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SUBSURFACE INVESTIGATION AND DESIGN REPORT

Installation of NPS 16 Gas Pipeline - Proposed Horizontal Directional Drilling (HDD) Crossing of Highway 400, King Township, Ontario

Submitted to:
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REPORT

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Table of Contents

TABLES

DRAWINGS

FIGURES

APPENDICES

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Enbridge Gas Distribution Inc. (Enbridge) to provide geotechnical engineering services as part of the proposed horizontal directional drilling (HDD) installation of a nominal pipe size (NPS) 16 gas pipeline (400 mm diameter) under Highway 400, in King Township, Ontario (Site or Study Area).

The subject HDD crossing comprises part of the planned installation of 17 km of NPS 16 steel pipeline, originating from 4955 Lloydtown-Aurora Road, travelling east along Lloydtown-Aurora Road, crossing Highway 400, extending north on Jane Street, east on Davis Drive, and finally north on Dufferin Street, terminating at 18781 Dufferin Street. The Study Area for the crossing discussed in this report is located on the south side of Lloydtown-Aurora Road from west of the southbound on-ramp to Highway 400 to east of the northbound off-ramp from the highway. The crossing of Highway 400 has been identified to require HDD or other trenchless methods to install the pipeline. The Request for Proposal (RFP) provided by Enbridge indicates that the preferred crossing method is HDD. This report only discusses the proposed HDD crossing within the MTO Right-of-Way (ROW) which is approximately 500 m in length. Investigation for the remainder of the proposed pipeline alignment is outside of the scope of this report.

The purpose of the investigation is to address the Ministry of Transportation (MTO) requirements for determining the local subsurface soil and groundwater conditions, to provide site specific geotechnical engineering recommendations for the proposed pipeline installation at the crossing location and to provide comments regarding ground displacement monitoring at the site. The subsurface investigation program developed for this project is based on the requirements noted in the Ministry of Transportation, Ontario (MTO) “Guidelines for Foundation Engineering – Tunneling Specialty for Corridor Encroachment Permit Application (April 3, 2008)”.

This report addresses the geotechnical and hydrogeological issues associated with the crossing of Highway 400 only and should be read in conjunction with the “Important Information and Limitations of this Report” following the text of the report. The reader’s attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report.

2.0 SITE AND PROJECT DESCRIPTION

The site of the proposed HDD crossing of Highway 400 commences west of the on-ramp from Lloydtown-Aurora Road to the Highway 400 South Bound Lanes (SBL), and extends to east of the Highway 400 North Bound Lanes (NBL) off-ramp to Lloydtown-Aurora Road as shown on Drawing 1. The proposed crossing runs roughly parallel to and south of the existing Lloydtown-Aurora Road, for a total length of approximately 500 m under the Highway 400 ROW. The Key Plan (Drawing 1) provides an overview of the site location.

The terrain in the area of the proposed pipeline installation is relatively flat, typically varying between elevations of about 303 m and 305 m (referenced to Geodetic Datum) with local ditches as well as increases in elevation at Highway 400 and at the on-ramp and off-ramp locations. Lloydtown-Aurora road crosses over Highway 400 and approach embankments for the overpass structure are present to the north of the pipeline alignment. In general, the ground surface above the proposed Enbridge pipeline alignment is grass covered. Trees are present to the south of the proposed pipeline alignment on the west side of the highway.

Based on our understanding, the pipeline invert depths have not been finalized at the time this report was prepared. The proposed preliminary pipeline alignment provided to us by Enbridge, indicate that the minimum depth of cover directly below the travelled surface of Highway 400 will be about 15 m or more below existing ground surface with the overall pipeline depth decreasing as it approaches the proposed west and east ends of the trenchless installation. Pipeline depths in the range of 8 m to 10 m below existing grades are proposed at the locations of the on-ramp and off-ramp crossing locations. The approximate proposed pipeline depths are outlined on the stratigraphic cross-section, Profile A-A' on Drawing 1.

3.0 INVESTIGATION PROCEDURES

The following section provides an overview of the investigation procedures used during the geotechnical investigation carried out for this project. A hydrogeological investigation of the site was carried out concurrently with the geotechnical investigation. The results of the hydrogeological investigation, which included a review of water well records available from the Ministry of the Environment (MOE), a door-to-door water well survey, as well as water level monitoring and in situ conductivity testing in monitoring wells installed as part of the drilling investigation, are summarized in Section 5 of this report.

A subsurface investigation was carried out by Golder between February 23 and March 30, 2010 at the site of the proposed pipeline crossing of Highway 400. At this time, eleven (11) boreholes (designated as Boreholes 1 to 11) were advanced at the site using a rubber track-mounted D50 drill rig supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The borehole locations are identified on Drawing 1.

During the investigation, each of the boreholes were advanced using 108 mm inside diameter (I.D.) continuous flight hollow stem augers, to depths ranging between 8.1 m and 20.4 m below the existing ground surface. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using 50 mm O.D. split-spoon samplers. The frequency of sampling was increased in the soils at and above the proposed pipe invert. In several of the deeper boreholes, water and drilling "Quick Gel" were used at depth to minimize "blowback" of sands into the hollow stem augers. The groundwater conditions in each of the open boreholes were observed during the drilling operations. The Record of Borehole sheets generated from the drilling operation are included in Appendix A.

Monitoring wells, 50 mm in diameter, were installed in five (5) of the boreholes to allow subsequent groundwater level readings and in-situ testing for a hydrogeological assessment of the subsurface conditions and materials. These monitoring wells should be abandoned in accordance with MOE Regulation 903 and Section 7.3.1 of this report prior to the commencement of the pipeline installation. The remaining boreholes were sealed with bentonite upon completion of the drilling operations.

The field work was observed on a full-time basis by a member of Golder's engineering staff who arranged for the clearance of underground utility services, directed the sampling and in situ testing operations, and logged the subsurface conditions encountered in the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Whitby for further examination and testing. Index and classification tests consisting of water content determinations, Atterberg limits and grain size distributions were carried out on selected soil samples.

The boreholes were initially located in the field by Sexton McKay Limited, and the as-drilled locations were subsequently surveyed by Sexton McKay Limited following the drilling operations. The borehole locations for the investigation (including MTM NAD83 northing and easting coordinates) and ground surface elevations (referenced to Geodetic datum) used for preparation of this report are shown on Drawing 1 and summarized below.

Table 1: Borehole Elevations and NAD83 Coordinates

Borehole	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)
1	4872908.8	613186.6	303.8
2	4872925.6	613234.6	304.3
3	4872942.4	613273.7	304.1
4	4872959.3	613314.7	304.2
5	4872975.0	613353.7	305.0
6	4872995.6	613398.7	305.1
7	4873022.2	613445.5	304.7
8	4873050.1	613491.7	304.4
9	4873075.7	613534.8	303.9
10	4873101.9	613579.1	303.5
11	4873124.7	613611.9	303.1

4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geology

The site is located within the Oak Ridges Moraine physiographic region (as shown in the Third Edition of the Physiography of Southern Ontario, by Chapman and Putnam). The Oak Ridges Moraine predominantly consists of sand and gravel, although in the King Township area these soils are often overlain by till. The Quaternary Map of the Study Area is shown on Drawing 2.

A review of available water well records (WWRs) within the Study Area indicates the near surface materials consist of clay and hardpan (Appendix B Table B-1). These records are consistent with the geological material descriptions of deep water lacustrine deposits and till as defined by Chapman and Putnam (1984) which form the Schomberg clay plains.

Water well records drilled in the Study Area show that overburden materials are in excess of 164 m in thickness (Table B-1). No water well records in the Study Area report intersecting bedrock.

4.2 Site Stratigraphy

Eleven (11) boreholes were advanced for the proposed crossing of the Highway 400 ROW. The location of these boreholes, as well as the proposed pipeline alignment, is shown on Drawing 1.

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing as encountered are provided on the Record of Borehole sheets (following the text of this report). The results of the laboratory tests performed on selected samples obtained from the boreholes are presented on Figures 1 to 13. The gradational analyses were conducted on standard split-spoon samples, and as such, the materials identified on these analytical figures may also contain gravel, cobbles, and/or boulders.

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

In summary, the site contains surficial deposits of topsoil, fill, and variable soils ranging in composition from clayey silt to sand. The surficial deposits are underlain at the borehole locations by a variable till, ranging in composition from clayey silt to silt and sand. The tills overlie a compact to very dense silty sand to sand deposit. The sand deposit overlies a clayey silt till in the deeper boreholes within the west portion of the site, and a silty clay to clayey silt deposit in the deeper boreholes within the east portion of the site.

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

4.2.1 Topsoil

A surficial layer of topsoil was encountered at the ground surface in each of the boreholes advanced at the site. The topsoil encountered was observed to range between approximately 100 mm and 400 mm in thickness.

4.2.2 Fill and Asphalt

Fill materials were encountered in Boreholes 7 and 8. The fill material in these boreholes was brown, sandy silt to clayey silt, with a thickness of about 2.2 m in both boreholes. Organic matter, as well as pieces of plastic were also observed in the fill material. The fill was encountered underlying the topsoil in each of the boreholes.

Standard Penetration Test (SPT) N-values measured within the fill varied from 7 blows to 20 blows per 0.3 m of penetration suggesting a firm consistency for the cohesive fill materials, and a compact relative density for the cohesionless soils.

Asphalt was not encountered at the borehole locations but was observed at ground surface at the highway and on-ramp and off-ramp locations.

4.2.3 Surficial Deposits

Relatively thin native soil deposits varying in composition from clayey silt to sand/silty sand were encountered beneath the topsoil in Boreholes 2, 3, 9, 10 and 11.

Native shallow deposits of clayey silt were encountered underlying the topsoil in Boreholes 2, 9 and 11. The clayey silt deposit contains trace to some sand and trace to some gravel, except in Borehole 11, in which the soil is described as clayey silt with sand. The clayey silt deposits were encountered to depths ranging from about 1.0 m to 2.4 m in thickness. The results of a grain size distribution test completed on a sample of the clayey silt with sand from Borehole 11 are shown on Figure 1. Atterberg limit testing was also completed on this sample; the measured plastic limit was 14 percent, the measured liquid limit was 23 percent, and the resulting plasticity index was 9 percent. These results, which are plotted on the plasticity chart on Figure 2, indicate this material consists of clay of low plasticity. The measured SPT N-values within the upper clayey silt ranged from 4 blows to 22 blows per 0.3 m of penetration. Based on the SPT N-values, the deposit is considered to have a firm to very stiff consistency. The natural water contents measured on samples of the clayey silt deposit vary from about 15 percent to 17 percent.

Native shallow deposits of sand to silty sand were also encountered underlying the topsoil in Boreholes 3 and 10. The sand/silty sand deposit ranges from 0.9 m to 2.7 m in thickness. The sand/silty sand contains trace clay and trace gravel. The measured SPT N-values within the upper sand/silty sand ranged from 23 blows to 27 blows per 0.3 m of penetration. Based on the SPT N-values, the deposit is considered to have a compact relative density. The natural water content measured on the samples of the upper sand/silty sand deposit is about 10 percent.

4.3 Clayey Silt to Silty Sand (Upper Till)

A till deposit was encountered below the topsoil, fill, or upper clayey silt to silt and sand/silty sand in each of the boreholes except Borehole 8. This upper till deposit was noted to vary in composition both between boreholes and at depth within individual boreholes. In some areas, the till is comprised of a non-plastic sand and silt to silty sand containing trace to some gravel and clay while in other areas this deposit consists of a cohesive, clayey silt till containing varying amounts of sand and gravel. The cohesive till materials were generally more prevalent in the western and central portions of the Study Area.

During the investigation, auger grinding inferred to represent the presence of cobbles or boulders within the till was noted in the upper till unit in Borehole 4 at a depth of 3.7 m below existing grade. Cobbles and/or boulders are common within till deposits in Southern Ontario and are expected to be present throughout the till deposits at the site.

The upper till deposit was fully penetrated in each of the boreholes and was found to range from 0.4 m to 7.0 m in thickness at these locations. The elevations of the surface and base of the till deposit and the deposit thickness as encountered in the boreholes in each of the boreholes are summarized below.

Table 2: Upper Till Depths and Elevations

Borehole	Depth to Till Surface (m)	Till Surface Elevation (m)	Till Deposit Thickness (m)	Till Base Elevation (m)
1	0.3	303.5	6.7	296.8
2	1.6	302.7	2.4	300.3
3	1.1	303.0	2.9	300.1
4	0.2	304.0	7	297.0
5	0.1	304.9	5.5	299.4
6	0.3	304.8	3.8	301.0
7	2.5	302.2	1.5	300.7
8	Not Encountered			
9	1.1	302.8	1.4	301.4
10	3.1	300.4	0.9	299.5
11	2.4	300.7	0.4	300.3

The measured SPT N-values within the cohesionless portion of the till deposit range from 4 blows to 81 blows per 0.3 m of penetration, but were generally greater than 10 blows per 0.3 m of penetration indicating these materials are typically compact to very dense. The measured SPT N-values within the clayey silt to silty clay portion of the till range from 4 blows to 93 blows per 0.3 m of penetration. In addition, field vane testing carried out within the clayey silt till in Borehole 6 measured undrained shear strengths ranging from approximately 63 kPa to 68 kPa. Based on the field vane tests and SPT N-values, the deposit is considered to have a firm to hard (typically stiff to hard) consistency.

The natural water content measured on the collected samples of the upper till deposit were varied from about 5 percent to 18 percent. The results of grain size distribution tests on selected samples of the silty clay till to silty sand till deposit are shown on Figures 3 (Clayey Silt Till) and 4 (Silty Sand to Silt and Sand Till). The results of Atterberg limit tests on selected samples of the plastic portions of the upper till carried out as part of the investigation are shown on Figure 5 and are summarized in the table below.

Table 3: Summary of Atterberg Limits for Upper Till

Borehole.	Sample No.	Sample Elevation (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
1	3	302.3	24	14	10
2	3	301.2	18	12	6
3	3	301.0	16	12	4
4	2	302.7	25	15	10
4	4	300.4	Non-Plastic		
5	2	303.6	25	14	11
6	2	301.6	Non-Plastic		
9	2	302.9	Non-Plastic		

4.4 Sand to Silt and Sand

A deposit of brown to grey, compact to very dense silt and sand to sand, containing trace to some silt, trace clay, and trace gravel was encountered below the upper till in each of the boreholes, except Borehole 8, where the sand deposit was encountered immediately beneath the surficial fill materials. One sample of the sandy soils collected directly beneath the till materials in Borehole 1 contained some gravel.

As noted in the table below, the surface of the sand was encountered between elevations of about 296.8 m and 301.9 m and the thickness of the sand deposits varies from about 5.6 m to greater than 13 m.

Table 4: Silty Sand to Sand Deposit Depths and Elevations

Borehole	Depth to Sand Surface (m)	Sand Surface Elevation (m)	Sand Deposit Thickness (m)	Sand Base Elevation (m)
1	7.0	296.8	> 1.1	Below 295.7
2	4.0	300.3	> 8.7	Below 291.7
3	4.0	300.1	6.2	293.9
4	7.2	297.0	5.6	291.4
5	5.6	299.4	9.0	290.4
6	4.1	301.0	8.7	292.3
7	4.0	300.7	11.9	288.8
8	2.5	301.9	12.7	289.2
9	2.5	301.4	> 13.6	Below 290.3
10	4.0	299.5	> 11.3	Below 292.2
11	2.8	300.3	> 8.2	Below 294.8

The measured SPT N-values within the silty sand to sand deposit range from 11 blows to 145 blows per 0.3 m of penetration, but were generally greater than 30 blows per 0.3 m of penetration indicating these materials are compact to very dense but more typically dense to very dense. The lower SPT ‘N’ values measured within the sandy soils may have been influenced by drilling disturbance.

The natural water contents of samples of the silty sand to sand deposit collected during the investigation were measured to vary from about 2 percent to 23 percent.

The results of grain size distribution tests on selected samples of the sand deposit are shown on Figures 6 and 7. Figure 8 presents the grain size distributions for samples of the silt and sand materials.

4.4.1 Sandy Silt to Silt

Localized deposits of grey, very dense sandy silt to silt containing trace clay and trace gravel were encountered below or within the sand deposit in Boreholes 3, 6, 7 and 9. Interlayers of clayey silt till were encountered near the bottom of these deposits in some of the boreholes. The sandy silt to silt deposit ranges from about 1.1 m to 3.8 m in thickness.

SPT N-values within the sandy silt to silt deposits were measured to range from 18 blows to 157 blows per 0.3 m of penetration indicating these materials are compact to very dense (but typically dense to very dense).

The natural water contents of samples of the sandy silt to silt deposit collected during the investigation were measured to vary from about 13 percent to 21 percent.

The results of grain size distribution tests on selected samples of the sandy silt deposit are shown on Figure 9.

4.4.2 Clayey Silt (Lower Till)

A lower deposit of hard, grey, clayey silt till containing trace to some sand and trace gravel, was encountered below the sand and silt deposits in Boreholes 3, 4, 5 and 6. As previously noted, cobbles and/or boulders are common within till deposits in Southern Ontario and are expected to be present throughout the till deposits at the site.

The elevations of the surface and base of the lower till deposit and the thickness of this deposit (where penetrated) are summarized below.

Table 5: Lower Till Depths and Elevations

Borehole	Depth to Till Surface (m)	Till Surface Elevation (m)	Till Deposit Thickness (m)	Till Base Elevation (m)
3	13.7	290.4	> 5.1	below 285.3
4	12.8	291.4	> 6.1	below 285.3
5	14.6	290.4	0.7	289.7
5	18.6	286.5	> 1.8	below 284.6
6	15.1	289.6	1.5	288.1

SPT N-values measured within the lower clayey silt till range from 39 blows to 113 blows per 0.3 m of penetration. Based on the SPT N-values, the till is considered to have a hard consistency.

The natural water content measured on the collected samples of the lower till deposit from the investigation varies from about 8 percent to 21 percent.

The results of grain size distribution tests on selected samples of the clayey silt till deposit are shown on Figure 10. The results of Atterberg limit tests carried out on selected samples of the lower till are shown on Figure 11 and summarized in the table below; these tests in conjunction with the grain size distribution tests, indicate that the lower till deposit is classified as clayey silt of low plasticity.

Table 6: Summary of Atterberg Limits for Lower Till

Borehole	Sample No.	Sample Elevation (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
3	13	288.9	16	12	4
4	12	289.7	24	15	9
5	12A	290.4	25	15	10

4.4.3 Silty Clay to Clayey Silt

A deposit of hard, grey silty clay to clayey silt, trace to some sand, trace to some gravel, was encountered within the lower till in Borehole 5 and below the sand/silt deposits in Boreholes 6, 7 and 8.

The elevations of the surface and base of the hard silty clay to clayey silt deposit and the thickness of this deposit (where penetrated) are summarized below.

Table 7: Silty Clay to Clayey Silt Depths and Elevations

Borehole	Depth to Silty Clay to Clayey Silt Surface (m)	Silty Clay to Clayey Silt Surface Elevation (m)	Silty Clay to Clayey Silt Deposit Thickness (m)	Silty Clay to Clayey Silt Base Elevation (m)
5	15.3	289.7	3.3	286.4
6	16.6	288.5	> 3.8	below 284.7
7	17.0	287.7	> 1.9	below 285.8
8	15.2	289.2	> 3.7	below 285.5

The measured SPT N-values within the silty clay to clayey silt range from 33 blows to 89 blows per 0.3 m of penetration. Based on the SPT N-values, the silty clay to clayey silt is considered to have a hard consistency.

The natural water content measured on the collected samples of the silty clay to clayey silt deposit from the investigation varies from about 14 percent to 20 percent.

The results of grain size distribution tests on selected samples of the silty clay to clayey silt deposit are shown on Figure 12. The results of Atterberg limit tests carried out on selected samples of this deposit are shown on Figure 13 and summarized in the table below.

Table 8: Summary of Atterberg Limits for Silty Clay to Clayey Silt

Borehole	Sample No.	Sample Elevation (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
5	16	287.5	36	18	18
6	16	286.8	38	17	21
7	16	286.4	30	16	14
8	14	287.6	35	17	18

4.4.4 Groundwater Conditions

Groundwater levels observed in the open boreholes during and after the drilling operations are provided on the Record of Borehole sheets. Water was introduced into the boreholes as part of the drilling process; therefore, these water levels may not represent actual groundwater levels.

The water level measurements made upon completion of drilling, as well as subsequently measured groundwater levels within the installed monitoring wells, are summarized in the table below. It should be noted that the groundwater levels are subject to seasonal fluctuations, and typically higher groundwater levels are present during the spring months and at times of sustained rainfall.

Table 9: Groundwater Levels and Elevations

Borehole	Surface Elevation (m)	Upon Completion		March 26, 2010	
		Groundwater Depth (m)	Groundwater Elevation (m)	Groundwater Depth (m)	Groundwater Elevation (m)
1	303.8	1.5	302.3	4.0	299.8
2	304.3	4.7	299.6		
3	304.1	6.5	297.6		
4	304.2	7.2	297.0	3.2	301.0
5	305.0	6.5	298.5		
6	305.1	5.6	299.5	5.0	300.1
7	304.7	4.0	300.7		
8	304.4	4.9	299.5	4.6	299.8
9	303.9	5.6	298.3		
10	303.5	4.0	299.5	3.9	299.6
11	303.1	3.2	299.9		

5.0 HYDROGEOLOGICAL INVESTIGATION

The following provides a summary of the results of tasks carried out to assess the hydrogeological characteristics of the site. The purpose of the hydrogeological assessment was to characterize the hydrogeological conditions in the vicinity of the proposed crossing based on the boreholes and monitoring wells drilled as part of this investigation; to characterize local groundwater resources used in a review of Ministry of the Environment (MOE) water well record printouts and in a door-to-door water well survey of local residences and businesses; and to carry out an assessment of the potential for impacts on hydrogeological resources as a result of the construction of the proposed HDD crossing.

5.1 Hydrogeological Scope of Work

During the field investigations and in-situ testing conducted between the dates of March 26, 2010 and March 30, 2010, the following tasks were performed to assess and evaluate local water supplies and aquifer parameters:

1) A review and summary of local water well records was carried out to characterize existing groundwater use;
2) A door-to-door interview style survey was conducted with well owners within a 500 m radius of the Study Area. This was carried out to collect known information on domestic well resources and supply as well as to attempt to correlate private domestic wells to the well records in the MOE water well records database;
3) A site reconnaissance was completed to identify any surface water features in the Study Area, and
4) Static water level measurements were made in the observation wells installed in Boreholes 1, 4, 6, 8 and 10. In addition, in situ hydraulic testing was conducted in the monitoring wells installed in Boreholes 1, 6 and 8 using falling head test methods to assess the hydraulic conductivity of the materials adjacent to the monitoring well screens.

Based on the information collected as part of the desktop review, the door-to-door survey, and hydraulic testing of selected geological horizons, an assessment to identify water wells potentially susceptible to impacts from the proposed construction activities was completed.

5.2 Existing Groundwater Resources

A review of the available records in the MOE water well database indicates that there are 22 water wells within 500 m of the site.

A summary of these 22 water well records (Table 10) show that wells are drilled between 7.01 metres below measuring point (mbmp) (WWR# 6913837) and 164.29 mbmp (WWR# 6909577), with an average depth of 43.77 mbmp. Of the 22 records within a 500 m radius of the Site, 4 (18 percent) are test/observation wells, 14 (64 percent) are drilled wells, and 4 (18 percent) are relatively shallow, large-diameter precast concrete cased bored and dug wells. Of the 18 wells in the well records not drilled for monitoring purposes, 3 (17 percent) are drilled to a depth of less than 10 m (WWR# 6902135, WWR# 6908558, WWR# 6913837, 2 (11 percent) are drilled to a depth of 10 m to 20 m, 5 (28 percent) are drilled to a depth of 20 m to 30 m, and the remaining 8 (44 percent) are drilled to a depth of greater than 30 m.

Table 10: Summary of Domestic Well Completion Depths

Well Depth (m)	Number of Wells in the WWR (Including 4 previously drilled test/observation wells)
<10	7
10-20	2
20-30	5
30-40	1
>40	7

Of the 22 wells in the water well records, 16 (73 percent) wells reported a static water level. Of these 16 wells, the static water levels range from 4.57 mbmp (WWR# 6913837) to 77.72 mbmp (WWR# 6902131).

Of the 22 water well records, 14 (64 percent) reported a pumping test at the time of drilling. Of the 14 wells, one was tested at 4.5 L/min. Of the remaining 14 wells, 6 (43 percent) were tested between 14 and 40 L/min, 2 (14 percent) were tested between 41 and 80 L/min, 2 (14 percent were tested between 81 and 120 L/min, and 3 (21 percent) were tested above 121 L/min. The highest pumping rate recorded in the records was tested at 409 L/min for 180 min, with a drawdown of 43.89 m (WWR # 6921271). Of the 22 wells in the well records, 16 (73 percent) reported fresh water supplies while the remaining 6 (27 percent) did not report any water quality (Table B-1).

