Golder Associates

REPORT ON

108025-90.

FOUNDATION INVESTIGATION AND DESIGN
WATERMAIN CROSSING
BENEATH HIGHWAY 403 AND 407 RAMP
AT RIDGEWAY DRIVE EXTENSION/OVERPASS
MISSISSAUGA, ONTARIO

Submitted to:

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Philips Engineering Ltd. (Philips) on behalf of the Corporation of the City of Mississauga to provide geotechnical engineering services and a hydrogeological assessment for the proposed installation of a new 400 mm diameter watermain to cross beneath Highway 403 and Highway 407 ramp, approximately one kilometer west of Winston Churchill Boulevard in the City of Mississauga, Ontario. The geotechnical investigation was carried out at this site in May 2008 to obtain subsurface data pertinent to the design of the access shafts and the tunnel crossing and to facilitate approval of the crossing by the Ministry of Transportation, Ontario (MTO). Further, pavement engineering services were also requested, as outlined in Addendum No. 2, for the proposed Highway 403 shoulder strengthening required during construction of the Ridgeway Drive Extension, and will be provided under separate cover.

This report addresses the geotechnical investigation carried out for the proposed watermain crossing of Highway 403 and the Highway 407 ramp. The purpose of this report is to describe subsurface conditions anticipated along the proposed watermain alignment at the Highway 403/407 crossing, to present recommendations and comment on the geotechnical/hydrogeological aspects of the design works and to provide an interpretation of the ground behaviour in relation to anticipated tunnelling operations.

The terms of reference and scope of work for the geotechnical/hydrogeological investigations are outlined in The Corporation of the City of Mississauga's Request for Proposal (RFP) document for Procurement No. FA.49.586-07 and in Golder's Proposal No. P81-1018 dated January 10, 2008.

The factual data, interpretations and recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location or elevation, or if the project is not initiated within twelve months of the date of this report, Golder Associates Ltd. should be given an opportunity to confirm that the recommendations are still valid. The contents of this report have been based on information pertinent to the proposed watermain alignment provided to us by Philips Engineering Ltd. and have been prepared solely for use by The City of Mississauga, its consultants (Philips) retained to design the watermain crossing and government agencies from whom permitting for the crossing is required. Golder Associates Ltd. (Golder) accepts no responsibility for any reliance upon, including any decisions made on the basis of, the contents of this report by any other third party.

This report 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 DESCRIPTION

The site for the proposed watermain crossing of Highway 403/407 ramp is located between Winston Churchill Boulevard and Ninth Line, approximately one kilometer west of Winston Churchill Boulevard in Mississauga, Ontario. The proposed watermain crossing is to be constructed approximately 20 m east of the proposed Ridgeway Drive extension/overpass, as shown on Drawing 1.

In the areas of the Highway 403/407 ramp crossing, the project will consist of installing a 400 mm diameter watermain inside a steel liner by means of tunnelling/trenchless installation methods with two access shafts; one located on either side of Highway 403. Conventional open-cut excavations will be carried out beyond the proposed highway crossing. We understand that the proposed cased portion of the crossing may be up to approximately 180 m in length with a length of about 95 m constituting the actual tunnel crossing under the highway, and the invert of the watermain is to be installed at depths between approximately 4 m and 5 m below the Highway 403 road grade.

The terrain in the area of the crossing is generally flat-lying with the exception of two drainage ditches that run along the north and south sides of Highway 403 and an embankment / berm, approximately 5 m high relative to the surface of the highway, located directly south of the Highway 403 Eastbound lanes. A natural water course cuts through the relatively flat-lying field; about 100 m north of Highway 403/407 ramp and flows to the south through an existing box culvert, located about 150 m east of the proposed crossing.

Fill materials have been locally placed along the north and south sides of Highway 403 and the grade across the site varies between approximately Elevation 177 m and Elevation 183m, while the Highway 403/407 grades vary from about Elevation 179 m to Elevation 179.5 m at the proposed crossing, based on the topographic plan/profile provided by Philips.

For the purpose of this investigation, preliminary design drawings were provided to Golder by Philips on June 10, 2008, including survey information and the proposed watermain alignment and profile (revised date May 28, 2008).

2.1 Previous Investigations

Borehole information from a previous investigation carried out west of the site for the proposed extension/overpass to connect Ridgeway Drive north and south of Highway 403 was reviewed in preparation of this report. The results of this previous investigation are provided and discussed in the following report and the relevant borehole information is included in Appendix B following the text of this report:

- Golder Associates Ltd. Report No. 06-1111-021 entitled "Foundation Investigation and Design Report, Municipal Class Environmental Assessment Study, Ridgeway Drive/Highway 403 Grade Separation, Mississauga, Ontario, Procurement No: FA.49.333-05", dated July 2007;

Based on the available information from the above referenced investigation, the subsurface conditions generally consisted of fill materials underlain by a deposit of clayey silt till, underlain by a layer of clayey silt to silty clay and/or silty sand to sandy silt till, overlying shale bedrock at depths of 9 m to 12 m below ground surface (Elevation 165 m to Elevation 170 m).

3.0 INVESTIGATION PROCEDURES

A subsurface investigation was carried out at the site of the proposed watermain crossing beneath Highway 403/Highway 407 ramp between May 1 and May 5, 2008. At this time, three (3) boreholes (numbered WM1, WM2, and WM3) were advanced at the site using a track-mounted CME 55 drill rig supplied and operated by Geo-Environmental Drilling Ltd. of Milton, Ontario.

The boreholes were advanced using 108 mm inside diameter (I.D.) continuous flight hollow stem augers and 102 mm outside diameter (O.D.) solid stem augers, to depths ranging from 11.1 m to 13.9 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 in accordance with the Standard Penetration Test (SPT) procedure.

The groundwater conditions in the open boreholes were observed during the drilling operations and three monitoring wells were installed permit monitoring of the groundwater levels at the site; one drilled adjacent to WM1 screened within the silty sand/ sandy silt till deposit, one in WM3 screened within deep till deposit and one adjacent to WM3 screened in shallower clayey till deposit. The wells consist of 50 mm diameter PVC pipe with 1.5 m long screens surrounded by a sand pack, sealed with bentonite from the top of the sand pack to the ground surface. The installation details and water level readings are described on the Record of Borehole sheets that follow the text of this report. Upon completion of the drilling operations, the non-instrumented boreholes were backfilled to the ground surface using bentonite pellets, as per Ontario Regulation 372 (amendment to O.Reg. 903). Further, hydraulic conductivity testing was carried out on May 14, 2008 to measure the permeability of the existing site soils in the three recently installed monitoring wells and in three wells installed during the proposed Ridgeway Drive Extension/overpass investigation (in Boreholes BH5, BH12 and BH18, included in Appendix B).

The field work was monitored 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 boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further examination and testing. Index and classification tests consisting of water content determinations, Atterberg limits and grain size distribution were carried out on selected soil samples.

The boreholes were located in the field and measured by a member of our engineering staff relative to site features and the proposed alignment staked by Philips. As the boreholes were drilled approximately 2m to 3 m from the proposed staked alignment, the northings, eastings and elevations of the as-drilled boreholes were adjusted based on our field measurements and the available survey information provided by Philips.

The borehole locations (referenced to UTM NAD83 74, Zone 17 northing and easting coordinates) and ground surface elevations (referenced to Geodetic datum) are shown on Drawing 1 and summarized below.

Borehole Number	*Borehole Locations*	*UTM NAD83 Northing (m)*	*UTM NAD83 Easting (m)*	*Ground Surface Elevation (m)*
WM1	North Shaft	4821008.1	603454.0	177.4
WM2	Along alignment (shoulder of Highway 403 westbound lane)	4820984.1	603470.5	179.2
WM3	South Shaft	4820940.2	603516.1	183.1

4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geology

According to *The Physiography of Southern Ontario*[1], the site is located within the physiographic regions known as the Peel Plain and the Trafalgar Moraine portion of the South Slope. This area slopes gradually downward towards Lake Ontario. The overburden generally consists of silty clay till to clayey silt till with significant shale content. The till in turn overlies shale bedrock of the Queenston Formation, with interbedded grey limestone / siltstone layers.

4.2 Site Stratigraphy

Three boreholes were advanced at the site of the proposed watermain crossing at the locations shown on Drawing 1. Two boreholes were drilled north and south of Highway 403, and one borehole was drilled on the shoulder of the Highway 403 westbound lanes.

The detailed subsurface conditions encountered in the boreholes and the results of in-situ and laboratory testing are given on the Record of Borehole sheets; and the results of the laboratory tests are also presented on Figures 1 to 6. 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. The inferred soil stratigraphy based on the results of the boreholes is shown on Drawing 1.

In summary, the boreholes advanced along the proposed Highway 403/407 ramp crossing consist of fill materials underlain by deposits of clayey silt till and silty sand till. The fills were generally granular pavement materials and/or a cohesive material containing varying amounts of topsoil. The till is comprised of an upper clayey silt layer and a lower sandy silt to silty sand layer. The till is underlain in places by sand and/or clayey silt deposits.

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

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[1] Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*, Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,000.

4.2.1 Fill Materials

Borehole WM2 was advanced through the south shoulder of the westbound lanes of Highway 403. At this location, a surficial layer of sand and gravel fill was encountered at ground surface to a depth of about 0.8 m.

A clayey silt fill material was encountered in all three boreholes (WM1 to WM3) either beneath the sand and gravel fill or at ground surface north and south of Highway 403. The clayey silt fill contains some sand, trace gravel and varying amounts of organic matter including pockets of topsoil and rootlets. In the boreholes, the fill extends to depths ranging from about 1.5 m to 3.1 m, corresponding to Elevation 175.9 m to Elevation 180.1 m. It is noted that the fill generally increases in thickness from north to south at the borehole locations (from Boreholes WM1 to WM3).

Standard Penetration Tests (SPT) 'N' values measured within the clayey silt fill materials in the three boreholes, range from 3 to 14 blows per 0.3 m of penetration, and a single 'N' value of 21 blows per 0.3 m of penetration, suggesting a variable consistency ranging from soft to very stiff. The water content measured on three samples of these fill materials range from about 15 percent to 18 percent.

4.2.2 Silty Clay

Beneath the fill material at the location of Borehole WM3, a deposit of dark grey silty clay containing variable organic matter and topsoil pockets was encountered at a depth of about 3.1 m and was about 3 m thick. It should be noted that this material may be indicative of an old creek channel that used to cross through this area. Three SPT 'N' values measured within the silty clay material varied from 1 to 5 blows per 0.3 m of penetration, suggesting a very soft to firm consistency.

The result of a grain size distribution test carried out on a sample of the silty clay deposit is provided on Figure 1. An Atterberg limit test performed on the same sample measured a liquid limit of 39 percent, a plastic limit of 19 percent and a corresponding plasticity index of 20 percent, suggesting that this material is a silty clay of intermediate plasticity, as shown on Figure 2. A water content measured on a selected sample of the silty clay deposit was about 24 percent.

4.2.3 Clayey Silt with Sand (Till)

A till deposit of brown to grey clayey silt with sand was encountered below the fill materials in Boreholes WM1 and WM2 and beneath the silty clay in Borehole WM3. The top of the clayey silt till deposit was encountered between Elevation 175.9 m and Elevation 177.1 m and it varied in thickness from 3.1 m to 6.1 m.

SPT ‘N’ values measured within the clayey silt till deposit range from 16 blows to 41 blows per 0.3 m of penetration, suggesting a very stiff to hard consistency.

The results of the four grain size distribution tests carried out on selected samples of the clayey silt till deposit are provided on Figure 3. The results of four Atterberg limit tests carried out on select samples measured liquid limits ranging from 16 percent to 26 percent, plastic limits between 11 percent and 15 percent and plasticity indices ranging from 5 to 12. The results of the Atterberg limits testing suggest that this material is a clayey silt of low plasticity, as shown on Figure 4. Natural water contents measured on samples of the clayey silt till deposit varied from 7 to 14 percent.

4.2.4 Silt and Sand to Sandy Silt (Till)

A deposit of grey silt and sand to sandy silt till consisting of trace to some gravel, trace clay and shale and/or limestone fragments was encountered directly below the clayey silt till deposit in all three Boreholes. It should be noted that fragments and cobbles/boulders may be present within the till at some borehole locations.

The surface of the silt and sand to sandy silt till across the site was encountered between approximately Elevation 171.0 m and Elevation 173.1 m with a thickness, where fully penetrated, varying between about 2.5 m and 4.5 m. At the location of Borehole WM2, approximately 3.9 m of this till deposit was encountered to the termination depth of the borehole.

SPT ‘N’ values measured within the silt and sand to sandy silt till deposit varied from 50 to 67 blows per 0.15 m of penetration to 50 blows per 0.08 m of penetration, indicating a hard consistency to very dense relative density.

The results of three grain size distribution tests carried out on samples of the silt and sand to sandy silt till are shown on Figure 5. An Atterberg limit test carried out on a sample of this till measured a liquid limit of 14 percent, a plastic limit of 12 percent and a corresponding plasticity index of 2 percent; these results suggest that portions of this till deposit consist of a sandy silt of low plasticity, as shown on Figure 6. Natural water contents measured on three samples of this till were 6 percent, 7 percent and 13 percent.

4.2.5 Sand

A deposit of grey sand was present below the silt and sand to sandy silt till at a depth of 9.1 m in Borehole WM1. This sandy layer was encountered at an Elevation of about 168.3 m, and had a thickness of 1.6 m.

SPT 'N' values measured within the sand were 50 blows for 0.08 m of penetration, indicating a very dense relative density.

4.2.6 Clayey Silt

A deposit of grey clayey silt was encountered in Boreholes WM1 and WM2 advanced in the area of the north portion of the proposed alignment. This deposit was found underlying the sand deposit in Borehole WM1 and silt and sand till in Borehole WM2 at a depth of about 10.7 m below ground surface, corresponding to Elevation 166.7 m and Elevation 168.5 m, respectively. Approximately 0.5 m of clayey silt was encountered prior to termination of both boreholes. Shale and limestone rock fragments were noted within this deposit at the location of WM2.

Two SPT 'N' value recorded within the clayey silt were 32 blows per 0.3 m of penetration and 93 blows per 0.25 m of penetration, indicating a hard consistency.

4.2.7 Groundwater Conditions

The water levels were observed in the open boreholes during and after drilling and three monitoring wells were installed at the locations of Boreholes WM1 and WM3. A single well was installed adjacent to Borehole WM1, screened within the silty sand/ sandy silt till deposit and two wells were installed in the area of Borehole WM3; one screened within the deep sandy silt till deposit in WM3, and one screened in the shallower clayey till deposit adjacent to Borehole WM3. Details of the monitoring well installations are shown on the Record of Borehole Sheets following the text of this report. The water levels in the monitoring wells are summarized below:

Borehole No.	*Ground Surface Elevation (m)*	*Water Level Measurement June 4, 2008*	
		Depth (m)	*Elevation (m)*
WM1	177.4	1.5	175.9
WM3 (shallow)	183.1	7.9	175.2
WM3 (deep)	183.1	7.3	175.8

It should be noted that groundwater levels in the area are expected to fluctuate seasonally and are expected to rise during wet periods of the year.

4.3 In-situ Hydraulic Conductivity Testing

In-situ hydraulic conductivity tests (rising head tests) were carried out in the previously installed monitoring wells of Boreholes BH5, BH12, BH18 (advanced in January/February 2007 for the proposed Ridgeway Drive Extension/Overpass investigation), and at the location of Boreholes WM1 and WM3 (advanced in May 2008 for the proposed watermain crossing investigation). The results of the rising head hydraulic conductivity testing are summarised below.

Borehole No.	Well Screen Depths (m)		Material Screened In	Depth to Water Level (m)	Water Elevation (m)	Measured Hydraulic Conductivity (cm/s) (cm/sec)
	Top	Base				
BH5	9.4	13.0	Bedrock	0.6	177.8	7 x 10^{-6}
BH12	11.2	14.7	Residual Soil / Bedrock Contact	0.1 (above ground)	176.7	1 x 10^{-7}
BH18	8.6	12.1	Silty Sand to Sandy Silt Till	1.8	176.8	5 x 10^{-5}
WM1	5.6	7.6	Silt and Sand to Silty Sand till	1.5	175.9	4 x 10^{-5}
WM3	6.9	9.1	Clayey Silt Till	7.9	175.2	3 x 10^{-7}
WM3	11.2	13.9	Sandy Silt Till	7.3	175.8	2 x 10^{-6}

Based on the response to these tests, the hydraulic conductivity of the glacial till overburden and shallow bedrock deposits is considered to be relatively low (e.g., less than 5 x10^{-5} cm/s).

5.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides geotechnical and hydrogeological comments and recommendations for the proposed Highway 403/407 ramp watermain crossing east of Ridgeway Drive. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation at this site. The interpretation and recommendations provided are intended only to provide the designers with sufficient information to assess the feasible tunneling alternatives and to design the proposed watermain crossing. As such, where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

It is understood that the proposed 400 mm diameter watermain is to extend beneath the Highway 403/407 corridor by means of trenchless (tunneling) techniques; connecting the two existing service lines north of Highway 403 at Ridgeway Drive/Sladeview Crescent and south of Highway 403 at Ridgeway Drive/Angel Pass Drive. The installation of the watermain beyond the proposed highway crossing is to be installed by conventional open cut methods and will not be discussed herein.

Based on available drawings and discussions with Philips, the proposed highway tunnel crossing is approximately 95 m, and an overall length of approximately 180 m is to be installed inside a steel liner; although the size diameter of the liner has not been proposed at this time and may vary depending on the preferred method of installation. The invert of the proposed tunnel casing will range in depth from approximately 4.5 m to 5.5 m below the existing ground surface, equivalent to about Elevation 173.8 m. The actual location of the two access shafts are not known at this time; but are expected to be located with one on each side of Highway 403, in the area of Boreholes WM1 and WM3.

The following sections provide recommendations/comments related to the geotechnical and hydrogeological aspects of the watermain design for the Highway 403/407 crossing.

5.2 Temporary Works

This section provides a discussion of and parameters for conceptual design of temporary ground support systems that will be required for the access shafts to the watermain tunnel. It is assumed that the contractor will be responsible for the detailed design of any temporary support systems, if required.

5.2.1 Excavation Support

It is not known at this time whether the entry and exit shafts will be constructed vertically or will be conventional open cuts with sloping banks.

Care should be taken to direct surface water away from the open excavations and all temporary excavations should be carried out in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects. For excavations at this site, the cohesive fill materials would be classified as a "Type 3" soil under the Act, the native silty clay encountered on the south side of Highway 403 would be classified as a "Type 4" soil and the native clayey silt till to sandy silt till deposits would be classified as a "Type 2" soil. Temporary excavations through the "Type 2" and "Type 3" soils may be made with side slopes no steeper than 1H: 1V, as measured from the bottom of the excavation. Temporary excavations through the "Type 4" soils may be made with side slopes no steeper than 3H: 1V.

Temporary excavation support/shoring will be required in areas where sufficient space is not available to carry out the excavation using these side slopes and in areas where settlement/deformation sensitive structures and/or existing utilities are present adjacent to the excavation.

Where shafts will be vertical and constructed by sheeted and braced excavations, the temporary support systems for the excavation, including the headwalls for the tunnel entry and exit shaft, should be designed to resist the earth and surcharge load distribution presented on Figure 7, and the design parameters provided below may be used for conceptual design. The loading from existing adjacent structures and/or construction equipment should be included as a surcharge.

Material	Elevation Range (m)	γ (kN/m^3)	K_A	γ_w	h_w
Fill	175.9 to 183.1	19	0.35	9.81 kN/m^3	From Elev. 177.5 m
Very Soft to Firm Silty Clay (WM3)	177 to 180.1	18	0.4		
Very Stiff to Hard Clayey Silt Till	171 to 177.1	20	0.3		
Very Dense Silt and Sand to Sandy Silt Till	Below 173.1	22	0.25		

* The subsurface conditions will vary in layer thickness and elevation at each shaft and should be reviewed separately for the design of the temporary shoring system.

The distribution shown on Figure 7 should be applied to the design of the vertical support members, as well as for the calculation of horizontal restraint loads. The design must also include water pressure assuming groundwater levels.

Although the locations of the shafts are not known at this time, they are anticipated to remain inside of MTO property; therefore, if temporary excavation support is required at this site within the MTO road allowance, it should be designed and constructed in accordance with MTO's Special Provision 105S19, such that lateral movement of the temporary shoring system meet Performance Level 2, as specified.

5.2.2 Thrust Block Resistance

It is anticipated that the entry shaft for tunnelling beneath Highway 403/407 ramp will be located such that tunnelling proceeds "up-gradient" allowing any seepage water to flow by gravity back to the entry shaft. It is also anticipated that thrust blocks constructed at the rear of the entry shaft will bear against the clayey silt till to silt and sand till.

The thrust block may be sized in accordance with the passive resistance pressure calculated from the following equation:

$$P_p = K_p \sigma_z'$$

where P_p is the passive pressure (kPa)
K_p Coefficient of passive pressure, which can be assumed to be 3.25
σ_z' Effective Stress at the depth of the thrust block (kPa)

The passive earth pressure derived using the above equation is an ultimate value and should be reduced by a Factor of Safety of 2 for calculation of allowable jacking stresses.

5.2.3 Shaft Preparation and Groundwater Control

Depending on the size of liner casing and the proposed tunnelling methodology, the entry and exit shafts are anticipated to be located below the groundwater table and will be generally within the very stiff to hard clayey silt till. Assuming a tunnel invert of about Elevation 173.8 m, the base of the shaft will potentially extend into the upper portion of the very dense silt and sand to sandy silt till and there may be lenses or layers of saturated cohesionless soil encountered in the excavation. Therefore, base treatment measures will be required in the shafts to provide a stable working base for the tunnelling operations. A levelling and drainage mat of compacted granular material should be placed at the base and covered with a working mat of lean mix concrete. Pumping of groundwater from the shafts will be required to relieve pressure from under the working slab and to remove groundwater that seeps from cohesionless soil lenses. Removal of such groundwater can be carried out with several pumps installed in properly filtered sumps that extend below the working slab and intersect the drainage layer below the slab.

If thick interlayers or lenses of cohesionless deposits are encountered at and/or below the base of the excavation, then supplementary groundwater lowering by dewatering wells or a temporary shoring system that would provide cut-off to groundwater flow will be necessary to maintain stability of the excavation base. The proximity of adjacent services or structures and their tolerance for settlement must be assessed and confirmed that they can tolerate some movement as a consequence of the excavation and potential dewatering.

Based on the subsurface information at the borehole locations and the preliminary alignment, the underlying cohesionless tills deposits are anticipated to be approximately 0.7 m to 1.0 m below the proposed tunnel invert. Depending on the final shaft invert level, this condition may result in basal uplift for the north shaft. Once the final design is completed, the stability of the shaft bases against basal uplift should be reviewed and if an adequate factor of safety does not exist, dewatering of the underlying water-bearing deposits will be required.

5.2.4 Potential Dewatering Requirements

Based on the measured hydraulic conductivity test results, the permeability of the till and bedrock deposits is considered to be relatively low (less than 5 x10^{-5} cm/s). As such, it is anticipated that if dewatering is required to maintain dry conditions within the access shafts, the quantity will likely be less than 50 m^3/day

The area around the access shafts should be graded to promote surface water drainage away; consideration could also be given to elevating the access shafts with respect to the surrounding terrain to eliminate the potential for entry of overland drainage.

To develop a preliminary indication of potential groundwater quality issues in the vicinity of the proposed construction site, a field filtered groundwater sample was collected from WM1 and submitted to Maxxam Analytics Inc. (an independent CAEAL accredited laboratory) in Mississauga, Ontario for general chemistry analyses. The results of the general chemistry analysis, as provided in Appendix D, show no indication of groundwater contamination near WM1. The concentration of groundwater constituents at WM1 is reasonably consistent with groundwater quality of Southern Ontario shallow overburden aquifers.

During construction, pumped groundwater from the shafts must be disposed of in an acceptable manner. Considering the low pumping rate anticipated from the construction area, containment of the pumped groundwater in a storage tank and subsequent disposal at a licensed facility may be the most cost effective approach. Other alternatives include diversion to the municipal sewer system or local water courses (under a Section 53 Certificate of Approval). It is to be noted that additional groundwater quality analysis would be required to support any application for the municipal sewer use permit or groundwater discharge to local surface water courses.

As discussed, grouting of the annular space around the casing will minimize groundwater seepage along the main. As such, the watermain is not anticipated to have any significant long-term impact on local groundwater flow.

6.0 GROUND BEHAVIOUR IN RELATION TO TUNNELLING

It is understood that the tunnelling contractor will be responsible for choosing the method and equipment for tunnelling. The preferred alternative should be chosen to ensure that ground movements as monitored at the ground surface do not exceed 15 mm. The description of the anticipated ground behaviour provided in this section only applies to anticipated construction methods described herein and in the previous section. Ground behaviour will vary if methods different from those considered in the report are adopted. It should not be construed that the Contractor is restricted to the particular methods considered herein, although in the event of alternative methods, the Contractor must make his own interpretation of the anticipated ground behaviour, based on the factual information provided herein.

Descriptions of anticipated soil behaviour such as "firm" ground are based on Terzaghi's[2] classifications of soils for tunnelling as referenced below.

6.1 Highway 403/407 Ramp Tunnel Crossing

The proposed watermain invert is expected to be at approximate Elevation 173.8 m that is approximately 5.5 m below the centreline of Highway 403, resulting in a minimum of about 4.8 m of cover material above the casing/liner obvert. The entry and exit shaft locations are not known at this time but are expected to be located on each side of Highway 403 in the general area of Boreholes WM1 and WM3. The subsurface soil conditions in these boreholes (at the approximate location of the shafts on the north and south side of Highway 403), generally consist of surficial fill materials which are underlain by very stiff to hard clayey silt till, underlain by very dense silt and sand to sandy silt till. At the location of Borehole WM1, a deposit of very soft to firm silty clay containing variable amounts of organic matter was encountered, considered to be natural infilling of an old creek bed. Although it is anticipated that the proposed tunnel alignment will extend through the clayey silt till, above the silt and sand to sandy silt till interface, the presence of layers/lenses of silty sand may be expected within the clayey till near the surface of the silt and sand to sandy silt till and therefore, groundwater seepage may occur due to the presence of thin seams of water-bearing cohesionless soils. The relatively shallow groundwater levels within these deposits is above the proposed tunnel obvert, and therefore, these layers and seams would potentially flow into unsupported tunnel headings, causing localized ground loss at and above the tunnel heading. The following information is provided regarding the geotechnical aspects of the design of the tunnelling operations.

