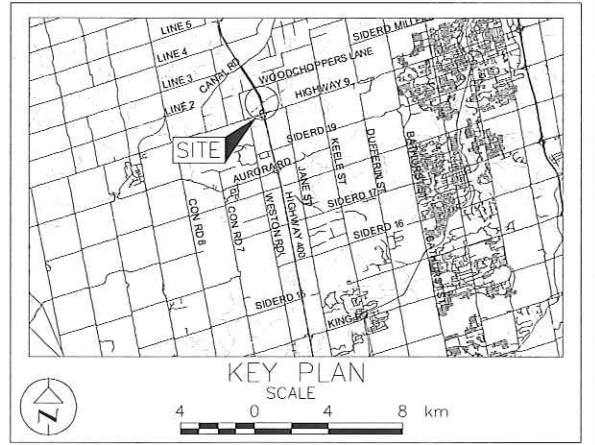


METRIC
 DIMENSIONS ARE IN METRES AND/OR
 MILLIMETRES UNLESS OTHERWISE SHOWN.
 STATIONS IN KILOMETRES + METRES.

CONT No.
 GWP No. 2835-02-00

HIGHWAY 400 WIDENING
 STORMWATER MANAGEMENT POND 6
 BOREHOLE LOCATIONS

Golder Associates Ltd.
 MISSISSAUGA, ONTARIO, CANADA



LEGEND
 Borehole - Current Investigation

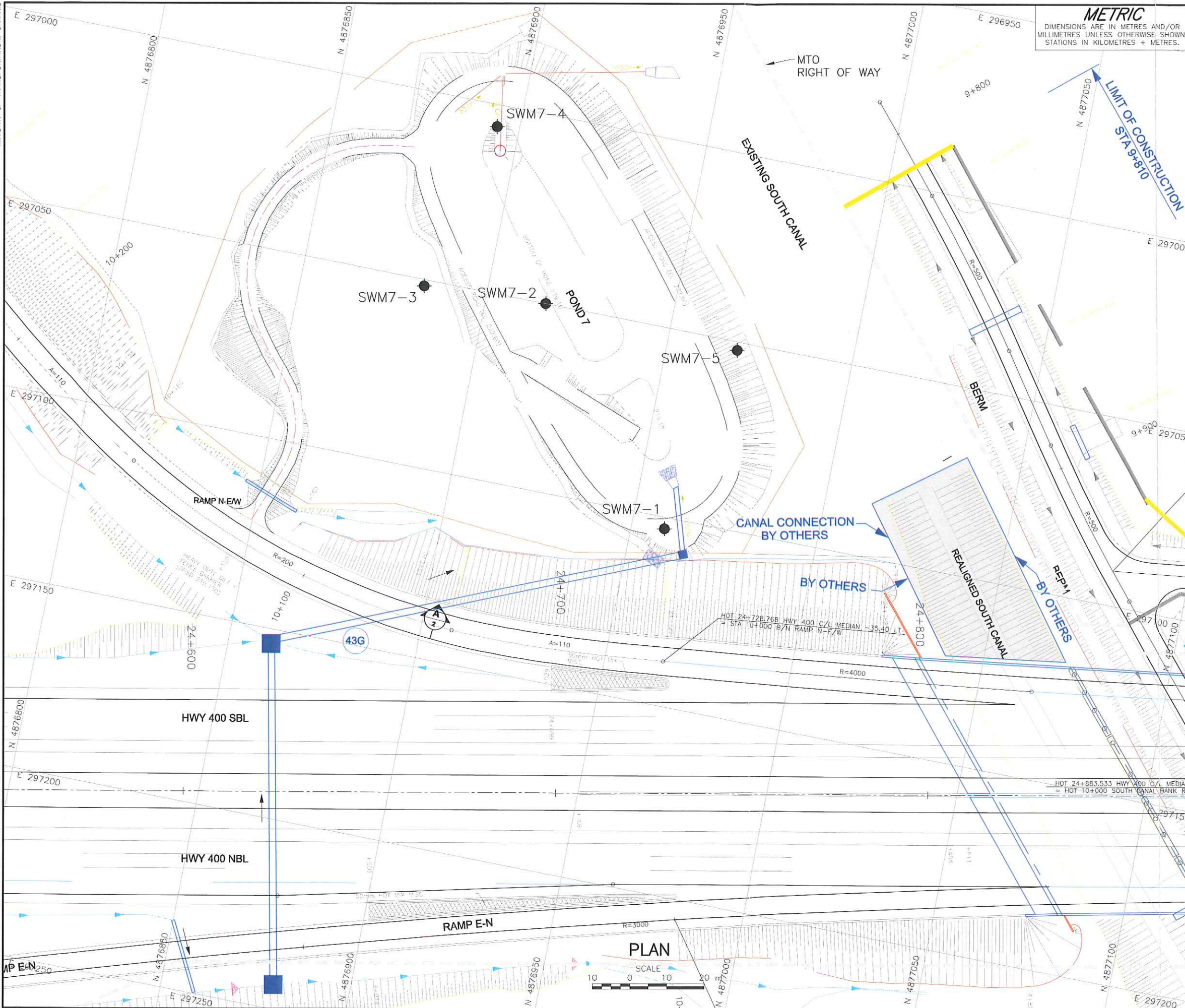
BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
SWM6-1	252.6	4875803.0	297338.6
SWM6-2	252.8	4875778.0	297274.7
SWM6-3	250.8	4875863.0	297276.7
SWM6-4	250.0	4875900.0	297284.7
SWM6-5	250.4	4875884.0	297247.6