5.3 Door-to-Door Survey

A door-to-door water well survey (Survey) was conducted on March 26, 2010 and included nine residences located within 500 m of the Study Area. Domestic well owners were interviewed regarding information on the basic construction and operation of their water well. The details collected in the survey included the name of the well owner at the time of construction, well construction details, and existing well condition. Of the nine residences included in the Study Area, 5 (55 percent) interviewees were home during the door-to-door survey. Four residents (44 percent) participated in the survey. One resident (AUR-3245) did not want to participate in the survey. A summary of the interviews that are in the 500 m radius are tabulated below in Table 11: Summary of Door-to-Door Survey. The water wells identified in the survey along with water wells listed in the water well records are shown on Drawing 3.

During the door-to-door survey, three wells (33 percent), AUR-3205, AUR-3286, and AUR-3305, were correlated to wells listed in the MOE water well records (WWR# 6925209, WWR# 6902136, and WWR# 6902137 respectively).

During the survey one resident (AUR-3205) stated that he had low pressure and possible iron and sulphur issues. One interviewee (AUR-3286) stated that water pressure was low during times of heavy use.

Table 11: Summary of Door-to-Door Survey

Well ID	MOE Record	Contacted (Yes / No)	Well Depth (m)	Comments
AUR-3185		No		
AUR-3205	6925209	Yes	60.96*	Drilled in 2007 Homeowner was Bolland
AUR-3225		No		
AUR-3245		Yes		Resident did not participate in the survey
AUR-3250		Yes		
AUR-3265		No		
AUR-3285		No		
AUR-3286	6902136	Yes	25.3	Drilled by King City Well Drilling in ~ 1995
AUR-3305	6902137	Yes	27.43* (25.3 m reported in the drilling record)	Attributed by location and completion date (1967)

*This depth is from the interview and may not reflect actual well depth

The interview sheets collected from the survey are included in Appendix C

5.4 Surface Water Features

Surface water features were identified based on a visual reconnaissance of the Study Area from public roads on March 26, 2010 and are shown on Plates 1 through 4 (Appendix E). The ditches along the on and off ramps of Highway 400 did not contain any water.

To the west of the site, south of Lloydtown–Aurora Road there is, what appears to be, a pond (Plate 4, Appendix E). The surface elevation of the pond is roughly 303 metres above sea level (masl).

Approximately 500 m to the south of the Lloydtown – Aurora Road and Highway 400 intersection, there is a drainage ditch / intermittent stream which flows east behind the residential homes along Lloydtown–Aurora Road. The location where this ditch / stream meets Highway 400 is shown on Drawing 3 as W5. South of this location, the drainage ditch / stream follows Highway 400 on the east side and appears to be used seasonally or during periods of heavy rain. Due to limited roadside access a photograph of the ditch / stream was not possible. This drainage ditch / intermittent stream forms the headwaters of the Holland River which flows north into Cook's Bay on Lake Simcoe. The elevation of this watercourse is roughly 300 masl at its closest point to the site.

5.5 Hydraulic Conductivity Testing

In situ hydraulic conductivity testing consisting of falling head tests were conducted between the dates of March 26 and March 30, 2010 within the monitoring wells installed in Boreholes 1, 6, and 8. A second hydraulic conductivity test using the rising head method was conducted on 6 to confirm that field readings were repeatable given an alternative method of testing. The rising and falling head test data was analysed using the Hvorslev analysis method. The results of these tests can be found in Figures D-1, D-2, D-3 and D-4 in Appendix D.

An alternative method of calculating the hydraulic conductivity of materials is the application of the Hazen grain size distribution method. Although this method is designed for sediments that range from 0.1 mm to 3 mm, it can give an estimate of the hydraulic conductivity of fine grained materials. In the Hazen approach, the hydraulic conductivity is estimated using grain size taken from grain size distribution results in Figures 1 through 13, using the following formula:

$$K = C(d_{10})^2$$

Where:

K is hydraulic conductivity in cm/s

d_{10} is the erective grain size (cm), and

C is the coefficient based on the following table

Geological Material	Value for C
Very fine sand, poorly sorted	40-80
Fine sands with appreciable fines	40-80
Medium sand, well sorted	80-120
Coarse sand, poorly sorted	80-120
Coarse sand, well sorted, clean	120-150

Given the fine grained nature of the materials encountered during drilling and the results of the grain size distributions, a value of 40 was used in the above equation as a value for the constant C.

A summary of the calculated hydraulic conductivities using the in-situ testing and the Hazen grain size approximation are summarized below in Table 12: Summary of Calculated Hydraulic Conductivities .

Table 12: Summary of Calculated Hydraulic Conductivities

Well ID	Date	Type of Test	Depth of Screen (mbgl)	Geologic Material	Calculated Hydraulic Conductivity (cm/s)	
					In-Situ Testing	Grain Size Method (C=40)
Borehole 1	March 30, 2010	Falling Head	5.2 -7.0	Silty Sand Till	1×10^{-4}	6.4×10^{-6}
Borehole 6	March 30, 2010	Rising Head	18.0 – 19.8	Clayey Silt Till	3×10^{-4}	6.4×10^{-8}
Borehole 6	March 26, 2010	Falling Head	18.0 – 19.8	Clayey Silt Till	2×10^{-4}	6.4×10^{-8}
Borehole 8	March 26, 2010	Falling Head	12.6 – 14.4	Sand	2×10^{-4}	3.6×10^{-4}

6.0 HYDROGEOLOGICAL IMPACT ASSESSMENT

6.1 Groundwater Levels and Artesian or Flowing Conditions

Throughout this investigation, no flowing conditions were observed in the field work component or identified in the water well database. Surface water was observed in the constructed pond to the west of the Site (south of Lloydtown–Aurora Road) as well as in the eastward draining ditch behind the residents on the south side of Lloydtown–Aurora Road, on the east side of Highway 400. The elevation of this drainage ditch / intermittent stream is roughly 3 metres below the surface elevation of Borehole 11 (in a south-easterly direction). From this point, the watercourse drops in elevation towards the east before heading north to the Holland River.

6.2 Potential Impacts to Local Water Wells from Construction Activities

Based on our local experience with the above noted soil and groundwater conditions, the hydrogeological information and data compiled for this assessment, and the proposed construction work, it is not anticipated that the water quantity or quality in the domestic wells would be adversely impacted as a result of pipeline drilling under Highway 400.

The closest domestic water supply well (WWR# 6902137) is located approximately 25 m to the south of Borehole 11 (Drawing 3). This well has a reported screen depth of 24.0 m to 25.3 m. The static water level in this well at the time of construction is reported to have been 12.2 mbmp, giving a total available drawdown of 10.3 m. A 27.3 L/min pumping test was conducted on this well at the time of construction. At the end of the pumping test (180 minutes) the drawdown was 5.18 m, leaving an additional available drawdown of 5.12 m. As a result, it is not anticipated that this well will be adversely impacted during construction activities.

Despite the fact that we do not anticipate an impact on water supply quantities, heavy equipment needed for the proposed construction activities may cause vibration in the subsurface. This vibration may increase turbidity and mobilize fine sediment in the nearest water supplies. This increased turbidity has the potential to impact water supplies and negate the current water treatment process being used by residents. There is very little that can be done to reduce the subsurface vibration caused by vehicle traffic other then implementing lower speed limits.

This condition should be temporary and will subside after the cessation of the vibrations. No long term adverse effects to the local domestic water supply are anticipated.

Shallow overburden wells are susceptible to seasonal reductions in water supply and as the construction season typically coincides with the seasonal low water supply in shallow overburden wells (late summer), seasonal reductions in supply can be construed by residents to represent construction interference.

Mobile vehicle re-fuelling and maintenance during construction presents a risk of impact to local wells as a result of accidental releases of fuel. Shallow wells are the most susceptible to fuel impacts. In general, only large volume releases (i.e. greater than 100 L) are likely to have an adverse impact on local water well supplies. This risk can be minimized or managed by allowing re-fuelling only in designated areas preferably situated on a contained paved impermeable surface and by having an emergency response plan in place to clean up all releases of fuel.

7.0 DISCUSSION OF PROPOSED PIPE INSTALLATION

7.1 General

This section of the report provides geotechnical comments and recommendations related to the proposed installation of the gas pipeline segment to be installed beneath the Highway 400 ROW from the west side of the on-ramp to the Highway 400 SBL to the east side of the off-ramp from the Highway 400 NBL at the location identified previously in this report and on Drawing No. 1. The recommendations are based on interpretation of the factual geotechnical data obtained from the boreholes advanced during subsurface investigations at the Site. It is understood that the proposed invert of the gas pipeline is planned to be located approximately 15 m below the existing surface of Highway 400 and rises to within 2 to 3 m of existing ground surface at the east and west limits of the Study Area.

Traditional open trench construction is not considered feasible for the crossing of the highway, as significant disruptions to traffic flow along the highway would occur if this construction method is used.

Pipe ramming and/or pipe jacking is also not considered feasible for this crossing due to the long crossing distance of up to 500 m. Conventional tunnelling is not considered appropriate for the highway corridor crossing because the equipment to provide human access would necessitate a tunnel much larger in diameter than is required for the utility. In addition, dewatering works could be required if conventional open-face shields were to be used. Micro-tunnelling is also considered impractical due to a lack of local experience and appropriately equipped local contractors which would have resulted in very high mobilization costs, for a relatively short tunnel section thus making microtunnelling uneconomical.

Further to the above, the use of pipe ramming, pipe jacking and tunnelling/microtunnelling methods require the installation of liners during construction and it is understood that the installation of the gas pipeline within a liner is not preferable from a pipeline operations standpoint.

Based on the above, the installation of the NPS 16 pipeline using horizontal directional drilling (HDD) methods as proposed by Enbridge is considered the most practical option for installation of the gas pipeline. The use of HDD will allow the intended crossing to be completed in one continuous installation while eliminating the need for deep shaft construction. Furthermore, potential effects of the HDD installation (e.g. ground surface settlement) on Highway 400 will be reduced as the pipeline is proposed to be installed at significant depth below the highway.

The following sections of this report provide a discussion on the construction issues that will need to be addressed and managed by a contractor experienced in the use of HDD installation techniques. Where comments are made on construction, they are provided only in order to highlight aspects of construction that could affect the design of the project (e.g. how the site features and subsurface conditions could affect the design and specifications for installation of the service crossing using HDD methods). Since not all potential aspects relating to the specific equipment and installation methods selected by the pipe installation contractor can be identified at this time, it should be clearly understood that contractors bidding on the project will be solely responsible for independently reviewing and confirming the feasibility of installing the pipe using the proposed HDD installation method and confirming the suitability of the contractor's equipment and proposed construction procedures for this purpose and for the ground conditions that are documented for the site.

The professional services for this assignment address only the geotechnical aspects of design and installation of the proposed HDD pipe installation. The interpretation and recommendations provided are intended to provide the designers with information to assess and specify the construction methodology and equipment. This report does not assess other aspects of the design of the HDD crossing (e.g. identifying pipe lay-down area and confirming that pulling forces associated with the pullback installation will not damage the pipeline, etc.). Furthermore, the installation of the pipeline should be carried out in general accordance with all applicable municipal and provincial regulations/guidelines including OPSS 450, "Construction Specification for Pipeline and Utility Installation in Soil by HDD".

7.2 General HDD Considerations

The horizontal directional drilling process involves the drilling of an initial pilot hole from an entry/sending pit to an exit/receiving pit using drilling mud to support the sidewalls of the drillhole. Following completion of the pilot hole, the hole is reamed successively in increasing diameters until the drillhole is of sufficient size to permit the installation of the product pipe. The pipe is then typically installed by attaching it to the drill rods and pulling it back through the drillhole from the exit/receiving pit to the entry/sending pit.

The final HDD alignment should be selected such that the radii of curvature in all sections of the alignment, including those which may involve complex curves, are sufficiently large such that the HDD drill rods can readily accommodate the proposed alignment, and that the pipeline can be installed/pulled along the proposed alignment without being overstressed.

Typically, the entire length of the proposed product pipe to be installed using HDD techniques is assembled and laid out in a single piece to minimize the time it takes to install/pull the pipe into the drillhole and, thereby, reduce the potential for instability of the drillhole. Minimizing the time that the final drillhole is required to stay open is an important consideration for a HDD operation, particularly at sites where the pipeline alignment will pass through cohesionless soils (e.g. sandy soils). Therefore, it is recommended that the final alignments be selected to permit sufficient room for assembly of the pipeline in a single piece.

The contractor undertaking the work should submit a detailed and comprehensive drilling plan addressing all aspects of the drilling operations providing the proposed installation, equipment, drilling fluids and construction methods for review prior to construction.

7.3 HDD Profile and Installation Considerations

Based on the preliminary pipeline alignment information provided to us by Enbridge, the entry/exit pits for the HDD installation for the proposed NPS16 gas pipeline are planned to be installed to the west of the on-ramp to the Hwy 400 SBL and to the east of the off-ramp from the Hwy 400 NBL to Lloydtown-Aurora Road (i.e., in the vicinity of Boreholes 1 and 11). At the on-ramp and off-ramp locations, the pipeline is proposed to be installed at depths in the range of about 8 m to 10 m below existing site grades. The pipeline alignment deepens as it approaches Highway 400 with the pipeline proposed to be installed at depths of about 15 m between the on-ramp and off-ramp locations including the Highway 400 crossing location. The approximate pipeline alignment depth at each of the borehole locations has been identified on Drawing No. 1.

Based on this alignment, the HDD drill path will be advanced through the surficial materials and upper till, and into the predominantly cohesionless, compact to very dense sand/silty sand to silt deposits. In the vicinity of Boreholes 3 to 6, the proposed pipeline alignment also passes through the hard silty clay to clayey silt and lower clayey till units encountered at depth. In general, the suitability of these deposits below the groundwater table for HDD is summarized in ASTM Designation, F1962-05[1]; the designation suggests that hard clay soils and medium to dense sands above and below the water table (not more than 30 percent gravel by weight) are generally suitable for HDD installations.

Maintaining the stability of an HDD hole within, and installing the pipeline through the above noted materials using HDD methods is considered feasible. However, the HDD contractor will have to carefully select and control the properties of the drilling fluid and drilling fluid pressures in order to deal with the issues associated with the variability of the site soils (e.g. selecting the viscosity/thixotropic properties of the drilling fluid such that they are capable of maintaining the stability of the HDD hole, while being able to transport variable cuttings out of the HDD hole). It is imperative that the contractor select a suitable fluid mix design; if the drill fluid properties and drilling pressures are not carefully monitored/controlled, there is a greater potential for 'over-cutting' (i.e. enlarging) of materials from the sidewall of portions of the HDD hole, leading to the potential for increased settlement above the HDD alignment and the travelled surface of the highway. In addition to the careful selection of the drilling fluid properties, the contractor will have to carefully monitor the HDD operations, including backream rate, fluid pressures, etc., to mitigate the potential for ground heave, in particular within the travelled surface of the highway. Further details in regard to the identification of either settlement or ground heave are provided below in Section 7.4.

Based on the interpreted stratigraphy, the pipeline alignment will be located in close proximity and/or pass through the interface between the sand/silt deposits and the underlying silty clay and clayey silt till soils in the vicinity of the Highway 400 crossing. In order to reduce construction related issues associated with installing the pipeline through the variable soils encountered at depth, consideration could be given to adjusting the alignment to avoid having to drill through the interface of cohesive and cohesionless soils.

Sidewalls of the HDD drillhole formed within the sandy soils are considered to be susceptible to erosion when subjected to ongoing exposure to drilling fluid action. In this regard, the time that the drillhole remains open should be minimized (particularly at the final drill hole diameter) in order to maintain hole stability.

[1] ASTM, Designation: F 1962-05. Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings.

As noted previously in this report, cobbles and/or boulders are expected to be present throughout the till deposits at the site. The presence of these materials can obstruct the drilling process causing delay, increased wear-and-tear of tools, misalignment, and possible additional cost and/or the need to alter the drill path to avoid large obstructions such as boulders.

7.3.1 Hydraulic Fracture (“Frac-out”) Potential

For assessment of the HDD installation, a number of issues must be considered, such as hydraulic fracture (typically referred to as “frac-out”), methods for settlement reduction and maintaining surface stability. Latorre et al (2002)[2] provides some guidance relating to the recommended minimum depth of cover for various pipe diameters as reproduced below.

Table 13: Recommended Minimum Depth of Cover for Various Pipe Diameters (Latorre et al.)

Diameter	Depth of Cover
50 mm (2 in.) to 150 mm (6 in.)	1.2 m (4 ft)
200 mm (8 in.) to 350 mm (14 in.)	1.8 m (6 ft)
375 mm (15 in.) to 600 mm (24 in.)	3.0 m (10 ft)
625 mm (25 in.) to 1,200 mm (48 in.)	4.5 m (15 ft)

The proposed 400 mm diameter steel pipeline will be installed at depths ranging from about 2 to 3 m at the east and west limits of the Highway 400 ROW, to about 15 m below the centerline of the Highway 400, based on the currently proposed pipeline alignment. This is significantly greater than the minimum depth of cover suggested by Latorre et al. (i.e. 3.0 m).

Based on the proposed pipeline alignment depth and our experience with similar HDD installations, the potential for frac-out is considered to be low, however, the potential for frac-out is dependent on the type of drilling equipment, drilling and reaming methodology, down-hole drilling fluid properties (density, viscosity, etc.), drill path geometry (particularly the elevation of entry and exit pits in relation to the HDD hole profile elevation and depth of cover beneath the right-of-way) and drilling fluid pressures used by the contractor. Pipeline installation variables should be assessed by an experienced contractor with reference to the actual soil conditions and HDD hole geometry to assess the depth of cover and to minimize the risk of frac-out and prevent settlement of the ground along the alignment, especially over the entire width of the Highway ROW.

Boreholes advanced as part of the geotechnical investigations were located in close proximity to (i.e. offset approximately 5 m from) the proposed HDD pipeline alignment and monitoring wells were installed in several of the boreholes. The HDD drill fluids will take the path of least resistance and potentially migrate to the ground surface through these borehole locations. **Prior to installation of the pipeline**, all monitoring wells should be decommissioned/grouted in order to limit the potential for fluid migration. The piezometers should be

[2] *Latorre, Carlos, A., Wakeley, Lillian D., Conroy, Patrick J., 2002. Guidelines for Installation of Utilities Beneath Corp of Engineers Levees Using Horizontal Directional Drilling. US Army Corp of Engineers – Engineer Research and Development Center ERDC/GSL TR-02-9. 43 pgs.*

decommissioned by a licensed well driller in accordance with Ontario Regulation (O. Reg.) 903 amended by O. Reg. 128/03 of the Ontario Water Resources Act.

The remaining boreholes were typically sealed with bentonite; however, as the HDD drill fluids will take the path of least resistance, there is a potential for migration of the drill fluids through the boreholes. Visual monitoring of the borehole locations for signs of drill fluid migration should be carried out on a regular basis during the HDD operations. It is also recommended that the contractor should be required to have contingency/mitigation plans in place to control/reduce drill fluid pressures and to clean up any drill fluid in the event that drilling fluid migration takes place.

7.4 Settlement and Settlement Monitoring

The installation of the proposed gas pipeline using HDD methods may result in ground displacements of the soils located above and adjacent to the proposed pipe. The magnitude of such displacements is highly dependent on the construction procedures utilized (i.e. final reamer size, depth of installation, drilling fluid etc.). During the proposed HDD installation, provision for monitoring should be required in the contract documents as per MTO's document "Guideline for Foundation Engineering – Tunnelling Specialty for Corridor Encroachment Permit Application" (April, 2008).

Ground surface displacements at the proposed Highway 400 crossing are not expected to affect the safe operations of highway traffic since the intended alignment will have in the order of 15 m of soil cover directly below the traffic lanes of the highway.

Provided that appropriate construction procedures are specified and implemented, the potential ground displacement at the ground surface during pipe installation, above the proposed pipe, is estimated to be less than 10 mm (the Review Level as described below) at both the highway and on-ramp and off-ramp locations. However, long-term settlement can occur after the pipe installation is completed due to consolidation of the mud slurry and progressive collapse of the oversized drillhole between the ground and the pipe. The maximum amount of settlement from this mechanism is estimated to be less than 15 mm below Highway 400 and less than 25 mm below the on-ramp and off-ramp. If this settlement occurs it would be over a period of several years as the drillhole, and material above it, compresses. If this is not acceptable, the future long-term settlement could be mitigated by grouting the annulus between the product pipe and the HDD drillhole following the installation of the pipe.

An inspection, instrumentation and ground monitoring program is necessary on this project to:

- document the effects of the HDD installation on the overlying highway;
- obtain prior warning of ground movements that could occur due to the construction methods and equipment or unforeseen ground conditions;
- verify the contractor's compliance with the ground movement limits imposed in the Contract; and
- allow adjustments to be made to the HDD methods such that the ground movement limits established are not exceeded.

The proposed monitoring program for the 400 mm diameter steel pipe crossing of Highway 400 is consistent with the "Appendix – Settlement Monitoring Guideline-Tunneling" included in the above noted guideline and is summarized below:

- A series of surface monitoring points and in-ground monitoring points should be installed along the intended HDD alignment, at spacings of not more than 5 m, under travelled roadways. The in-ground monitoring points should extend to a depth of between 7 m and 10 m below existing grade (into the sand stratum). In-ground monitoring points should be installed to similar depths on the east and west sides of Highway 400 near the highway shoulders.
- In-ground monitoring points should be installed on each side of the on and off-ramps, to depths of 1.5 m above the top of the drillhole, along the intended HDD pipe alignment.
- A series of shallow in-ground monitoring points should be installed between the on/off-ramp and Highway 400, along the intended HDD alignment, at spacings of not more than 50 m. These in-ground monitoring points should extend to a depth of 1.5 m.
- Surface monitoring points (reflectors) should be installed directly over the alignment along the centreline of the pipeline where it crosses the highway and access ramps. The surface monitoring points should be installed on the pavement and the east and west shoulders within the limits of the highway. The maximum spacing between such points should not exceed 5 m along the pipeline alignment.
- Prior to the start of construction all monitoring points should be read a minimum of two times to provide a baseline.
- The monitoring points should be surveyed a minimum of three times per day during installation of the pilot hole and reaming activities, while drilling within the limits of, or approaching the limits of the highway, including during shut-down periods and weekends. An allowance should be made for more frequent monitoring (up to every 4 hours) should observations dictate.
- The surface monitoring points should be read and recorded during the construction period and after construction for a period of at least two weeks, provided that further settlement has ceased.

Monitoring of the instrumentation on this project will be constrained by the continuous and high traffic volume and the limited periods during which access to the highway can be obtained. The elevation of the top of the monitoring points would have to be read using conventional precision levelling equipment. By necessity, monitoring points on the road must be read remotely and the use of EDM equipment reading reflectors installed on the highway is suggested. A specialist surveying firm should be retained to confirm the set-up and to carry out the monitoring during construction; their equipment and procedures must be capable of surveying the settlement point elevation to within ± 1 mm of the actual elevation.

The following procedure should be followed if settlement levels of 10 mm (Review Level) and 15 mm (Alert Level) are reached:

- If the Review Level is reached the contractor would be required to provide a formal plan that states what is going to be done to ensure that the Alert Level is not reached

- If the Alert Level is reached, the contractor shall stop drilling and MTO would have the authority to order that the contractor alter the drilling methods prior to continuing with the installation.

In addition to ground movement monitoring, the HDD alignment (line and grade) should be carefully monitored using a downhole tracking system during installation of the pilot hole and the as-drilled pilot hole alignment should be submitted to the owner for approval.

7.5 Need for PTTW

It is assumed that the entry and exit pits for the directional drilling will be excavated to depths of approximately 2 to 3 meters in the vicinity of Boreholes 1 and 11. The subsurface conditions anticipated to be encountered at the pit locations consist of clayey silt to silty clay till and silty sand till. Groundwater is not expected to be encountered in the excavations based on the groundwater elevations measured on March 26, 2010. Given the relatively fine to medium grained soil conditions and that we anticipate the presence of weighted drilling mud in the pits, we do not expect dewatering of the excavation will be required to an extent that a Permit to Take Water will be required (i.e. >50,000 L per day).

7.6 Impact Assessment

We do not anticipate that the proposed construction works will interfere with local water supplies. The entry and exit pit excavations are expected to encounter relatively fine-grained till soils and are anticipated to be above the water table. We do not expect the directional drilling to require removal of groundwater. As well, the majority of local wells utilize deeper confined aquifers which are hydraulically isolated from the shallower work zone.