- Excavation progress and selection of excavation equipment must take due account of the hard nature of the clayey silt till deposit.

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[2] Terzaghi, K. "Geologic Aspects of Soft Ground Tunnelling", Chapter 2 of Applied Sedimentation, P.D. Trask ed; John Wiley & Sons, New York, 1950.

- Although not encountered in the boreholes drilled on the proposed tunnel alignment, cobbles and boulders are generally present within till deposits and provisions must be made in the proposed tunnelling method for handling cobbles and boulders without loss of ground.

- An unsupported tunnel in the clayey silt till deposit is expected to behave as firm to bouldery ground if exposed as an open face. However, relatively thin water-bearing seams and interlayers of cohesionless silty sand may be present within the clayey silt till, particularly near the interface with the underlying silt and sand to sandy silt till. Such lenses are expected to be initially stable due to dilation in response to stress relief upon initial exposure. However, if left unsupported, the material will behave as slow ravelling ground. Therefore, while it is considered feasible to advance a tunnel with an unsupported face through these ground conditions anticipated along the alignment, contingency measures for controlling water-bearing seams and lenses must be incorporated into the tunnelling methodology.

- To maintain face stability and minimize ground movements it is recommended that mining operations continue non-stop once started. If it is necessary to stop tunnelling operations for any reason, the face should be completely supported by breasting boards. Such face support should be pre-cut and assembled prior to the start of tunnelling so that it can be readily installed, if required. Further, filter fabric, straw and other packing materials should be available on site for use in containing any localized occurrences of ravelling or flowing ground.

- If the tunnel alignment is to extend through the underlying silt and sand to sandy silt till deposit, greater amounts of water seepage may occur. Tunnelling methods that utilize a closed-face (pressurized face), such as micro-tunnelling slurry pressure balance shields or air-pressure shields, will control the surrounding groundwater pressures and therefore, minimize the risk of ground losses occurring.

- Whatever tunnelling method is selected, it is emphasized that the resulting performance of the completed tunnel crossing is largely dependant upon construction procedures and techniques. The work should be carried out by a qualified contractor experienced in this type of work. The contractor's proposed methodology should be reviewed by the geotechnical engineer prior to construction. During construction, the tunnelling operations should be monitored by the geotechnical engineer.

6.2 Tunnelling Options

It is understood that the proposed watermain is to be installed beneath Highway 403/407 ramp by trenchless technology. Trenchless technology covers a wide range of methods, such as “jack and mine”, “jack and bore”, “microtunneling” and “pipe ramming” techniques. With any of these options, the equipment must be able to handle the presence of water-bearing sand layers and the removal and/or breaking of boulders, if encountered during tunnelling, such that the stability of the tunnel face is maintained and tunnelling advance can be assumed. Based on drawings provided to us by Philips, it is intended that the tunnel will be constructed with a liner, and the watermain will be installed in the liner and then surrounded by grout. It is understood that the steel liner is a protection requirement for watermains installed below highways.

Given the requirement for a permanent (steel) liner to surround the watermain, it is anticipated that "pipe" jacking operations will be utilized to install the casing behind soil mining operations at the tunnel face. It is anticipated that the casing/liner will be installed and advanced in sections with the segment connections designed to provide a smooth flush exterior to minimize resistance along the pipe exterior and facilitate jacking. Given the proposed length of the tunnel crossing (i.e. approximately 95 m), the use of a bentonite slurry for lubrication and/or an intermediate jacking station may need to be considered during installation of the casing/liner.

While the use of a conventional steel ribs and lagging primary lining is feasible at the site, it would not provide satisfactory permanent protection to the watermain and a (steel) liner would therefore be required to be placed inside the ribs and lagging. This lining process would increase the required tunnel diameter and increase tunnelling costs, and for these reasons, it is not considered further in this report.

For this reason, methods that do not permit installation of a (steel) liner prior to installation of the pipe, such as Horizontal Directional Drilling, are not considered feasible and will not be discussed herein.

A discussion of the various tunnelling methods are outlined below and a summary comparison of the advantages, disadvantages and risks associated with these installation methods, is presented in Table 1 following the text of this report. Some of the options discussed below are dependent on the proposed diameter of the tunnel and may not be considered feasible once this casing/liner size is confirmed.

6.2.1 Jack and Mine

As noted, the clayey silt till is anticipated to behave as firm to bouldery ground if exposed in an open tunnel face. Thus, it is considered feasible to advance the tunnel using an open face shield in which material at the face is excavated by "hand" or with a hydraulic excavator arm (digger shield). Such an open shield should have the capability of being jacked independently ahead of the steel liner to provide alignment control. The shield should be equipped with a suitable tail skin to support the ground above the jacks.

The principal risk associated with this method is from encountering thick cohesionless water-bearing interlayers and/or the interface of the underlying sandy till in areas between the locations where boreholes were advanced. To control this risk, consideration should be given to specifying a "hooded" shield for hand-mining (or "digger" shield) operation, as this would allow the tunnel face to be maintained at an angle for face stability as the tunnel heading is advanced. A pre-fabricated bulkhead that could be readily erected at the face of the shield should also be specified to be on site throughout tunnel construction to allow the face to be rapidly secured, in the event that unstable cohesionless soils are encountered at the tunnel face.

Hand-mining and "digger" shield mining may both be carried out ahead of a temporary lining that is jacked into place. The length of the proposed tunnel crossing is significant for jacking from a single jacking station and the contractor should consider the use of an intermediate jacking station(s) part way along the pipe alignment. Alternatively, consideration could be given to the use of a temporary tunnel lining of steel ribs and timber lagging that would be erected within the tunnel shield and expanded to contact the ground after the shield is jacked forward.

6.2.2 Jack and Bore

The pipe that will form the watermain cannot be installed as a jacked-in-place tunnel liner; therefore, a larger diameter temporary liner would need to be constructed prior to placement of the carrier pipe. The implementation of jack and bore installation is dependent on the diameter of the casing/liner. Although this diameter has not been confirmed, for a larger diameter tunnel at this site, some disadvantages associated with this methodology include:

- The consistency of the clayey silt till is generally very stiff to hard and it may be difficult to jack the pipe and advance the auger through the hard portions of the deposit;
- To control jacking forces, the use of a lubricating bentonite grout injected around the exterior of the casing/liner may be required;
- The clayey silt till deposit (particularly near the silty sand/sandy silt till) is expected to contain cobbles and boulders which will both obstruct progress of the auger and lining and tend to deflect the liner off alignment; and
- If the operation is deflected off alignment, it is difficult to detect the misdirection and it is not possible to correct the alignment.

If jacking and boring is used for the watermain crossing then it should be specified that the casing always be advanced as far ahead of the augers as possible, that the auger be maintained at least 150 mm behind the leading edge of the casing and that under no circumstances should the auger be advanced ahead of the casing. Furthermore, if jacking and boring were to be carried out, the specifications should require that a plug of spoil material remains in the casing at all times and that the jacking and boring operations continue without stoppage until completed. However, it must be noted that in the event that an obstruction such as a boulder or nest of cobbles is encountered, it will be necessary to remove the augers and the soil plug and if a cohesionless water-bearing interlayer is present at the same location, uncontrolled ground loss could occur during the removal operation.

6.2.3 Micro-Tunnel Boring Machine (MTBM)

It is considered that the risk of ground loss during tunnelling through potential cohesionless and/or wet layers and lenses would be reduced if tunnelling were carried out using a micro-tunnel boring machine (MTBM). These machines typically utilize pressurized bentonite slurry to counterbalance the earth and water pressures acting at the tunnel face. The slurry is circulated back through the tunnel to transport cuttings to a settling tank. Given the presence of cobbles and potentially boulders in the till soils along the proposed tunnel alignment, an MTBM capable of crushing boulders would be required for the work. Consistent with other tunnelling methods, if a micro tunnel boring machine were to be used for this project, consideration would have to be given to the use of an intermediate jacking station(s) to ensure that the casing/liner pipe could be advanced over the full length of the tunnel drive.

6.2.4 Pipe Ramming

Pipe ramming is a method for installing steel casings utilizing the energy from a percussion hammer attached to the end of the pipe. The casing is generally advanced open-ended and the soil within the casing is typically removed (with an auger) after the casing has been driven the entire length of the installation, thereby reducing the potential for ground loss into the casing. Pipe ramming methods are also better suited for penetrating through potential obstructions such as cobbles and boulders; however, deflection and/or refusal to penetration of the casing can still occur if large obstructions are encountered. Further, vibrations from the pipe ramming operations may result in settlement of loose materials in the immediate vicinity of the installation. Lubrication (i.e. bentonite) at the face may be required to aid in reducing side friction and advancing the steel pipe. Furthermore, a “plug” of soil may form at the head of the casing inducing surficial heave as the pipe is advanced. This could be controlled by stopping the operation and removing spoil from within the pipe before advancing further. Also, from the current borehole information, the proposed tunnel alignment would extend through the clayey silt till that generally increases in consistency from very stiff to hard with depth, and therefore, it may be difficult to advance the casing/liner through the harder portions of the till resulting in refusal or deviation. Given the concerns with handling boulders, the risk of significant alignment deviation, the inability to adjust the alignment and the significant tunnel length during ramming operations, pipe ramming is not recommended for this crossing.

6.3 Settlement and Settlement Control

The measures described in the preceding sections for the various tunneling methods must be implemented to control settlement above the tunnel; however, the effects of stress relief at the tunnel face and partial closure of the over-cut between the shield and pipe will result in some settlement of the ground above the tunnel. It is anticipated that ground surface settlement can be restricted to 15 mm or less, if:

- measures to control face stability are implemented;
- the over-cut between the tunnelling shield and the liner casing is 12 mm or less;
- suitable lubricant is applied directly behind the shield to minimize friction between the casing and the ground; and
- the gap created between the soil and the pipe is grouted with cement grout at the completion of jacking.

To achieve appropriate grouting, it is recommended that grout ports around the circumference of the pipe be not further than 2 m apart.

To verify that tunnelling movements are maintained within specified levels, to verify the suitability of the Contractor's tunnelling methods and to provide an early warning that will allow tunnelling methods to be modified to meet the specified settlement limits, it is essential that a monitoring program as described in Section 8.0 be implemented during tunnelling.

6.4 Jacking Resistance

In addition to the subsurface conditions and pipe geometry, the jacking forces required to advance the casing are dependent upon a number of factors directly related to construction equipment and methodology, including:

- the size of the shield over-cut;
- the use of lubricants and the timing of lubricant injection;
- the alignment maintained during jacking;

- the rate of mining achieved; and
- the frequency and duration of stoppages in the work.

For these reasons and considering the natural variability of the ground, it is not possible to predict actual jacking forces prior to construction. In comparison to the unit jacking resistance on the surface area of the casing, higher face resistance will be met where boulders are encountered.

Given the uncertainties in predicting jacking forces and the limitations on jacking forces imposed by the pipe strength, it is recommended that an assessment is made to determine if intermediate jacking stations are required along the pipe length. Jacking forces should be monitored throughout the tunnelling operation to ensure that allowable pipe stresses are not exceeded and to determine if jacking from the intermediate jacking stations is necessary.

6.4.1 Obstructions

Boulders are commonly encountered in the overburden soils/tills of Southern Ontario. The specific presence of boulders can significantly affect the selection of equipment and progress of construction works, especially in tunneling. The soils at the site are glacially derived, and thus, are anticipated to contain boulders (rock of such a size that it is unable to pass through a 0.3 m square opening); sizes much larger than this should be anticipated at this site. Further, boulders within the till deposits can originate from the igneous and metamorphic rocks of the Canadian Shield and, these can have uniaxial compressive strengths of up to 250 MPa. Therefore, suitable equipment will be required to remove any boulders encountered during tunnelling; either the tunnelling equipment itself or methodology to allow careful excavation at the face.

7.0 INSPECTION, INSTRUMENTATION AND MONITORING

Regardless of the tunnelling method selected, it is recommended that a monitoring program be implemented during the construction operation. An inspection, instrumentation and monitoring program is necessary on this project to:

- document the effects of tunnelling 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 settlement limits imposed in the Contract; and,
- allow adjustments to be made to the tunnelling methods such that the settlement limits established are not exceeded.

Control of ground settlement on this project depends on the behaviour of the ground at the tunnel face and on the control exercised by the contractor during excavation work at the tunnel face. Therefore, if the method and tunnel size permit, it is recommended that inspection of the tunnel face by a qualified geotechnical engineering personnel be carried out at least once per shift to verify that the ground conditions are consistent with those anticipated based on the borehole investigations and that the contractor is excavating the material at the face in a controlled manner.

It is recommended that the monitoring program include measures to track the quantity of material excavated from the tunnel and measure the amount of settlement resulting from the tunnelling operation. The amount of material excavated from the tunnelling operation should be recorded in terms of estimated volume of excavated material (for example number of muck cars/buckets) per convenient unit of advance (length of liner pipe or distance of each shield push). The volume of material per unit advance should be compared to the calculated volume of excavated tunnel length (i.e. establish a theoretical relationship between the spoil volume and insitu volume). A change in the excavated volume over a particular tunnel increment could indicate that uncontrolled ground losses are occurring into the tunnel.

Recommendations for the proposed monitoring program for the Highway 403/407 ramp tunnel crossing, consistent with the MTO "Guideline Foundation Engineering – Tunneling Specialty for Corridor Encroachment Permit Application; Appendix: Settlement Monitoring Guidelines - Tunnelling", for the monitoring program are summarized below.

- A series of "surface" monitoring points and "in ground" monitoring points (at depths of 1.5 m to 1.8 m below the surface grade) should be installed along the tunnel alignment.

- "Surface" monitoring points should be regularly spaced, on the asphalt pavement and along side slopes of the highway embankment, over the centre-line of the tunnel. The maximum spacing of such points should be 5 m.

- The monitoring program should include an "array" of "in ground" monitoring points installed roughly perpendicular to the tunnel alignment to measure the lateral extent of any settlement. The arrays of "in ground" monitoring points should extend on both sides of the tunnel alignment at a distance of one horizontal to one vertical from the centre of the tunnel invert. The "in ground" monitoring points should be installed at the outside edges of the Highway and in the median.

- 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 2 times per day during tunnelling operations, with allowance made for more frequent monitoring (up to every 4 hours) should observations dictate. For monitoring points that have stable readings and are located more than 10 m away from the active tunnel face, the monitoring frequency may be reduced to once per day.

Monitoring of settlement points on this project is constrained by the continuous and high traffic volume and the limited periods during which access to the Highways can be obtained. By necessity, settlement points on the road must be read remotely and the use of EDM equipment reading reflectors installed on the Highway is suggested. Positioning of the equipment to read the instruments at this site is constrained by the elevated pavement surface relative to the surrounding ground. If survey measurements cannot be adequately made from the sides of Highway 403/407 ramp, an elevated platform may need to be constructed to allow the reflective targets to be read. It is assumed that a specialist surveying firm will be retained to confirm the setup and to carry out the settlement 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, as stated in MTO's "Guideline for Foundation Engineering – Tunnelling Specialty for Corridor Encroachment Permit Application; Appendix: Settlement Monitoring Guidelines - Tunnelling", for the monitoring program are summarized below.:

- If the Review Level (10 mm) 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 (15 mm) is reached, the contractor shall stop tunnel advance and the owner would have the authority to order that the contractor make the face secure and suspend all tunnelling activities.

7.1 Inspection and Testing

Consideration should be given to carrying out a "public digging" during the tender stage to allow prospective bidders to assess their methods of construction and type of groundwater control, consistent with their equipment capabilities and the existing groundwater conditions at that time. The location of the test pits should be determined in consultation with the geotechnical engineer.

Prior to tendering, the geotechnical aspects of the final design drawings and specifications should be reviewed by the geotechnical engineer to confirm that the intent of this report has been met. During construction, sufficient tunnel monitoring and inspection at the face should be carried out to confirm that the conditions exposed are consistent with those encountered in the boreholes and to monitor conformance to the pertinent project specifications. Monitoring of the tunnel operation should, as a minimum, include measurement of the volume of tunnel muck as noted above, the jacking forces required to advance the pipe/lining and in the case of use of a MTBM, the slurry pressure at the face of the machine.

8.0 CLOSURE

The Geotechnical Investigation Report was prepared by Ms. Shannon Palmer, P.Eng. and was reviewed by Ms. Anne Poschmann, P.Eng., a Principal and geotechnical engineer with Golder. Mr. Jorge Costa, P.Eng., a Designated MTO Foundations Contact for Golder, conducted a quality control review of this report.

GOLDER ASSOCIATES LTD.

17/03/09
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SLP/ASP/JMAC/SD/slp/sm

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TABLE 1
EVALUATION OF ALTERNATIVE TUNNELLING METHODS
WATERMAIN CROSSING OF HIGHWAY 403/407
AT RIDGEWAY DRIVE EXTENSION/OVERPASS
MISSISSAUGA, ONTARIO

Installation Method	*Feasibility*	*Advantages*	*Disadvantages*	*Risk/Consequences*
Jack and Mine (Hydraulic excavator arm or hand-mining)	Feasible	• Ability to adjust alignment • Easy access to remove obstructions. • Provides access for break-up and handling boulders. • Hooded shield would allow inclined face to be maintained.	• Difficulty controlling cohesionless water-bearing interlayers (would require supplementary support measures) • May require an intermediate jacking station to fully advance the steel casing or the use of temporary ribs and lagging tunnel lining.	• Localized ground loss if water-bearing cohesionless layers encountered.
Jack and Bore Installation	Feasible	• Does not require personnel at tunnel face.	• Large diameter steel liner will be difficult to install through till. • Obstructions (e.g. cobbles, boulders) may deflect and/or halt bore. Removal of augers and man entry would be required to remove boulders. • Misalignment cannot be detected or corrected during advance. • Water-bearing cohesionless interlayers can go undetected until ground loss and settlement has occurred. • Hard clayey silt till and/or dense to very dense sandy silt till will make augering difficult.	• Risk of encountering refusal on obstructions. • Obstructions can result in deflection of the casing resulting in misalignment of watermain. • Greatest risk of ground subsidence of highway because unstable cohesionless water-bearing interlayers could go undetected.

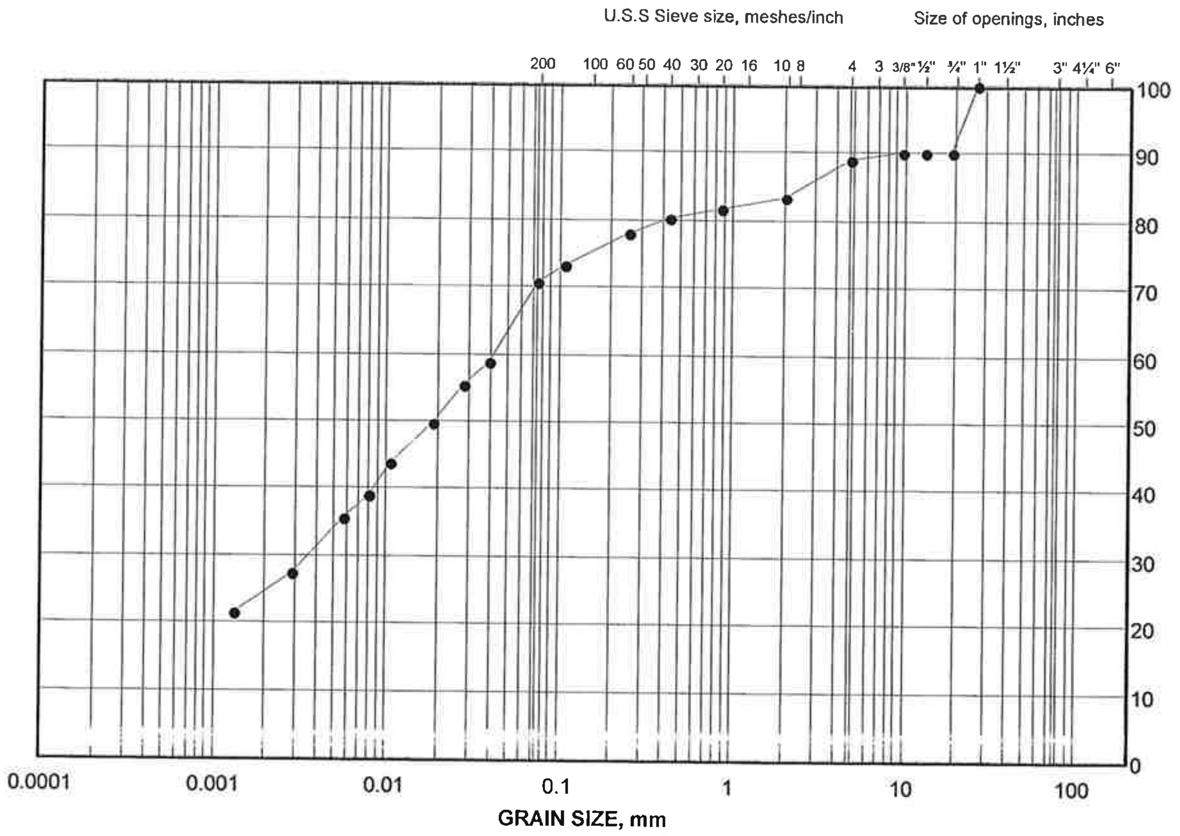
TABLE 1
EVALUATION OF ALTERNATIVE TUNNELLING METHODS WATERMAIN CROSSING OF HIGHWAY 403/407 AT RIDGEWAY DRIVE EXTENSION/OVERPASS MISSISSAUGA, ONTARIO

Installation Method	*Feasibility*	*Advantages*	*Disadvantages*	*Risk/Consequences*
Micro-tunnel Boring Machine	Feasible	• Counter-balance groundwater and earth pressures with tunnel muck or slurry providing face support when advancing through cohesionless water-bearing interlayers. • Does not require man entry.	• May require an intermediate jacking station to fully advance the steel casing. • Will require a machine capable of crushing boulders • Greater cost for muck handling and disposal. • Lack of local experience and/or equipment.	• Machine could be halted by boulders if appropriate crushers are not provided. • May not receive competitive tenders if this method is specified.
Pipe Ramming	Not Feasible	• Suitable to penetrate through obstructions (dependent on size and strength of obstruction). • Continuous casing installation. • Spoil is removed once the exit pit is reached, minimizing subsidence and overcut.	• Large obstructions/boulders can result in deflection or refusal. • Potential for heave at ground surface. • Potential for settlement of near surface fills due to vibration. • Removal of spoil may be required after advancing the pipe partway due to the weight of and drag on the pipe. • Hard clayey silt till and/or dense to very dense sandy silt till will make ramming difficult and subsequent augering of spoil from inside the pipe.	• Misalignment of tunnel may occur if large obstructions are encountered and this cannot be corrected. • Nests of cobbles and/or boulders can stop penetration of casing requiring hand mining. • Vibration from pipe ramming may be experienced by the users of the highway. • Significant jacking/ramming forces would be required due to the hard/dense nature of the overburden and the proposed length of the pipe.
Horizontal Directional Drilling	N/A	• N/A	• Not capable of installing a steel liner to isolate the watermain below the highway • Pipe material would have to consist of HDPE.	• N/A

GRAIN SIZE DISTRIBUTION

Silty Clay

FIGURE 1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM3	6	179.0

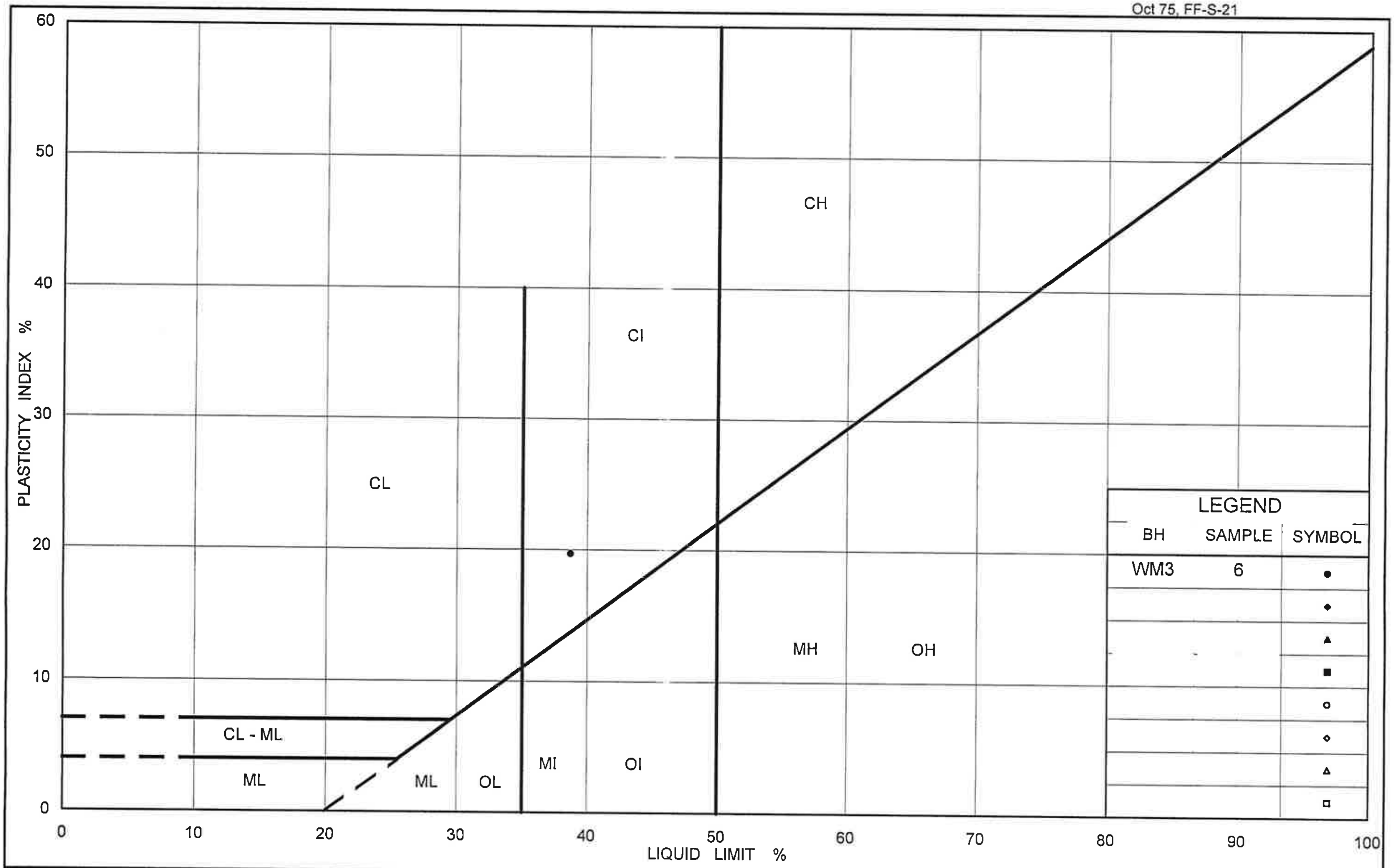
Project Number: 08-1111-0014

Checked By:

Golder Associates

Date: 03-Jul-08

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Silty Clay

Figure No. 2

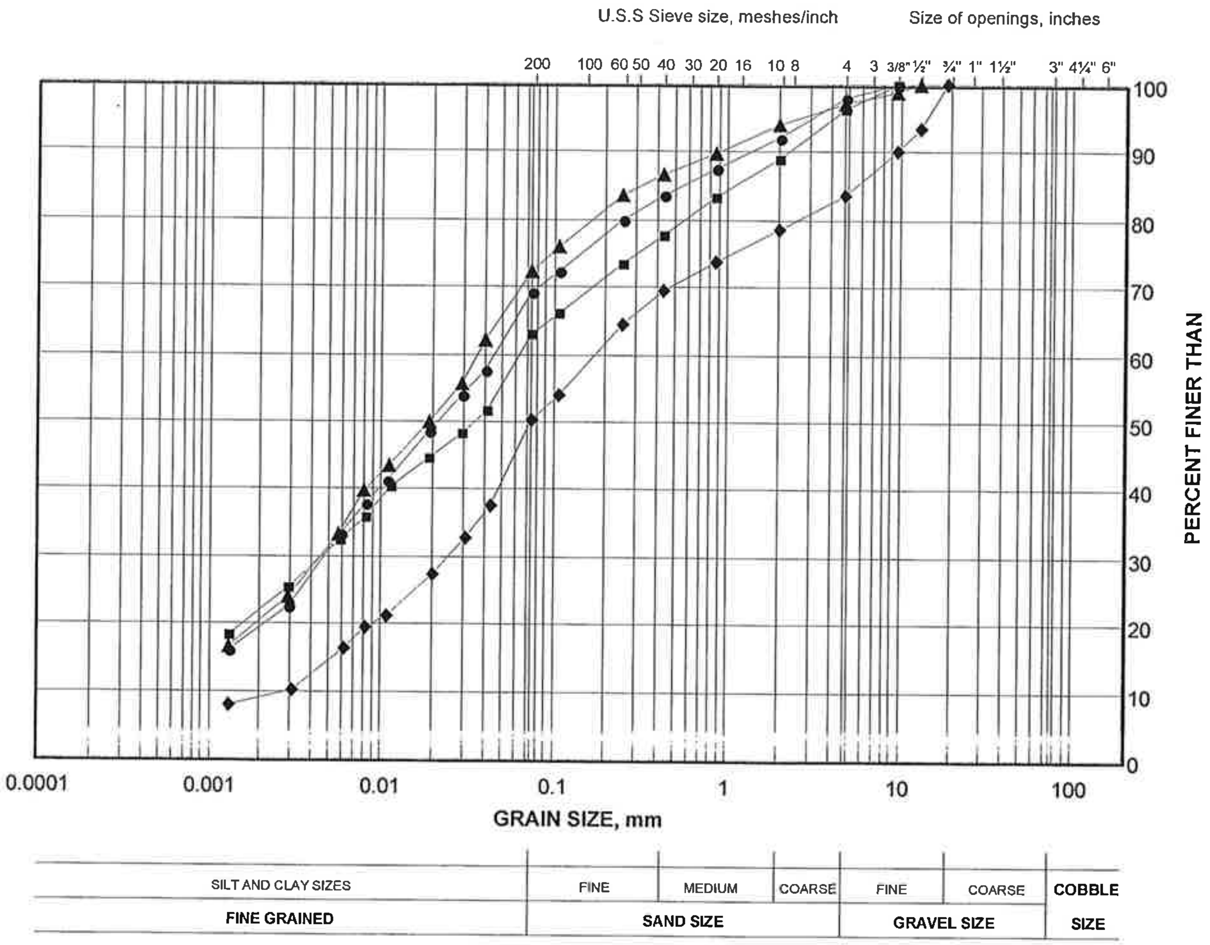
Project No. 08-1111-0014

Checked By:

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Till)

FIGURE 3



LEGEND

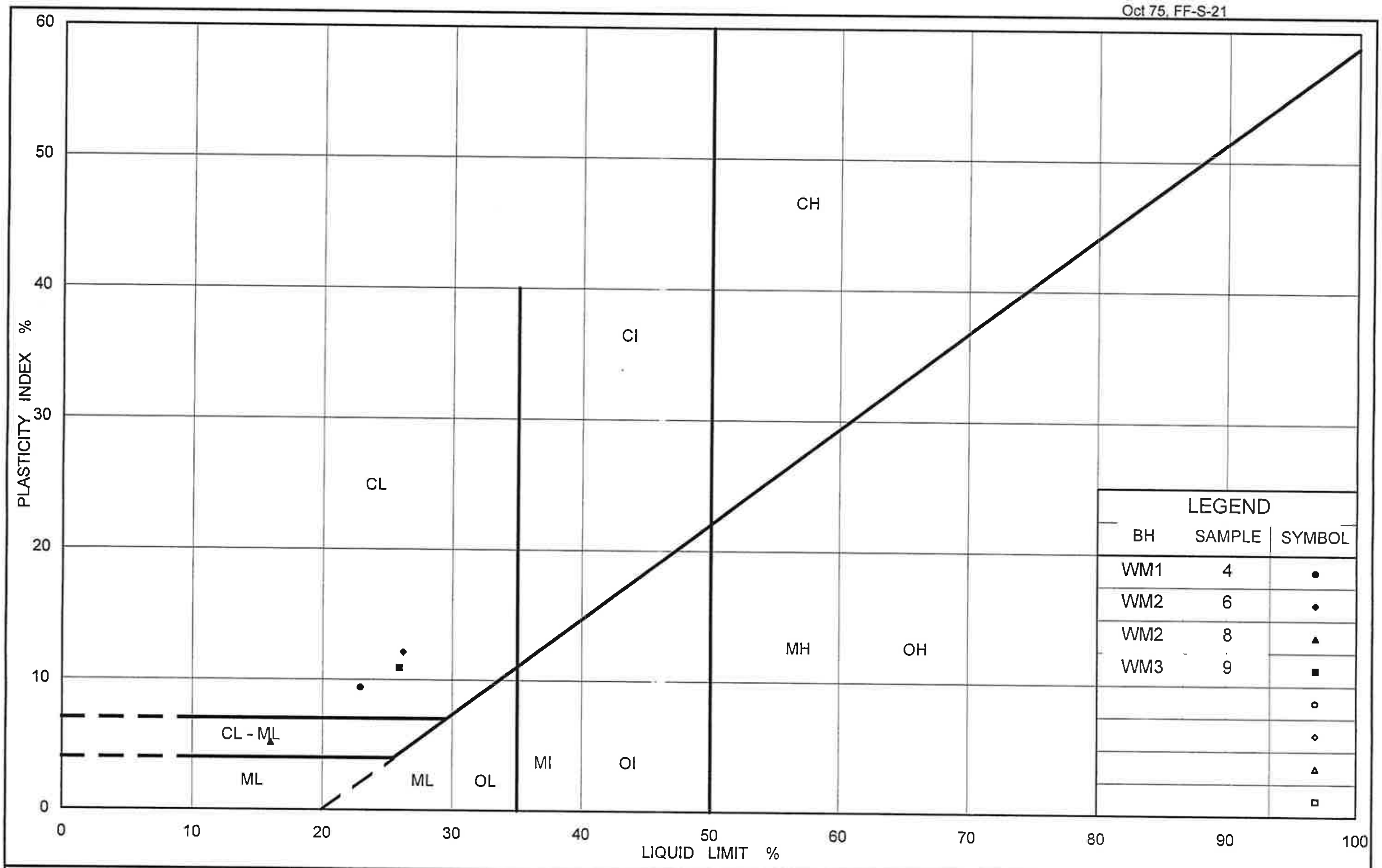
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM1	4	174.7
■	WM2	6	174.4
◆	WM2	8	171.3
▲	WM3	9	175.1

Project Number: 08-1111-0014

Checked By: ____________

Golder Associates

Date: 03-Jul-08



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt with Sand (Till)

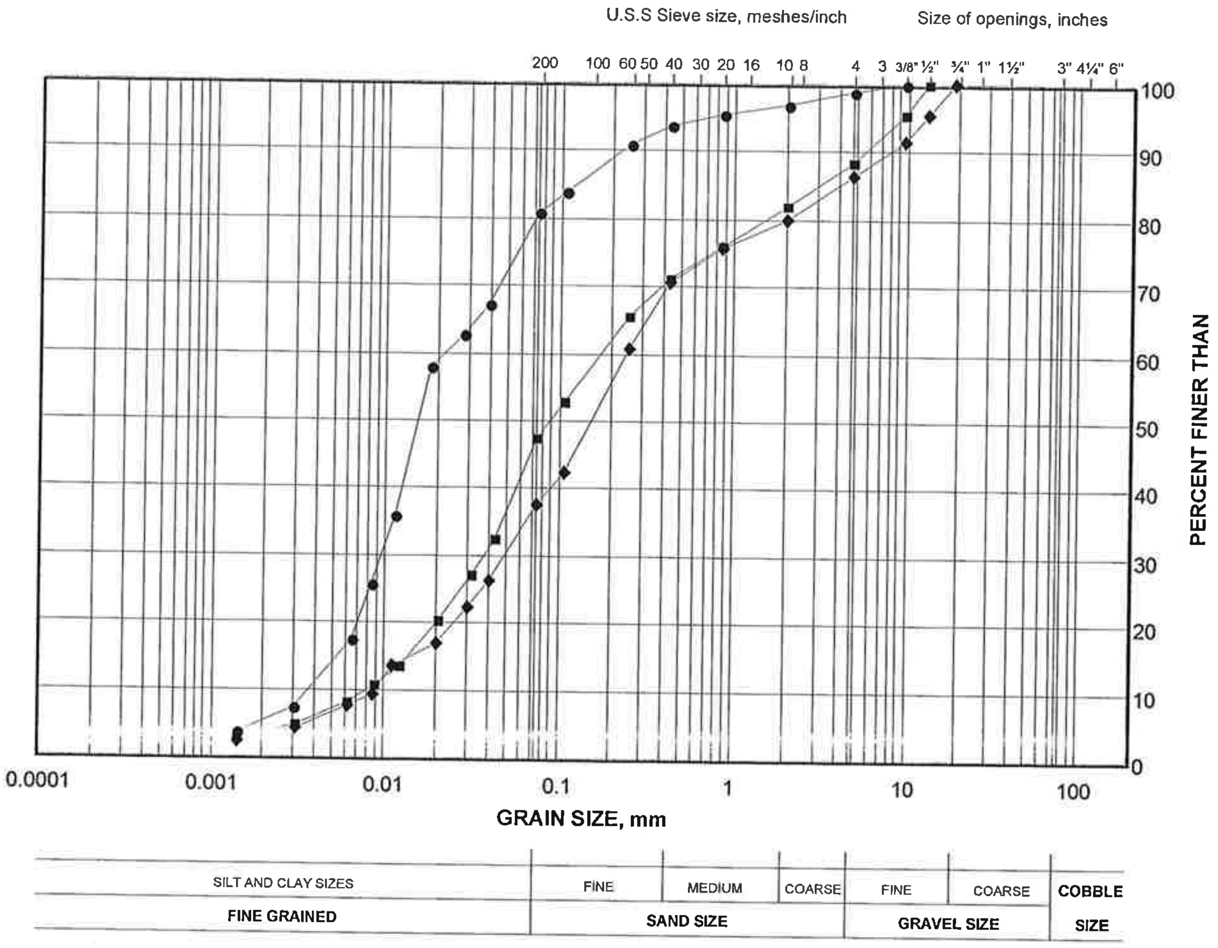
Figure No. 4

Project No. 08-1111-0014

Checked By:

GRAIN SIZE DISTRIBUTION
Silt and Sand to Sandy Silt (Till)

FIGURE 5



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WM3	11	172.3
■	WM1	7	172.5
◆	WM1	9	169.6

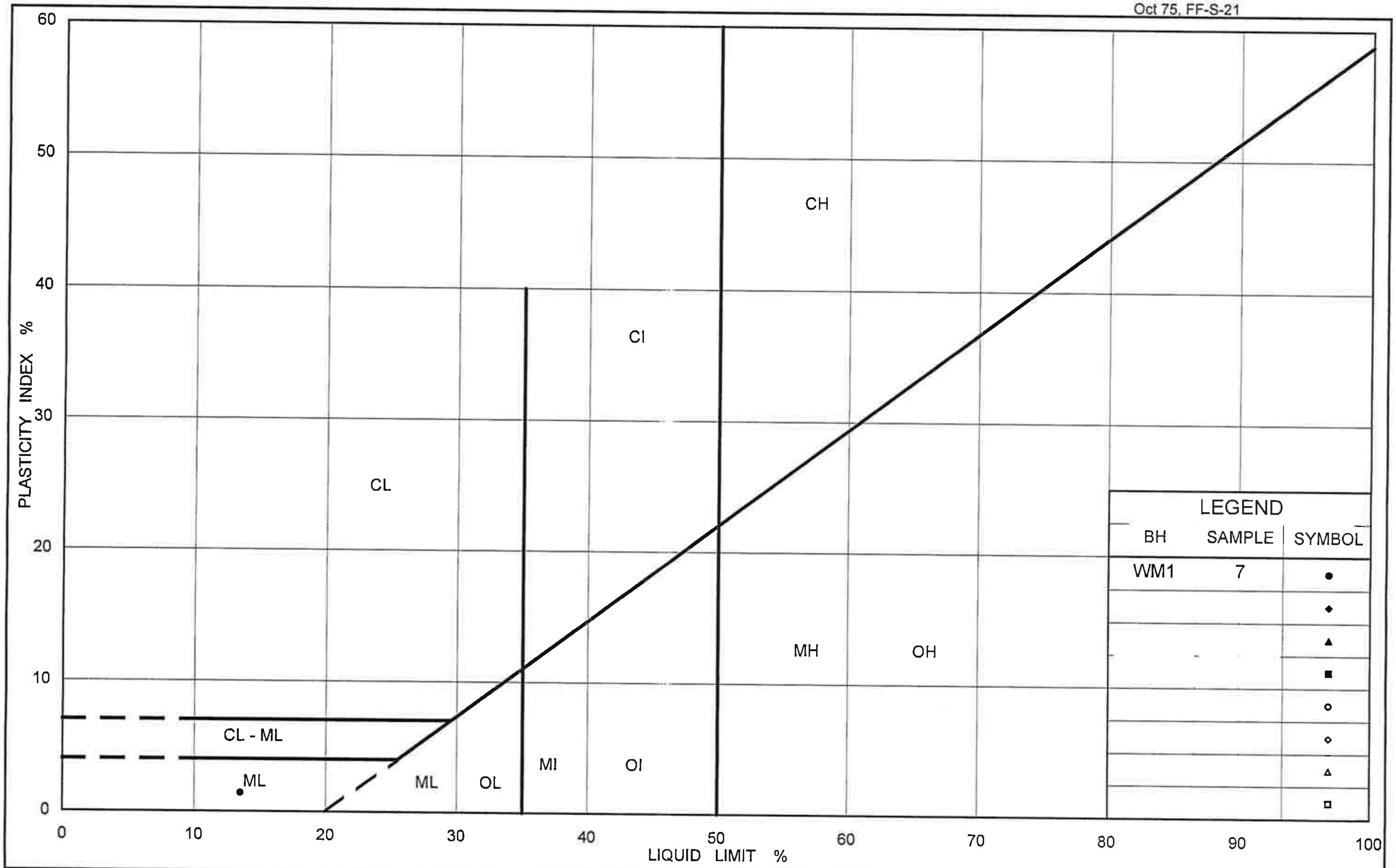
Project Number: 08-1111-0014

Checked By: ____________

Golder Associates

Date: 03-Jul-08

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
WM1	7	●
		◆
		▲
		■
		○
		◇
		△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART
Sandy Silt (Till)

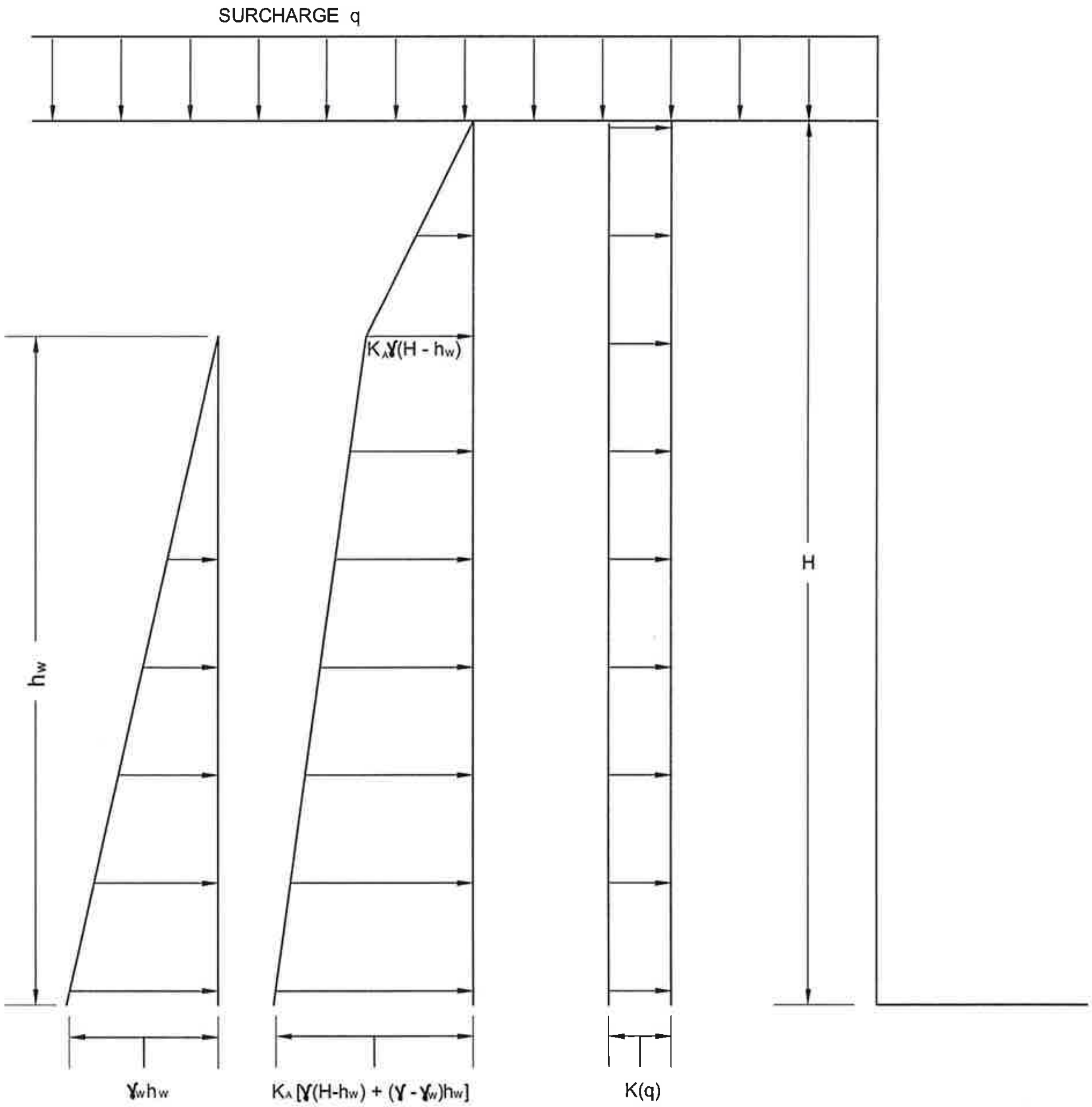
Figure No. 6

Project No. 08-1111-0014

Checked By:

DESIGN LATERAL EARTH PRESSURES
FOR TEMPORARY SHORING SYSTEM AT SHAFT LOCATIONS

FIGURE 7



γ - UNIT WEIGHT OF SOIL

γ_w - UNIT WEIGHT OF WATER

K_A - EARTH PRESSURE COEFFICIENT

H - HEIGHT OF EXCAVATION

h_w - HEIGHT OF WATER

DATE: July 2, 2009

PROJECT: 08-1111-0014

Golder Associates

CAD: DD

CHK: SLP

PLOT DATE: July 02, 2009
FILENAME: T:\Projects\2008\08-1111-0014 (PHILIPS ENGINEERING, Mississauga)\-AB- Geotech Investigation\0811110014AB007.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

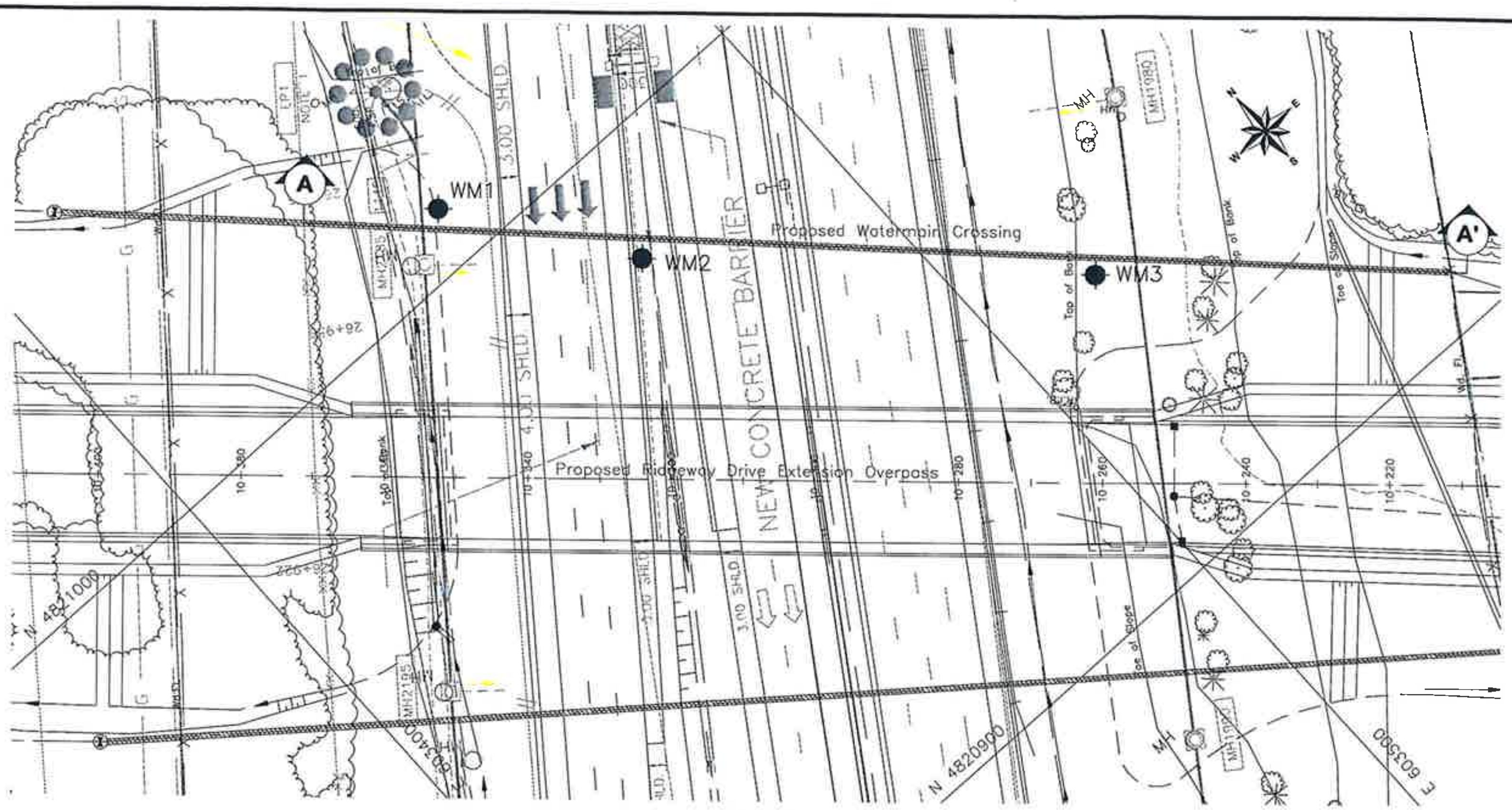
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.