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

 The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE
 Base plan provided in digital format by URS, drawing files no. Hwy400_plan.dwg, received May 18, 2014.

NO.	DATE	BY	REVISION
Geocres No.			
HWY. 400		PROJECT NO. 09-1111-0018	DIST. CENTRAL
SUBM'D. MWK	CHKD. TJG	DATE: May 2014	SITE:
DRAWN: JFC	CHKD. MWK	APPD. LCC	DWG. 1



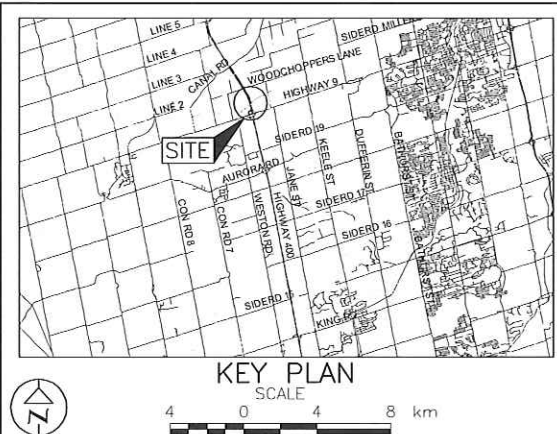
METRIC
 DIMENSIONS ARE IN METRES AND/OR
 MILLIMETRES UNLESS OTHERWISE SHOWN.
 STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2835-02-00

HIGHWAY 400 WIDENING
STORMWATER MANAGEMENT POND 7
BOREHOLE LOCATIONS

Golder Associates
 Golder Associates Ltd.
 MISSISSAUGA, ONTARIO, CANADA

SHEET



LEGEND

● Borehole - Current Investigation

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
SWM7-1	221.7	4876959.0	297103.1
SWM7-2	220.7	4876916.0	297050.0
SWM7-3	224.5	4876883.0	297051.7
SWM7-4	220.2	4876894.0	297005.9
SWM7-5	219.7	4876969.0	297052.2

NOTES

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

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plan provided in digital format by URS, drawing files no. Hwy400_plan.dwg, received May 18, 2014.

NO.	DATE	BY	REVISION
Geacres No.			
HWY. 400		PROJECT NO. 09-1111-0018 DIST. CENTRAL	
SUBM'D. MWK	CHKD. TJG	DATE: May 2014	SITE:
DRAWN: JFC	CHKD. MWK	APPD. LCC	DWG. 2