Based on the proposed construction activities outlined herein, no permanent adverse impacts to private water wells in the Study Area are anticipated as a result of construction for the pipeline installation as extensive dewatering is not anticipated. As extensive dewatering (>50,000 L/day) is not anticipated, a Permit to Take Water is not expected to be required.

Local water supply wells are not expected to be adversely impacted as a result of the proposed pipeline construction; however, given the potential for seasonal reductions in water supply concurrent with construction activities, and the potential for vibration related impacts during construction, we recommend that Enbridge consider establishing a monitoring well network within the ROW to facilitate monitoring. The monitoring well network could consist of one monitoring well at the west limit of the work site, and one monitoring well at the east limit of the work site. The availability of monitoring data will assist Enbridge in the timely addressing of water well interference complaints. In addition, monitoring private wells prior to and during construction will establish a baseline in the event that impacts resulting from construction are reported.

7.7 Additional Investigation Work, Review of Methodology and Construction Inspection

The potential for the HDD drillhole to become larger than the design drillhole diameter due to loss of ground into the drillhole and the associated potential for ground surface movements above the HDD crossings are largely dependent upon the construction procedures and techniques utilized. In this regard, a qualified contractor experienced in this type of work should carry out the work. A geotechnical engineer retained by Enbridge should review the contractor's proposed methodology prior to construction. During construction, the geotechnical engineer should monitor the HDD operations including measuring approximate volumes of soil/slurry/cuttings removed per unit of drill hole advance. Where the pipeline crosses below the highway, the implementation of a ground monitoring program as defined above should be carried out to confirm that ground movements are within tolerable limits. Monitoring points should be established and surveyed prior to construction and throughout the HDD operations to determine if the installation methods are adequately controlling ground movement.

8.0 CLOSURE

This Geotechnical Investigation and Design Report was prepared by Mr. Nick La Posta, P.Eng. The report was reviewed by Mr. Ty Garde, P.Eng., a Principal of Golder and a designated MTO Contact for Golder, as well as Mr. John Westland, P. Eng., a Principal of Golder and the RAQS tunnelling specialist.

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Hwy400105'13

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APPENDIX A

Record of Boreholes

Golder Associates

RECORD OF BOREHOLE No 1

 METRIC

PROJECT 09-1111-6064			
G.W.P. 2009-20T-364	LOCATION N 4872908.8 ;E 613186.6		ORIGINATED BY AB
DIST Central	HWY Highway 400	BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers	COMPILED BY NLP
DATUM Geodetic		DATE February 23, 2010	CHECKED BY KN

SOIL PROFILE / SAMPLES

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
303.8	GROUND SURFACE				
0.0	Clayey Silt Topsoil	1	SS	22	
0.3	Brown Moist	1A			
	Clayey Silt, some sand to sandy, trace gravel (TILL) Firm to very stiff Brown Moist to wet	2	SS	7	
		3	SS	4	3 25 48 24
		4	SS	29	
300.7 / 3.1	Silty Sand, trace to some gravel, trace to some clay, contains zones of clayey silt with sand (TILL) Dense to very dense Brown Moist	5	SS	39	
		6 / 6A	SS	81	
		7	SS	64	16 46 31 7
		8	SS	75	
296.8 / 7.0	Sand, some gravel, trace to some silt Very dense Brown Wet	9A	SS	54	19 66 11 4
295.9 / 8.1	Sand, trace to some silt, trace gravel, trace clay Very dense Brown Wet	9B			
	END OF BOREHOLE				

Elevation scale: 303, 302, 301, 300, 299, 298, 297, 296

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

NOTES:

1. Water level in open borehole at a depth of 1.5 m (Elev. 302.27 m) on completion of drilling.

2. Water level in monitoring well measured at a depth of 4.0 m (Elev. 299.8 m) on March 26, 2010.

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

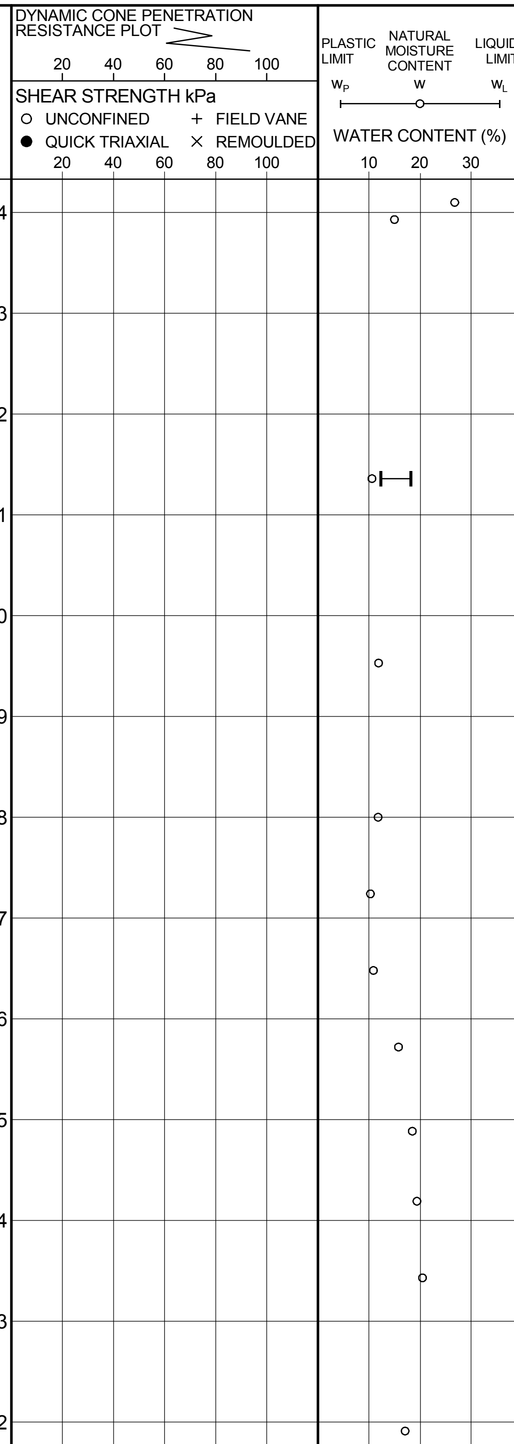
RECORD OF BOREHOLE No 2

 METRIC

PROJECT 09-1111-6064
G.W.P. 2009-20T-364 LOCATION N 4872925.6 ;E 613234.6 ORIGINATED BY AB
DIST Central HWY Highway 400 BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers COMPILED BY NLP
DATUM Geodetic DATE February 24 & 25, 2010 CHECKED BY KN

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.3	GROUND SURFACE				
0.0	Clayey Silt Topsoil				
0.2	Brown, Moist	1	SS	22	
	Clayey Silt, trace to some sand; Stiff; Brown; Moist				
302.7 / 1.6	Clayey Silt with sand, trace gravel (TILL); Stiff to very stiff; Brown; Moist	2	SS	9	
		3	SS	25	5 35 44 16
300.4 / 4.0	Silt and Sand to Silty Sand, trace to some gravel, trace clay; Very dense; Brown; Moist to wet	4	SS	56	
		5	SS	50	
		6	SS	89	
		7	SS	99	
296.1 / 8.2	Sand, trace to some silt, trace to some gravel, trace clay; Compact to very dense; Brown; Wet; Clayey Silt zones noted at a depth of 8.8 m; SPT "N" Value of Sample 9 likely influenced by drilling disturbance	8	SS	41	7 78 11 4
		9	SS	11	
		10	SS	23	1 89 6 4
		11	SS	58	
		12	SS	42	
291.7 / 12.7	END OF BOREHOLE				

Ground water level symbol shown at approx. Elev. 299.6.



NOTES:

1. Water level in open borehole at a depth of 4.7 m (Elev. 299.63 m) on completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 3

 METRIC

PROJECT 09-1111-6064
G.W.P. 2009-20T-364 LOCATION N 4872942.4 ;E 613273.7 ORIGINATED BY AB
DIST Central HWY Highway 400 BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers COMPILED BY NLP
DATUM Geodetic DATE February 23, 2010 CHECKED BY KN

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.1	GROUND SURFACE					
0.0	Clayey Silt Topsoil					
0.2	Brown Moist Silty Sand, trace gravel Compact Brown Moist	1	SS	23		
303.0 1.1	Clayey Silt with sand, trace gravel (TILL) Very stiff to hard Brown Moist	2	SS	18		
		3	SS	37		3 34 47 16
300.0 4.0	Sand, trace to some silt, trace to some clay, trace gravel Compact to very dense Brown to grey Moist to wet	4	SS	99		
		5	SS	73	∇	
		6	SS	80		
		7	SS	17		
293.9 10.2	Silty Sand to Sandy Silt, trace clay Compact to very dense Grey Wet	8	SS	58		
		9	SS	18		0 36 60 4
		10	SS	37		
290.3 13.7	Clayey Silt with sand, trace gravel (TILL) Hard Grey Moist	11	SS	58		
		12	SS	50/0.10		

Elevation scale: 303, 302, 301, 300, 299, 298, 297, 296, 295, 294, 293, 292, 291, 290

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

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No 3

 METRIC

PROJECT 09-1111-6064

G.W.P. 2009-20T-364 LOCATION N 4872942.4 ;E 613273.7 ORIGINATED BY AB

DIST Central HWY Highway 400 BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers COMPILED BY NLP

DATUM Geodetic DATE February 23, 2010 CHECKED BY KN

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---													
	Clayey Silt with sand, trace gravel (TILL) Hard Grey Moist		13	SS	39						2	33	48	17
							288							
			14	SS	68		287							
							286							
285.3			15	SS	79									
18.8	END OF BOREHOLE													

NOTES:

1. Water level in open borehole at a depth of 6.5 m (Elev. 297.5 m) on completion of drilling.

Legend: PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED

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

RECORD OF BOREHOLE No 4

 METRIC

PROJECT 09-1111-6064
G.W.P. 2009-20T-364
LOCATION N 4872959.3 ;E 613314.7
ORIGINATED BY AB
DIST Central HWY Highway 400
BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers
COMPILED BY NLP
DATUM Geodetic
DATE February 25, 2010
CHECKED BY KN

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
304.2	GROUND SURFACE							
0.0	Clayey Silt Topsoil, trace to some sand, Brown, Moist							
0.2	Clayey Silt, some sand, trace gravel (TILL), Very stiff, Brown, Moist	1	SS	19				
		2	SS	20	1	18	52	19
301.7 / 2.5	Silty Sand to Sand, some silt, trace to some gravel, trace to some clay (TILL), Very dense, Brown, Moist to wet. Auger grinding at a depth of 3.7 m. Atterberg limit testing indicates Sample 4 is non-plastic	3	SS	59				
		4	SS	68	13	49	31	7
		5	SS	79				
297.0 / 7.2	Sand, trace silt to silty, trace gravel, Compact to very dense, Brown, Wet	6	SS	20				
		7	SS	60				
		8	SS	51				
		9	SS	64	0	78	20	2
291.4 / 12.8	Clayey Silt, trace to some sand, trace gravel (TILL), Hard, Grey, Moist to wet	10	SS	108/0.23				
		11	SS	76				
		12	SS	46	0	13	63	24

Elevation scale: 304, 303, 302, 301, 300, 299, 298, 297, 296, 295, 294, 293, 292, 291, 290

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L — WATER CONTENT (%): 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No 4

 METRIC

PROJECT 09-1111-6064
G.W.P. 2009-20T-364 | LOCATION N 4872959.3 ;E 613314.7 | ORIGINATED BY AB
DIST Central HWY Highway 400 | BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers | COMPILED BY NLP
DATUM Geodetic | DATE February 25, 2010 | CHECKED BY KN

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---							
	Clayey Silt, trace to some sand, trace gravel (TILL) Hard Grey Moist to wet						289	
			13	SS	91			w ≈ 13
							288	
			14	SS	62		287	w ≈ 10
							286	
285.3			15	SS	88			w ≈ 9
18.9	END OF BOREHOLE							

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

NOTES:

1. Water level in open borehole at a depth of 7.2 m (Elev. 297.00 m) on completion of drilling.

2. Water level in monitoring well measured at a depth of 3.2 m (Elev. 301.0 m) on March 26, 2010.

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

Golder Associates

RECORD OF BOREHOLE No 5

 METRIC

PROJECT 09-1111-6064

G.W.P. 2009-20T-364 | LOCATION N 4872975.0 ;E 613353.7 | ORIGINATED BY DD

DIST Central | HWY Highway 400 | BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers | COMPILED BY NLP

DATUM Geodetic | DATE March 1, 2010 | CHECKED BY KN

ELEV / DEPTH (m)	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
305.0	GROUND SURFACE					
0.0 / 0.1	Clayey Silt Topsoil, some sand; Brown; Moist					
	Clayey Silt with sand, trace gravel (TILL); Firm to hard; Brown; Moist to wet	1	SS	20		
		2	SS	5		5 35 43 17
		3	SS	32		
		4	SS	93		
299.4 / 5.6	Sand, trace to some silt, trace gravel, trace clay; Very dense; Brown; Wet. Contains zones of clayey silt from 5.5 to 7.1 m					
		5	SS	55	∇	
		6	SS	103		
		7	SS	63		
		8	SS	71		
		9	SS	73		0 89 8 3
		10	SS	82		
		11	SS	81		
		12	SS	43		
290.4 / 14.6		12A	SS			3 14 58 25

Elevation scale: 304, 303, 302, 301, 300, 299, 298, 297, 296, 295, 294, 293, 292, 291

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

Continued Next Page

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

MIS-MTO 001 09-1111-6064.GPJ GAL-MISS.GDT 5/12/10 SAC

RECORD OF BOREHOLE No 5

 METRIC

PROJECT 09-1111-6064
G.W.P. 2009-20T-364 LOCATION N 4872975.0 ;E 613353.7 ORIGINATED BY DD
DIST Central HWY Highway 400 BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers COMPILED BY NLP
DATUM Geodetic DATE March 1, 2010 CHECKED BY KN

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.7 / 15.3	Clayey Silt, trace to some sand, trace gravel (TILL) Hard Grey Wet	13	SS	33		
	Clayey Silt to Silty Clay, trace sand, trace gravel Hard Grey Wet	14	SS	43	289	
		15	SS	62	288	
		16	SS	80	287	1 3 50 46
286.4 / 18.6	Clayey Silt, some sand, trace gravel (TILL) Hard Grey Wet	17 / 17A	SS	53		
		18	SS	47	286	
284.6 / 20.4		19	SS	73	285	
	END OF BOREHOLE					

NOTES:

1. Water level in open borehole at a depth of 6.5 m (Elev. 298.50 m) on completion of drilling.

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

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

RECORD OF BOREHOLE No 6

 METRIC

PROJECT 09-1111-6064
G.W.P. 2009-20T-364 LOCATION N 4872995.6 ;E 613398.7 ORIGINATED BY AB
DIST Central HWY Highway 400 BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers COMPILED BY NLP
DATUM Geodetic DATE March 9, 2010 CHECKED BY KN

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
305.1	GROUND SURFACE					
0.0 / 304.8 / 0.3	Clayey Silt Topsoil, Brown, Moist	1	SS	21	305	
	Clayey Silt with sand, trace gravel (TILL), Firm to very stiff, Brown, Moist				304, 303	
302.5 / 2.6	Silt and Sand, trace gravel, trace to some clay (TILL), Loose, Brown, Moist, Atterberg limit testing indicates Sample 2 is non-plastic	2	SS	4	302	1 43 45 11
301.0 / 4.1	Sand, trace to some silt, Dense to very dense, Brown, Moist to wet, Trace to some gravel present in Sample 3	3	SS	56	301, 300	
		4	SS	36	299	
		5	SS	66	298, 297	
		6	SS	68	296	
		7	SS	40	295, 294	
	Trace clay present in Sample 8	8	SS	92	293	0 90 7 3
292.3 / 12.8	Sandy Silt to Silty Sand, trace clay, Very dense, Grey, Wet	9	SS	154	292	
		10	SS	66	291	
		11	SS	97		0 24 74 2

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

Continued Next Page

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

RECORD OF BOREHOLE No 6

 METRIC

PROJECT 09-1111-6064
G.W.P. 2009-20T-364 | LOCATION N 4872995.6 ;E 613398.7 | ORIGINATED BY AB
DIST Central HWY Highway 400 | BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers | COMPILED BY NLP
DATUM Geodetic | DATE March 9, 2010 | CHECKED BY KN

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Sandy Silt to Silty Sand, trace clay Very dense Grey Wet	12A 12B	SS	157	290	
	Contains interlayers of Clayey Silt (TILL) below 15.1 m	13	SS	113	289	
288.5 16.6	Clayey Silt to Silty Clay, trace sand, trace gravel Hard Grey Wet	14	SS	64	288	
		15	SS	73	287	
		16	SS	50	286	0 4 51 45
284.7		17	SS	85	285	
20.4	END OF BOREHOLE					

NOTES:

1. Water level in open borehole at a depth of 5.6 m (Elev. 299.50 m) on completion of drilling.

2. Water level in monitoring well measured at a depth of 5.0 m (Elev. 300.1 m) on March 26, 2010.

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

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

RECORD OF BOREHOLE No 7

 METRIC

PROJECT 09-1111-6064

G.W.P. 2009-20T-364

LOCATION N 4873022.2 ;E 613445.5

ORIGINATED BY AB

DIST Central HWY Highway 400

BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers

COMPILED BY NLP

DATUM Geodetic

DATE March 3, 2010

CHECKED BY KN

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
304.7	GROUND SURFACE
0.0	Clayey Silt Topsoil, Black, Moist
304.4 / 0.3	Sandy silt with clay pockets, trace gravel, trace plastics (FILL), Compact, Brown, Moist
303.6 / 1.1	Clayey silt, trace sand, trace topsoil (Probable FILL), Firm, Brown, Moist
302.2 / 2.5	Silt and Sand, trace to some gravel, trace to some clay (TILL), Very dense, Brown, Moist. Spoon encountered rock at a depth of 3.3 m
300.7 / 4.0	Sand, trace to some silt, to Silty Sand, trace clay, Dense to very dense, Brown to grey, Wet
	Sample 12 not collected

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	16	(water content 42.8 plotted)
2	SS	7	
3	SS	56/0.25	3 44 43 10
4	SS	45	
5	SS	40	
6	SS	30	
7	SS	62	
8	SS	44	
9	SS	52	
10	SS	99	
11	SS	68	0 82 15 3
12	SS	-	

GROUND WATER CONDITIONS: water level symbol (∇) at approx. elevation 300.7

ELEVATION SCALE: 304, 303, 302, 301, 300, 299, 298, 297, 296, 295, 294, 293, 292, 291, 290

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

Continued Next Page

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

MIS-MTO 001 09-1111-6064.GPJ GAL-MISS.GDT 5/12/10 SAC

Golder Associates

RECORD OF BOREHOLE No 7

 METRIC

PROJECT 09-1111-6064			
G.W.P. 2009-20T-364	LOCATION N 4873022.2 ;E 613445.5		ORIGINATED BY AB
DIST Central	HWY Highway 400	BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers	COMPILED BY NLP
DATUM Geodetic		DATE March 3, 2010	CHECKED BY KN

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---							
288.8	Sand, trace to some silt, to Silty Sand, trace clay Dense to very dense Brown to grey Wet		13	SS	48		289	0 87 10 3
15.9 / 287.7	Silt to Silt and Sand with interlayers of clayey silt, trace sand, trace gravel Very dense Grey Wet		14A / 14B	SS	135		288	
17.0	Clayey Silt to Silty Clay, trace sand, trace gravel, with interlayers of silt Hard Grey Wet		15	SS	89		287	
285.8			16	SS	77		286	0 7 56 37
18.9	END OF BOREHOLE							

NOTES:

1. Water level in open borehole at a depth of 4.0 m (Elev. 300.71 m) on completion of drilling.

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

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

RECORD OF BOREHOLE No 8

 METRIC

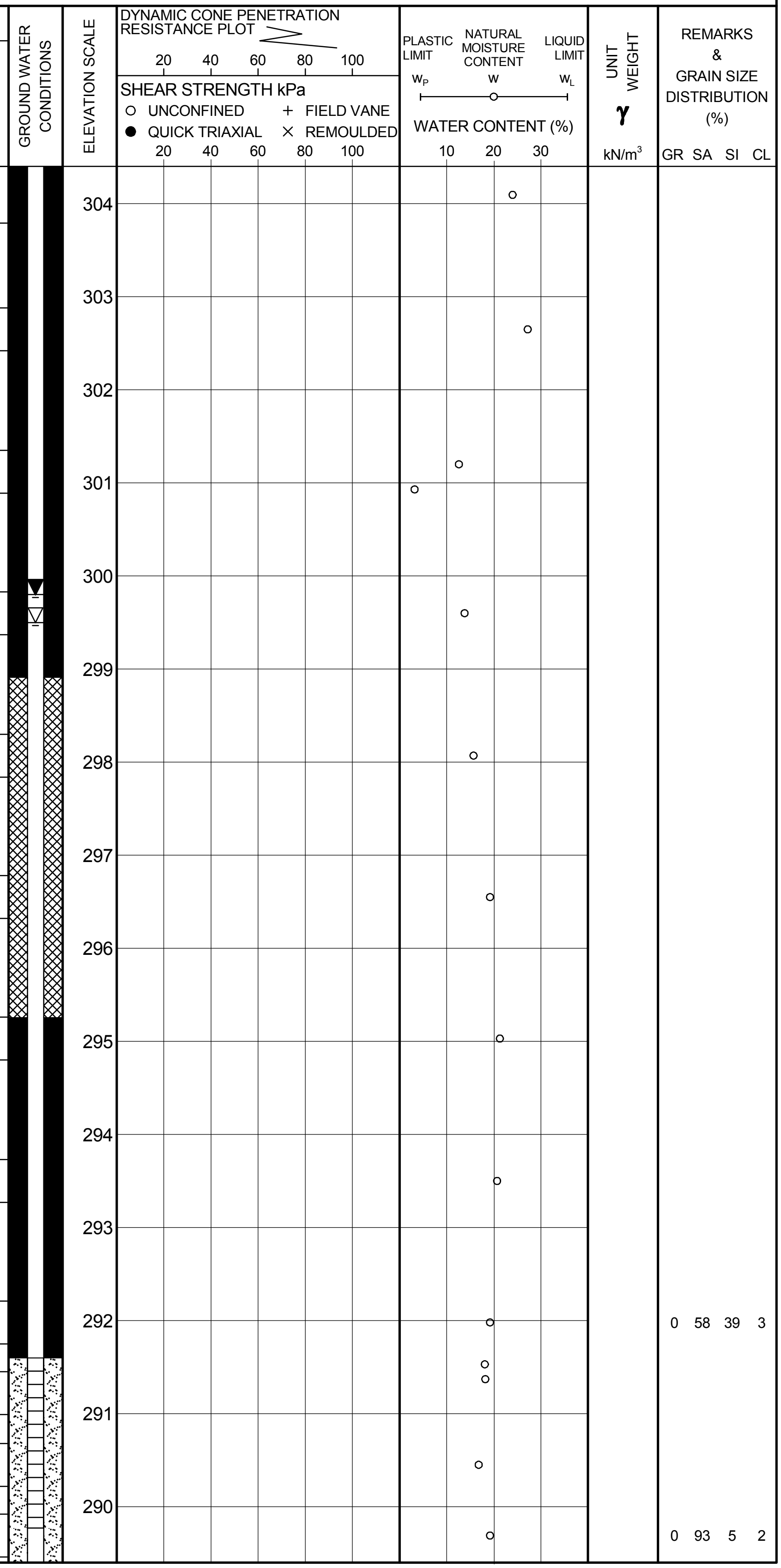
PROJECT 09-1111-6064

G.W.P. 2009-20T-364 | LOCATION N 4873050.1 ;E 613491.7 | ORIGINATED BY AB

DIST Central HWY Highway 400 | BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers | COMPILED BY NLP

DATUM Geodetic | DATE March 5, 2010 | CHECKED BY KN

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS (GR SA SI CL)
304.4	GROUND SURFACE				
0.0 / 304.1 / 0.3	Clayey Silt Topsoil, Brown, Moist	1	SS	20	
	Clayey silt, some sand, trace to some gravel, trace organic matter/topsoil (FILL), Brown, Moist	2	SS	8	
301.9 / 2.5	Silty Sand to Sand, trace to some silt, trace clay, Compact to very dense, Brown to grey, Moist to wet	3A / 3B	SS	15	
		4	SS	53	
		5	SS	56	
		6	SS	49	
		7	SS	57	
		8	SS	67	
		9	SS	61	0 58 39 3
		10	SS	98	
		11	SS	162	
		12	SS	45	0 93 5 2



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

RECORD OF BOREHOLE No 8

 METRIC

PROJECT 09-1111-6064
G.W.P. 2009-20T-364 LOCATION N 4873050.1 ;E 613491.7 ORIGINATED BY AB
DIST Central HWY Highway 400 BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers COMPILED BY NLP
DATUM Geodetic DATE March 5, 2010 CHECKED BY KN

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---						
289.2 15.2	Clayey Silt to Silty Clay, trace to some gravel, trace to some sand Hard Grey Wet	13	SS	51	289	○ (~14)	
					288		
		14	SS	53		wP ~17, w ~17, wL ~35	0 5 50 45
					287		
		15	SS	52	286	○ (~16)	
285.5 18.9	END OF BOREHOLE						

NOTES:

1. Water level in open borehole at a depth of 4.9 m (Elev. 299.50 m) on completion of drilling.

2. Water level in monitoring well measured at a depth of 4.6 m (Elev. 299.8 m) on March 26, 2010.

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

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

RECORD OF BOREHOLE No 9

 METRIC

PROJECT	09-1111-6064		
G.W.P.	2009-20T-364	LOCATION	N 4873075.7 ;E 613534.8
DIST	Central	HWY	Highway 400
BOREHOLE TYPE	D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers		
DATUM	Geodetic	DATE	March 5, 2010
ORIGINATED BY	AB	COMPILED BY	NLP
CHECKED BY	KN		

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
303.9	GROUND SURFACE
0.0	Clayey Silt Topsoil, Brown, Moist
303.6 / 0.3	Clayey Silt, some sand, trace to some gravel, Stiff, Brown, Moist
302.8 / 1.1	Silty Sand, trace gravel, trace to some clay (TILL), Compact, Brown, Moist. Atterberg limit testing indicates Sample 2 is non-plastic
301.4 / 2.5	Sand, trace to some silt, trace clay, Dense to very dense, Brown, Moist to wet
295.5 / 8.4	Sand and Silt, trace clay, Very dense, Brown, Wet. Interbedded zone of Silt, trace sand, trace clay from 9.0 m to 9.8 m
293.4 / 10.5	Sand, trace to some silt, trace clay, Dense to very dense, Brown, Wet
290.3 / 13.6	

Continued Next Page

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	15				
2	SS	18	4	47	39	10
3	SS	33				
4	SS	56				
5	SS	76				
5A	SS	77				
6	SS	144	0	90	8	2
6A-1 / 6A-2	SS	74				
7	SS	125				
7A	SS	98	0	43	54	3
8	SS	69				
9	SS	52				
10	SS	46				

GROUND WATER CONDITIONS: water level symbol at approx. elevation 298.4

ELEVATION SCALE: 303, 302, 301, 300, 299, 298, 297, 296, 295, 294, 293, 292, 291

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20, 40, 60, 80, 100

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

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%): 10, 20, 30

UNIT WEIGHT γ kN/m³

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

RECORD OF BOREHOLE No 9

 METRIC

PROJECT 09-1111-6064

G.W.P. 2009-20T-364 LOCATION N 4873075.7 ;E 613534.8 ORIGINATED BY AB

DIST Central HWY Highway 400 BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers COMPILED BY NLP

DATUM Geodetic DATE March 5, 2010 CHECKED BY KN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE NOTES: 1. Water level in open borehole at a depth of 5.6 m (Elev. 298.27 m) on completion of drilling. 2. Samples 5A, 6A and 7A obtained from supplemental borehole advance 3 m south of Borehole 9.										