SHEET

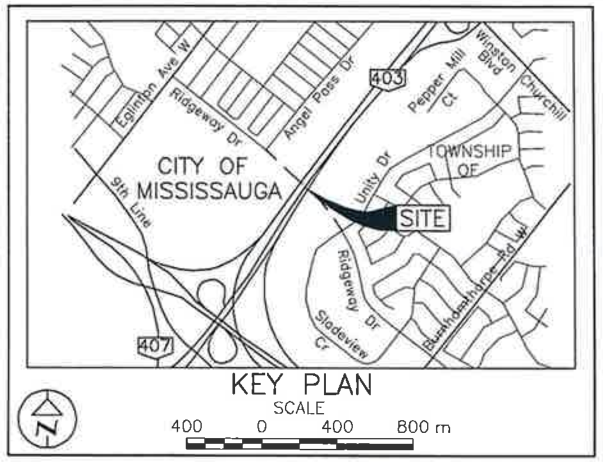
Highway 403/407 Watermain Crossing
Ridgeway Drive Extension
BOREHOLE LOCATION
AND SOIL STRATA

Golder Associates
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



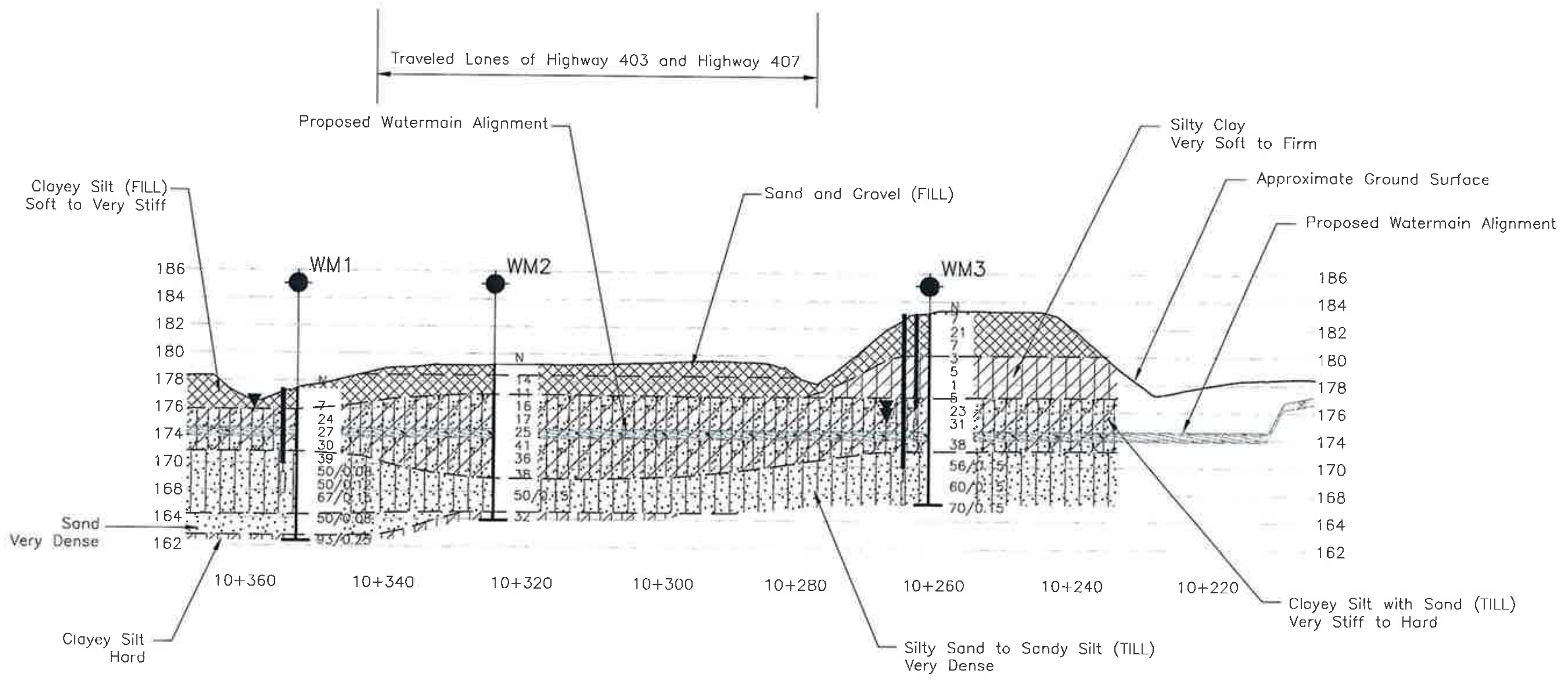
PLAN

SCALE
10 0 10 20 m



KEY PLAN

SCALE
400 0 400 800 m



PROFILE A – A'

VERTICAL SCALE
5 0 5 10 m
10 0 10 20 m
HORIZONTAL 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)
▼	WL in piezometer, measured on June 4, 2008

No.	ELEVATION	CO–ORDINATES	
		NORTHING	EASTING
WM1	177.4	4821008.1	603454.0
WM2	179.2	4820984.1	603470.5
WM3	183.1	4820940.2	603516.1

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.

Borehole locations were measured relative to existing site features and the proposed alignment as staked/surveyed by MMM Group.

The northings, eastings and elevations were inferred from plan and profiles drawing provided by Philips Engineering Ltd.

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

REFERENCE

Base plans provided in digital format by Philips Engineering Ltd., drawing file nos. "wm–boreholes.dwg" and "xprof.dwg", received on June 10, 2008.

NO.	DATE	BY	REVISION

Geocres No.

HWY. 403		PROJECT NO. 08–1111–0014	DIST.
SUBM'D.	CHKD. SLP	DATE: Jul. 2, 2009	SITE:
DRAWN: DD	CHKD. JMAC	APPD.	DWG. 1

PLOT DATE: July 2, 2009
FILENAME: T:\Projects\2008\08-1111-0014 (PHILIPS ENGINEERING, Mississauga)\-AB- Geotech Investigation\08111100144B001.dwg

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

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

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

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

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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

(b) Cohesive Soils

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

IV. SOIL TESTS

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

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

LIST OF SYMBOLS

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

I. General

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes:

1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

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

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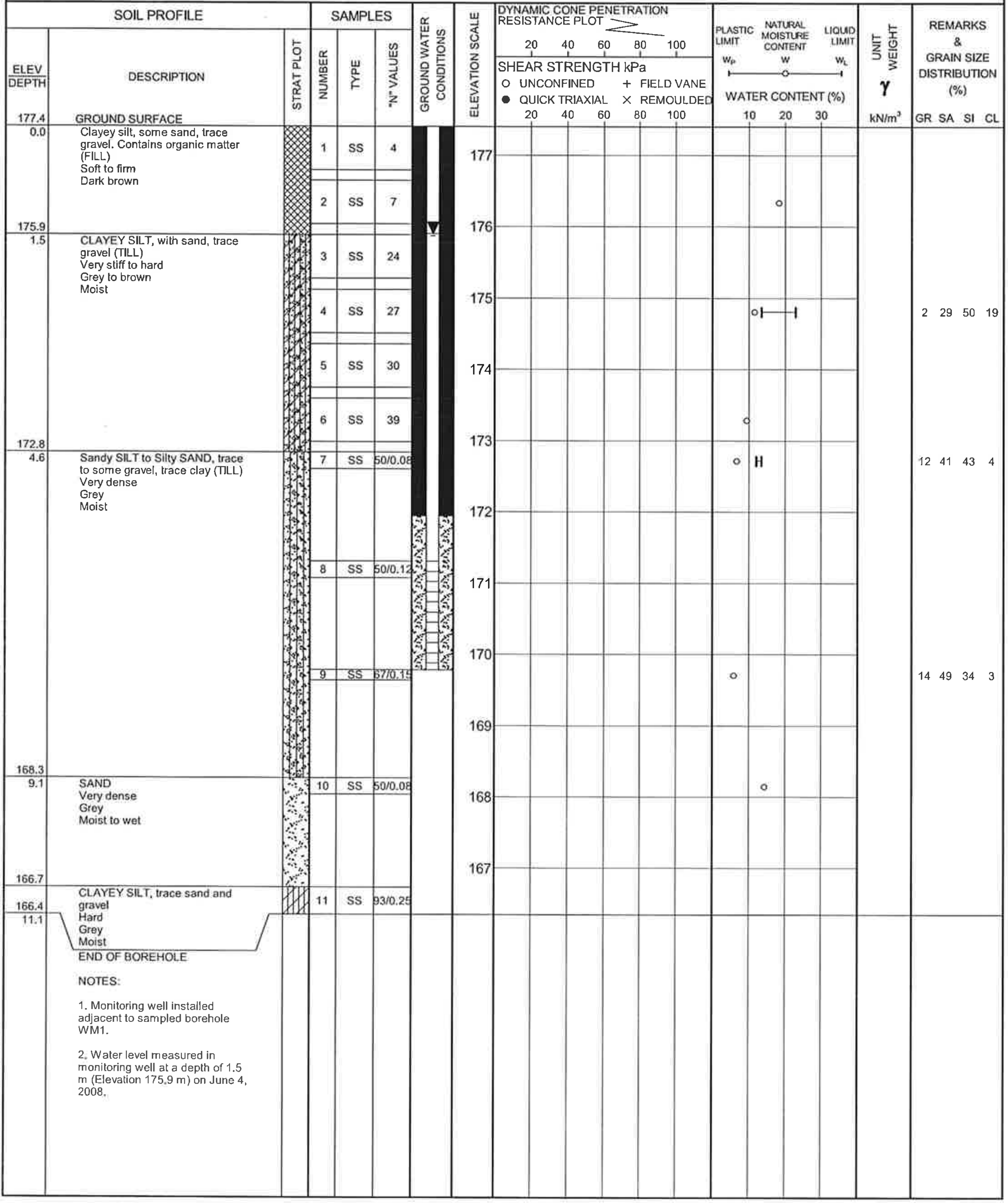
Golder Associates

RECORD OF BOREHOLE No WM1

1 OF 1 **METRIC**

PROJECT 08-1111-0014
W.P.
DIST HWY 403
DATUM Geodetic
LOCATION N 4821008.1 ;E 603454.0
BOREHOLE TYPE 108 mm I.D. Hollow Stem Power Auger
DATE May 1, 2008
ORIGINATED BY SB
COMPILED BY DD
CHECKED BY SLP



ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
177.4	GROUND SURFACE							
0.0	Clayey silt, some sand, trace gravel. Contains organic matter (FILL) Soft to firm Dark brown	1	SS	4				
		2	SS	7				
175.9 1.5	CLAYEY SILT, with sand, trace gravel (TILL) Very stiff to hard Grey to brown Moist	3	SS	24				
		4	SS	27	2	29	50	19
		5	SS	30				
		6	SS	39				
172.8 4.6	Sandy SILT to Silty SAND, trace to some gravel, trace clay (TILL) Very dense Grey Moist	7	SS	50/0.08	12	41	43	4
		8	SS	50/0.12				
		9	SS	67/0.15	14	49	34	3
168.3 9.1	SAND Very dense Grey Moist to wet	10	SS	50/0.08				
166.7	CLAYEY SILT, trace sand and gravel Hard Grey Moist	11	SS	93/0.25				
166.4 11.1	END OF BOREHOLE							

NOTES:

1. Monitoring well installed adjacent to sampled borehole WM1.

2. Water level measured in monitoring well at a depth of 1.5 m (Elevation 175.9 m) on June 4, 2008.

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

RECORD OF BOREHOLE No WM2

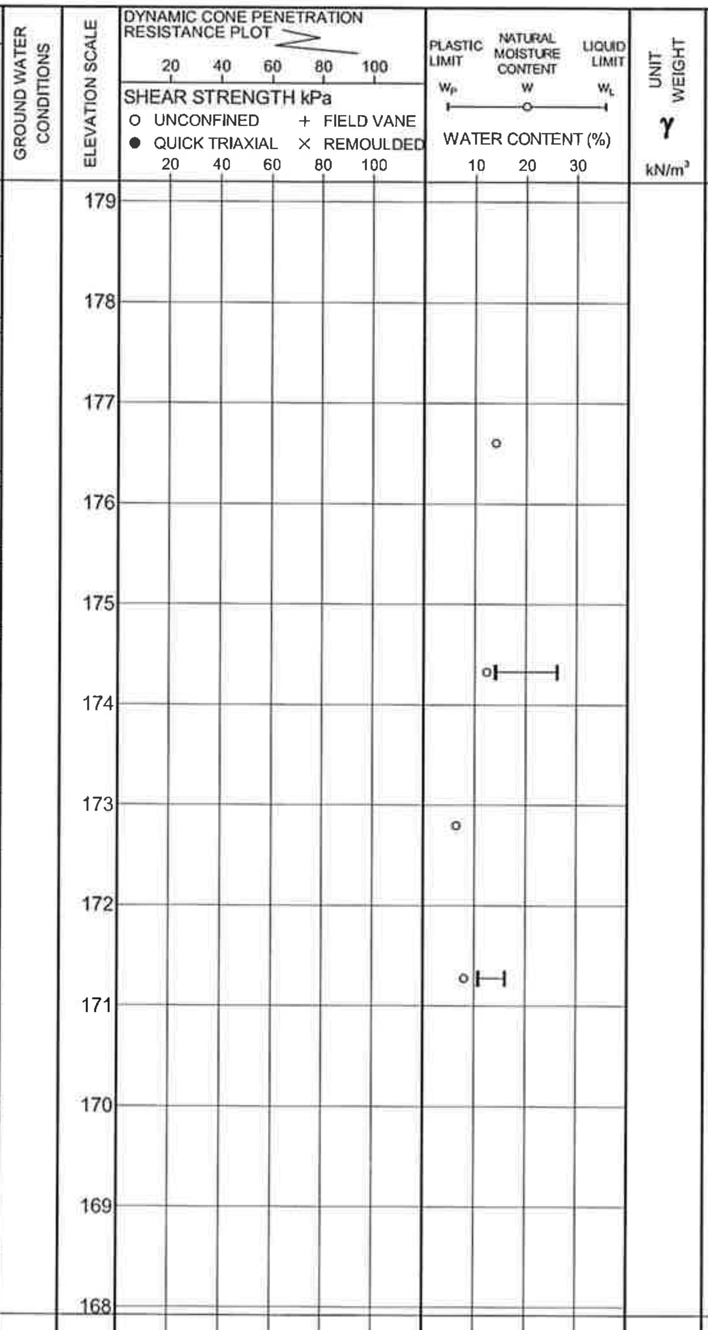
1 OF 1 **METRIC**

PROJECT 08-1111-0014
W.P.
DIST HWY 403
DATUM Geodetic
LOCATION N 4820984.1 ;E 603470.5
BOREHOLE TYPE 108 mm I.D. Hollow Stem Power Auger
DATE May 5, 2008
ORIGINATED BY SB
COMPILED BY DD
CHECKED BY SLP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
179.2	GROUND SURFACE							
0.0	Sand and gravel (FILL) Brown Moist							
178.4 0.8	Clayey silt, some sand, trace gravel. Contains rootlets (FILL) Stiff Brown and grey	1	SS	14				
		2	SS	11				
177.1 2.1	CLAYEY SILT with SAND, trace gravel (TILL) Very stiff to hard Brown Moist	3	SS	16				
		4	SS	17				
		5	SS	25				
		6	SS	41	3	34	40	23
		7	SS	36				
		8	SS	38	17	33	41	9
171.0 8.2	SILT and SAND to Sandy SILT, some gravel, trace clay (TILL) Very dense Grey Moist to wet	9	SS	50/0.15				
168.5 10.7	CLAYEY SILT, trace sand and gravel. Contains shale and limestone fragments Hard Grey Moist	10	SS	32				
167.9 11.3	END OF BOREHOLE							

NOTE:

1. Borehole open and dry upon completion of drilling.

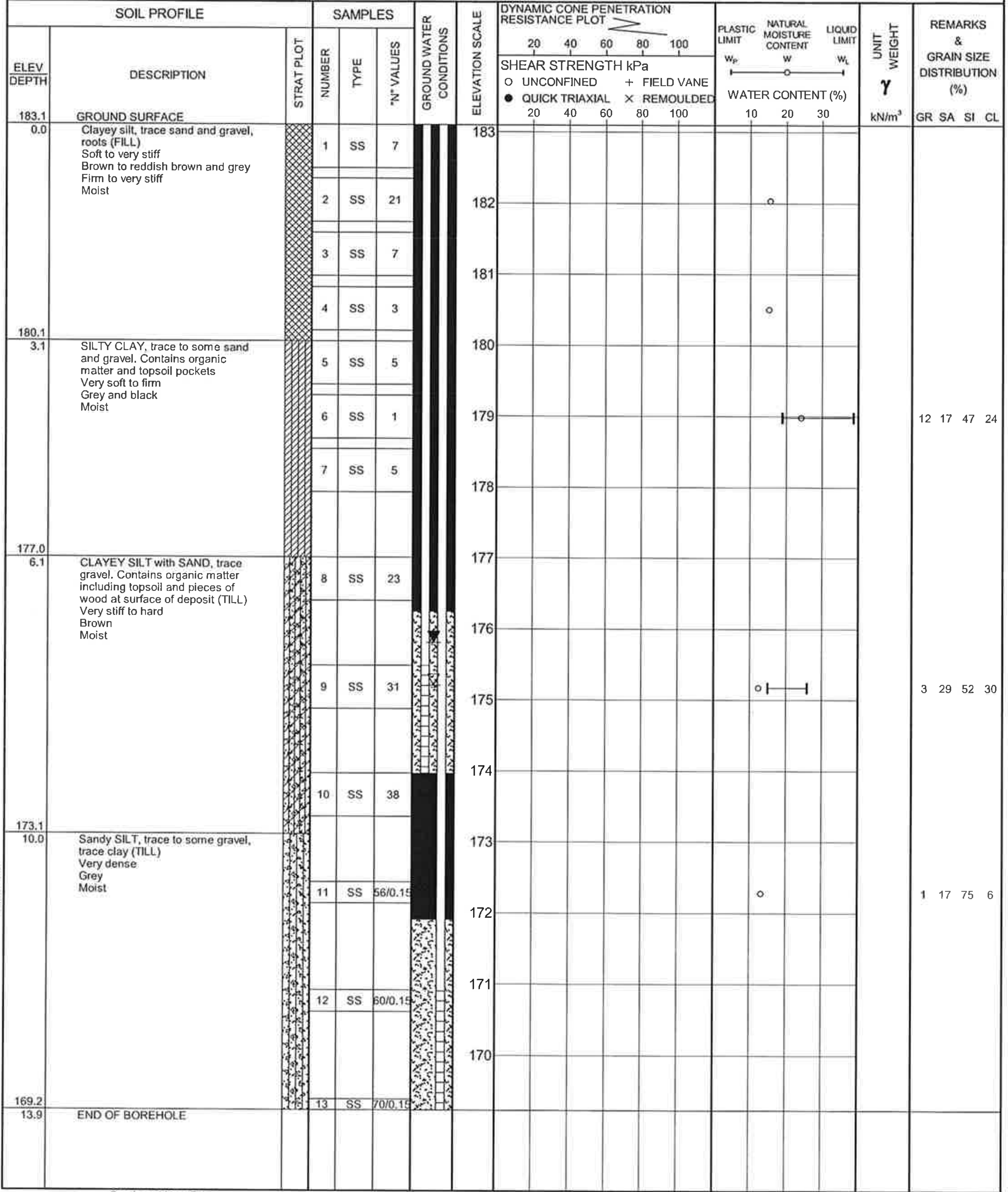


$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No WM3

1 OF 2 **METRIC**

PROJECT 08-1111-0014			
W.P.	LOCATION N 4820940.2 ;E 603516.1		ORIGINATED BY SB
DIST	HWY 403	BOREHOLE TYPE 108 mm I.D. Hollow Stem Power Auger	COMPILED BY DD
DATUM Geodetic		DATE May 5, 2008	CHECKED BY SLP



ELEV DEPTH	DESCRIPTION
183.1	GROUND SURFACE
0.0	Clayey silt, trace sand and gravel, roots (FILL) Soft to very stiff Brown to reddish brown and grey Firm to very stiff Moist
180.1 3.1	SILTY CLAY, trace to some sand and gravel. Contains organic matter and topsoil pockets Very soft to firm Grey and black Moist
177.0 6.1	CLAYEY SILT with SAND, trace gravel. Contains organic matter including topsoil and pieces of wood at surface of deposit (TILL) Very stiff to hard Brown Moist
173.1 10.0	Sandy SILT, trace to some gravel, trace clay (TILL) Very dense Grey Moist
169.2 13.9	END OF BOREHOLE

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	7				
2	SS	21				
3	SS	7				
4	SS	3				
5	SS	5				
6	SS	1	12	17	47	24
7	SS	5				
8	SS	23				
9	SS	31	3	29	52	30
10	SS	38				
11	SS	56/0.15	1	17	75	6
12	SS	60/0.15				
13	SS	70/0.15				

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM3

2 OF 2 **METRIC**

PROJECT 08-1111-0014		
W.P.	LOCATION N 4820940.2 ;E 603516.1	ORIGINATED BY SB
DIST HWY 403	BOREHOLE TYPE 108 mm I.D. Hollow Stem Power Auger	COMPILED BY DD
DATUM Geodetic	DATE May 5, 2008	CHECKED BY SLP

SOIL PROFILE			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
ELEV DEPTH	DESCRIPTION — CONTINUED FROM PREVIOUS PAGE —	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	NOTES: 1. Deep monitoring well installed in sampled borehole and shallow monitoring well installed 1.5 m south of sampled borehole. 2. Water level measured in shallow monitoring well at a depth of 7.9 m (Elevation 175.2 m) and in deep monitoring well at depth of 7.3 m (Elevation 175.8 m) on June 4, 2008.										

MIS-MTO 001 08-1111-0014.GPJ GAL-MISS.GDT 7/2/09 DD

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

APPENDIX A

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

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

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

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

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

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

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

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

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

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

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

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

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

APPENDIX B

PREVIOUS INVESTIGATION BY GOLDER

Golder Associates

Foundation Design

RECORD OF BOREHOLE No BH1

1 OF 1 **METRIC**

PROJECT 06-1111-021

W.P. ____

DIST ____ HWY Ridgeway Dr

DATUM Geodetic

LOCATION N 4820789.2 ;E 603605.4

BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers

DATE January 24, 2007

ORIGINATED BY BML

COMPILED BY BML

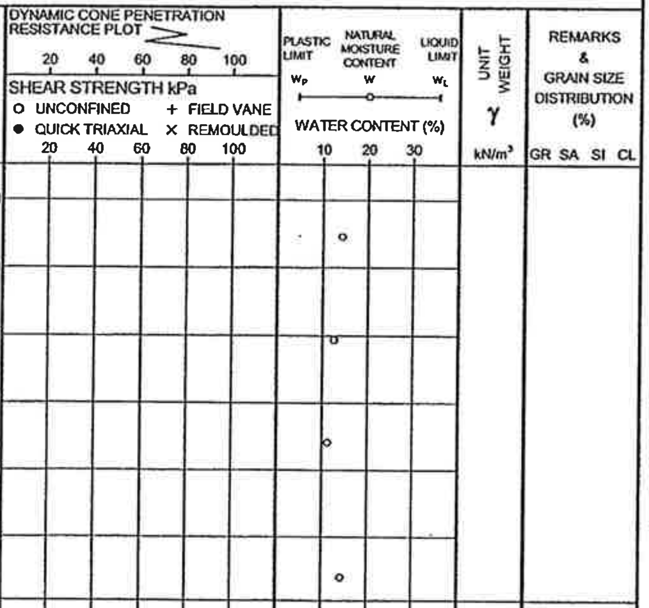
CHECKED BY HJ

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES		
180.5	GROUND SURFACE					
0.0 180.1	Topsoil	1	SS	4		180
179.6 0.9	Sandy Silt, some gravel, trace clay (FILL) Loose Brown Moist	2	SS	17		
	Clayey Silt with Sand (TILL) Very stiff to hard Brown Moist	3	SS	28		179
		4	SS	22		178
		5	SS	29		177
		6	SS	31		176
175.5 5.0	Sandy Silt, some clay Very dense Grey Moist to wet	7	SS	21		175
		~~8~~	~~SS~~	~~50/0.07~~		
174.1 6.5	End of Borehole					

Notes:

1. Open borehole dry upon completion of drilling.

2. Borehole open to 6.5 m depth upon completion of drilling.



$+^{3}, \times^{3}$: Numbers refer to Sensitivity

O $^{3\%}$ STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No BH2

1 OF 1 **METRIC**

PROJECT 06-1111-021
W.P.
DIST
HWY Ridgeway Dr
LOCATION N 4820831.8 ;E 603579.3
BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers
DATUM Geodetic
DATE January 24, 2007
ORIGINATED BY BML
COMPILED BY BML
CHECKED BY HJ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			GR	SA	SI	CL
180.2	GROUND SURFACE										
0.0	Topsoil		1	SS	3		180				
0.3	Clayey Silt, trace gravel (FILL), occasional boulders Stiff to hard Reddish brown Moist		2	SS	14		179				
			3	SS	50/0.0						
							178				
177.6 2.6	Clayey Silt with Sand (TILL) Very stiff to hard Brown Moist		4	SS	12						
			5	SS	20		177				
			6	SS	43		176	5	29	40	26
175.2 5.0	Sandy Silt, some clay Very dense Grey Moist		7	SS	46	⊻	175				
							174				
			8	SS	60						
							173				
172.0 8.2	End of Borehole		9	SS	55		172	0	21	65	14

Notes:

1. Water level in open borehole at 5.1 m depth (Elev. 175.1 m) upon completion of drilling.

2. Borehole open to 7.0 m depth upon completion of drilling.

MIS-MTO 001 06-1111-021.GPJ GAL-MISS.GDT 7/20/07 DD

$+^3, \times^3$: Numbers refer to Sensitivity

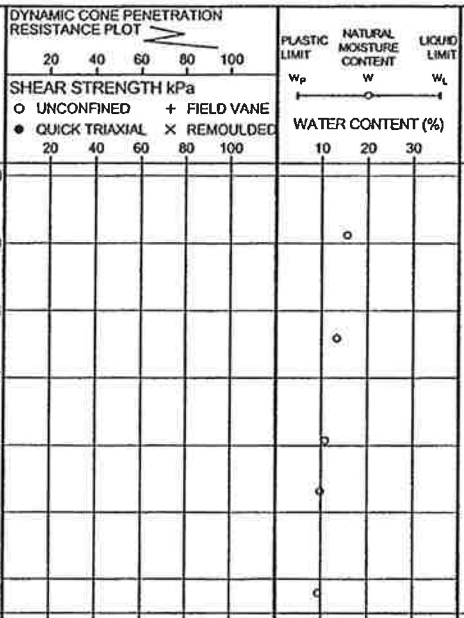
$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No BH3

1 OF 1 **METRIC**

PROJECT 06-1111-021
W.P.
LOCATION N 4820871.1 ;E 603548.2
ORIGINATED BY BML
DIST
HWY Ridgeway Dr
BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers
COMPILED BY BML
DATUM Geodetic
DATE January 24, 2007
CHECKED BY HJ

SOIL PROFILE			SAMPLES				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
180.2	GROUND SURFACE						
0.0	Topsoil						
0.2	Clayey Silt, some sand and gravel, occasional boulders (FILL) Stiff to soft Reddish brown Moist	▩	1	SS	15		180
			2	SS	12		179
			3	SS	4		
177.8 2.4	Clayey Silt with Sand (TILL) Very stiff to hard Brown Moist to dry						178
			4	SS	26		
			5	SS	24		177
			6	SS	28		176
			7	SS	60		175
173.9	Sandy Silt, some clay Very dense Grey Dry		8	SS	64		174
173.5 6.7	End of Borehole						



UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Notes:

1. Open borehole dry upon completion of drilling.

2. Borehole open to 6.7 m depth upon completion of drilling.

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

RECORD OF BOREHOLE No BH4

1 OF 1 METRIC

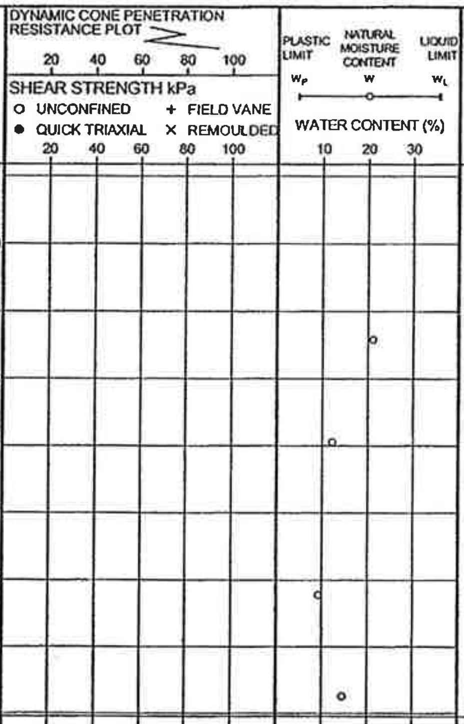
PROJECT 06-1111-021
W.P.
DIST
HWY Ridgeway Dr
DATUM Geodetic
LOCATION N 4820905.2 ;E 603511.4
BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers
DATE January 24, 2007
ORIGINATED BY BML
COMPILED BY BML
CHECKED BY HJ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				GR	SA	SI	CL
181.2	GROUND SURFACE											
0.0	Topsoil						181					
0.3	Clayey Silt, trace sand and gravel, frequent rootlets (FILL) Stiff to firm Brown to dark brown Moist		1	SS	14		180					
			2	SS	16		179					
			3	SS	8							
177.8 3.4	Clayey Silt with Sand (TILL) Very stiff to hard Brown Moist		4	SS	14		178					
			5	SS	25		177					
			6	SS	35		176					
			7	SS	65		175					
174.0 7.2	Clayey Silt to Silty Clay, trace sand Hard Grey Moist						174					
			8	SS	37				0	3	52	45
173.0 8.2	End of Borehole						173					

Notes:

1. Open borehole dry upon completion of drilling.

2. Borehole open to 8.2 m depth upon completion of drilling.



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

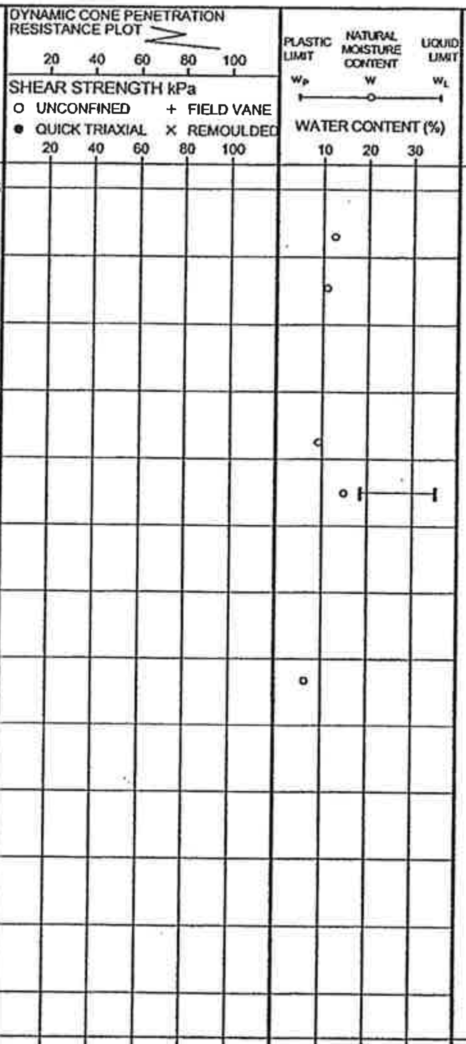
Golder Associates

RECORD OF BOREHOLE No BH5

1 OF 1 **METRIC**

PROJECT 06-1111-021			
W.P.	LOCATION N 4820914.0 ;E 603487.7		ORIGINATED BY BML
DIST	HWY Ridgeway Dr	BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers	COMPILED BY BML
DATUM Geodetic		DATE Started on Jan. 25, 2007; Completed on Feb. 1, 2007	CHECKED BY HJ

SOIL PROFILE		SAMPLES				REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
178.4	GROUND SURFACE								
0.0	Topsoil								
0.3	Clayey Silt with Sand (TILL) Very stiff to hard Brown Moist				178				
		1	SS	20	177				
		2	SS	33					
		3	SS	27	176				
		4	SS	35	175				
	Becoming grey below 3.5 m depth (Elev. 174.9 m)	5	SS	28					
174.0 4.4	Clayey Silt to Silty Clay, trace sand Hard Grey Dry				174				
		6	SS	49		0	2	51	47
					173				
		7	SS	46	172				
171.1 7.3	Sandy Silt, some clay (TILL) Very dense Reddish brown Dry				171				
		8	SS	100/0.15		5	33	49	13
					170				
169.4 9.0	Highly to moderately weathered, red, calcareous SHALE BEDROCK (Queenston Formation) with occasional grey siltstone and limestone layers up to 100 mm thick	9	SS	50/0.00	169				
		10	SS	50/0.10					
	NQ Coring from 10.3 m depth (Elev. 168.1 m)	1	NQ RC	REC 96%	168	RQD = 33%			
		2	NQ RC	REC 100%		RQD = 36%			
	For coring details see Record of Drillhole BH5	3	NQ RC	REC 100%	167	RQD = 53%			
		4	NQ RC	REC 93%	166	RQD = 48%			
165.4 13.0	End of Borehole								



Notes:

1. Water level in open borehole on Feb. 1, 2007 before resuming drilling at 1.5 m depth (Elev. 176.9 m).

2. Water level in piezometer on April 3, 2007 at 0.3 m depth (Elev. 178.1 m).

MIS-MTO 001 06-1111-021.GPJ GAL-MISS.GDT 7/20/07 DD

+³,×³: Numbers refer to Sensitivity

O ³% STRAIN AT FAILURE

PROJECT: 06-1111-021

RECORD OF DRILLHOLE: BH5

SHEET 1 OF 1

LOCATION: N 4820914.0 ;E 603487.7

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: Started on Jan. 25, 2007; Completed on Feb. 1, 2007

DRILL RIG: CME 75

DRILLING CONTRACTOR: Geo-Environmental Ltd.

DATUM: Geodetic

JN - Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock
FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided	NOTE: For additional abbreviations refer to list of abbreviations & symbols.
SHR - Shear	CO - Contact	UN - Undulating	SM - Smooth	
VN - Vein	OR - Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB - Mechanical Break	

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	COLOUR % RETURN	FLUSH	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	CAVITIES OBSERVED IN BOREHOLE VIDEO
		GROUND SURFACE		168.21						
		Highly to moderately weathered, thinly layered, red, very fine grained, very weak to weak, calcareous SHALE BEDROCK (Queenston Formation) Occasional interbeds of weathered, grey siltstone and limestone Elevation (m) Thickness (mm) 166.5 50 160.0 125 165.6 25 All fractures are rough bedding		10.16	1				,BC_ _JN, BD,PL_Ro	
					2					
12					3				,BC_ _JN, BD,PL_Ro _JN, BD,PL_Ro _JN, BD,PL_Ro	Screen
				165.34 13.03	4				_JN, BD,PL_Ro	
14		End of Drillhole								
16										
18										
20										
22										
24										
26										
28										
30										

DISCONTINUITY DATA: θ Angle; DIP w.r.t. CORE AXIS; TYPE AND SURFACE DESCRIPTION; Jr; Ja; Jn

HYDRAULIC CONDUCTIVITY K, cm/sec

Diametral Point Load Index (MPa)

RMC -Q' AVG.

DEPTH SCALE

1 : 100

Golder Associates

LOGGED: BML

CHECKED: HJ

Golder Associates

Foundation Design

RECORD OF BOREHOLE No BH6

1 OF 1 **METRIC**

PROJECT 06-1111-021
W.P.
DIST
HWY Ridgeway Dr
DATUM Geodetic
LOCATION N 4820927.5 ;E 603502.1
BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers
DATE January 25, 2007
ORIGINATED BY BML
COMPILED BY BML
CHECKED BY HJ

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
183.0	GROUND SURFACE
0.0	Topsoil
0.2	Clayey Silt, trace to some sand and gravel (FILL), occasional rootlets Firm to stiff Reddish brown Moist
177.8 5.2	Clayey Silt with Sand (TILL) Very stiff Brown Moist
173.5 9.4	Sandy Silt to Silty Sand, trace to some clay (TILL), contains rock fragments Very dense Reddish brown Moist
169.6 13.4	Clayey Silt to Silty Clay, trace sand Hard Grey Moist
168.0 14.9	Silty Sand, some gravel and clay (Residual Soil) Very dense Reddish brown Moist
166.2	Red SHALE BEDROCK (Queenston Formation) with interlayers of grey siltstone
165.7 17.2	End of Borehole

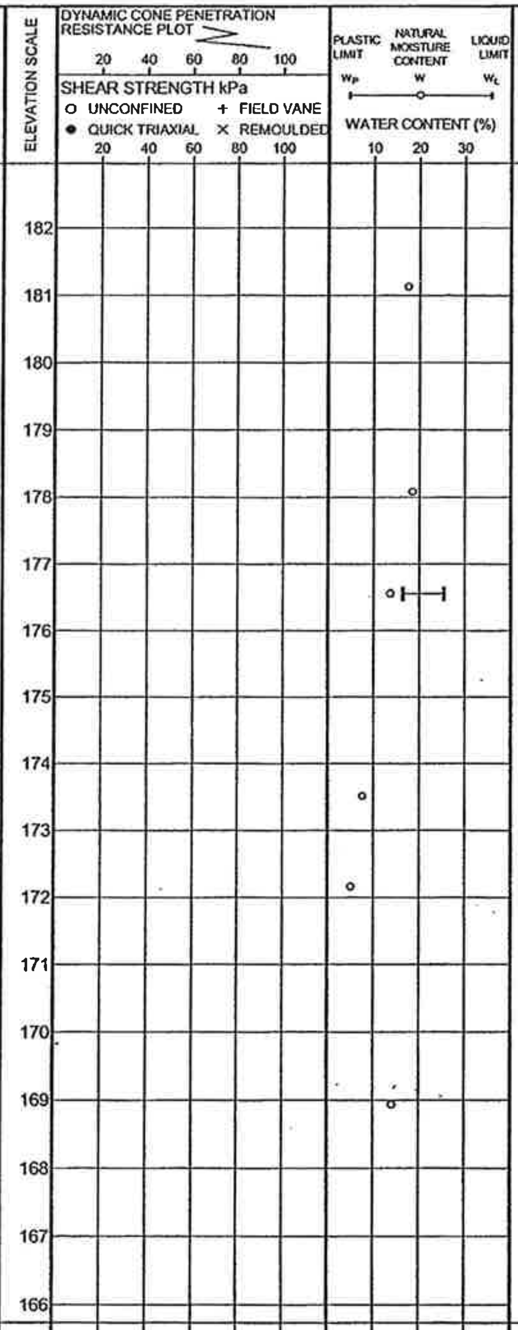
Note:

1. Water level in open borehole at 14.9 m depth (Elev. 168.1 m) upon completion of drilling.

SAMPLES

NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
1	SS	5						
2	SS	8						
3	SS	5						
4	SS	5						
5	SS	5						
6	SS	14						
7	SS	19			13	31	36	20
8	SS	25						
9	SS	43						
10	SS	50/0.25						
11	SS	70/0.1						
12	SS	60			0	2	53	45
			∇					
13	SS	50/0.0						
14	SS	118						

REMARKS & GRAIN SIZE DISTRIBUTION (%)



+³, ×³: Numbers refer to Sensitivity

O ³% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH7

1 OF 1 **METRIC**

PROJECT 06-1111-021
W.P.
DIST HWY Ridgeway Dr
DATUM Geodetic

LOCATION N 4820934.8 ;E 603457.6
BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers
DATE January 29, 2007

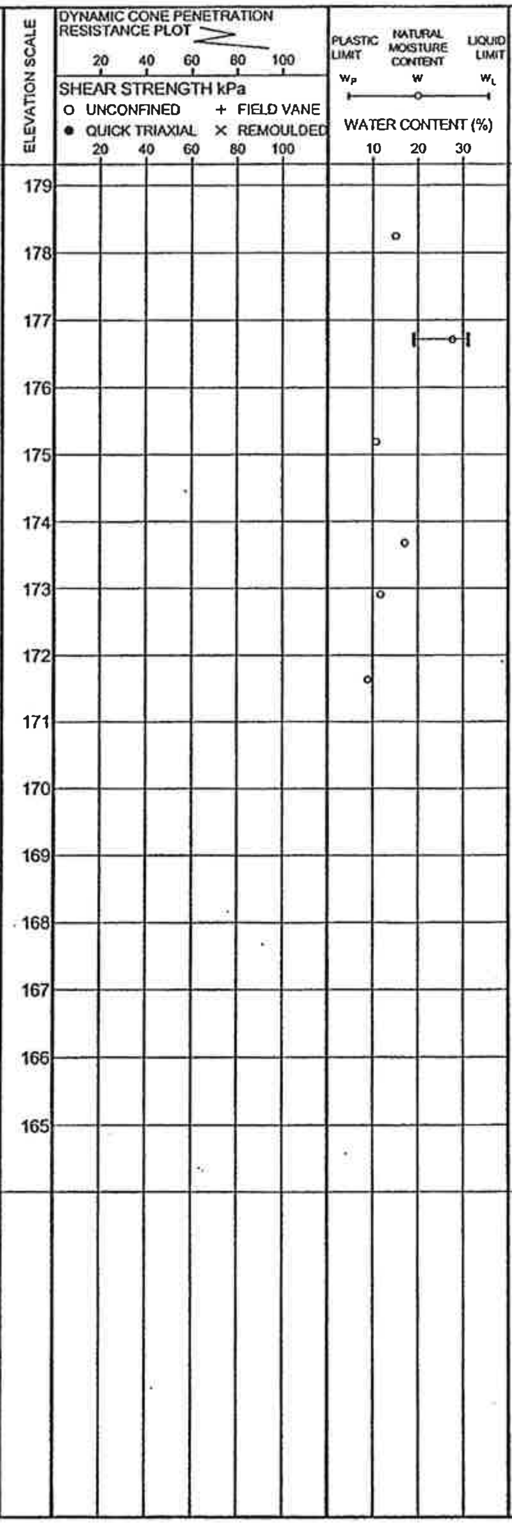
ORIGINATED BY BML
COMPILED BY BML
CHECKED BY HJ

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			GR	SA	SI	CL
179.3	GROUND SURFACE									
0.0	Asphalt									
	Sand and Gravel (FILL)									
178.5 0.8	Clayey Silt, some sand (Probable FILL) Stiff to firm Brown Moist Occasional dark brown organics/rootlets between 2.2 m and 3.1 m depth (Elev. 177.1 m to 176.2 m)	2	SS	14						
		3	SS	10						
		4	SS	6			6	18	50	26
176.0 3.4	Clayey Silt with Sand (TILL) Hard Brown Moist	5	SS	18						
		6	SS	42						
		~~7~~	~~SS~~	~~50/0.1~~						
173.7 5.6	Clayey Silt to Silty Clay, some sand Hard Grey Moist Reddish brown Clayey Silt, some sand from 6.1 m to 6.6 m depth	8	SS	44						
		9	SS	56			0	13	62	25
		10	SS	52						
171.8 7.5	Sandy Silt to Silty Sand, trace to some clay (TILL) Very dense Reddish brown Moist	~~11~~	~~SS~~	~~50/0.1~~						
170.2 9.1	Red SHALE BEDROCK (Queenston Formation) with interlayers of grey siltstone	~~12~~	~~SS~~	~~50/0.07~~						
		~~13~~	~~SS~~	~~50/0.07~~						
		14	SS	108						
		~~15~~	~~SS~~	~~00/0.1~~	∇					
164.0 15.3	End of Borehole	~~16~~	~~SS~~	~~50/0.0~~						

Notes:

1. Water level in open borehole at 14.0 m depth (Elev. 153.2 m) upon completion of drilling.

2. Borehole open to 15.3 m depth upon completion of drilling.



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

Golder Associates

RECORD OF BOREHOLE No BH8

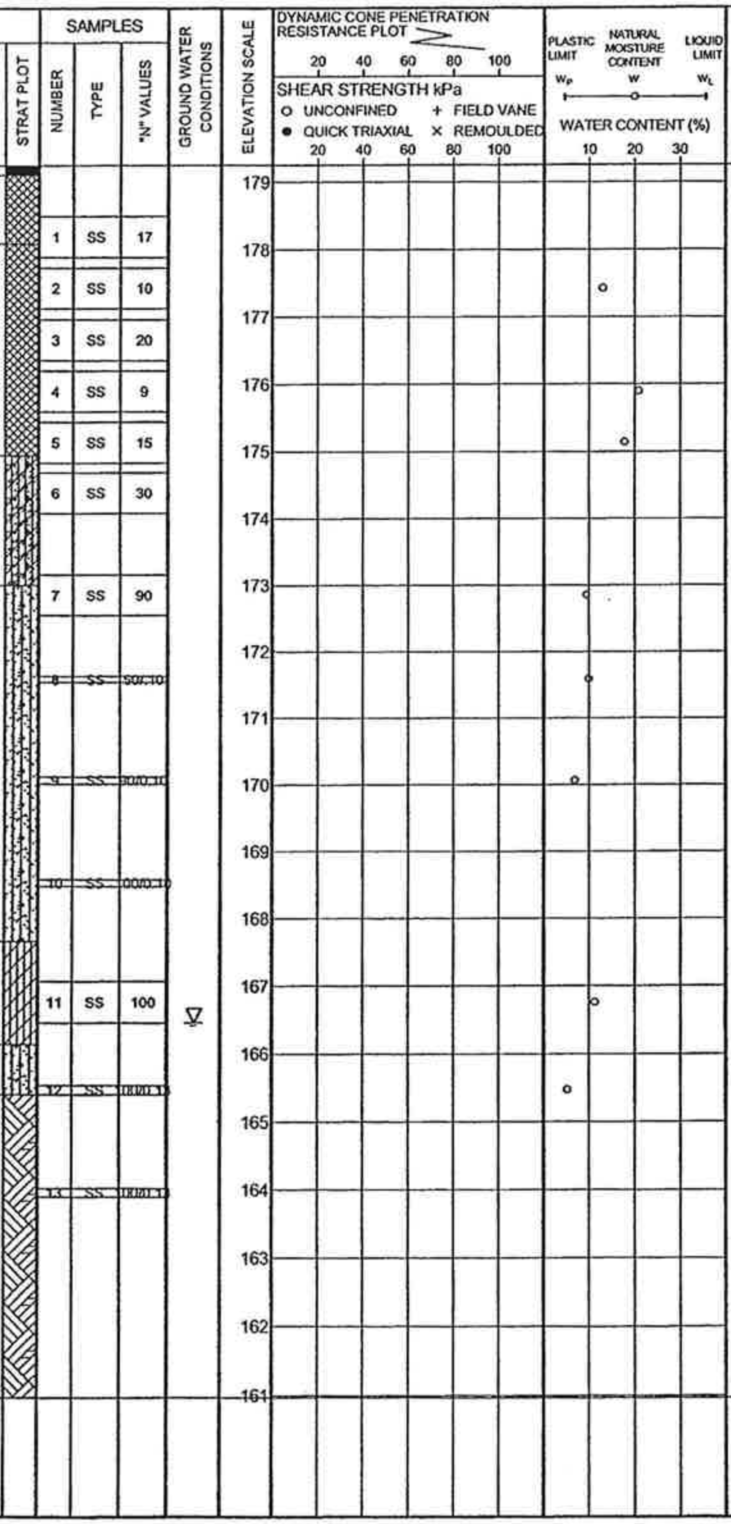
1 OF 1 **METRIC**

PROJECT 06-1111-021
W.P.
DIST HWY Ridgeway Dr
DATUM Geodetic
LOCATION N 4820952.8 ;E 603469.6
BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers
DATE January 30, 2007
ORIGINATED BY BML
COMPILED BY BML
CHECKED BY HJ

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.3	GROUND SURFACE					
0.0	Asphalt					
0.2	Sand and Gravel (FILL) Compact Light brown Moist	1	SS	17		
178.1 / 1.2	Clayey Silt, some sand (Probable FILL) Stiff to very stiff Brown Moist	2	SS	10		
		3	SS	20		
		4	SS	9		
		5	SS	15		
174.9 / 4.3	Clayey Silt with Sand (TILL) Very stiff Brown Moist	6	SS	30		
173.0 / 6.3	Silty Sand to Sandy Silt (TILL), trace to some gravel Very dense Grey to reddish brown Moist	7	SS	90		
		8	SS	50/0.10		
		9	SS	100/0.10		
		10	SS	100/0.10		
167.7 / 11.6	Clayey Silt to Silty Clay, trace sand Hard Grey Moist	11	SS	100	∇	
166.1 / 13.1	Silty Sand, some gravel and clay (Residual Soil) Very dense Reddish brown Moist	12	SS	100/0.10		17 44 25 14
165.4 / 13.9	Red SHALE BEDROCK (Queenston Formation) with interlayers of grey siltstone	13	SS	100/0.10		
161.0 / 18.3	End of Borehole					

Notes:

1. Water level in open borehole at 12.8 m depth (Elev. 166.5 m) upon completion of drilling.



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

Golder Associates

RECORD OF BOREHOLE No BH9

1 OF 1 **METRIC**

PROJECT 06-1111-021
W.P.
DIST HWY Ridgeway Dr
DATUM Geodetic

LOCATION N 4820951.1 ;E 603449.2
BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers
DATE January 31, 2007

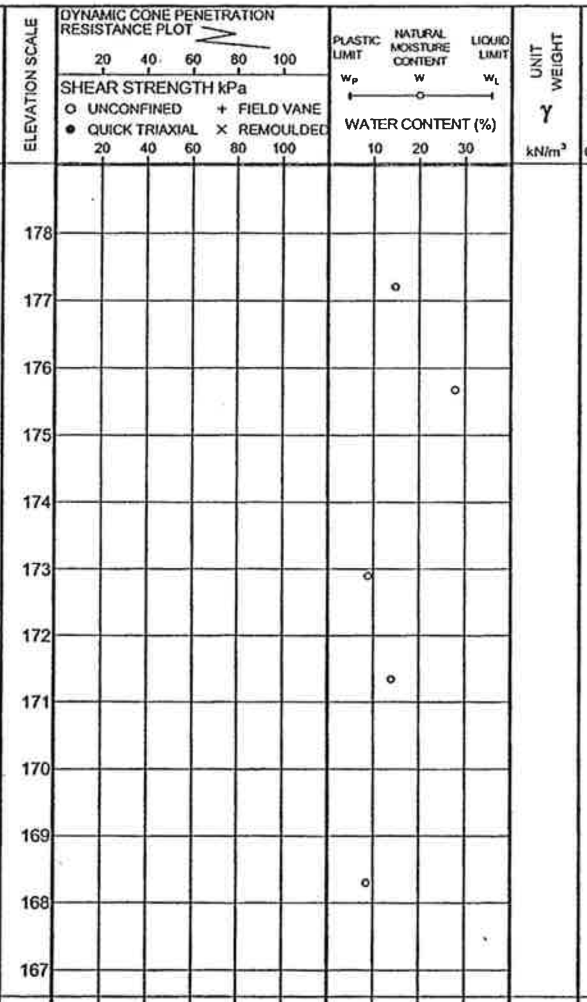
ORIGINATED BY BML
COMPILED BY BML
CHECKED BY HJ

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.0	GROUND SURFACE					
0.0	Sand and Gravel (FILL) Compact Brown Moist					
178.4 0.6	Clayey Silt, some sand (Probable FILL) Stiff Brown Moist	1	SS	9		
		2	SS	12		
		3	SS	11		
		4	SS	10		
174.6 4.4	Clayey Silt with Sand, trace gravel (TILL) Very stiff to hard Brown Moist	5	SS	30		
	Becoming grey below 5.5 m depth (Elev. 173.5 m)	6	SS	50/0.07		4 25 56 15
172.0 7.0	Clayey Silt to Silty Clay, trace sand Hard Grey Moist	7	SS	50/0.13		
		8	SS	79		
169.0 10.1	Silty Sand, some gravel and clay (Residual Soil) Very dense Reddish brown Moist	9	SS	50/0.13		
168.2 10.8	Red SHALE BEDROCK (Queenston Formation) with interlayers of grey siltstone	10	SS	50/0.07		
166.6 12.4	End of Borehole					

Notes:

1. Open borehole dry upon completion of drilling.

2. Borehole open to 12.4 m depth upon completion of drilling.



$+^3, \times^3$: Numbers refer to Sensitivity

$O^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No BH10

1 OF 1 **METRIC**

PROJECT 06-1111-021

W.P.