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

RECORD OF BOREHOLE No 10

 METRIC

PROJECT	09-1111-6064		
G.W.P.	2009-20T-364	LOCATION	N 4873101.9 ;E 613579.1
ORIGINATED BY	AB		
DIST	Central	HWY	Highway 400
BOREHOLE TYPE	D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers	COMPILED BY	NLP
DATUM	Geodetic	DATE	March 11, 2010
CHECKED BY	KN		

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
303.5	GROUND SURFACE
0.0	Clayey Silt Topsoil Brown Moist
303.1 / 0.4	Sand, some silt to Silty Sand, trace clay, trace gravel Compact Brown Moist
300.4 / 3.1	Silt and Sand, trace to some clay, trace to some gravel (TILL) Compact Brown Moist
299.4 / 4.0	Interbedded zones of clayey silt from 4.0 m to 4.1 m Sand, trace to some silt, trace clay Dense to very dense Brown Moist to wet Contains zones of silt and sand from 5.9 m to 9.0
292.2 / 11.3	END OF BOREHOLE

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	4				
2	SS	27				
3A / 3B / 3C	SS	20	11	46	34	9
4	SS	41				
5	SS	64	0	91	6	3
6	SS	49				
7	SS	73				
8	SS	71	0	38	59	3
9	SS	69				
10	SS	62				
11	SS	91				

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (303, 302, 301, 300, 299, 298, 297, 296, 295, 294, 293); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

NOTES:

1. Water level in open borehole at a depth of 4.0 m (Elev. 299.48 m) on completion of drilling.

2. Water level in monitoring well measured at a depth of 3.9 m (Elev. 299.6 m) on March 26, 2010.

+ ³, × ³: Numbers refer to Sensitivity

○ ³% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 11

 METRIC

PROJECT 09-1111-6064
G.W.P. 2009-20T-364
LOCATION N 4873124.7 ;E 613611.9
ORIGINATED BY AB
DIST Central HWY Highway 400
BOREHOLE TYPE D50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers
COMPILED BY NLP
DATUM Geodetic
DATE March 3, 2010
CHECKED BY KN

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
303.1	GROUND SURFACE						
0.0	Clayey Silt Topsoil, Brown, Moist						
302.7 / 0.3	Clayey Silt with sand, Firm, Brown, Moist	1	SS	9			
		2	SS	4		302	0 39 40 21
		3	SS	7		301	
300.7 / 2.4	Silty sand seams noted from 2.2 m to 3.7 m						
	Clayey Silt, trace to some sand, trace gravel (TILL), Very stiff, Brown, Moist	4	SS	19			
300.3 / 2.8	Sand and Silt to Sand, trace to some silt, trace clay, Dense to very dense, Brown, Moist to wet	5	SS	41	∇	300	0 56 42 2
		6	SS	40		299	
		7	SS	54		298	
		8	SS	80/0.10		297 / 296	
294.8		9	SS	145		295	
8.2	END OF BOREHOLE						

Dynamic Cone Penetration Resistance Plot: 20 40 60 80 100

Shear Strength kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100

Plastic Limit W_P — Natural Moisture Content W — Liquid Limit W_L; Water Content (%) 10 20 30

Unit Weight γ kN/m³

NOTES:

1. Water level in open borehole at a depth of 3.2 m (Elev. 299.87 m) on completion of drilling.

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

DRAWINGS

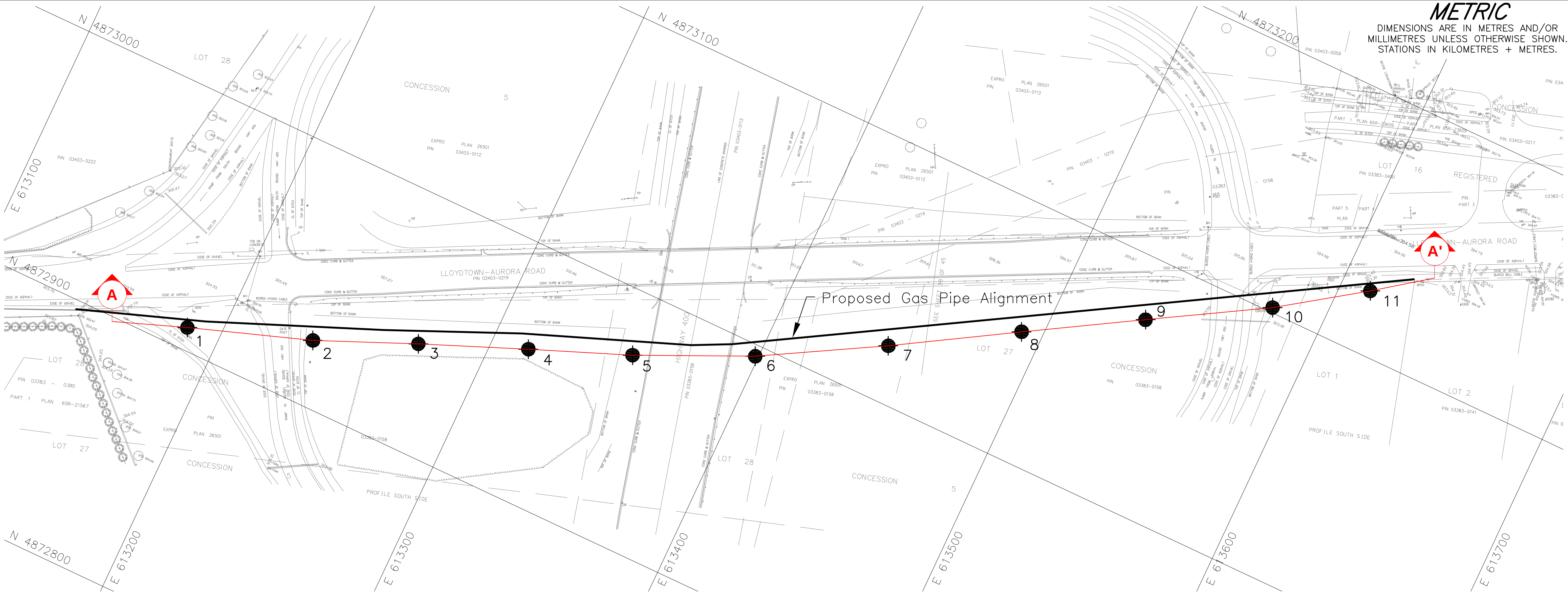
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 2009–20T–364

PROPOSED NPS 16 GAS PIPELINE CROSSING OF HIGHWAY 400 BOREHOLE LOCATIONS AND SOIL STRATA

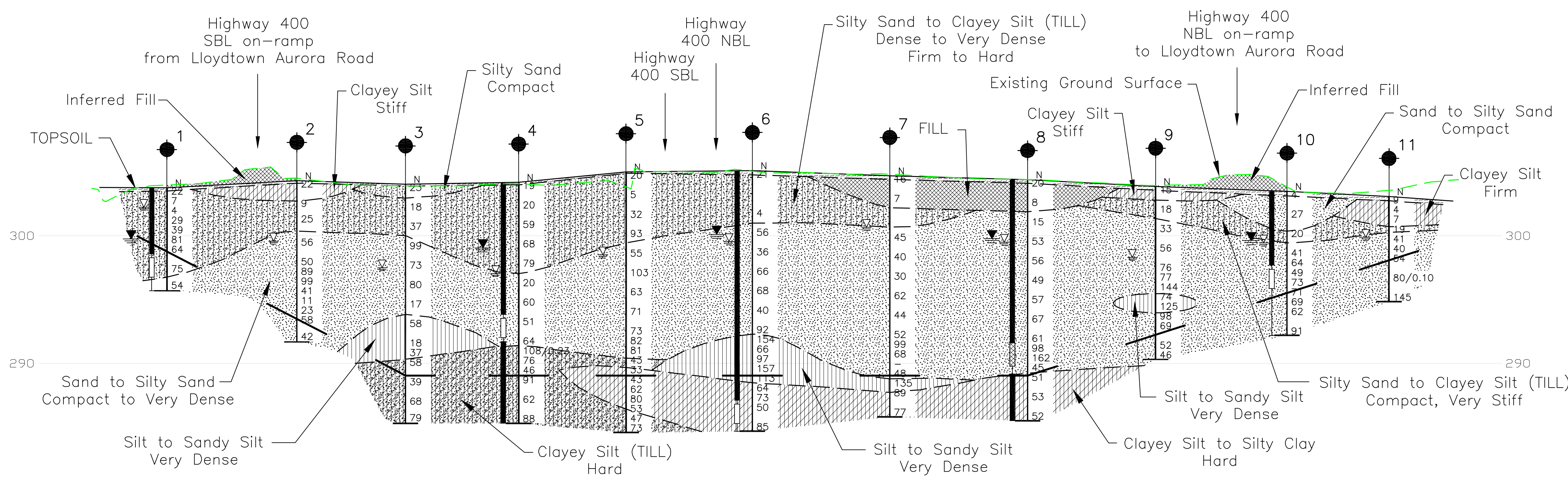
SHEET 1

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



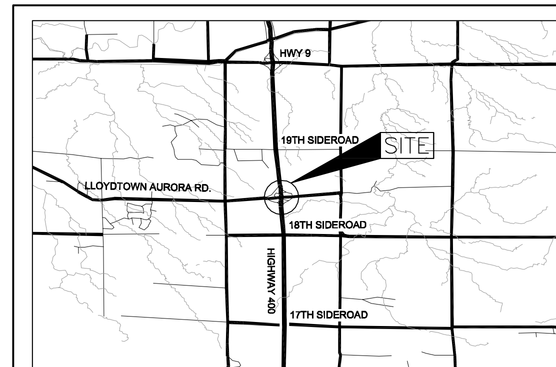
PLAN

SCALE
20 0 20 40 m



PROFILE A – A'

HORIZONTAL SCALE
20 0 20 40
4 0 4 8 m
VERTICAL SCALE



KEY PLAN

NOT TO SCALE

LEGEND

- Borehole – Current Investigation
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% — Rock Quality Designation (RQD)
- WL in piezometer, measured on Mar 26, 2010
- WL upon completion of drilling
- Approximare Proposed NPS16 Pipe Elevation at Borehole Location

No.	ELEVATION (Geodetic)	CO–ORDINATES NORTHING	EASTING
1	303.8	4872908.8	613186.6
2	304.3	4872925.6	613234.6
3	304.1	4872942.4	613273.7
4	304.2	4872959.3	613314.7
5	305.0	4872975.0	613353.7
6	305.1	4872995.6	613398.7
7	304.7	4873022.2	613445.5
8	304.4	4873050.1	613491.7
9	303.9	4873075.7	613534.8
10	303.5	4873101.9	613579.1
11	303.1	4873124.7	613611.9

NOTES

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

The boundaries between soil strata have been established only at borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

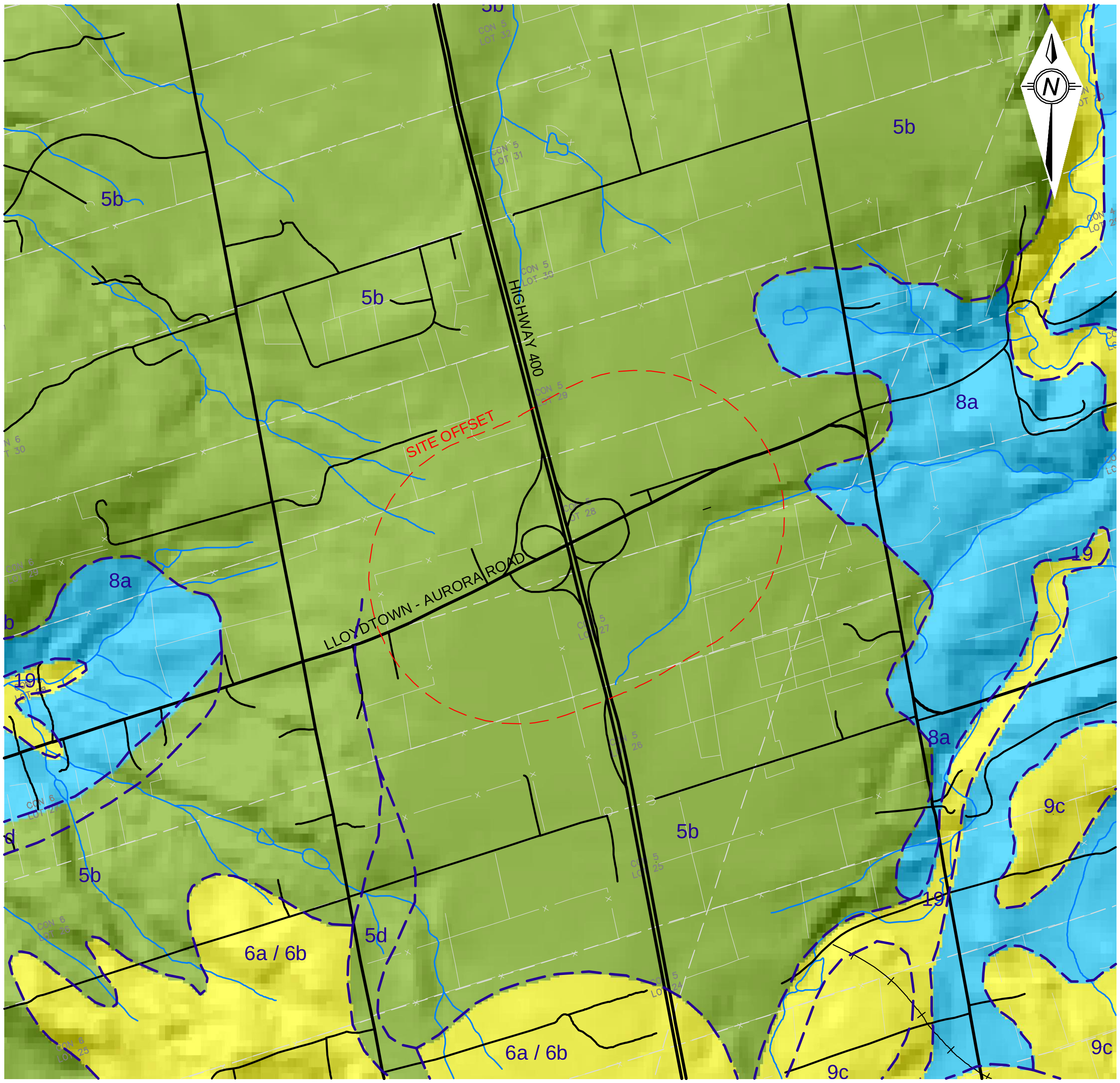
REFERENCE

Base plans provided in digital format by Sexton McKay Limited, drawing file 0911116064AASCT_BOREHOLES.dwg, dated March 22, 2010.

NO.	DATE	BY	REVISION

Geores No. 31D–517

HWY. 400		PROJECT NO. 09–1111–6064	DIST.
SUBM'D. NLP	CHKD. NLP	DATE: 8–Apr–2010	SITE:
DRAWN: DD/RJ	CHKD. KN	APPD.	DWG. 1



LEGEND:

19	Modern alluvial deposits: clay, silt, sand, gravel
9c	Coarse-textured glaciolacustrine deposits: Foreshore and basinal deposits
8a	Fine-textured glaciolacustrine deposits: Massive to well laminated
6a / 6b	Ice-contact stratified deposits: sand, gravel, minor silt and clay In moraines, eskers, kames and crevasse fills In subaqueous fans
	Till:
5d	Clay to silt-textured till (derived from glaciolacustrine deposits or shale)
5b	Stone-poor, sandy silt to silty sand-textured till

NOTES:

1. PROJECTION IS UTM NAD 83 ZONE 17

REFERENCES:

1. MAPPING BASED ON ONTARIO GEOLOGICAL SURVEY 2003

0 50 100 250 500

SCALE 1:10000 metres

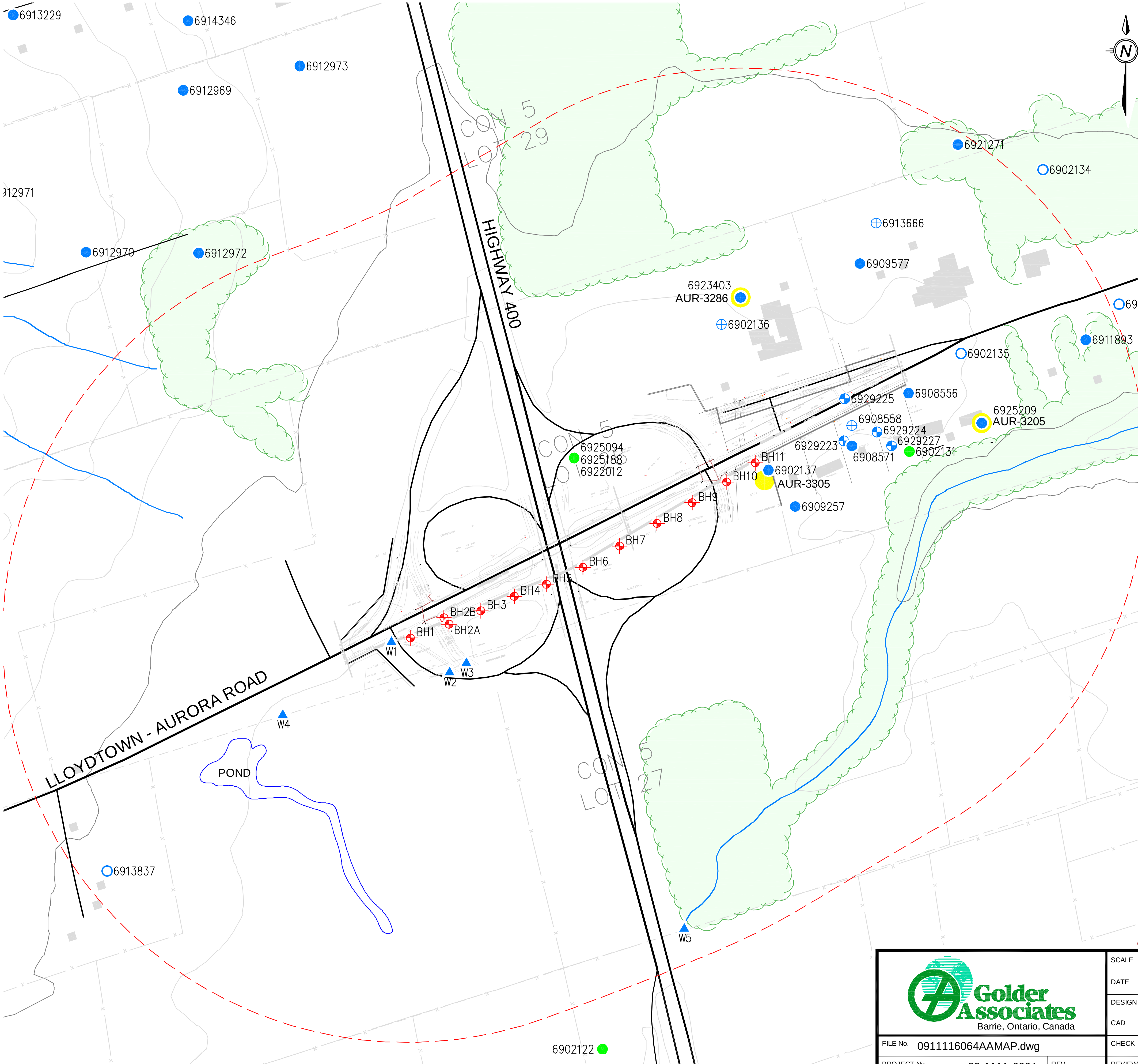
Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN	TITLE	QUATERNARY GEOLOGY MAP
DATE	06 MAY 2010		
DESIGN			
CAD	J REGIER		
CHECK			HWY 400 AURORA ROAD — FIGURE DWG. 2
REVIEW			

FILE No. 0911116064AAQUA.dwg : Drawing 2

PROJECT No. 09-1111-6064 REV.