DIST

HWY Ridgeway Dr

DATUM Geodetic

LOCATION N 4820965.9 ;E 603459.5

BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers

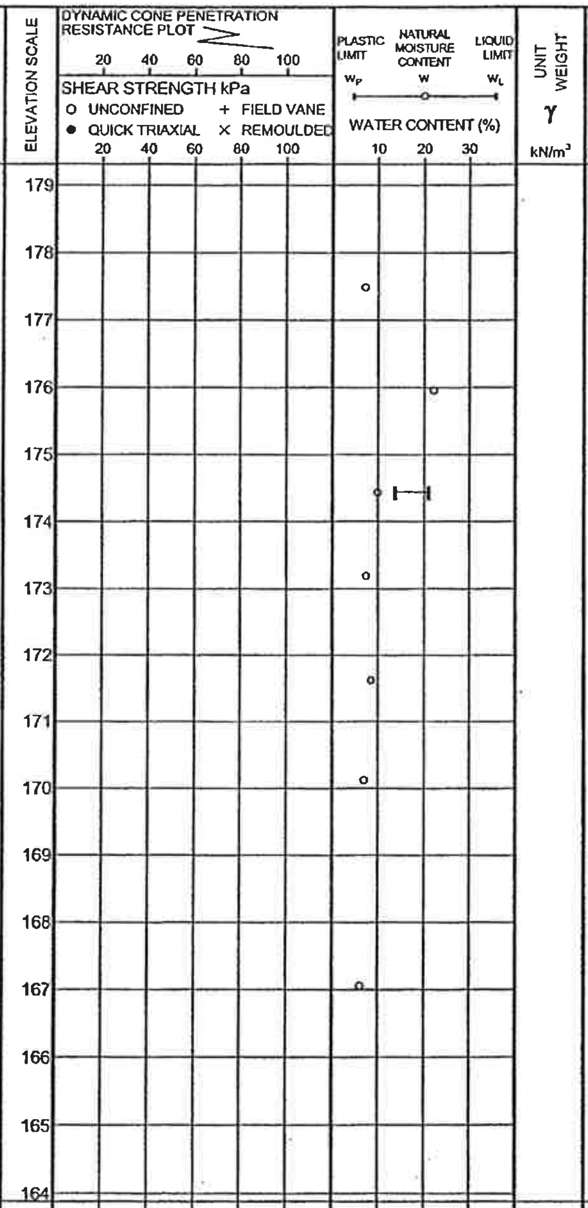
DATE January 31, 2007

ORIGINATED BY BML

COMPILED BY BML

CHECKED BY HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.3	GROUND SURFACE					
0.0	Sand and Gravel, trace asphalt (FILL) Dense Light brown Moist	1	SS	31		
177.5 1.8	Clayey Silt, some sand (Probable FILL) Stiff to very stiff Brown Moist	2	SS	26		
		3	SS	11		
	Sand seam, compact, dark brown to grey, moist between 3.7 to 4.1 m depth	4	SS	15		
174.7 4.6	Clayey Silt with Sand (TILL) Very stiff Brown Moist	5	SS	24		5 32 43 20
173.4 5.9	Silty Sand to Sandy Silt, trace to some clay (TILL), trace to some gravel, occasional boulders Very dense Grey Moist	6	SS	50/0.0		
		7	SS	[illegible]		
		8	SS	[illegible]		
		9	SS	[illegible]		
		10	SS	[illegible]	∇	5 36 50 9
166.4 12.9	Silty Sand, some gravel and clay (Residual Soil) Very dense Reddish brown Moist	11	SS	[illegible]		
165.5 13.9	Red SHALE BEDROCK (Queenston Formation) with interlayers of grey siltstone	12	SS	50/0.0		
163.9 15.4	End of Borehole					



Notes:

1. Water level in open borehole at 12.2 m depth (Elev. 167.1 m) upon completion of drilling.

2. Borehole open to 15.4 m depth upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity

$○^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No BH11

1 OF 1 **METRIC**

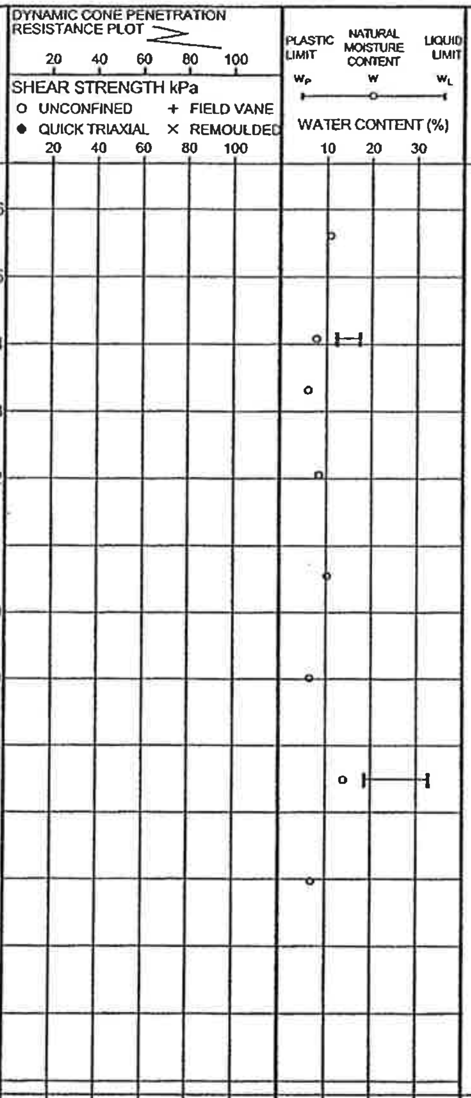
PROJECT 06-1111-021			
W.P.	LOCATION N 4820973.6 ;E 603423.8	ORIGINATED BY BML	
DIST	HWY Ridgeway Dr	BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers	COMPILED BY BML
DATUM Geodetic	DATE January 29, 2007	CHECKED BY HJ	

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
176.7	GROUND SURFACE
0.0	Topsoil
0.3	Clayey Silt with Sand (TILL) Very stiff to hard Brown Moist Becoming grey below 2.1 m (Elev. 174.6 m)
173.0 3.7	Silty Sand to Sandy Silt, trace to some clay (TILL) Very dense Grey Moist
167.8 8.8	Clayey Silt to Silty Clay, trace sand Hard Grey Moist
166.3	Silty Sand, some gravel and clay (Residual Soil) Very dense Reddish brown Moist
10.7	Red SHALE BEDROCK (Queenston Formation) with interlayers of grey siltstone
162.8 13.9	End of Borehole

SAMPLES

NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	28		
2	SS	37		
3	SS	26		
4	SS	58		
5	SS	56/0.15		
6	SS	50/0.10		
7	SS	84/0.07		
8	SS	75/0.10		
9	SS	50/0.10		0 4 51 45
10	SS	50/0.07	∇	
11	SS	50/0.07		
12	SS	80/0.15		



Notes:

1. Water level in open borehole at 10.7 m depth (Elev. 166.0 m) upon completion of drilling.

2. Borehole open to 12.5 m depth upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity

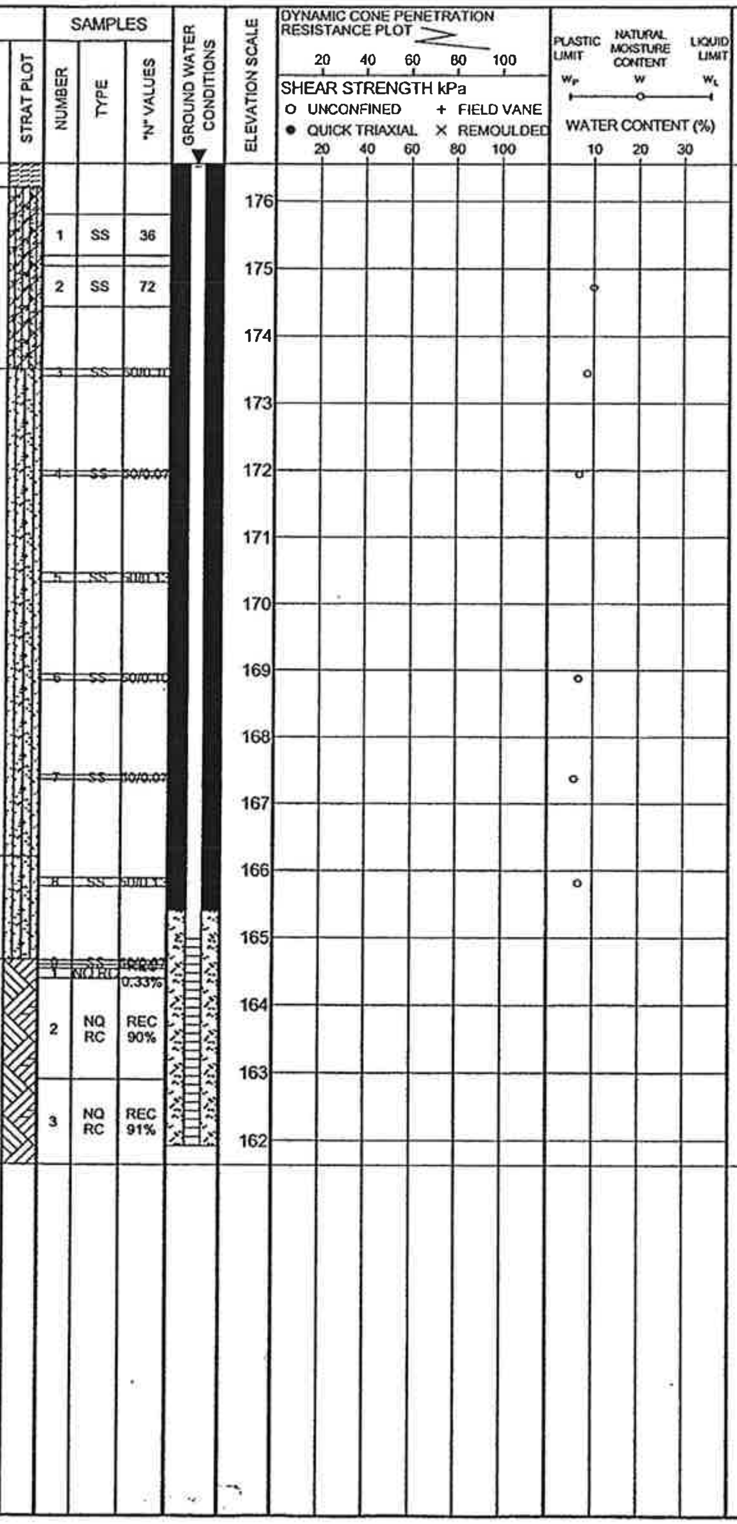
$O^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No BH12

1 OF 1 **METRIC**

PROJECT 06-1111-021			
W.P.	LOCATION N 4820987.6 ;E 603433.6		ORIGINATED BY BML
DIST	HWY Ridgeway Dr	BOREHOLE TYPE CME 75 Track Mount, 110 mm I.D. Solid Stem Augers	COMPILED BY BML
DATUM Geodetic		DATE February 1, 2007	CHECKED BY HJ

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
176.6	GROUND SURFACE				
176.2 0.0	Topsoil				
0.4	Clayey Silt with Sand (TILL) Hard Brown Moist	1	SS	36	
		2	SS	72	
	Becoming grey below 2.3 m depth (Elev. 174.3 m)				
173.5 3.1	Silty Sand to Sandy Silt, trace to some clay (TILL) Very dense Grey	3	SS	50/0.10	
		4	SS	50/0.07	
	Some gravel in auger cuttings, augers grinding on possible cobbles/boulders at 5.2 m depth	5	SS	50/0.13	
		6	SS	50/0.10	
		7	SS	10/0.07	
166.2 10.4	Silty Sand, some gravel and clay (Residual Soil) Very dense Reddish brown Moist	8	SS	50/0.13	
164.7 11.9	Red SHALE BEDROCK (Queenston Formation) with interlayers of grey siltstone and limestone	9	SS	50/0.07	
		1	NQ RC	REC 0.33%	RQD = 0%
	NQ Coring from 12.0 m depth to 14.9 m depth (Elev. 164.2 m to 161.7 m)	2	NQ RC	REC 90%	RQD = 63%
	For coring details see Record of Drillhole BH12	3	NQ RC	REC 91%	RQD = 18%
161.6 14.9	End of Borehole Note: 1. Water level in piezometer on April 3, 2007 at 0.0 m depth (Elev. 176.6 m).				



$+^3, \times^3$: Numbers refer to Sensitivity

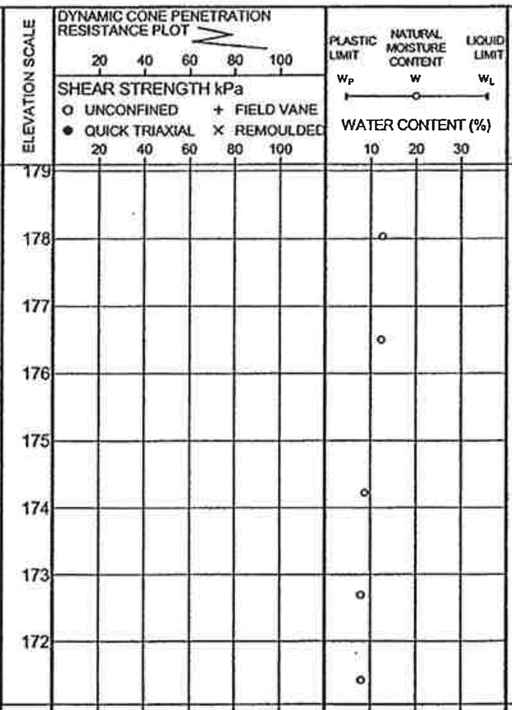
$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No BH13

1 OF 1 **METRIC**

PROJECT 06-1111-021
W.P.
DIST
HWY Ridgeway Dr
DATUM Geodetic
LOCATION N 4820997.5 ;E 603410.1
BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers
DATE January 30, 2007
ORIGINATED BY BML
COMPILED BY BML
CHECKED BY HJ

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.1	GROUND SURFACE						
0.0	Topsoil						
0.3	Clayey Silt with Sand (TILL) Very stiff to hard Brown Moist	1	SS	23			
		2	SS	28			
		3	SS	33			
		4	SS	43			
	Becoming grey below 4.3 m depth (Elev. 174.8 m)	5	SS	28			
172.7 6.4	Silty Sand to Sandy Silt, trace to some clay (TILL), contains rock fragments Very dense Moist	6	SS	65			
		7	SS	50/0.1			
171.1 8.1	End of Borehole						



Notes:

1. Open borehole dry upon completion of drilling.

2. Borehole open to 8.1 m depth upon completion of drilling.

MIS-MTO 001 06-1111-021.GPJ GAL-MISS.GDT 7/20/07 DD

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

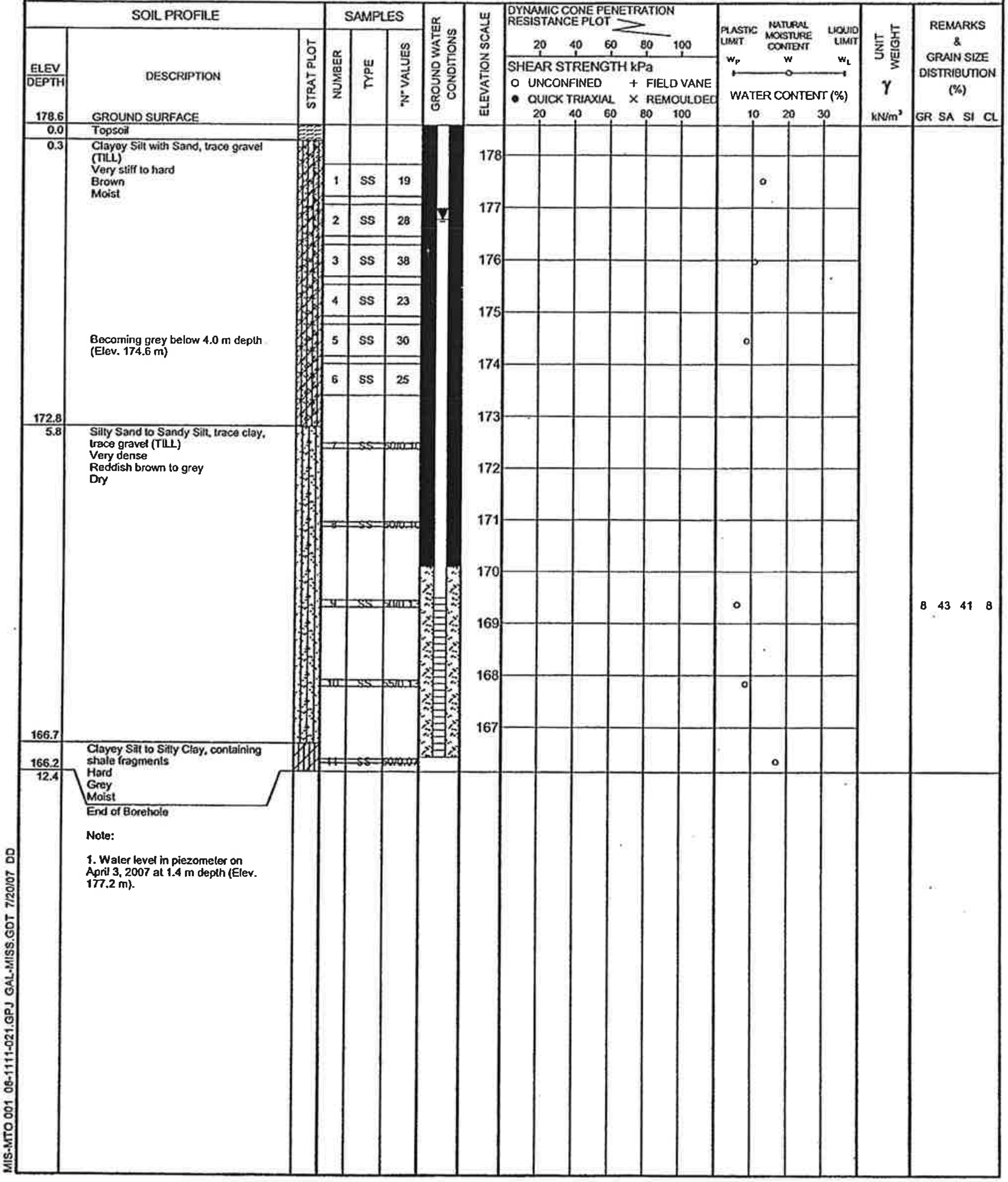
Golder Associates

Foundation Design

RECORD OF BOREHOLE No BH18

1 OF 1 METRIC

PROJECT 06-1111-021
W.P.
DIST
HWY Ridgeway Dr
DATUM Geodetic
LOCATION N 4821028.4 ;E 603386.5
BOREHOLE TYPE CME 75 Track Mount, 110 mm I.D. Solid Stem Augers
DATE January 22, 2007
ORIGINATED BY BML
COMPILED BY BML
CHECKED BY HJ



ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
178.6	GROUND SURFACE				
0.0	Topsoil				
0.3	Clayey Silt with Sand, trace gravel (TILL) Very stiff to hard Brown Moist	1	SS	19	
		2	SS	28	
		3	SS	38	
		4	SS	23	
	Becoming grey below 4.0 m depth (Elev. 174.6 m)	5	SS	30	
		6	SS	25	
172.8 5.8	Silty Sand to Sandy Silt, trace clay, trace gravel (TILL) Very dense Reddish brown to grey Dry	7	SS	50/0.10	
		8	SS	50/0.10	
		9	SS	50/0.13	8 43 41 8
		10	SS	55/0.13	
166.7	Clayey Silt to Silty Clay, containing shale fragments Hard Grey Moist	11	SS	50/0.07	
166.2 12.4	End of Borehole				

Note:

1. Water level in piezometer on April 3, 2007 at 1.4 m depth (Elev. 177.2 m).

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No BH19

1 OF 1 **METRIC**

PROJECT 06-1111-021		
W.P.	LOCATION N 4821046.6 ;E 603401.7	ORIGINATED BY BML
DIST HWY Ridgeway Dr	BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers	COMPILED BY BML
DATUM Geodetic	DATE January 23, 2007	CHECKED BY HJ

SOIL PROFILE			SAMPLES				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
177.9	GROUND SURFACE						
0.0 0.2	Topsoil						
	Silty Clay, some sand, trace gravel (TILL) Firm to stiff Brown Moist		1	SS	3		
			2	SS	10		177
			3	SS	14		176
175.6	Clayey Silt with sand, trace gravel (TILL) Hard Brown Moist		4	SS	40		175
			5	SS	44		
174.2 3.7	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

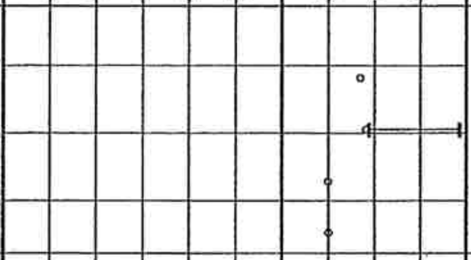
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL



Notes:

1. Open borehole dry upon completion of drilling.

2. Borehole open to 3.7 m depth upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity

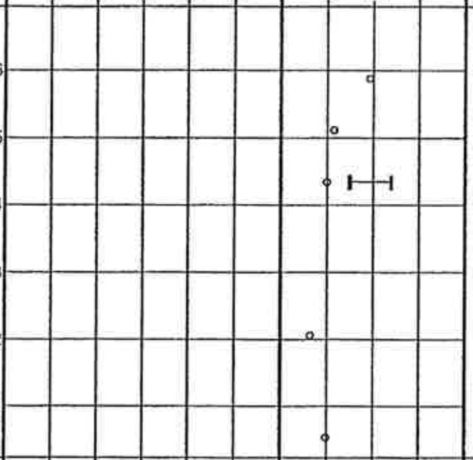
$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No BH20

1 OF 1 **METRIC**

PROJECT 06-1111-021
W.P.
DIST
HWY Ridgeway Dr
DATUM Geodetic
LOCATION N 4821058.6 ;E 603342.9
BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers
DATE January 22, 2007
ORIGINATED BY BML
COMPILED BY BML
CHECKED BY HJ

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE			kN/m³	GR	SA	SI	CL
176.9	GROUND SURFACE													
0.0	Topsoil													
0.3	Clayey Silt with Sand (TILL) Firm to hard Brown Moist		1	SS	6		176							
			2	SS	17		175							
			3	SS	45		174							
173.3			4	SS	32									
3.6	Silty Sand to Sandy Silt, trace to some clay (TILL), occasional cobbles Very dense Grey Moist Augers grinding from 3.6 m to 3.8 m depth						173							
			5	SS	92		172				10	31	42	17
							171							
170.2			6	SS	98									
6.7	End of Borehole Notes: 1. Open borehole dry upon completion of drilling. 2. Borehole open to 5.5 m depth upon completion of drilling.													



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

RECORD OF BOREHOLE No BH21

1 OF 1 **METRIC**

PROJECT 06-1111-021			
W.P.	LOCATION N 4821098.4 ;E 603299.1		ORIGINATED BY BML
DIST	HWY Ridgeway Dr	BOREHOLE TYPE CME 75 Track Mount, 102 mm Solid Stem Augers	COMPILED BY BML
DATUM Geodetic	DATE January 22, 2007		CHECKED BY HJ

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
179.9	GROUND SURFACE					
0.0	Clayey silt, trace to some sand, organics and rootlets (FILL) Very soft Dark brown Moist					179
		1	SS	1		
		2	SS	1		178
177.3 2.5	Clayey Silt with Sand (TILL) Very stiff to hard Brown Moist	3	SS	8		177
		4	SS	20		
		5	SS	33		176
		6	SS	41		175
						174
173.7	Silty Sand to Sandy Silt, trace to some clay (TILL), containing rock fragments Very dense Reddish brown Moist	7	SS	72		
173.2 6.7	End of Borehole					

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

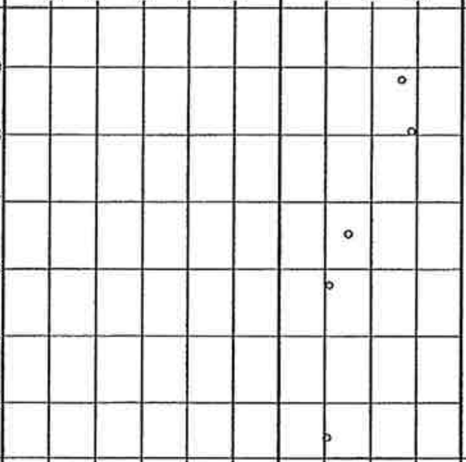
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

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

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL



Notes:

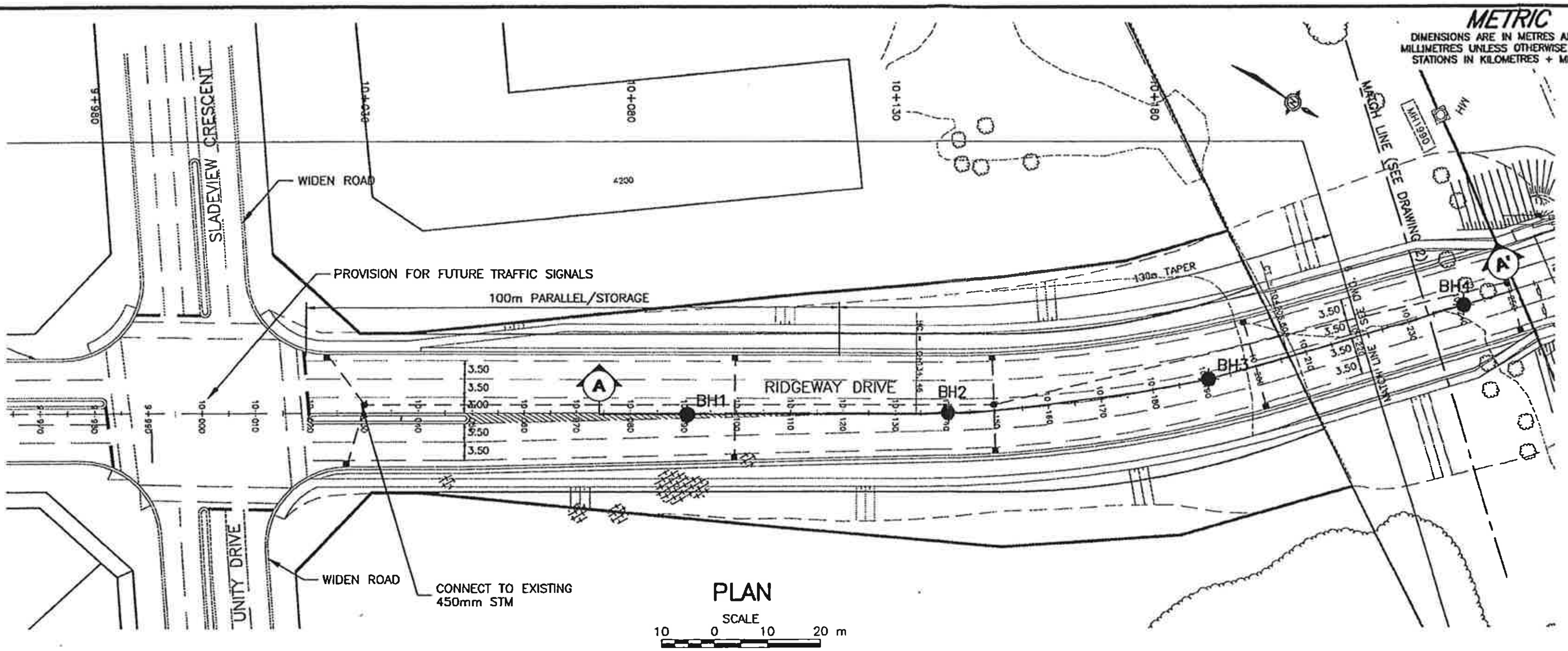
1. Open borehole dry upon completion of drilling.