PLOT DATE: May 12, 2010
FILENAME: T:\Projects\2009\09-1111-6064 (King Twp, Aurora Rd Enbridge)\-AA-\0911116064AAQUA.dwg



LEGEND:

- 500 m Offset from Construction Zone
- Golder Geotechnical Borehole
- Shallow Dug or Bored Well <10 m
- Deep Bored Well >10 m
- Drilled Overburden Well
- Test or Observation Well
- Surface Water Waypoint
- Wells Assigned to Lot Centroid (Highly Approximated)
- AUR-3305 Observed Well Casing with GPS Survey Reference

NOTES:

1. PROJECTION IS UTM NAD 83 ZONE 17
2. ALL MAPPED FEATURES ARE APPROXIMATE AND NOT TO SCALE

REFERENCES:

1. MAPPING BASED ON OBM FEATURES ESRI GEOGRAPHY NETWORK
2. ENBRIDGE SITE PLAN, 2009

0 25 50 100 250

SCALE 1:5000 metres

Plotted Tabloid 11x17

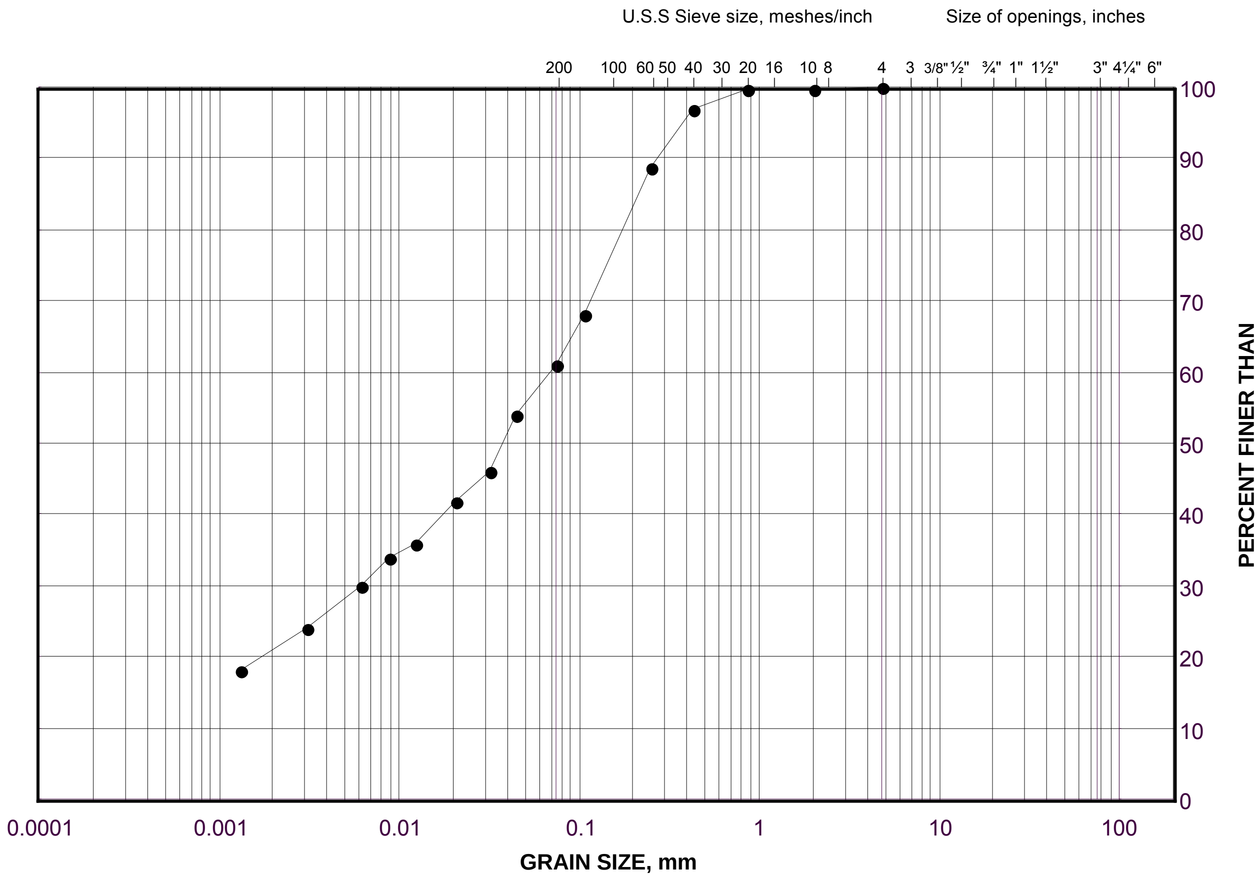
Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN	TITLE	WELL LOCATIONS
DATE	06 MAY 2010		
DESIGN			
CAD	J REGIER		
FILE No. 0911116064AAMAP.dwg	CHECK		HWY 400 AURORA ROAD
PROJECT No. 09-1111-6064 REV.	REVIEW		FIGURE DWG. 3

PLOT DATE: May 12, 2010
FILENAME: T:\Projects\2009\09-1111-6064 (King Twp, Aurora Rd Enbridge)\--AA--\0911116064AAMAP.dwg

FIGURES

# GRAIN SIZE DISTRIBUTION CLAYEY SILT	FIGURE 1



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

LEGEND

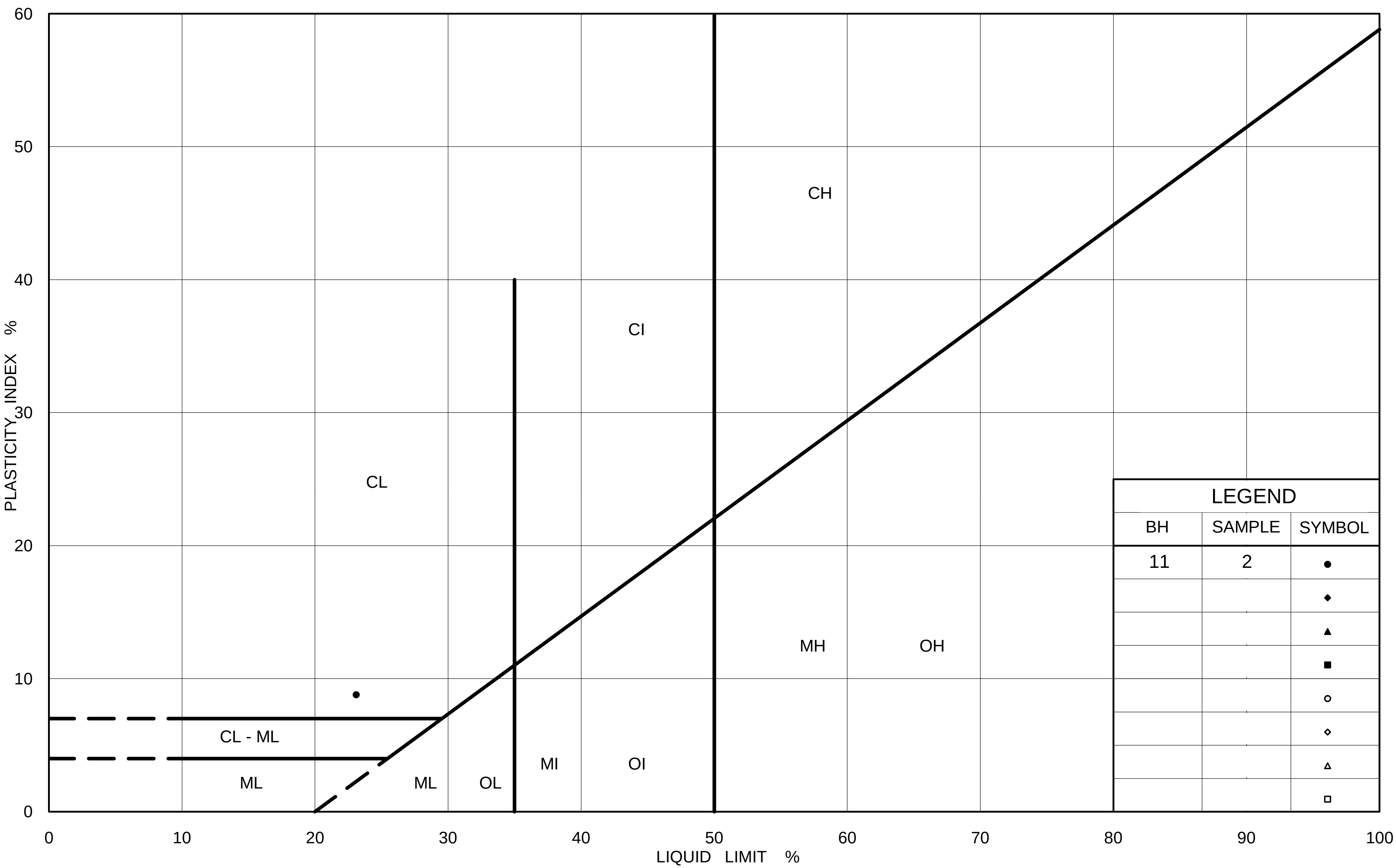
SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	11	2	302.3

Project Number: 09-1111-6064

Checked By: ____________________

Golder Associates

Date: 04-May-10



PLASTICITY CHART
CLAYEY SILT

Golder Associates

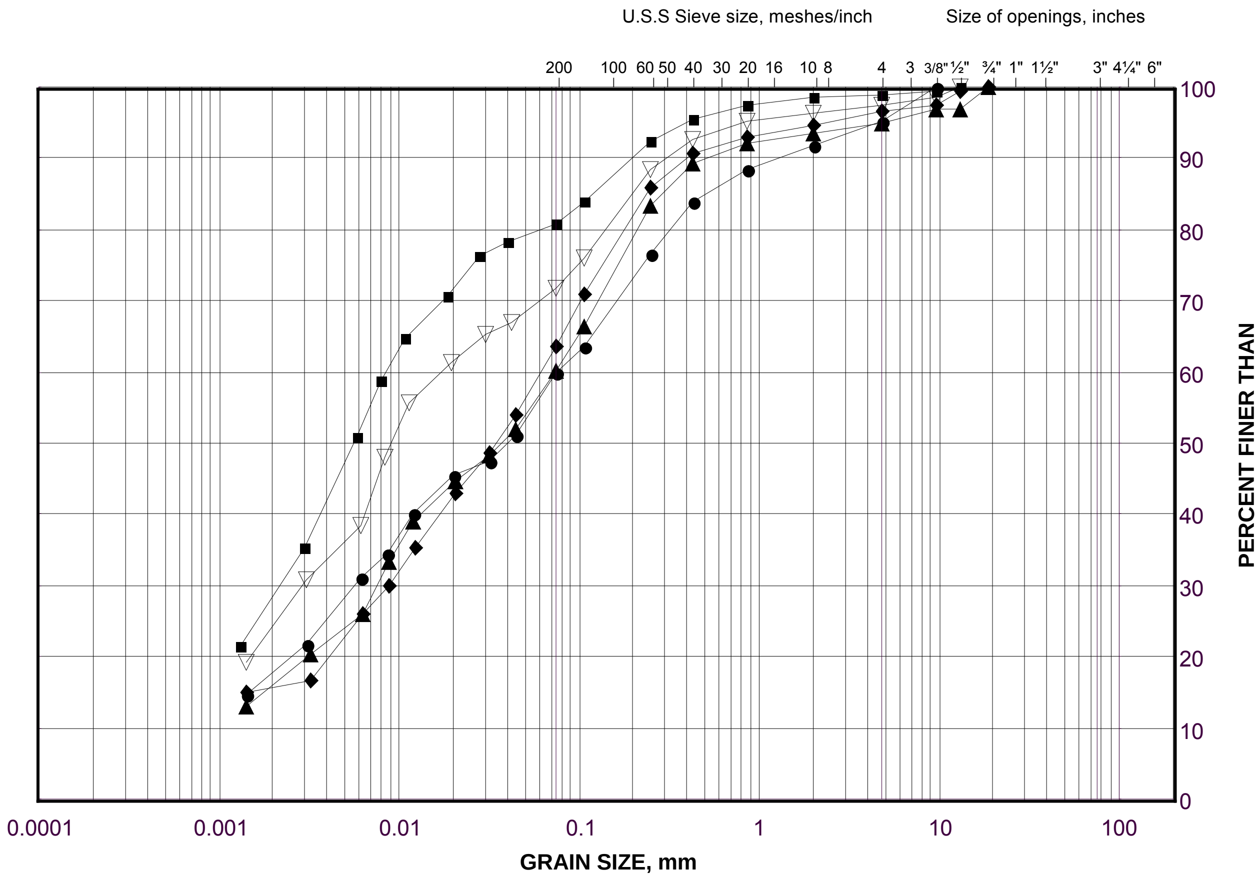
Figure No. 2

Project No. 09-1111-6064

Checked By:

GRAIN SIZE DISTRIBUTION
CLAYEY SILT (UPPER TILL)

FIGURE 3



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	5	2	303.5
■	4	2	302.7
◆	3	3	301.1
▲	2	3	301.3
▽	1	3	302.3

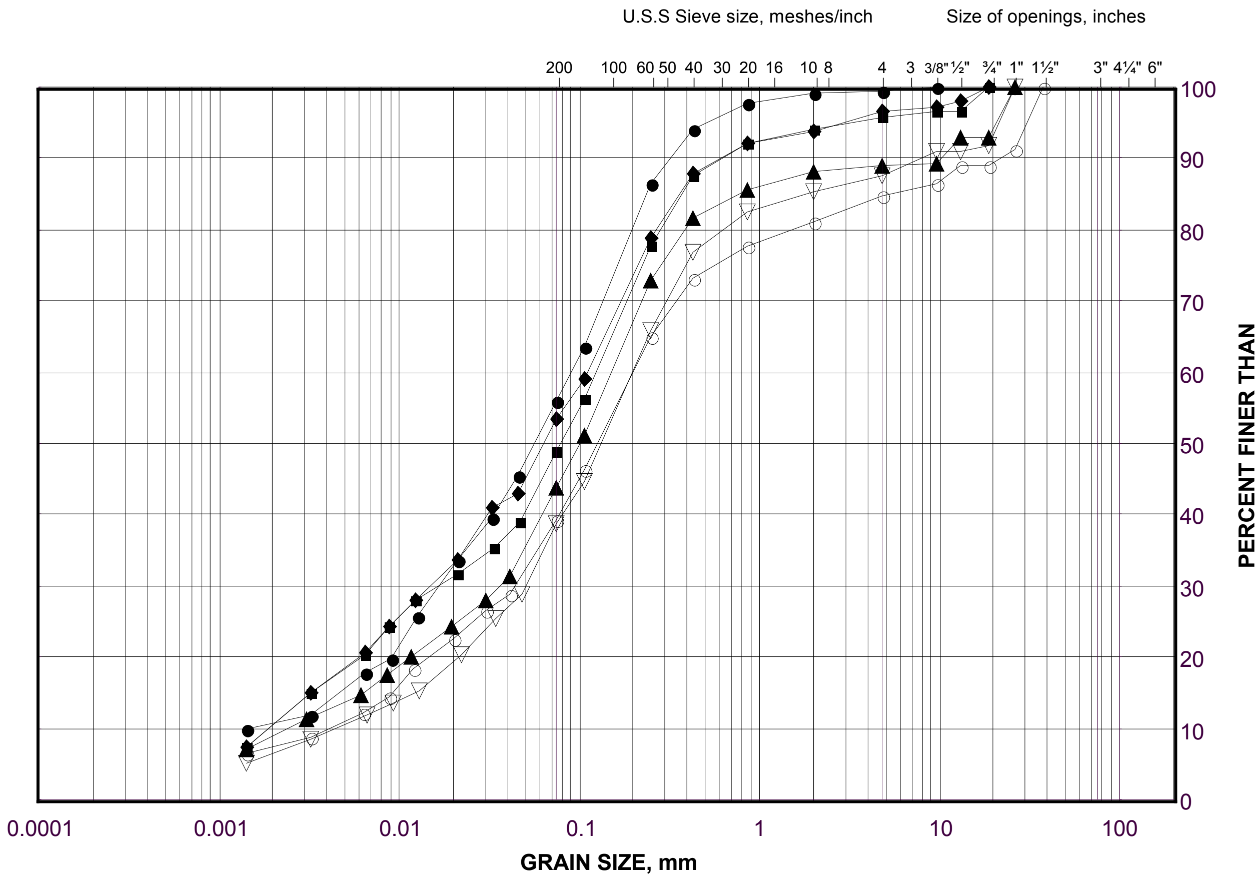
Project Number: 09-1111-6064

Checked By: ____________________

Golder Associates

Date: 04-May-10

GRAIN SIZE DISTRIBUTION SILTY SAND TO SILT and SAND (UPPER TILL)	FIGURE 4



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

LEGEND

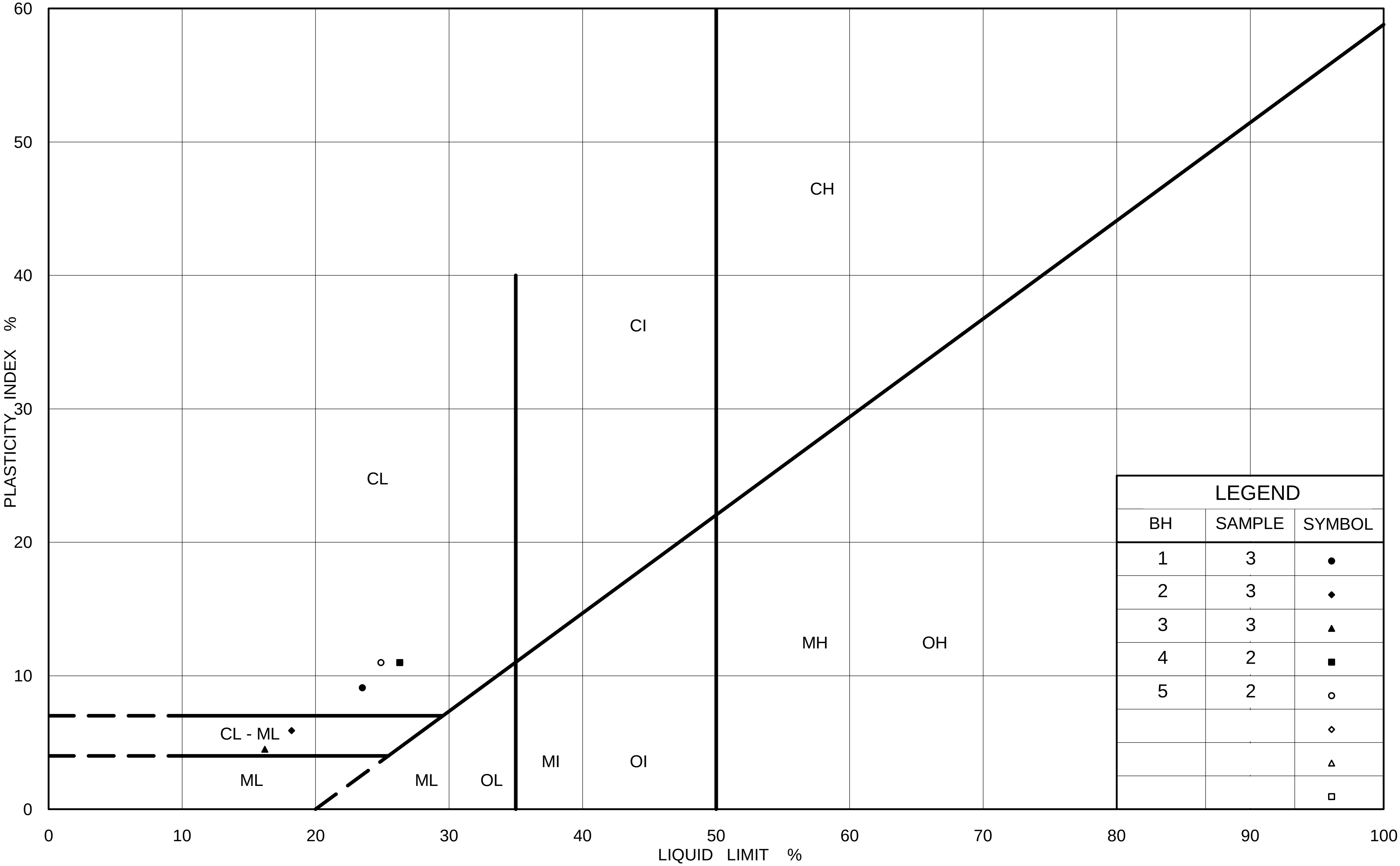
SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	6	2	302.1
■	9	2B	302.3
◆	7	3	301.7
▲	10	3A	300.5
▽	4	4	299.6
❍	1	7	299.2

Project Number: 09-1111-6064

Checked By: ____________________

Golder Associates

Date: 04-May-10



LEGEND		
BH	SAMPLE	SYMBOL
1	3	●
2	3	◆
3	3	▲
4	2	■
5	2	○
		◇
		△
		□

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PLASTICITY CHART
CLAYEY SILT TILL

Figure No. 5

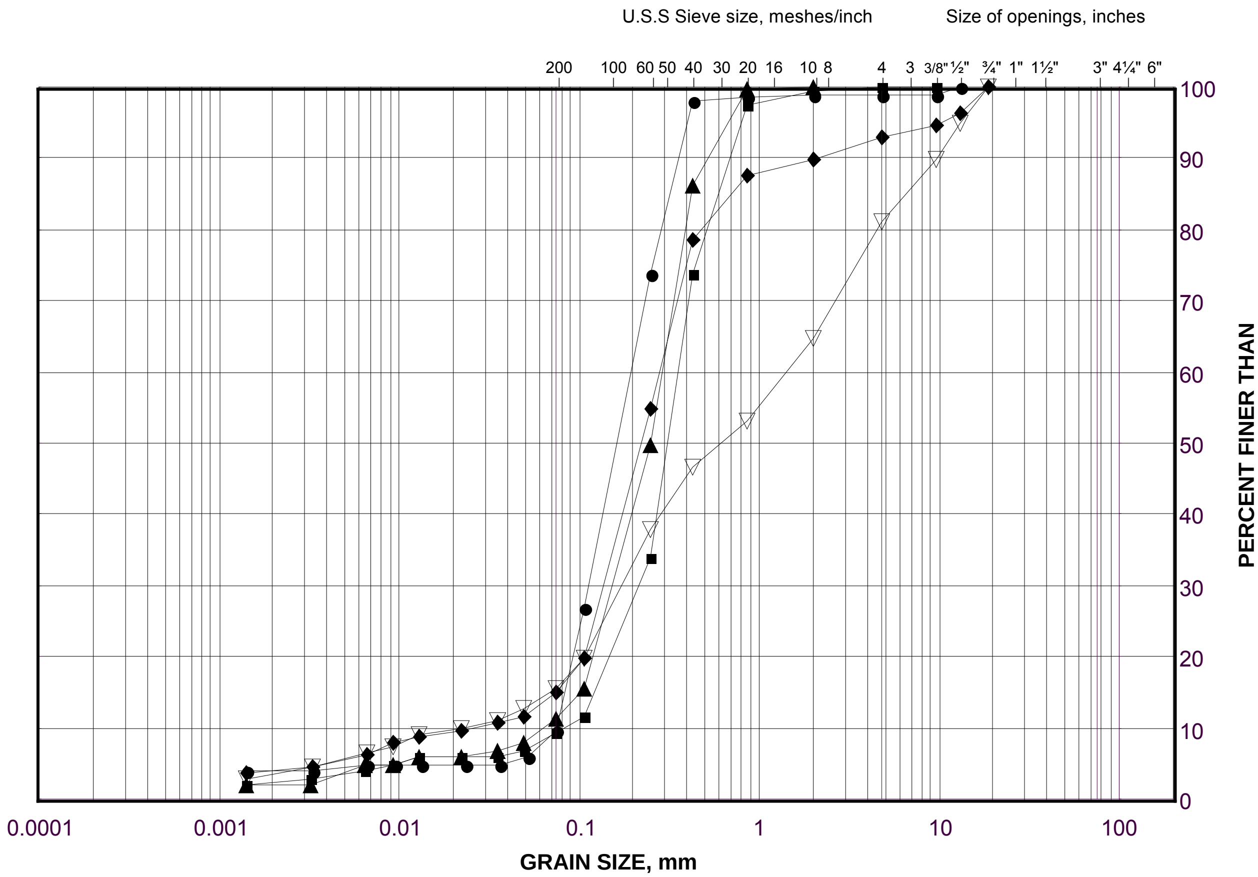
Project No. 09-1111-6064

Checked By:

GRAIN SIZE DISTRIBUTION

SAND to SANDY SILT

FIGURE 6



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	2	10	294.4
■	6	8	292.9
◆	2	8	295.9
▲	5	9	292.8
▽	1	9	296.2

Project Number: 09-1111-6064

Checked By: ______________________

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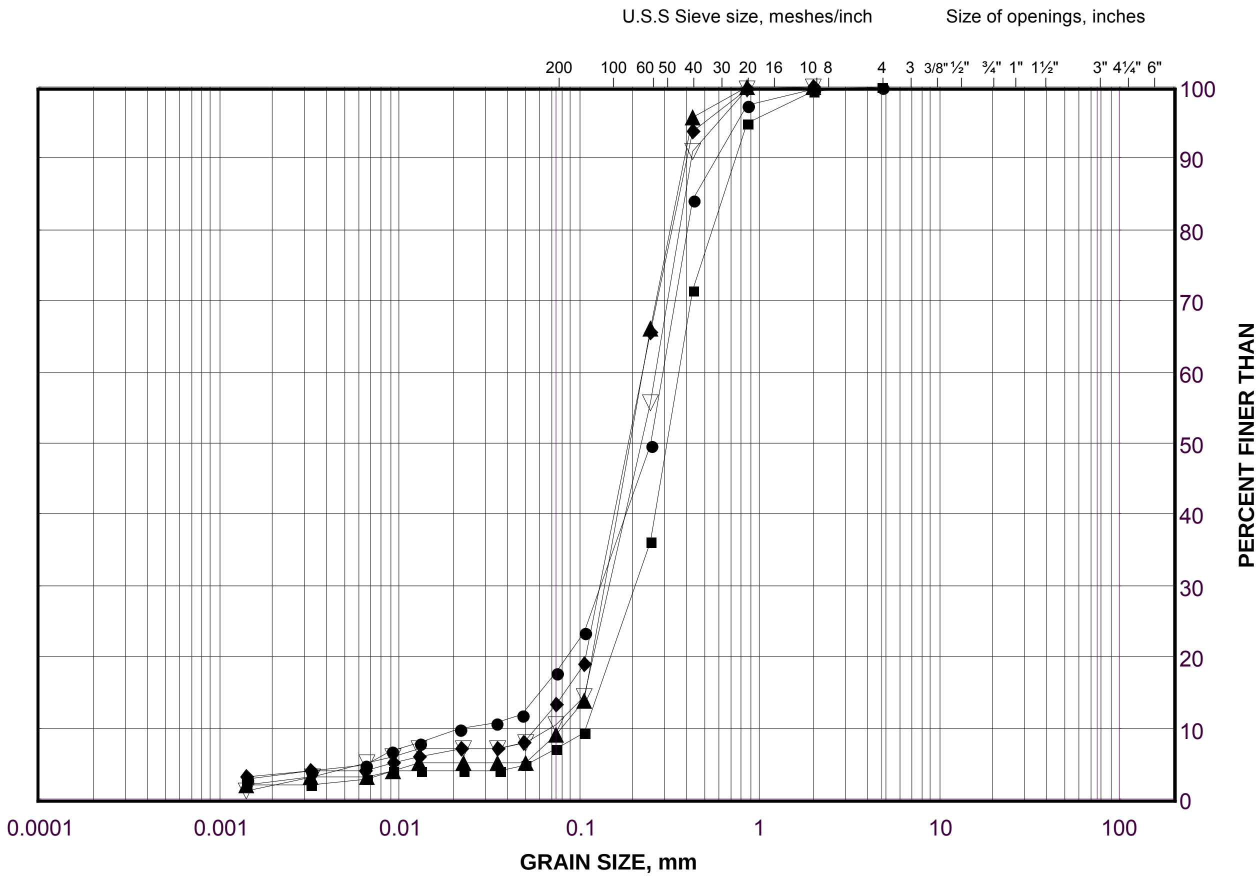
Date: 04-May-10

GRAIN SIZE DISTRIBUTION

SILTY SAND to SAND

FIGURE 7



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	7	11	291.0
■	8	12	289.9
◆	7	13	289.5
▲	10	5	298.2
▽	9	6	296.3

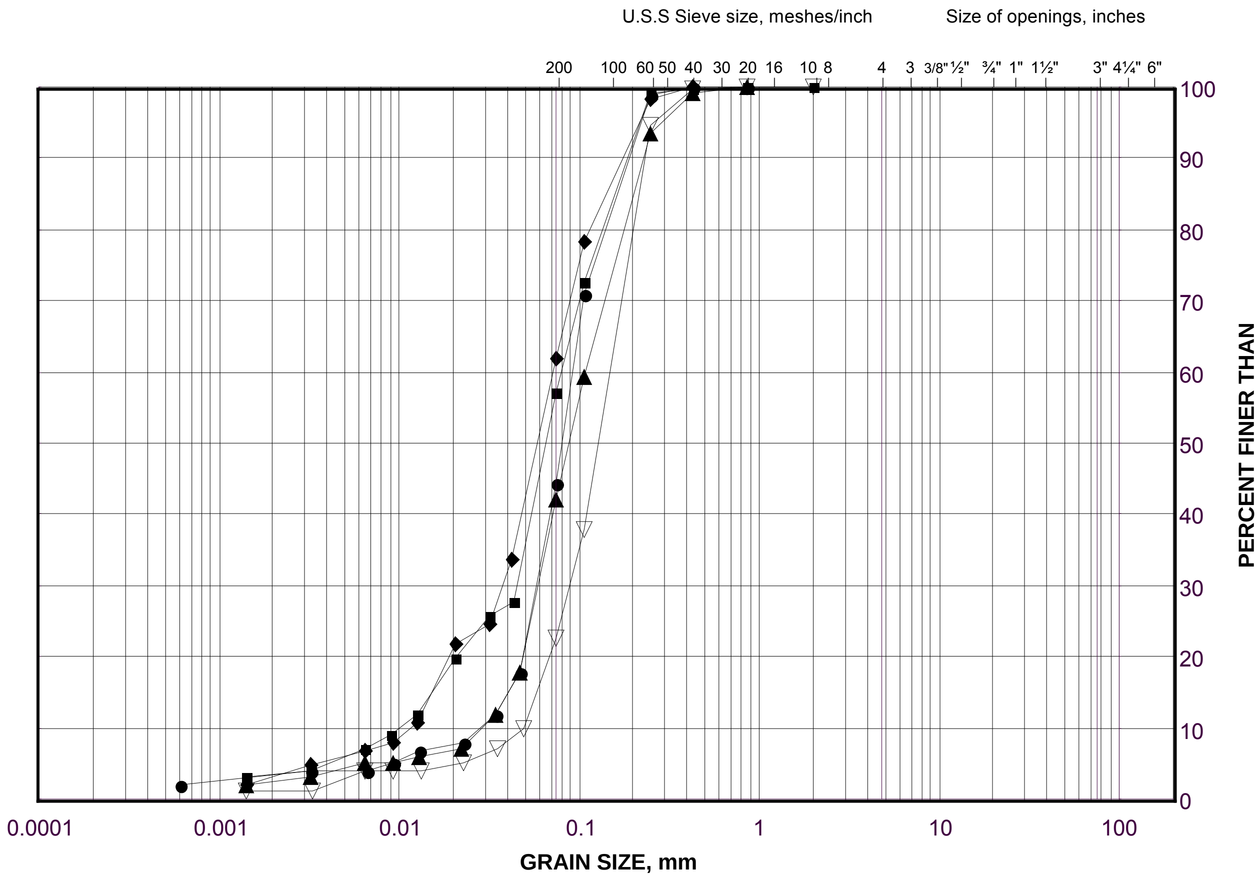
Project Number: 09-1111-6064

Checked By: ____________________

Golder Associates

Date: 06-May-10

GRAIN SIZE DISTRIBUTION SILT and SAND	FIGURE 8



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	11	5	300.1
■	9	7A	294.0
◆	10	8	295.9
▲	8	9	292.2
▽	4	9	292.0

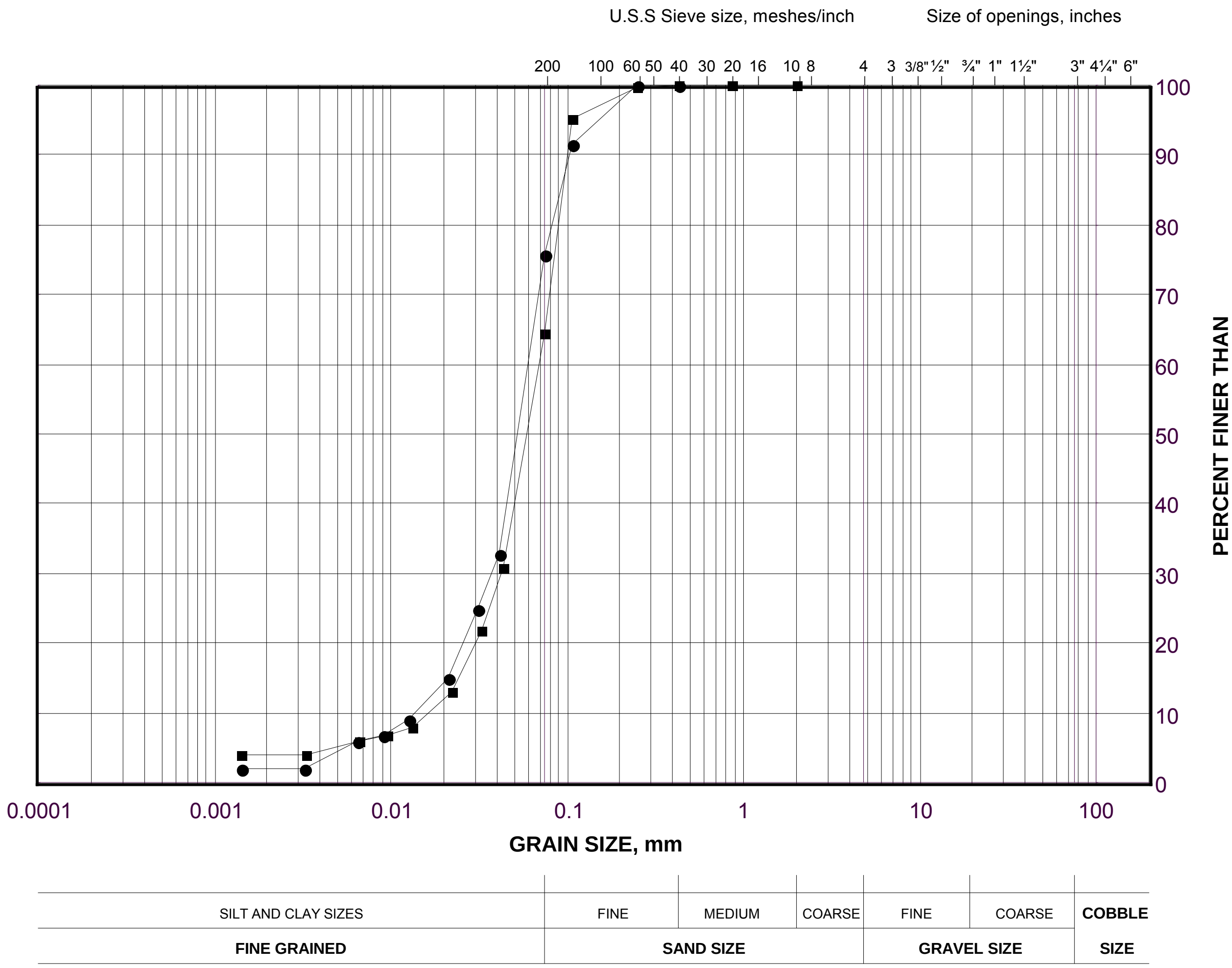
Project Number: 09-1111-6064

Checked By: ______________

Golder Associates

Date: 04-May-10

GRAIN SIZE DISTRIBUTION SANDY SILT	FIGURE 9



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	6	11	290.6
■	3	9	291.9

Project Number: 09-1111-6064

Checked By: ______________________

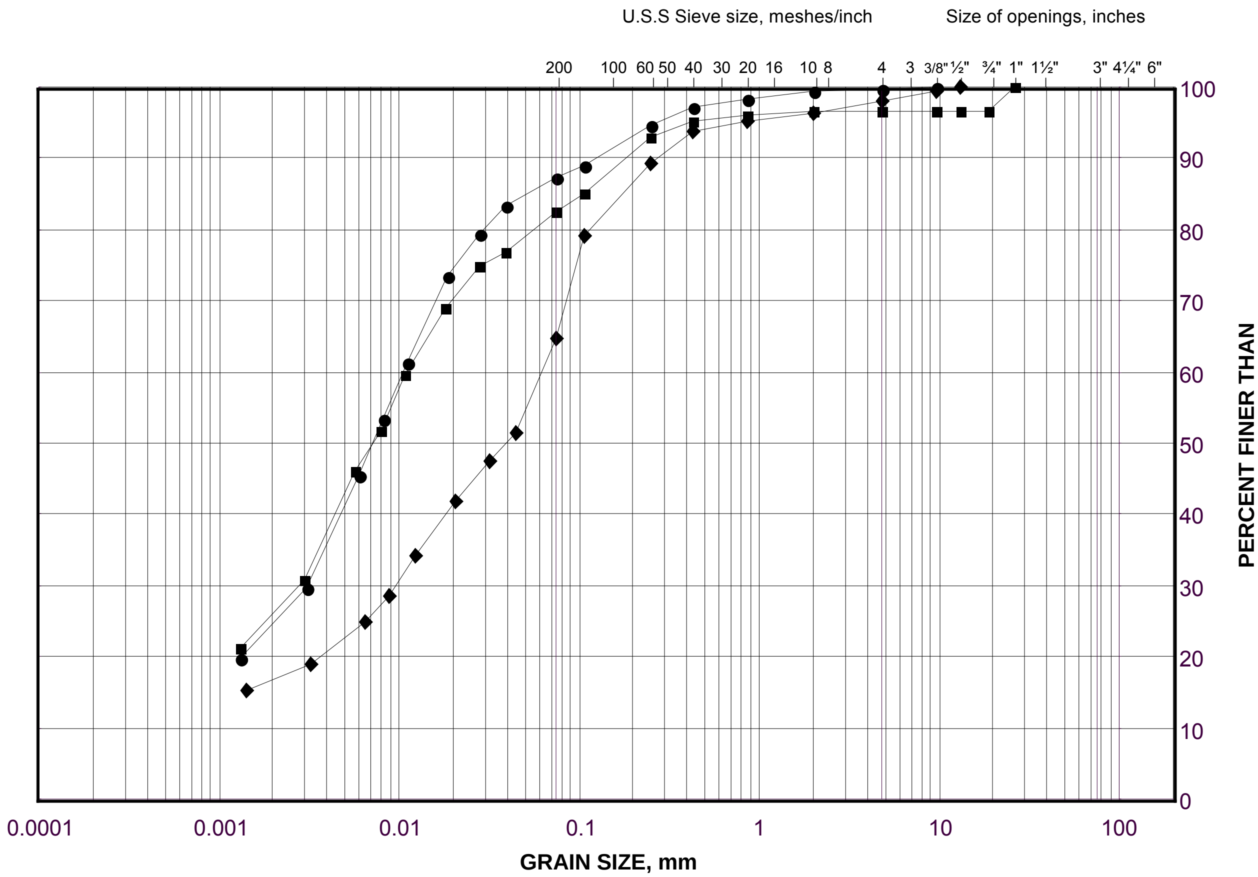
Golder Associates

Date: 04-May-10

GRAIN SIZE DISTRIBUTION

CLAYEY SILT (LOWER TILL)

FIGURE 10



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

LEGEND

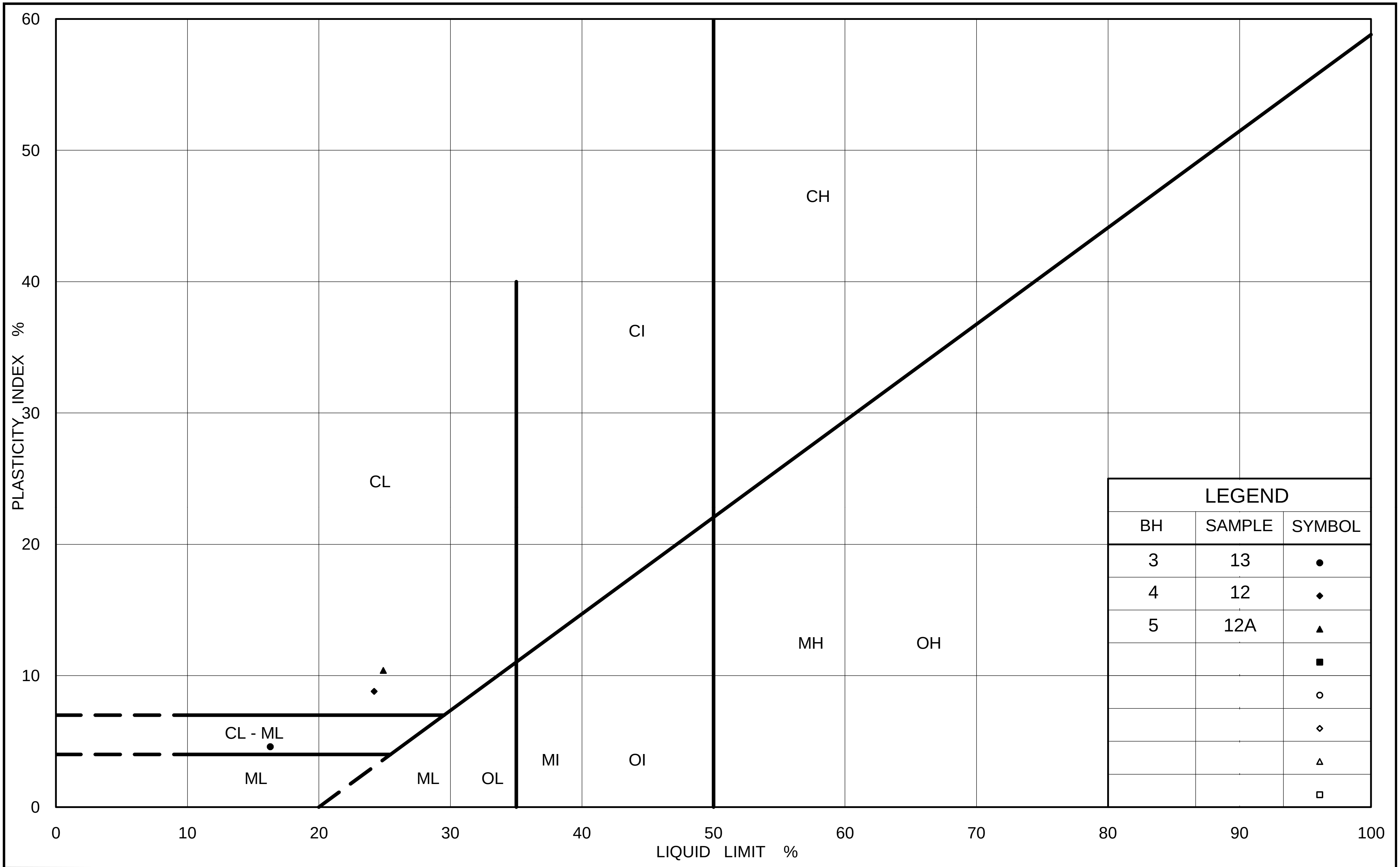
SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	4	12	289.7
■	5	12A	290.4
◆	3	13	288.9

Project Number: 09-1111-6064

Checked By: ____________

Golder Associates

Date: 04-May-10



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PLASTICITY CHART
CLAYEY SILT (LOWER TILL)

Figure No. 11

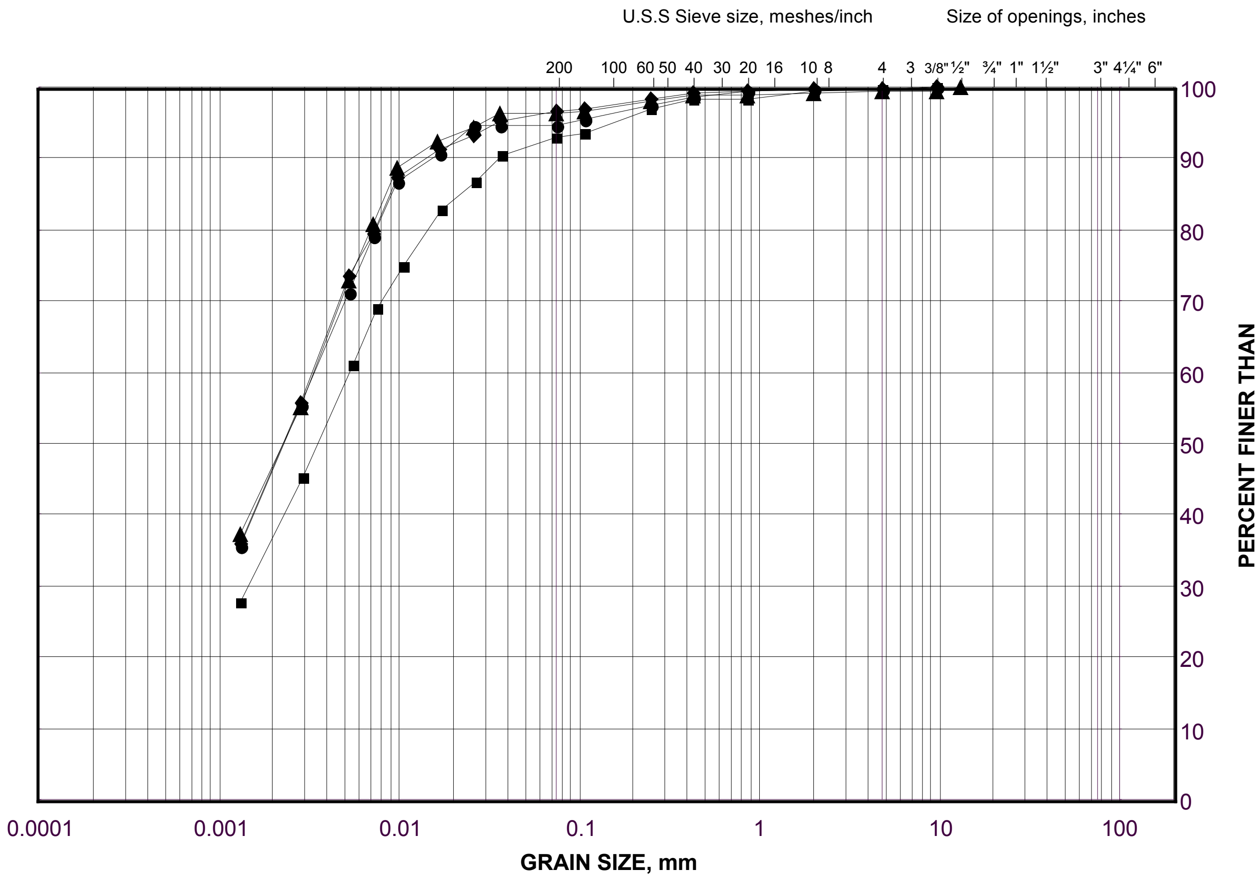
Project No. 09-1111-6064

Checked By:

GRAIN SIZE DISTRIBUTION

CLAYEY SILT TO SILTY CLAY (LOWER DEPOSIT)

FIGURE 12



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

LEGEND

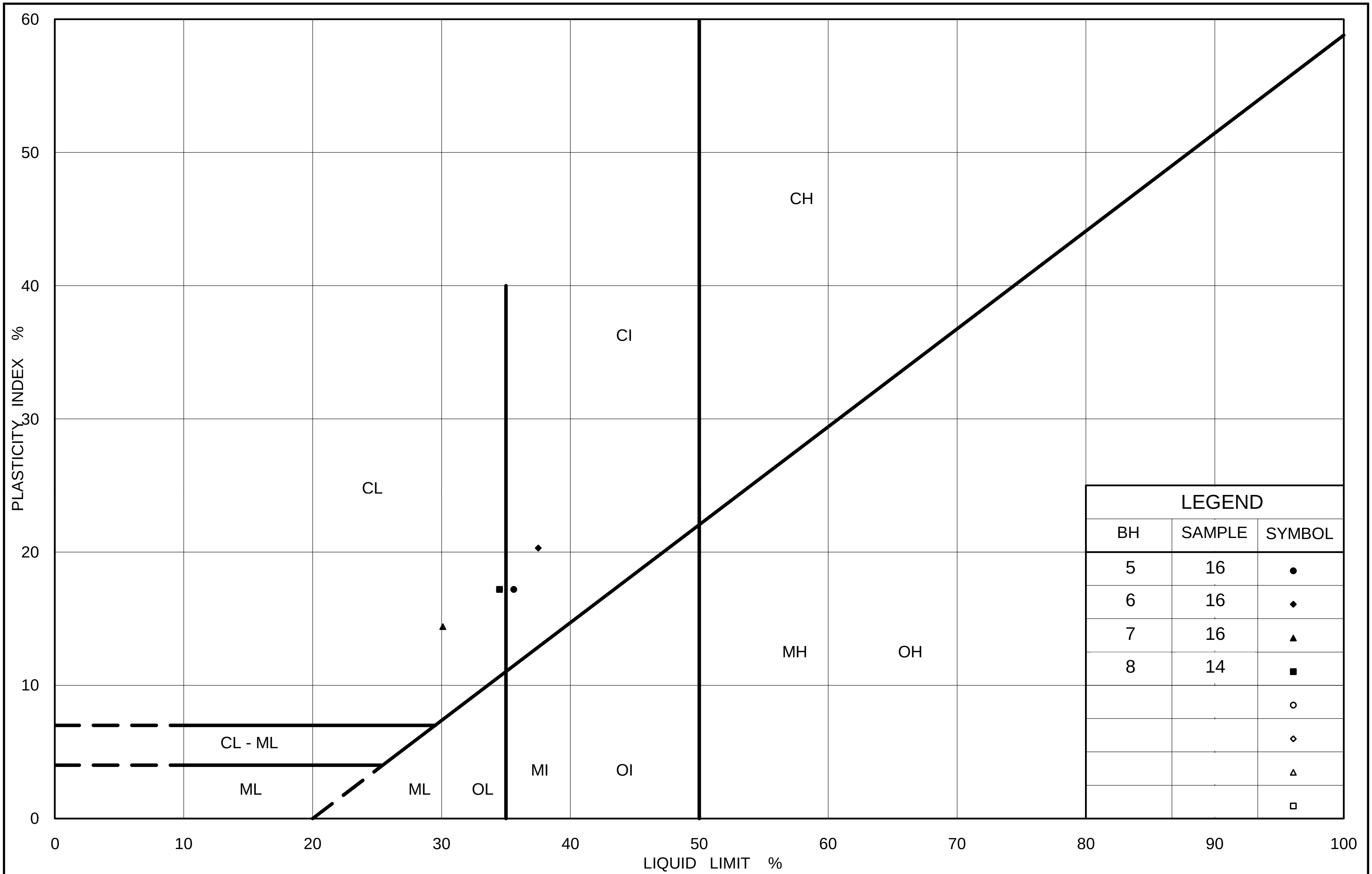
SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	8	14	287.6
■	7	16	286.4
◆	6	16	286.8
▲	5	16	287.5