2. Borehole open to 5.8 m depth upon completion of drilling.

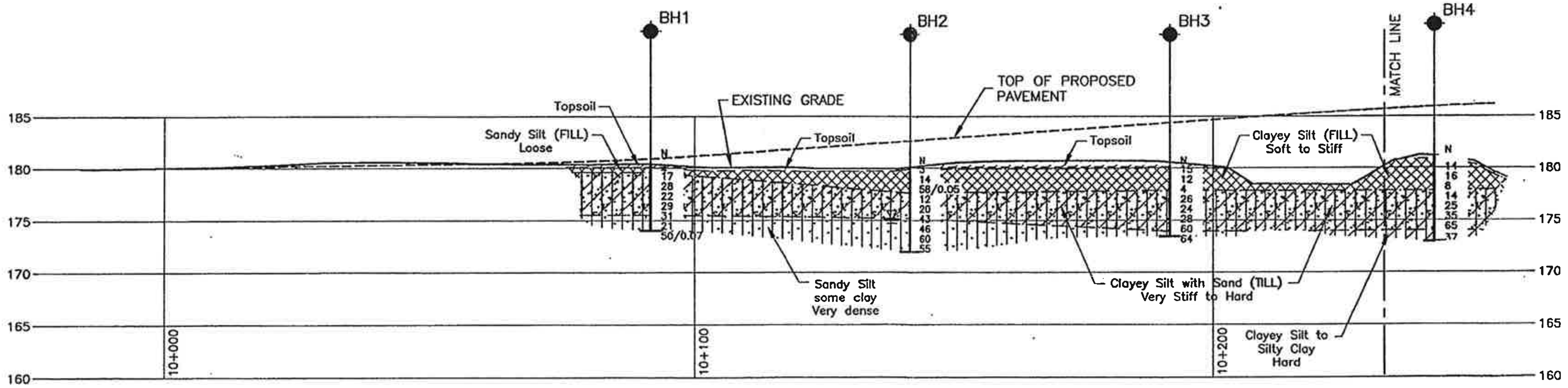
$+^3, \times^3$: Numbers refer to Sensitivity $○^{3\%}$ STRAIN AT FAILURE

MINISTRY OF TRANSPORTATION, ONTARIO

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



PLAN



PROFILE A–A' ALONG RIDGEWAY DRIVE STATION 10+075 TO STATION 10+232

SCALE
HOR 10 0 10 20 m

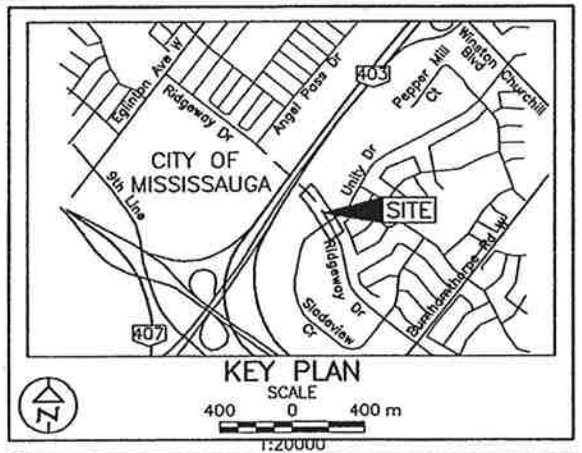
SCALE
VER 5 0 5 10 m
1:250

CONT No.
WP No.

SHEET

RIDGEWAY DR./HIGHWAY 403 GRADE SEPARATION
BOREHOLE LOCATIONS AND SOIL STRATA
SOUTH OF HIGHWAY 403/HIGHWAY 407 RAMPS

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

LEGEND

●	Borehole
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
▽	WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
BH1	180.5	4820789.2	603605.4
BH2	180.2	4820831.8	603579.3
BH3	180.2	4820871.1	603548.2
BH4	181.2	4820905.2	603511.4

NOTES

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

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

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

REFERENCE

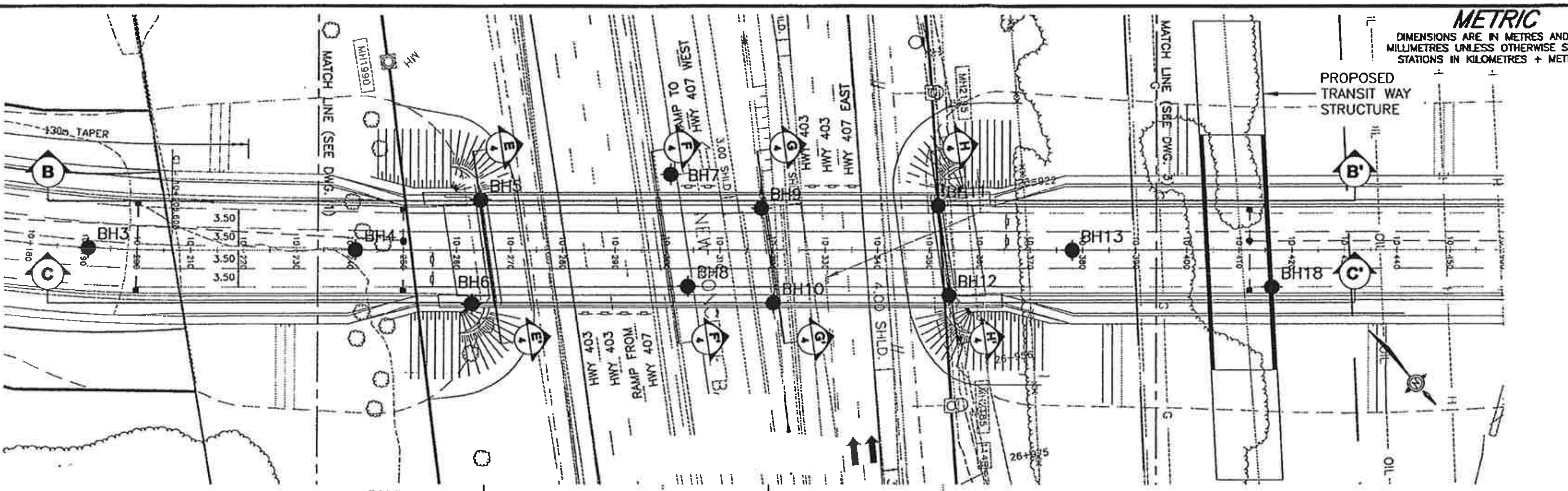
Base plans provided in digital format by Phillips Engineering Limited, drawing file nos. xdesign.dwg; xalign.dwg; 403xb1.dwg and xbase.dwg, received December 11, 2006. and drawing files nos. 06053–01.dwg, 06053–02.dwg and 06053–03.dwg, recieved December 14, 2006.

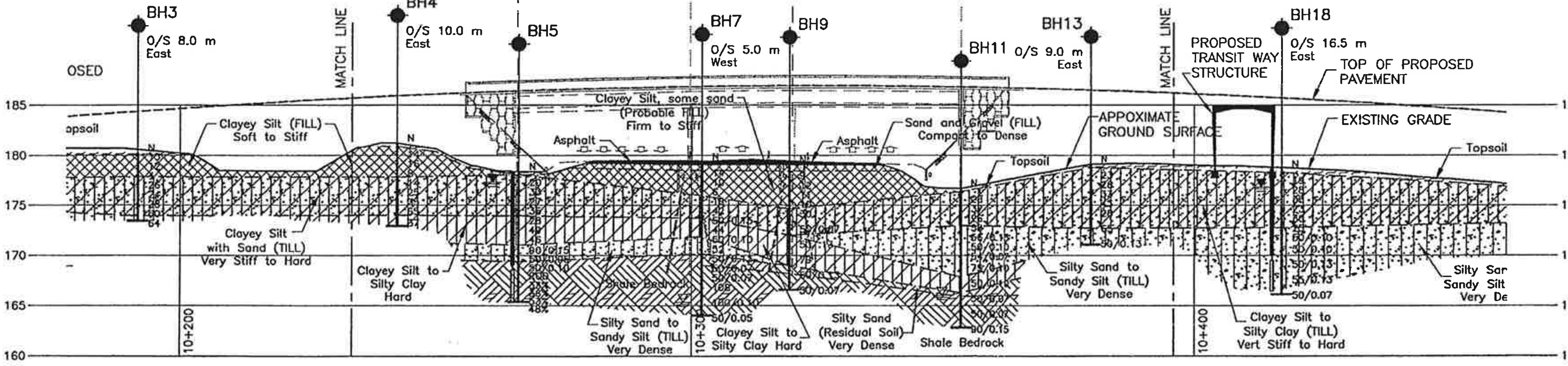
NO.	DATE	BY	REVISION

Geocres No.

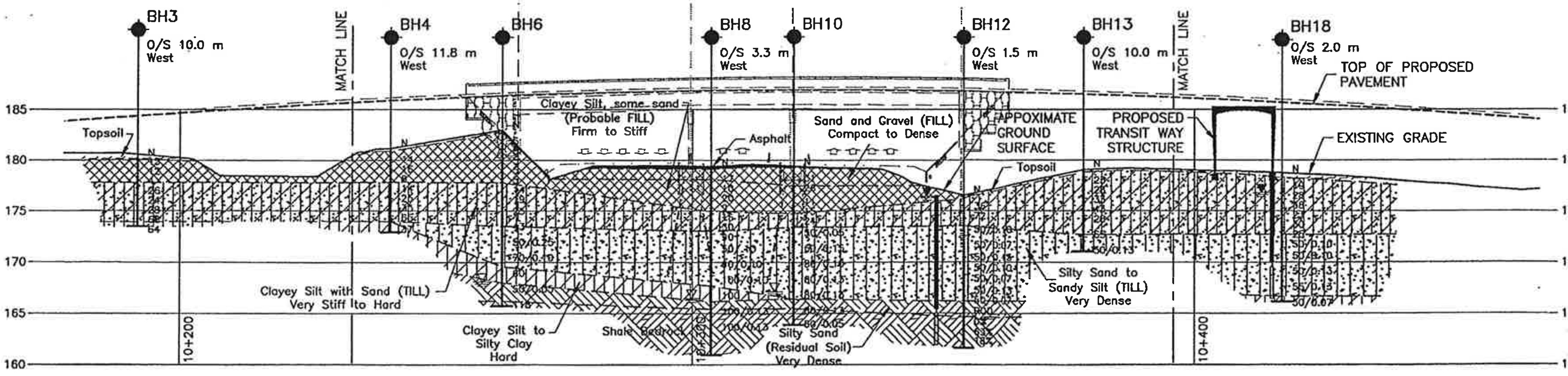
HWY. RIDGEWAY DR		PROJECT NO. 06–1111–021	DIST.
SUBM'D. BML	CHKD. BML	DATE: JULY 2007	SITE:
DRAWN: JFC/MSM	CHKD. HJ	APPD. JMAC	DWG. 1

MINISTRY OF TRANSPORTATION, ONTARIO





PROFILE B–B' RIDGEWAY DRIVE STATION 10+232 TO STATION 10+395



PROFILE C–C' RIDGEWAY DRIVE STATION 10+232 TO STATION 10+395

SCALE
HOR 10 0 10 20 m

SCALE
VER 5 0 5 10 m
1:250

REFERENCE

Base plans provided in digital format by Phillips Engineering Limited. drawing file nos. xdesign.dwg; xalign.dwg; 403xb1.dwg and xbase.dwg, received December 11, 2006. and drawing files nos. 06053–01.dwg, 06053–02.dwg and 06053–03.dwg, recieved July 10, 2007.

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

CONT No.
WP No.

SHEET

RIDGEWAY DR./HIGHWAY 403 GRADE SEPARATION
BOREHOLE LOCATIONS AND SOIL STRATA
HIGHWAY 403/HIGHWAY 407 RAMPS

Golder Associates

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

KEY PLAN
SCALE
400 0 400 m
1:20000

LEGEND

●	Borehole
	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 on April 3, 2007
	WL upon completion of drilling

No.	ELEVATION	CO–ORDINATES	
		NORTHING	EASTING
BH3	180.2	4820871.1	603548.2
BH4	181.2	4820905.2	603511.4
BH5	178.4	4820914.0	603487.7
BH6	183.0	4820927.5	603502.1
BH7	179.3	4820934.8	603457.6
BH8	179.3	4820952.8	603469.6
BH9	179.0	4820951.1	603449.2
BH10	179.3	4820965.9	603459.5
BH11	176.7	4820973.6	603423.8
BH12	176.6	4820987.6	603433.6
BH13	179.1	4820997.5	603410.1
BH18	178.6	4821028.4	603386.5

NOTES

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

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

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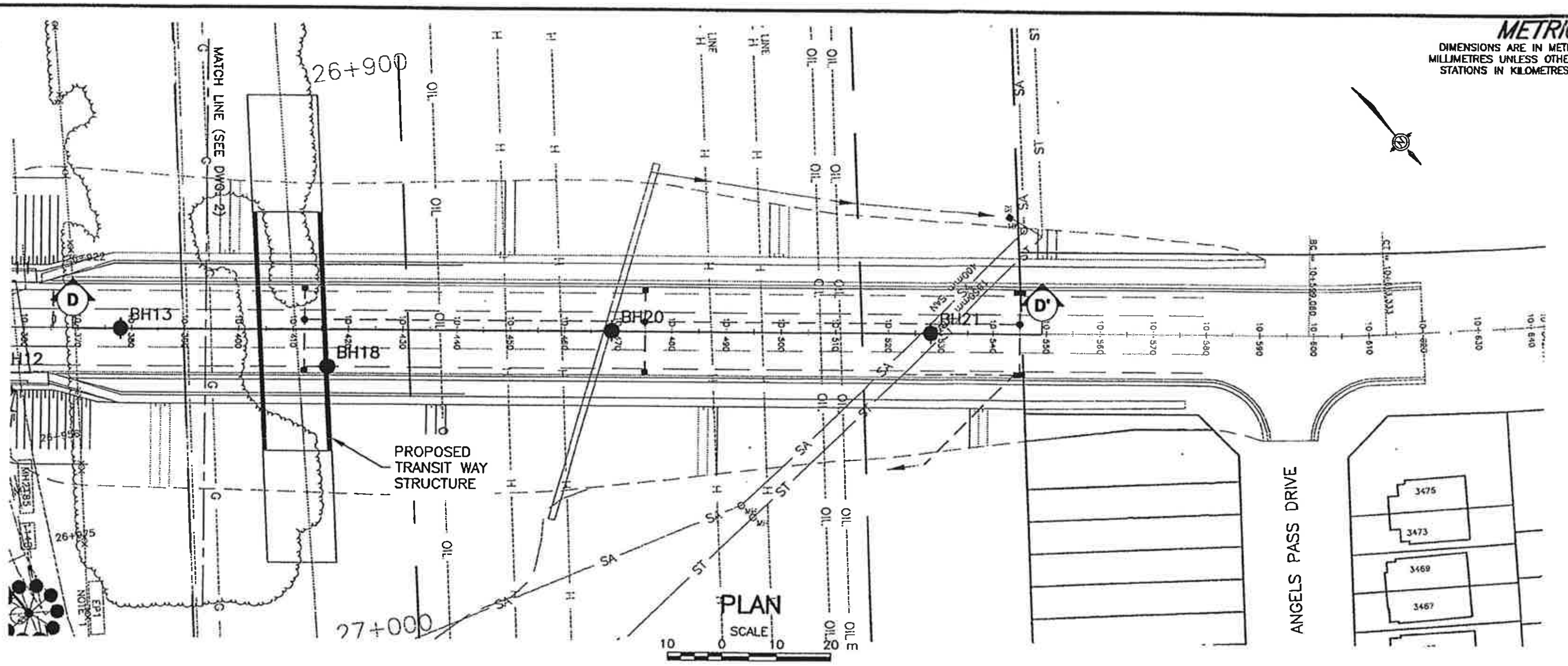
NO.	DATE	BY	REVISION

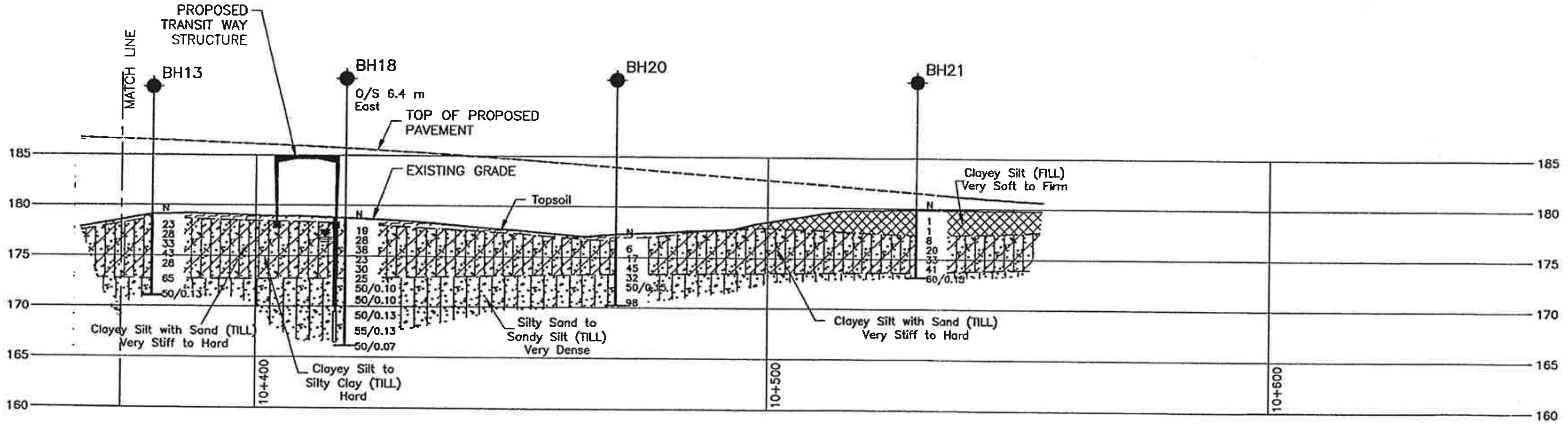
Geocres No.

HWY. RIDGEWAY DR		PROJECT NO. 06–1111–021	DIST.
SUBM'D. BML	CHKD. BML	DATE: JULY 2007	SITE:
DRAWN: JFC	CHKD. HJ	APPD. JMAC	DWG. 2

MINISTRY OF TRANSPORTATION, ONTARIO



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



PROFILE D–D' RIDGEWAY DRIVE STATION 10+395 TO STATION 10+555

SCALE
HOR 10 0 10 20 m

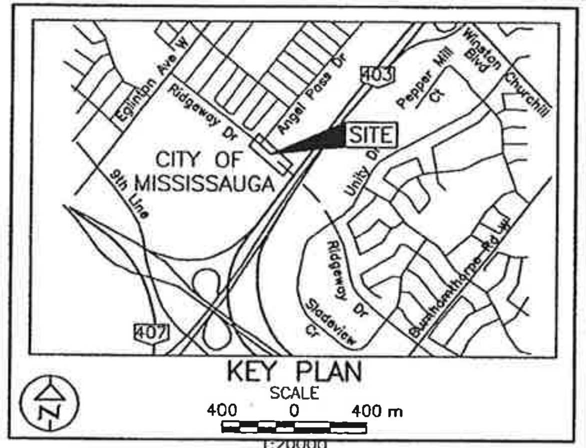
SCALE
VER 5 0 5 10 m
1:250

CONT No.
WP No.

SHEET

RIDGEWAY DR./HIGHWAY 403 GRADE SEPARATION
BOREHOLE LOCATIONS AND SOIL STRATA
NORTH OF HIGHWAY 403/HIGHWAY 407 RAMPS

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE
400 0 400 m
1:20000

LEGEND

●	Borehole
	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 on April 3, 2007

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
BH13	179.1	4820997.5	603410.1
BH18	178.6	4821028.4	603386.5
BH20	176.9	4821058.6	603342.9
BH21	179.9	4821098.4	603299.1

NOTES

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

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NO.	DATE	BY	REVISION

Geocres No.

HWY. RIDGEWAY DR		PROJECT NO. 06–1111–021	DIST.
SUBM'D. BML	CHKD. BML	DATE: JULY 2007	SITE:
DRAWN: JFC	CHKD. HJ	APPD. JMAC	DWG. 3