Project Number: 09-1111-6064

Checked By: ____________________

Golder Associates

Date: 04-May-10



PLASTICITY CHART
CLAYEY SILT to SILTY CLAY (LOW DEPOSIT)

Figure No. 13

Project No. 09-1111-6064

Checked By:

APPENDIX B

Water Well Records

LABEL	CON LOT	DATE	EASTING NORTHING	ELEV ft ASL	WATER 1)ft Type	DIA in	SCREEN ft TOS	Len	#	SWL ft	RATE IGM	TIME min	PL ft	TYPE USE	METHOD DRLR	MOE REFERENCE DESCRIPTION OF MATERIALS
6902122	05 026	Oct-54	613424 4872401	1017	97 Fr	6				32	10	60	70	WS DO	CT 1349	**MOE# 6902122** SILT 0010 MSND 0040 BLUE CLAY 0070 CLAY GRVL 0078 CLAY 0092 GRVL 0102
6902131	05 028	Oct-57	613803 4873139	975	387 Fr	6				255	3	180	325	AS	CT 2613	**MOE# 6902131** BRWN MSND 0040 HPAN 0127 CLAY SILT 0387
6902134	05 028	Oct-65	613968 4873487	984	14 Fr	30				10	6			WS PS	BR 4102	**MOE# 6902134** BRWN CLAY 0014 CSND 0027
6902135	05 028	Jan-59	613867 4873260	1000	20 Fr	36				20				WS DO	BR 1325	**MOE# 6902135** MSND 0020 QSND 0030
6902136	05 028	Nov-65	613571 4873296	1000	21 Fr	30				21	10			WS PS	BR 1307	**MOE# 6902136** BRWN TPSL MSND 0021 BRWN MSND 0028 GREY CLAY 0038
6902137	05 028	Apr-67	613629 4873116	1003	78 Fr	5	79	4		40	6	180	57	WS DO	CT 4813	**MOE# 6902137** BRWN TPSL 0003 MSND 0043 BLUE CLAY 0078 MSND 0083
6908556	05 028	Jun-68	613802 4873211	998	83 Fr	5	83	4		40	7	180	55	WS DO	CT 4813	**MOE# 6908556** BRWN TPSL 0003 MSND 0045 BLUE CLAY 0083 MSND 0087
6908558	05 028	Jun-68	613732 4873171	1000	20 Fr	30				20	1	60	27	WS DO	BR 4231	**MOE# 6908558** TPSL 0001 BLUE CLAY 0015 MSND 0032
6908571	05 028	Jun-68	613732 4873146	1000		4								AS	RC 3414	**MOE# 6908571** TPSL 0001 CLAY MSND 0013 MSND GRVL 0055 GREY CLAY 0304 GREY CLAY SILT 0445
6909257	05 028	Mar-69	613662 4873071	1000	90 Fr	4				50	5	1440	60	WS DO	CT 3519	**MOE# 6909257** PRDG 0025 BRWN MSND 0045 WHTE CLAY 0075 MSND 0090 HPAN 0093
6909577	05 028	Oct-69	613742 4873371	997		6								AS	RC 2801	**MOE# 6909577** BRWN MSND CLAY BLDR 0004 BRWN CLAY MSND 0035 GREY CLAY 0072 GREY CLAY GRVL MSND 0084 GREY FSND SILT CLAY 0093 GREY CLAY 0100 GREY CLAY MSND GRVL 0122 GREY CLAY 0180 GREY CLAY GRVL 0185 GREY CLAY 0243 GRVL MSND 0244 GREY CLAY 0280 GREY CLAY MSND GRVL 0295 GREY CLAY 0309 GREY CLAY MSND GRVL 0476 GREY CLAY 0518 GREY CLAY GRVL 0539
6911893	05 028	Oct-70	614021 4873277	975	180 Fr	5	181	4		102	6	180	175	WS DO	CT 2407	**MOE# 6911893** TPSL 0001 BRWN SAND 0022 BLUE CLAY 0084 BLUE SAND 0088 BLUE CLAY 0180 BLUE CSND 0185
6912969	05 029	Oct-75	612906 4873585	961	83 Fr	6				50	10	120	54	WS DO	RC 1413	**MOE# 6912969** BRWN CLAY STNS 0018 BRWN CLAY STNS 0054 BLUE CLAY 0073 BRWN GRVL SAND 0080 BRWN GRVL 0083
6912970	05 029	Oct-75	612786 4873385	927	93 Fr	6	89	4		35	10	120	60	WS DO	RC 1413	**MOE# 6912970** BRWN CLAY STNS 0020 BLUE CLAY STNS 0055 BLUE CLAY 0085 GREY FSND 0093
6912972	05 029	Oct-75	612925 4873384	957	249 Fr	6	245	4		165	6	210	215	WS DO	RC 1413	**MOE# 6912972** BRWN CLAY STNS 0019 BLUE CLAY STNS 0050 BLUE CLAY SILT 0240 BLCK SAND 0249
6912973	05 029	Oct-75	613050 4873615	974	160 Fr	6	156	4		95	6	180	132	WS DO	RC 1413	**MOE# 6912973** BRWN CLAY STNS 0028 GREY CLAY STNS 0072 BLCK SAND CLAY GRVL 0075 BRWN CLAY STNS 0086 BLUE CLAY 0131 BLUE CLAY 0153 GREY SAND SILT 0160
6913666	05 028	Oct-76	613762 4873421	994	22 Fr	48				16	20	5999	45	WS CO	BR 3413	**MOE# 6913666** TPSL 0001 BRWN CLAY 0018 FSND 0035 CSND 0045 BLUE CLAY 0060

LABEL	CON LOT	DATE	EASTING NORTHING	ELEV ft ASL	WATER 1)ft Type	DIA in	SCREEN ft TOS	 Len	 #	SWL ft	RATE IGM	TIME min	PL ft	TYPE USE	METHOD DRLR	MOE REFERENCE DESCRIPTION OF MATERIALS
6913837	05 027	May-76	612812 4872621	987	16 Fr	30				15				WS DO	BR 3109	**MOE# 6913837** TPSL 0002 CLAY SNDY 0016 SAND 0023
6921271	05 028	Sep-90	613863 4873518	984	370 Fr	6	371	12		236	90	180	380	WS CO	RC 3108	**MOE# 6921271** FILL 0003 BRWN SAND CLAY 0017 BLUE CLAY GRVL 0054 SAND GRVL 0065 BLUE CLAY SAND 0093 BRWN SAND 0097 BLUE CLAY GRVL 0229 BLUE SAND 0238 BLUE CLAY SAND 0265 BLUE CLAY HPAN 0370 BLUE SAND 0383
6922012	05 028	Jul-92	613389 4873131	981	80 Fr	6	81	9		65	7	180	88	WS DO	RC 3108	**MOE# 6922012** TPSL 0003 BRWN CLAY SAND 0042 BLUE CLAY SAND 0080 BLUE SAND GRVL 0090
6923403	05 028	Aug-95	613389 4873131	1005	81 Fr	12	84	10		58	20	1440	75	WS PS	RC 3108	**MOE# 6923403** TPSL 0001 BRWN SAND 0021 BRWN SAND GRVL 0032 BRWN SAND 0044 BLUE CLAY SOFT 0060 BLUE CLAY HARD 0081 SAND 0095 SAND CLAY 0101 BLUE CLAY 0110
6923539	05 028	Mar-96	613389 4873131	1000										AQ PS	 1413	**MOE# 6923539**
6925094	05 028	Aug-99	613389 4873131	995	176 Fr	6	180	5		110	40	480		WS DO	CT 6300	**MOE# 6925094** BRWN CLAY 0002 BRWN SAND 0054 BLUE CLAY 0090 BLUE SAND 0091 BLUE CLAY GRVL 0176 SAND CLN 0186 BLUE CLAY 0190
6925188	05 028	Dec-99	613389 4873131	877	82 Fr	6	76	6		40	15	60	60	WS DO	CT 1350	**MOE# 6925188** YLLW CLAY 0010 GREY CLAY 0032 GREY GRVL CLAY SAND 0035 GREY CLAY SILT SOFT 0054 GREY SAND SILT 0064 WHTE CLAY 0076 BRWN FSND 0082
6925208	05 007	Sep-99	613904 4873150	984										-- DO	RC 6300	**MOE# 6925208**
6925209	05 007	Sep-99	613903 4873155	986	178 Fr	6	173	6		115	50	720		WS DO	RC 6300	**MOE# 6925209** TPSL 0002 BRWN CLAY HARD 0044 BLUE CLAY SOFT 0099 FSND 0107 BLUE CLAY 0178 SAND CLN 0188 BLUE CLAY 0190
6929223	 008	Feb-05	613722 4873152	0		2	28	0						OW	####### 6571	**MOE# 6929223 TAG# A017931** BRWN SAND CLAY 0001 BRWN FSND STNS CLAY 0013 BRWN SAND CLAY 0015 BRWN CSND 0028
6929224	 008	Feb-05	613763 4873163	0		2	28	0						OW	####### 6571	**MOE# 6929224 TAG# A017932** BRWN CLAY 0001 BRWN SAND CLAY 0014 BRWN SAND 0028
6929225	 008	Feb-05	613723 4873204	0		2	28	0						OW	####### 6571	**MOE# 6929225 TAG# A017933** BRWN CLAY 0001 BRWN SAND CLAY 0014 BRWN CSND 0028
6929227	 008	Feb-05	613781 4873146	0		2	28	0						OW	####### 6571	**MOE# 6929227 TAG# A017934** BRWN CLAY 0001 BRWN FSND 0014 BRWN CSND 0028

QUALITY:		TYPE:		USE:		METHOD :	
Fr	Fresh	WS	Water Supply	CO	Comercial	CT	Cable Tool
Mn	Mineral	AQ	Abandoned Quality	DO	Domestic	JT	Jetting
Sa	Salty	AS	Abandoned Supply	MU	Municipal	RC	Rotary Conventional

LABEL	CON	DATE	EASTING	ELEV	WATER	DIA	SCREEN			SWL	RATE	TIME	PL	TYPE	METHOD	MOE REFERENCE
	LOT		NORTHING	ft ASL	1)ft Type	in	ft TOS	Len	#	ft	IGM	min	ft	USE	DRLR	DESCRIPTION OF MATERIALS

Su	Sulphur	PS	Public	RA	Rotary Air
--	Unrecorded	ST	Stock	BR	Boring

Easting and Northings UTM NAD 83 Zone 17, Translated from Recorded UTM NAD 27 or Field Verified.

APPENDIX C

Well Survey Inventory Sheets

GOLDER ASSOCIATES
PRIVATE WELL INVENTORY

CLIENT: Enbridge Gas Distributions Inc.				
JOB NO: 09-1111-6064		DATE : 26-Mar-2010	SAMPLE #	MAP SHEET #
SOURCE OF INFORMATION: Owner		BY: SMF		
STREET Aurora Rd.	911 HOUSE # 3305	REGISTERED PLAN		PHONE NO. 905-727-8593
OWNER/RESIDENT Pacitti	MAILING ADDRESS (If Sampled or Upon Request for Information) Same			
VISIT TALLY (CHECKMARKS): |				

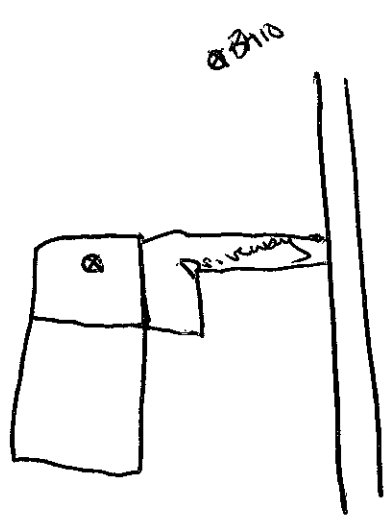
WATER SOURCE	SOFTENER	MOE #: /	YEAR: 1967
☐ Dug Well	☒ Yes ☐ No	DRILLER: /	
☒ Drilled Well	TREATMENT	HOME OWNER THAT YEAR IF KNOWN:	
☐ Sandpoint	1 /		
☐ Other	2 /	WELL DEPTH: 90 ft	
WATER USE	**PUMP**	INTAKE DEPTH: ft / metres	
☒ Domestic	☒ in House	STATIC WATER LEVEL: ft / metres	
☐ Stock	☐ in Well	WELL ABOVE GRADE: ft	
☐ Commercial	GPM:	WELL DIAMETER: in	

REMARKS	Resident Notes or Interviewer Comments
QUANTITY none (Any Problems / Marginal Supply ?)	
QUALITY 2 times a year - no issues (History of Bacti Testing / Does the Resident Drink Bottled)	

UTM NAD 83 ZONE 17T

Waypoint Name:

DIAGRAM OF WELL LOCATION



Description:

well in garage - renovations after original drilling.

GOLDER ASSOCIATES
PRIVATE WELL INVENTORY

Golder Associates

CLIENT: Enbridge Gas Distributions Inc.			
JOB NO: 09-1111-6064	**DATE :** 26-Mar-2010	**SAMPLE #**	**MAP SHEET #**
SOURCE OF INFORMATION:	**BY:** SMF		
STREET Aurora Rd.	**911 HOUSE #** 3285	**REGISTERED PLAN**	**PHONE NO.**
OWNER/RESIDENT	**MAILING ADDRESS (If Sampled or Upon Request for Information)**		
VISIT TALLY (CHECKMARKS): 11			

WATER SOURCE	**SOFTENER**	**MOE #:**	**YEAR:**
☐ Dug Well	☐ Yes ☐ No	**DRILLER:**	
☐ Drilled Well	**TREATMENT**	**HOME OWNER THAT YEAR IF KNOWN:**	
☐ Sandpoint	1		
☐ Other	2	**WELL DEPTH:**	ft
WATER USE	**PUMP**	**INTAKE DEPTH:**	ft / metres
☐ Domestic	☐ in House	**STATIC WATER LEVEL:**	ft / metres
☐ Stock	☐ in Well	**WELL ABOVE GRADE:**	ft
☐ Commercial	**GPM:**	**WELL DIAMETER:**	in

REMARKS	**Resident Notes or Interviewer Comments**
QUANTITY (Any Problems / Marginal Supply ?)	
QUALITY (History of Bacti Testing / Does the Resident Drink Bottled)	

UTM NAD 83 ZONE 17T

Waypoint Name:

DIAGRAM OF WELL LOCATION

Description:

GOLDER ASSOCIATES
PRIVATE WELL INVENTORY

Golder Associates

CLIENT: Enbridge Gas Distributions Inc.			
JOB NO: 09-1111-6064	DATE : 26-Mar-2010	SAMPLE #	MAP SHEET #
SOURCE OF INFORMATION:	BY: SMF		
STREET: Aurora Rd.	911 HOUSE #: 3265	REGISTERED PLAN	PHONE NO.
OWNER/RESIDENT	MAILING ADDRESS (If Sampled or Upon Request for Information)		
VISIT TALLY (CHECKMARKS): \\			

WATER SOURCE	SOFTENER	MOE #:	YEAR:
☐ Dug Well	☐ Yes ☐ No	DRILLER:	
☐ Drilled Well	TREATMENT	HOME OWNER THAT YEAR IF KNOWN:	
☐ Sandpoint	1		
☐ Other	2	WELL DEPTH:	ft
WATER USE	PUMP	INTAKE DEPTH:	ft / metres
☐ Domestic	☐ in House	STATIC WATER LEVEL:	ft / metres
☐ Stock	☐ in Well	WELL ABOVE GRADE:	ft
☐ Commercial	GPM:	WELL DIAMETER:	in

REMARKS	Resident Notes or Interviewer Comments
QUANTITY (Any Problems / Marginal Supply ?)	
QUALITY (History of Bacti Testing / Does the Resident Drink Bottled)	

UTM NAD 83 ZONE 17T

Waypoint Name:

DIAGRAM OF WELL LOCATION

Description:

GOLDER ASSOCIATES
PRIVATE WELL INVENTORY

CLIENT: Enbridge Gas Distributions Inc.			
JOB NO: 09-1111-6064	**DATE :** 26-Mar-2010	**SAMPLE #**	**MAP SHEET #**
SOURCE OF INFORMATION:	**BY:** SMF		
STREET Aurora Rd.	**911 HOUSE #** 3245	**REGISTERED PLAN**	**PHONE NO.**
OWNER/RESIDENT Gougon	**MAILING ADDRESS** (If Sampled or Upon Request for Information)		
VISIT TALLY (CHECKMARKS):			

WATER SOURCE	**SOFTENER**	**MOE #:**	**YEAR:**
☐ Dug Well	☐ Yes ☐ No	**DRILLER:**	
☐ Drilled Well	**TREATMENT**	**HOME OWNER THAT YEAR IF KNOWN:**	
☐ Sandpoint	1		
☐ Other	2	**WELL DEPTH:**	ft
WATER USE	**PUMP**	**INTAKE DEPTH:**	ft / metres
☐ Domestic	☐ in House	**STATIC WATER LEVEL:**	ft / metres
☐ Stock	☐ in Well	**WELL ABOVE GRADE:**	ft
☐ Commercial	**GPM:**	**WELL DIAMETER:**	in

REMARKS	**Resident Notes or Interviewer Comments**
QUANTITY (Any Problems / Marginal Supply ?)	
QUALITY (History of Bacti Testing / Does the Resident Drink Bottled)	

UTM NAD 83 ZONE 17T

Waypoint Name:

DIAGRAM OF WELL LOCATION

Description:
Resident upset that, I was on property didn't want to participate in survey.

- left card w office number and Daniels name.

GOLDER ASSOCIATES
PRIVATE WELL INVENTORY

CLIENT: Enbridge Gas Distributions Inc.				
JOB NO: 09-1111-6064	DATE : 26-Mar-2010		SAMPLE #	MAP SHEET #
SOURCE OF INFORMATION:	BY: SMF			
STREET Aurora Rd.		911 HOUSE # 3225	REGISTERED PLAN	PHONE NO.
OWNER/RESIDENT		MAILING ADDRESS (If Sampled or Upon Request for Information)		
VISIT TALLY (CHECKMARKS): \\				

WATER SOURCE	SOFTENER	MOE #:	YEAR:
☐ Dug Well	☐ Yes ☐ No	DRILLER:	
☐ Drilled Well	TREATMENT	HOME OWNER THAT YEAR IF KNOWN:	
☐ Sandpoint	1		
☐ Other	2	WELL DEPTH:	ft
WATER USE	PUMP	INTAKE DEPTH:	ft / metres
☐ Domestic	☐ in House	STATIC WATER LEVEL:	ft / metres
☐ Stock	☐ in Well	WELL ABOVE GRADE:	ft
☐ Commercial	GPM:	WELL DIAMETER:	in

REMARKS	Resident Notes or Interviewer Comments
QUANTITY (Any Problems / Marginal Supply ?)	
QUALITY (History of Bacti Testing / Does the Resident Drink Bottled)	

UTM NAD 83 ZONE 17T

Waypoint Name:

DIAGRAM OF WELL LOCATION

Description:

GOLDER ASSOCIATES
PRIVATE WELL INVENTORY

Golder Associates

CLIENT: Enbridge Gas Distributions Inc.

JOB NO: 09-1111-6064	DATE :	SAMPLE #	MAP SHEET #
SOURCE OF INFORMATION:	BY:		

STREET	911 HOUSE #	REGISTERED PLAN	PHONE NO.
	3203		

OWNER/RESIDENT	MAILING ADDRESS (If Sampled or Upon Request for Information)
Grant Smith. (Palwick)	
VISIT TALLY (CHECKMARKS): \	

WATER SOURCE
- [ ] Dug Well
- [x] Drilled Well
- [ ] Sandpoint
- [ ] Other

SOFTENER
- [x] Yes
- [ ] No

TREATMENT
1 ✓
2

MOE #:

DRILLER:

YEAR: 2007

HOME OWNER THAT YEAR IF KNOWN: Bolland

WELL DEPTH: ≈200 ft

WATER USE
- [x] Domestic
- [ ] Stock
- [ ] Commercial

PUMP
- [ ] in House
- [x] in Well

GPM:

INTAKE DEPTH:	ft / metres
STATIC WATER LEVEL:	ft / metres
WELL ABOVE GRADE:	ft
WELL DIAMETER:	in

REMARKS

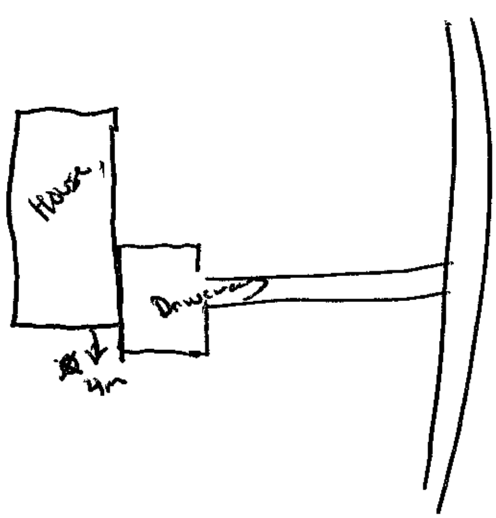
QUANTITY pressure
(Any Problems / Marginal Supply ?)
QUALITY ✓ possible issues iron sulfur.
(History of Bacti Testing / Does the Resident Drink Bottled)

Resident Notes or Interviewer Comments

UTM NAD 83 ZONE 17T

Waypoint Name:

DIAGRAM OF WELL LOCATION



Description:
recently Drilled
by previous owner

GOLDER ASSOCIATES
PRIVATE WELL INVENTORY

CLIENT: Enbridge Gas Distributions Inc.			
JOB NO: 09-1111-6064	**DATE :** 26-Mar-10	**SAMPLE #**	**MAP SHEET #**
SOURCE OF INFORMATION:	**BY:** SMF		
STREET Aurora Rd.	**911 HOUSE #** 3185	**REGISTERED PLAN**	**PHONE NO.**
OWNER/RESIDENT	**MAILING ADDRESS (If Sampled or Upon Request for Information)**		
VISIT TALLY (CHECKMARKS): \\\			

WATER SOURCE	**SOFTENER**	**MOE #:**	**YEAR:**
☐ Dug Well	☐ Yes ☐ No	**DRILLER:**	
☐ Drilled Well	**TREATMENT**	**HOME OWNER THAT YEAR IF KNOWN:**	
☐ Sandpoint	1		
☐ Other	2	**WELL DEPTH:**	ft
WATER USE	**PUMP**	**INTAKE DEPTH:**	ft / metres
☐ Domestic	☐ in House	**STATIC WATER LEVEL:**	ft / metres
☐ Stock	☐ in Well	**WELL ABOVE GRADE:**	ft
☐ Commercial	**GPM:**	**WELL DIAMETER:**	in

REMARKS	**Resident Notes or Interviewer Comments**
QUANTITY	
(Any Problems / Marginal Supply ?)	
QUALITY	
(History of Bacti Testing / Does the Resident Drink Bottled)	

UTM NAD 83 ZONE 17T

Waypoint Name:

DIAGRAM OF WELL LOCATION

Description:

GOLDER ASSOCIATES
PRIVATE WELL INVENTORY

Golder Associates

CLIENT: Enbridge Gas Distributions Inc.

JOB NO: 09-1111-6064	**DATE :** 26-Mar-2010	**SAMPLE #**	**MAP SHEET #**
SOURCE OF INFORMATION:	**BY:** SMF		
STREET	**911 HOUSE #**	**REGISTERED PLAN**	**PHONE NO.**
OWNER/RESIDENT GM Smith Ltd.	**MAILING ADDRESS (If Sampled or Upon Request for Information)**		
VISIT TALLY (CHECKMARKS):			

WATER SOURCE	**SOFTENER**	**MOE #:**	**YEAR:**
☐ Dug Well	☐ Yes ☐ No	**DRILLER:**	
☐ Drilled Well	**TREATMENT**	**HOME OWNER THAT YEAR IF KNOWN:**	
☐ Sandpoint	1		
☐ Other	2	**WELL DEPTH:**	ft
WATER USE	**PUMP**	**INTAKE DEPTH:**	ft / metres
☐ Domestic	☐ in House	**STATIC WATER LEVEL:**	ft / metres
☐ Stock	☐ in Well	**WELL ABOVE GRADE:**	ft
☐ Commercial	**GPM:**	**WELL DIAMETER:**	in

REMARKS	**Resident Notes or Interviewer Comments**
QUANTITY (Any Problems / Marginal Supply ?)	
QUALITY (History of Bacti Testing / Does the Resident Drink Bottled)	

UTM NAD 83 ZONE 17T

Waypoint Name:

DIAGRAM OF WELL LOCATION

Description:
Received Card from office staff for person w more information.

GOLDER ASSOCIATES
PRIVATE WELL INVENTORY

Golder Associates

CLIENT: Enbridge Gas Distributions Inc.			
JOB NO: 09-1111-6064	**DATE :** 26-Mar-2010	**SAMPLE #**	**MAP SHEET #**
SOURCE OF INFORMATION: Jeff Collins	**BY:** SMF		
STREET	**911 HOUSE #** 3206	**REGISTERED PLAN**	**PHONE NO.** 739-0243
OWNER/RESIDENT Kettleby School	**MAILING ADDRESS** (If Sampled or Upon Request for Information)		
VISIT TALLY (CHECKMARKS):			

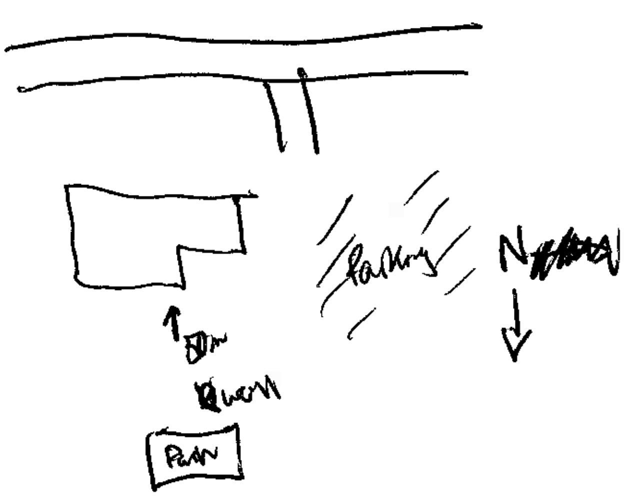
WATER SOURCE	**SOFTENER**	**MOE #:**	**YEAR:**
☐ Dug Well	☐ Yes ☒ No	**DRILLER:** King City Well Drilling	15+ years
☒ Drilled Well	**TREATMENT**	**HOME OWNER THAT YEAR IF KNOWN:**	
☐ Sandpoint	1 UV		
☐ Other	2 Cl	**WELL DEPTH:**	ft
WATER USE	**PUMP**	**INTAKE DEPTH:**	ft / metres
☒ Domestic	☐ in House	**STATIC WATER LEVEL:**	ft / metres
☐ Stock	☒ in Well	**WELL ABOVE GRADE:**	ft
☐ Commercial	**GPM:**	**WELL DIAMETER:**	in

REMARKS	**Resident Notes or Interviewer Comments**
QUANTITY slow during heavy used	
(Any Problems / Marginal Supply ?)	
QUALITY daily Cl, weekly bacteria	
(History of Bacti Testing / Does the Resident Drink Bottled)	

UTM NAD 83 ZONE 17T

Waypoint Name:

DIAGRAM OF WELL LOCATION



Description:
older well went dry and current well was installed to replace 15+ years ago

APPENDIX D

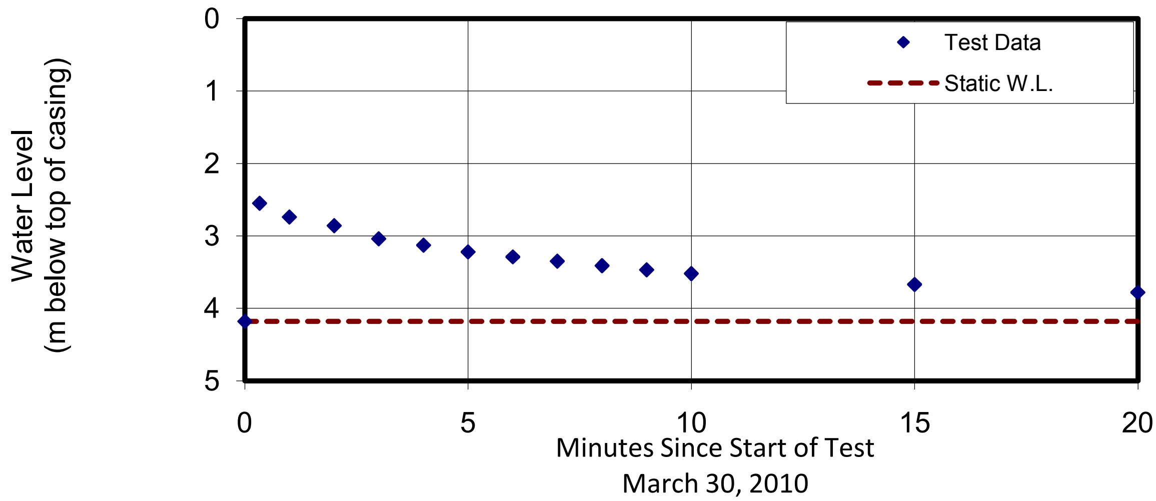
In-Situ Testing of Boreholes 1, 6, and 8

In-Situ Hydraulic Conductivity Test Report

Monitoring Well BH1 Tested on March 30, 2010

Figure D-1

BH1
Groundwater Level vs. Time



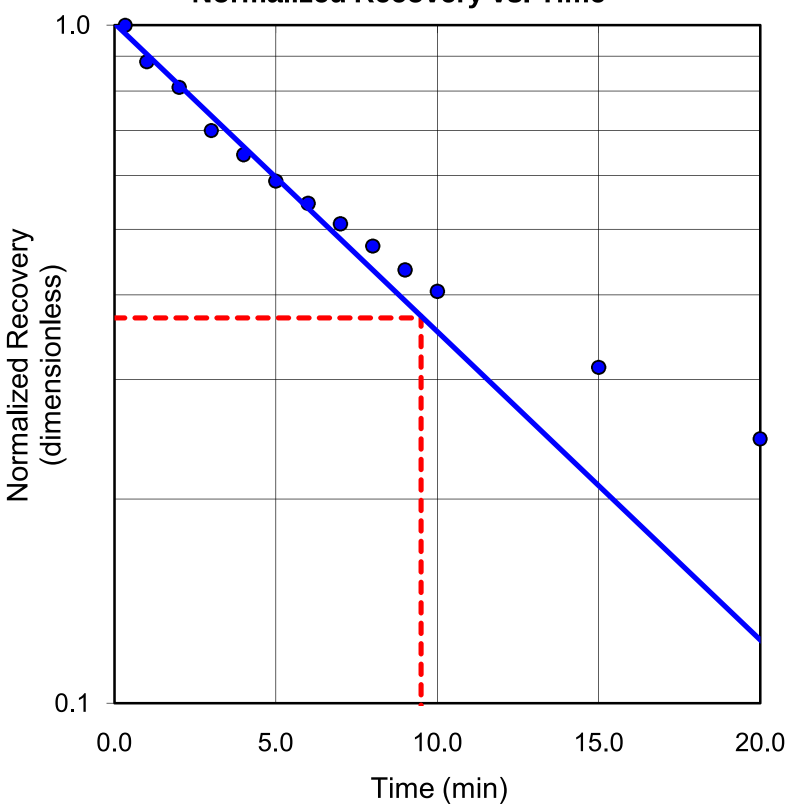
Sand Pack Interval (below ground surface)

5.2 m - 7.0 m

Well Completed in:

Silty Sand

Normalized Recovery vs. Time



Time Lag (T_0) = 9.5 min

Screen Length (L) = 1.5 m

Well Radius (r) = 0.0254 m

Hole Radius (R) = 0.1016 m

Hvorslev Analysis

$$K = \frac{(r^2)\ln(L/R)}{2T_0L} = \quad 1E\text{-}04 \text{ cm/s}$$

NOTES:

It should be noted that these values are lower then expected given the geological discriptions of the material encountered.

DATE: April 2010

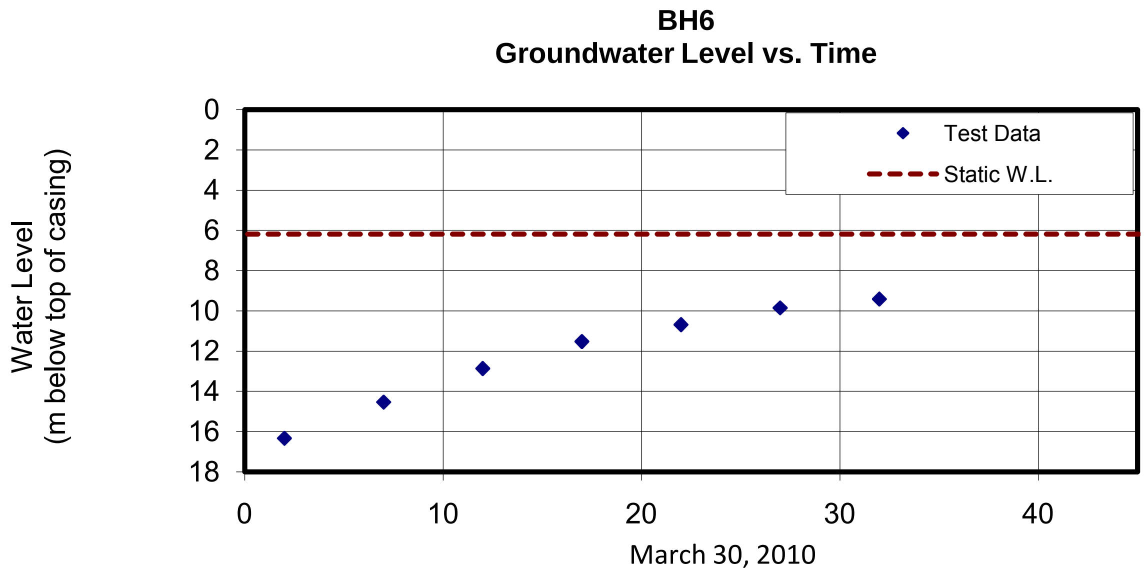
PROJECT: 09-1111-6064

Golder Associates

prepared by: MB

CHK:

In-Situ Hydraulic Conductivity Test Report Monitoring Well BH6 Tested on March 30, 2010	**Figure D-2**

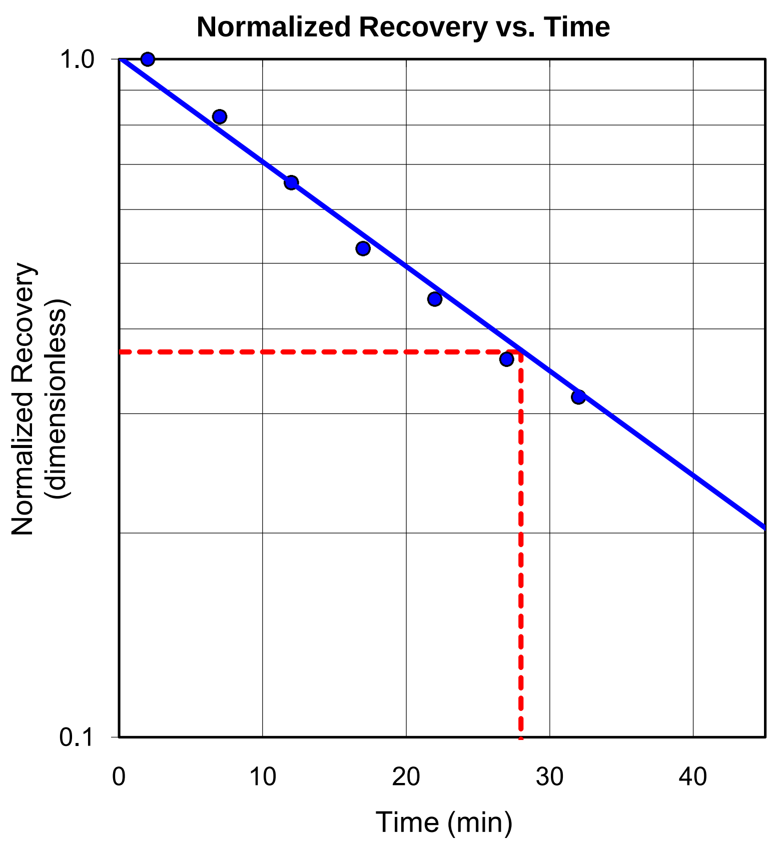


Sand Pack Interval (below ground surface)

18.0 m - 19.8 m

Well Completed in:

Clayey Silt to Silty Clay Till



Time Lag (T_0) = 28 min

Screen Length (L) = 1.5 m

Well Radius (r) = 0.0254 m

Hole Radius (R) = 0.1016 m

Hvorslev Analysis

$$K = \frac{(r^2)\ln(L/R)}{2T_0L} = \quad 3E\text{-}05 \text{ cm/s}$$

NOTES:

It should be noted that these values are lower then expected given the geological discriptions of the material encountered.

DATE: April 2010

PROJECT: 09-1111-6064

Golder Associates

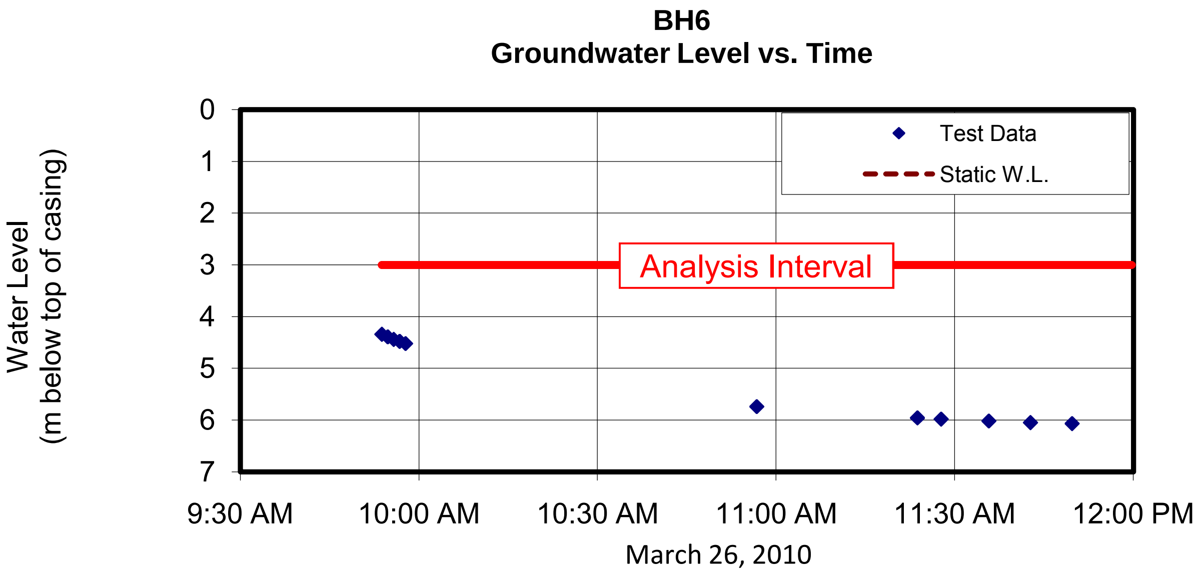
prepared by: MB

CHK:

In-Situ Hydraulic Conductivity Test Report

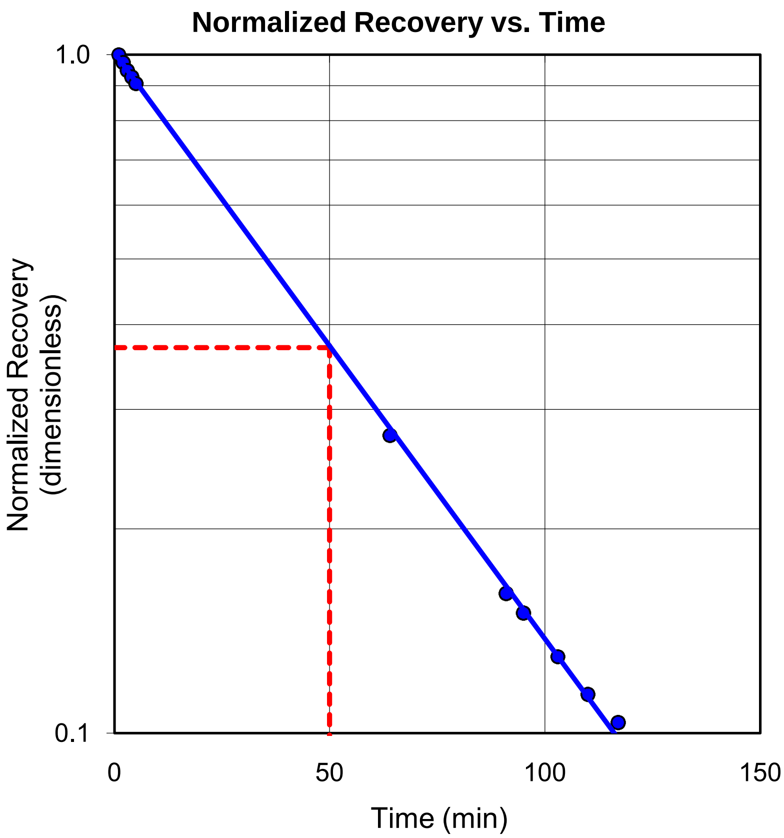
Monitoring Well BH6 Tested on March 26, 2010

Figure D-3



Sand Pack Interval (below ground surface)

18.0 m - 19.8 m



Well Completed in:

Clayey Silt to Silty Clay Till

Time Lag (T_0) = 50 min

Screen Length (L) = 1.5 m

Well Radius (r) = 0.0254 m

Hole Radius (R) = 0.1016 m

Hvorslev Analysis

$$K = \frac{(r^2)\ \ln(^L/_R)}{2T_0L} = \quad 2E\text{-}05\ \text{cm/s}$$

NOTES:

DATE: April 2010

PROJECT: 09-1111-6064

Golder Associates

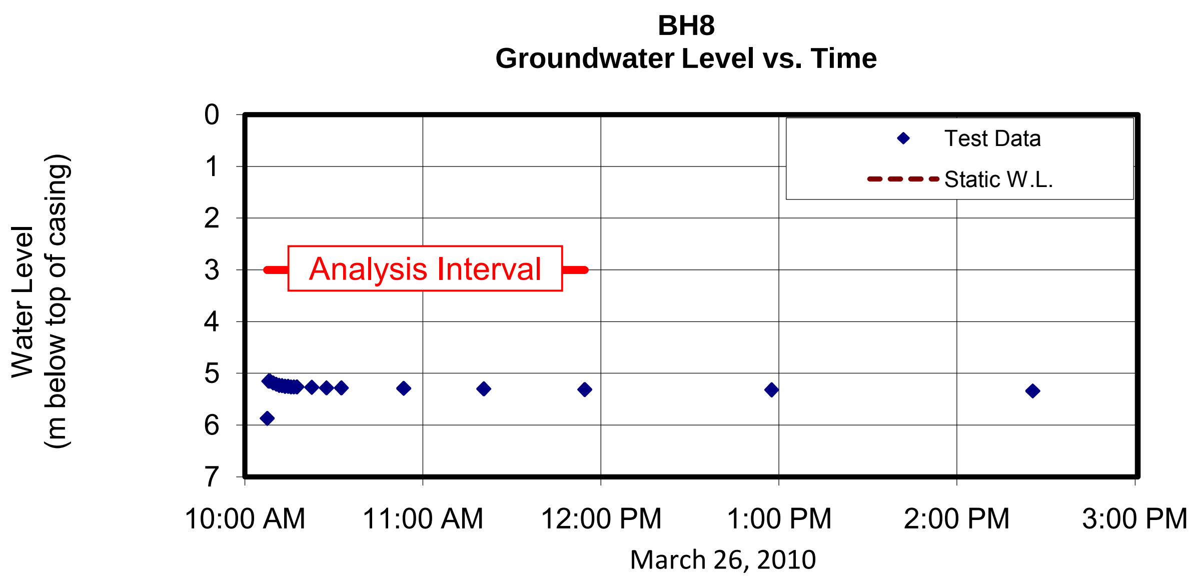
prepared by: MB

CHK:

In-Situ Hydraulic Conductivity Test Report

Monitoring Well BH8 Tested on March 26, 2010

Figure D-4

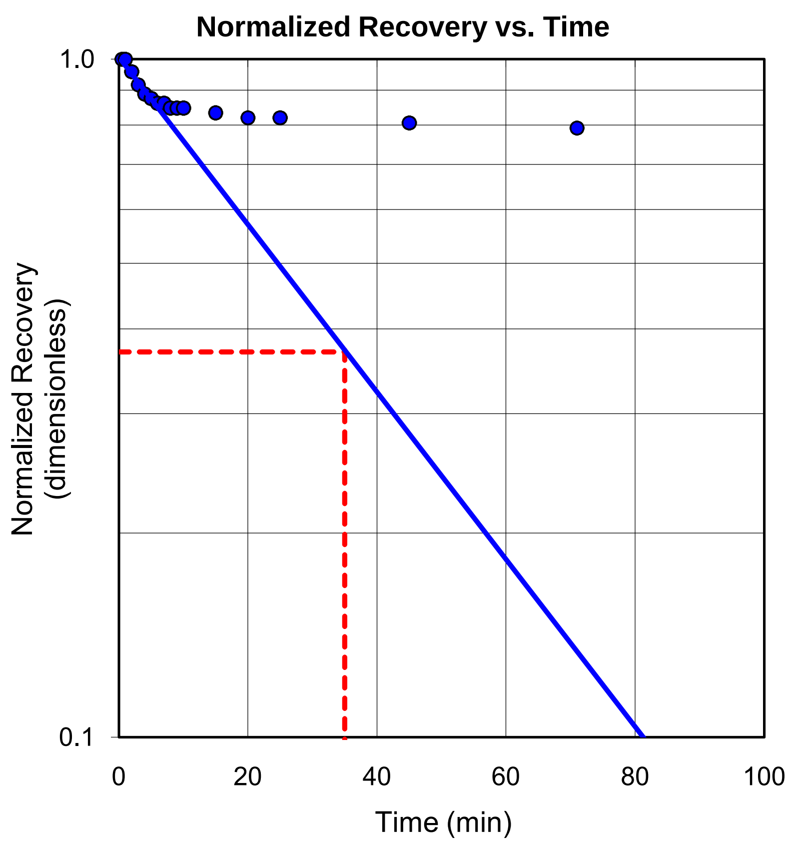


Sand Pack Interval (below ground surface)

12.6 m - 14.4 m

Well Completed in:

Sand



Time Lag (T_0) = 35 min

Screen Length (L) = 1.8 m

Well Radius (r) = 0.0254 m

Hole Radius (R) = 0.1016 m

Hvorslev Analysis

$$K = \frac{(r^2)\ln(^L/_R)}{2T_0L} = \quad 2E\text{-}05 \text{ cm/s}$$

NOTES:

It should be noted that these values are lower then expected given the geological discriptions of the material encountered.

DATE: April 2010

PROJECT: 09-1111-6064

Golder Associates

prepared by: MB

CHK:

APPENDIX E

Photo Plates

Surface Water Point W1 – Looking Northwest

Surface Water Point W1 – Looking North

PROJECT	Lloydtown – Aurora Road Pipeline Crossing
TITLE	**Surface Water Point W1**

Golder Associates	PROJECT No. 09-1111-6064		SCALE: N/A	REV. 0
	DESIGN		**Plate E-1**	
	GIS			
	CHECK	DAS		
	REVIEW			

Surface Water Point W2 – Looking Southeast

Surface Water Point W2 – Looking South

PROJECT Lloydtown – Aurora Road Pipeline Crossing

TITLE **Surface Water Point 2**

Golder Associates	PROJECT No. 09-1111-6064			SCALE: N/A	REV. 0
	DESIGN			Plate E-2	
	GIS				
	CHECK	DAS			
	REVIEW				

Surface Water Point W3 – Looking East

PROJECT	Lloydtown – Aurora Road Pipeline Crossing
TITLE	**Surface Water Point W3**

Golder Associates	PROJECT No. 09-1111-6064			SCALE: N/A	REV. 0
	DESIGN			**Plate E-3**	
	GIS				
	CHECK	DAS			
	REVIEW				

Surface Water Point W4 – Looking Southeast

PROJECT	Lloydtown – Aurora Road Pipeline Crossing
TITLE	**Surface Water Point W4**

Golder Associates	PROJECT No. 09-1111-6064			SCALE: N/A	REV. 0
	DESIGN			**Plate E-4**	
	GIS				
	CHECK	DAS			
	REVIEW				

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

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