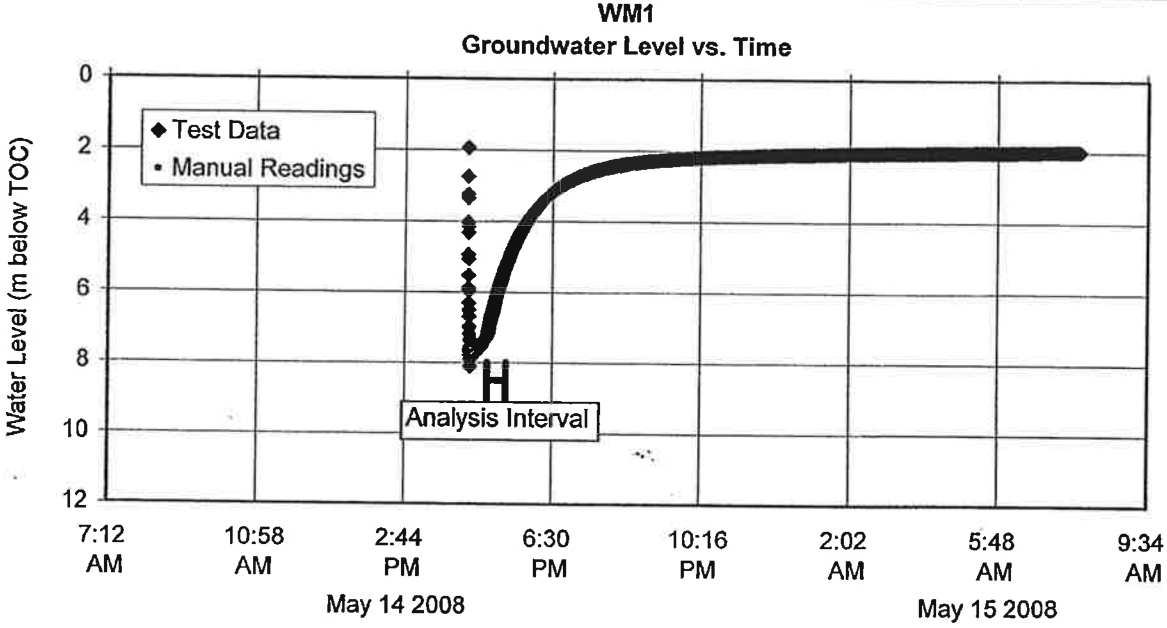
APPENDIX C

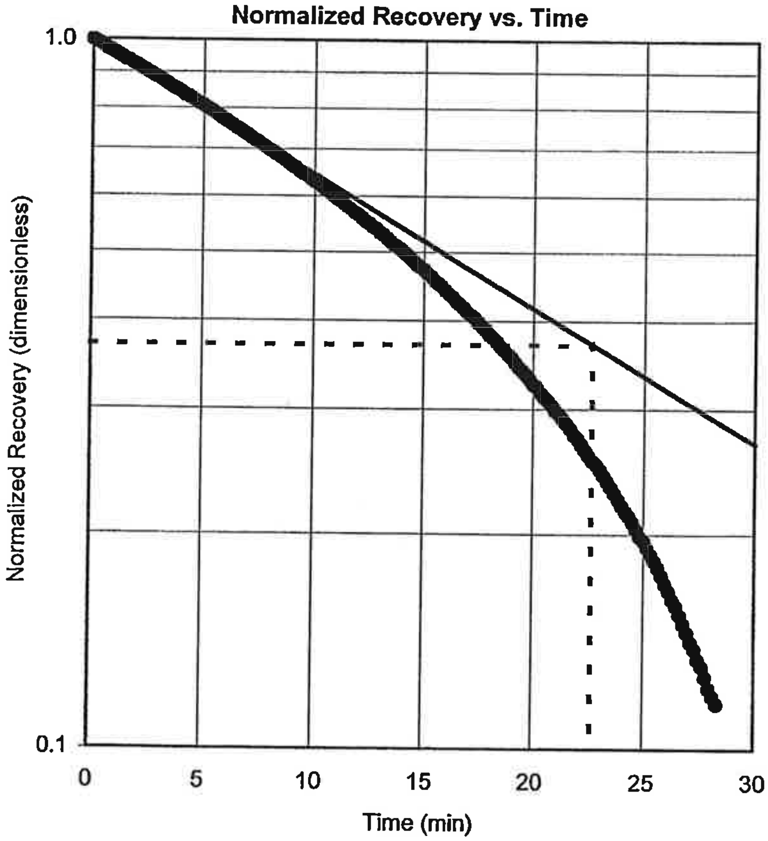
HYDRAULIC CONDUCTIVITY TEST RESULTS

In Situ Hydraulic Conductivity Test Report for WM1

Philips / Geotech Invest / Mississauga Groundwater Monitoring System

FIGURE C1





Sand Pack Interval

5.6m to 7.7m

Time Lag (T_0) = 1.8 min

Sand Pack Length (L) = 2.1 m

Well Radius (r) = 0.025 m

Hole Radius (R) = 0.051 m

Hvorslev Analysis

$$K = \frac{(r^2)\ln(L/R)}{2T_0L} = 4 \times 10^{-5} \text{ cm/s}$$

DATE: May 2008

PROJECT: 08-1111-0014

Golder Associates

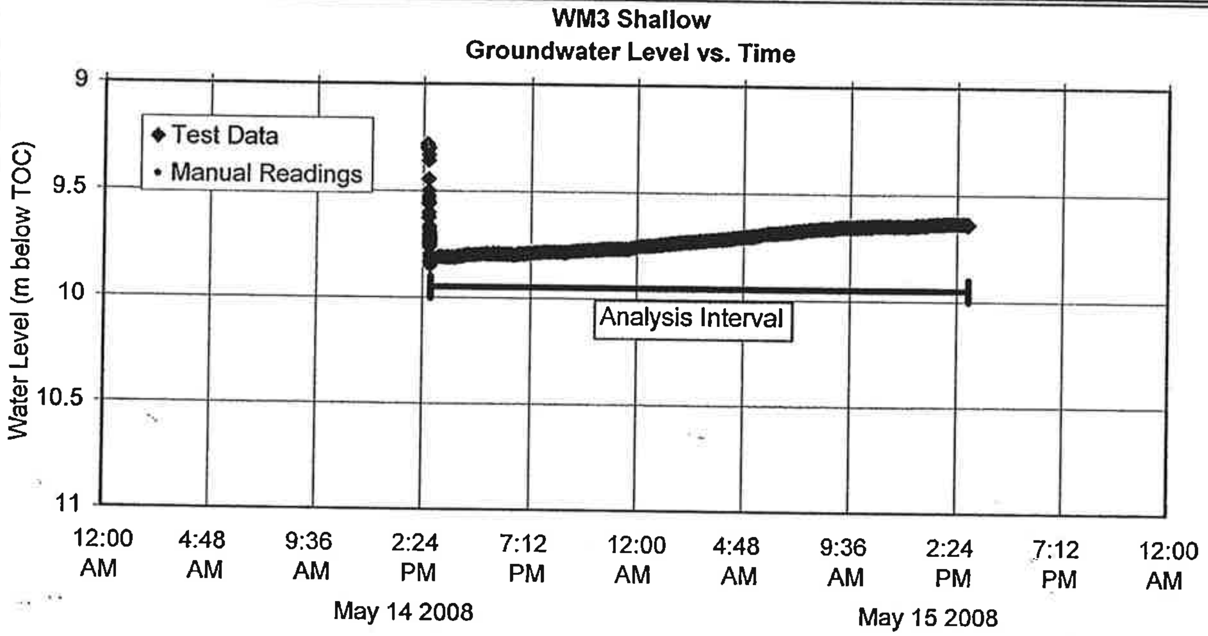
prepared by: LE

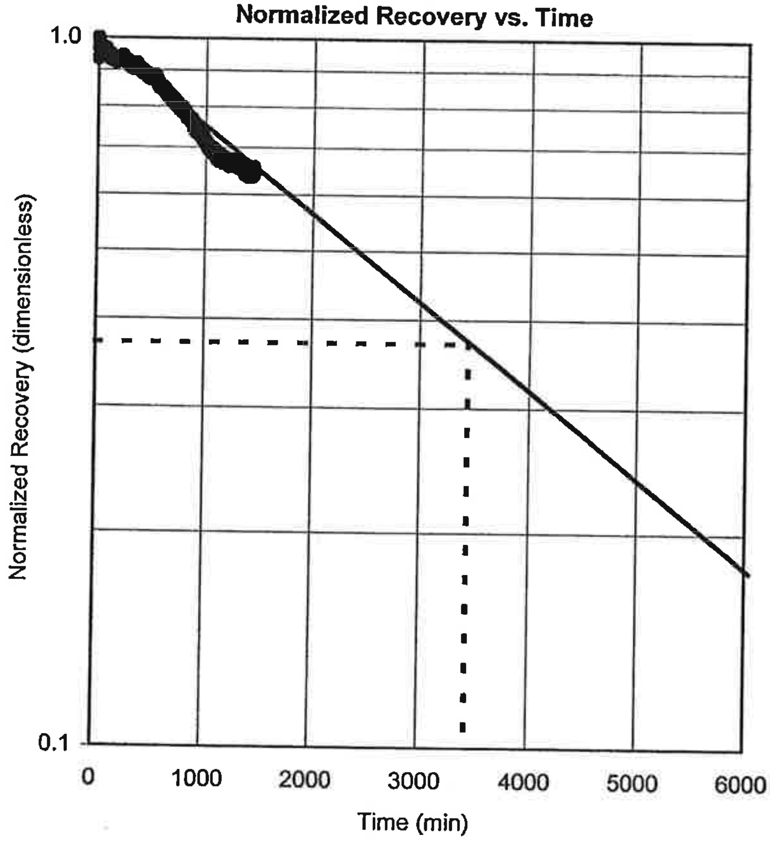
CHK: SMD

In Situ Hydraulic Conductivity Test Report for WM3-S

Philips / Geotech Invest / Mississauga Groundwater Monitoring System

FIGURE C2





Sand Pack Interval

6.9m to 9.1m

Time Lag (T_0) = 224.8 min

Sand Pack Length (L) = 2.2 m

Well Radius (r) = 0.025 m

Hole Radius (R) = 0.051 m

Hvorslev Analysis

$$K = \frac{(r^2)\ln(L/R)}{2T_0L} = 3 \times 10^{-7} \text{ cm/s}$$

DATE: May 2008

PROJECT: 08-1111-0014

Golder Associates

prepared by: LE

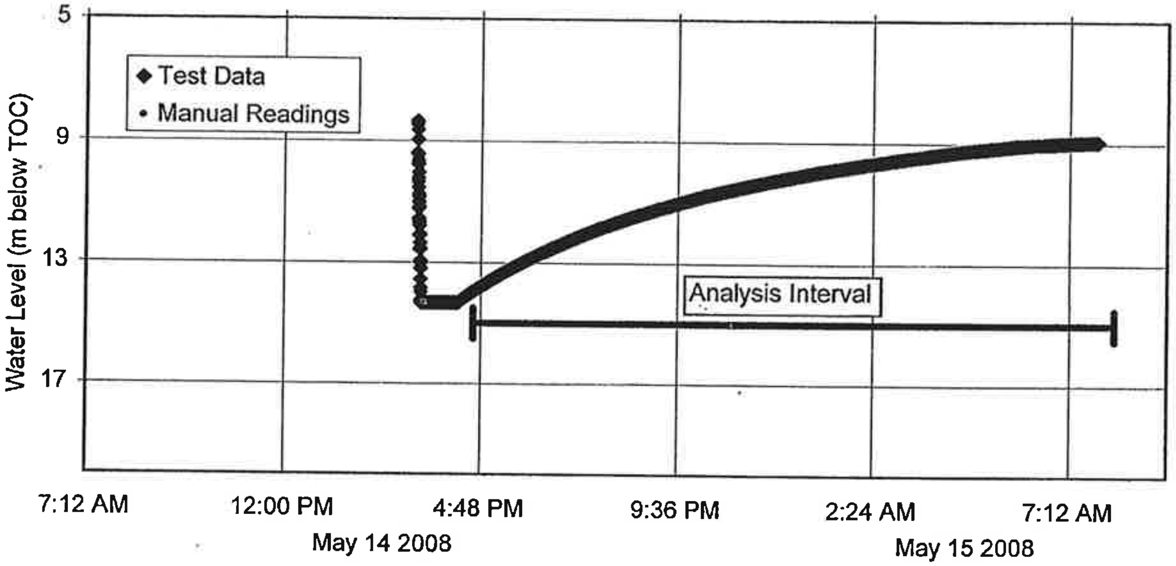
CHK: SMD

In Situ Hydraulic Conductivity Test Report for WM3-D

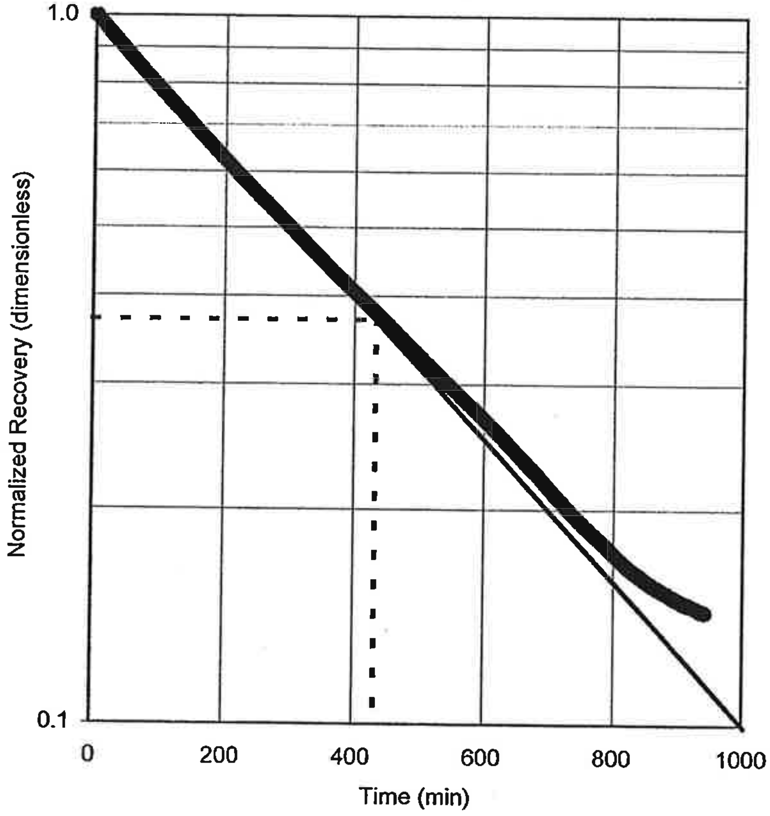
Philips / Geotech Invest / Mississauga Groundwater Monitoring System

FIGURE C3

WM3-Deep
Groundwater Level vs. Time



Normalized Recovery vs. Time



Sand Pack Interval

11.2m to 13.7m

Time Lag (T_0) = 42.2 min

Sand Pack Length (L) = 2.5 m

Well Radius (r) = 0.025 m

Hole Radius (R) = 0.051 m

Hvorslev Analysis

$$K = \frac{(r^2)\ln(L/R)}{2T_0L} = 2 \times 10^{-6} \text{ cm/s}$$

DATE: May 2008

PROJECT: 08-1111-0014

Golder Associates

prepared by: LE

CHK: SMD

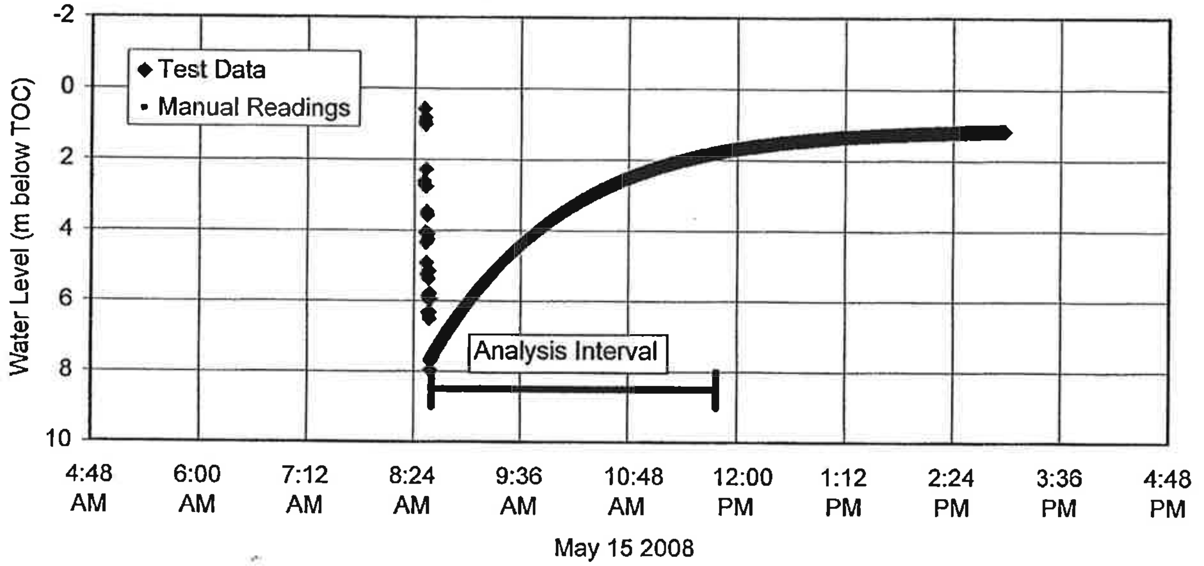
In Situ Hydraulic Conductivity Test Report for BH5

Philips / Geotech Invest / Mississauga Groundwater Monitoring System

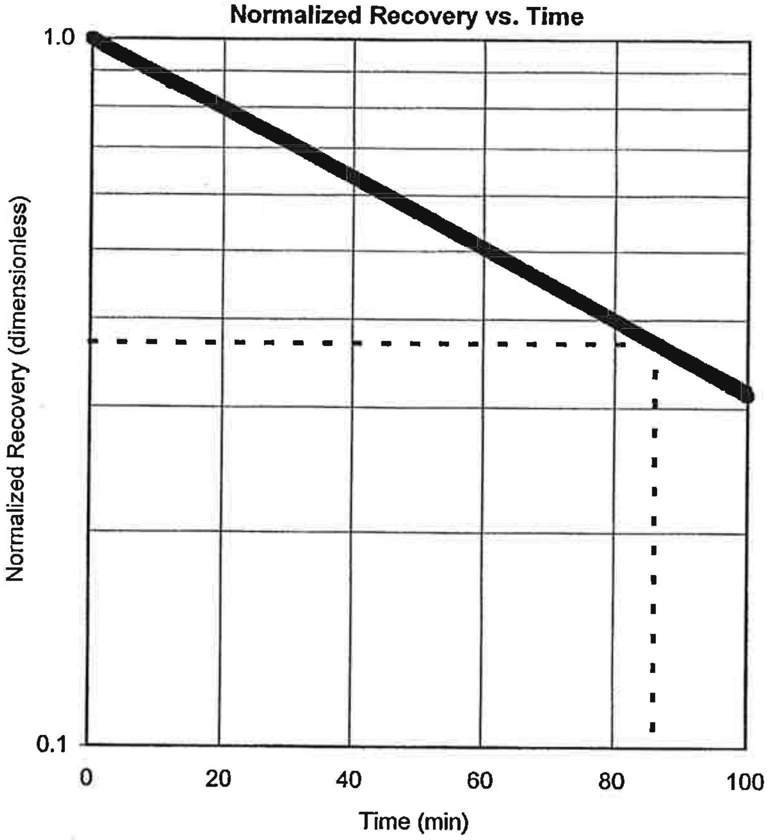
FIGURE C4

BH5

Groundwater Level vs. Time



Normalized Recovery vs. Time



Sand Pack Interval

9.4m to 13.0m

Time Lag (T_0) = 8.7 min

Sand Pack Length (L) = 3.6 m

Well Radius (r) = 0.025 m

Hole Radius (R) = 0.051 m

Hvorslev Analysis

$$K = \frac{(r^2)\ln(L/R)}{2T_0L} = 7 \times 10^{-6} \text{ cm/s}$$

DATE: May 2008

PROJECT: 08-1111-0014

Golder Associates

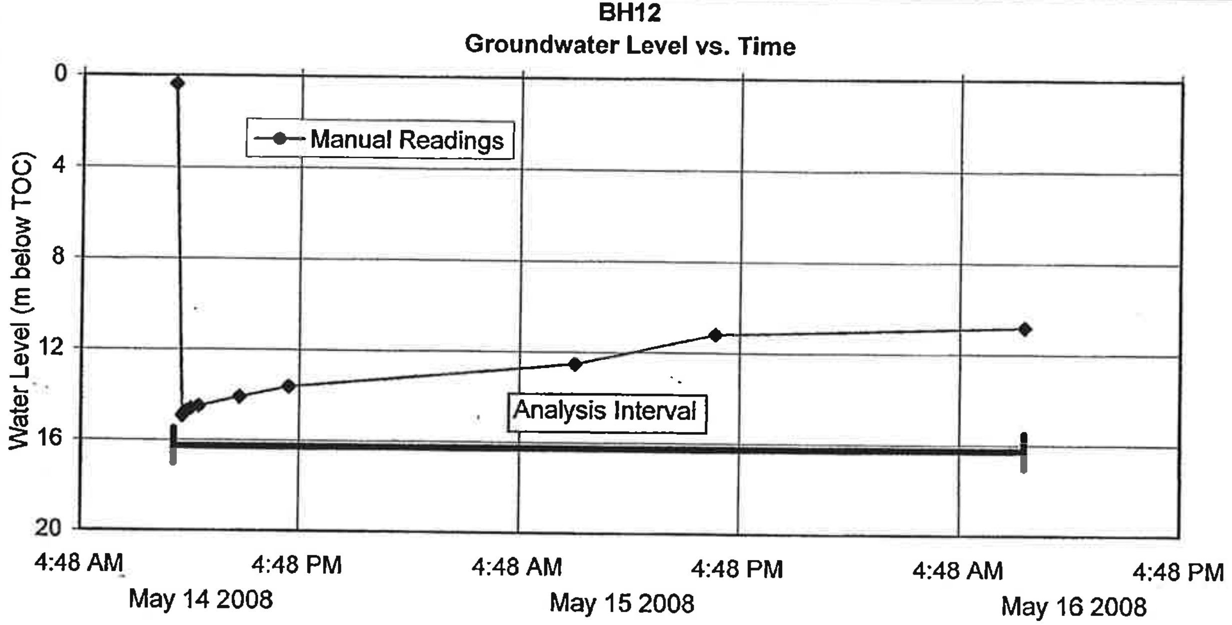
prepared by: LE

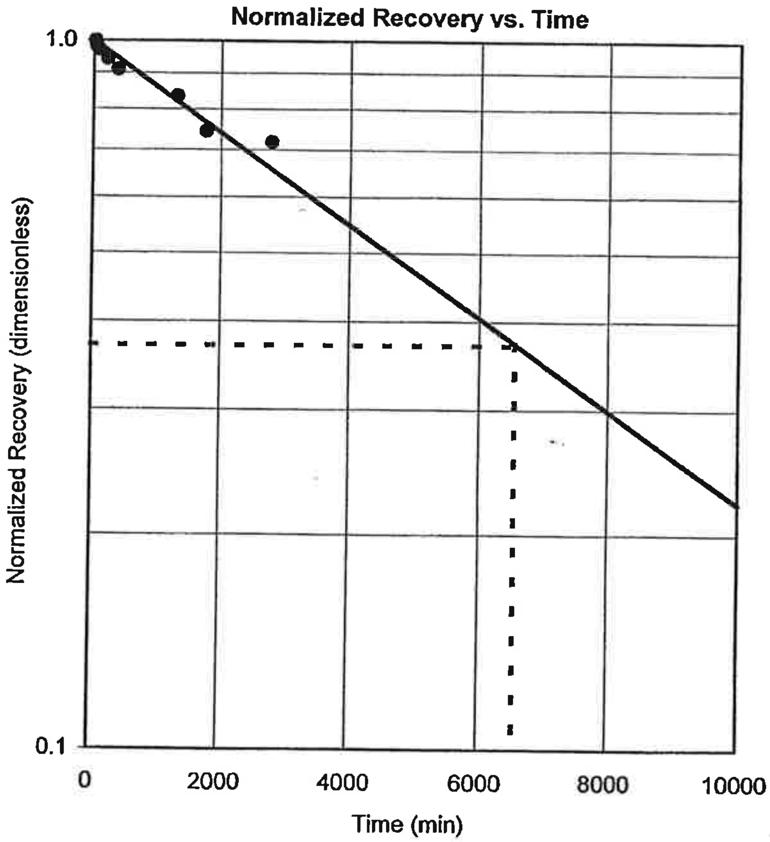
CHK: SMD

In Situ Hydraulic Conductivity Test Report for BH12

Philips / Geotech Invest / Mississauga Groundwater Monitoring System

FIGURE C5





Sand Pack Interval

11.2m to 14.7m

Time Lag (T_0) = N/A

Sand Pack Length (L) = 3.5 m

Well Radius (r) = 0.025 m

Hole Radius (R) = 0.051 m

Hvorslev Analysis

$$K = \frac{(r^2)\ln(L/R)}{2T_0L} = 1 \times 10^{-7} \text{ cm/s}$$

DATE: May 2008

PROJECT: 08-1111-0014

Golder Associates

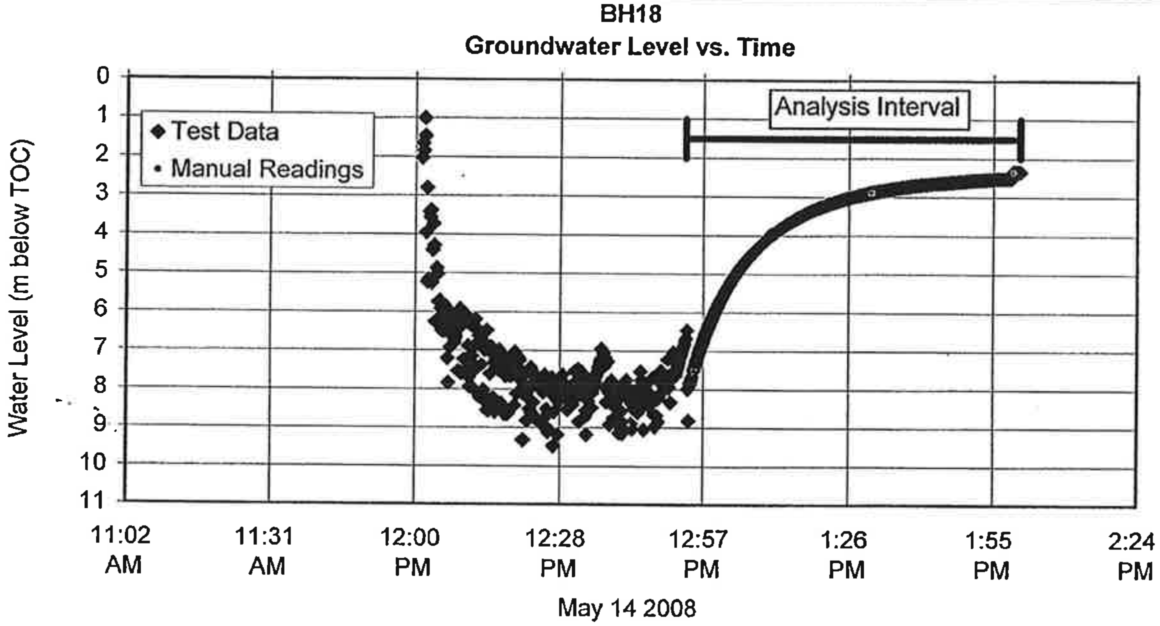
prepared by: LE

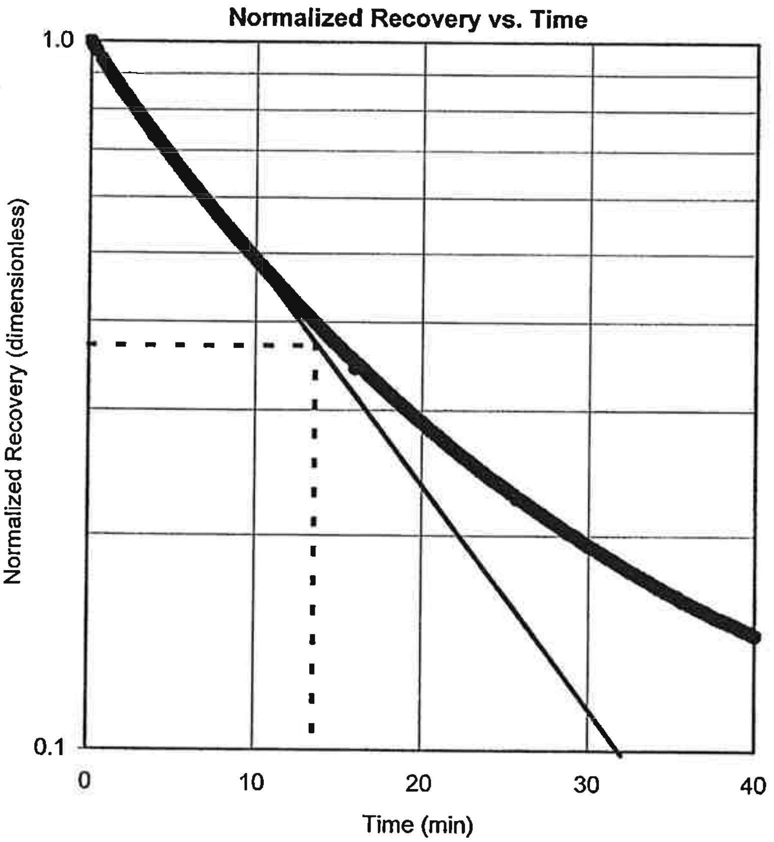
CHK: SMD

In Situ Hydraulic Conductivity Test Report for BH18

Philips / Geotech Invest / Mississauga Groundwater Monitoring System

FIGURE C6





Sand Pack Interval

8.6m to 12.1m

Time Lag (T_0) = 1.4 min

Sand Pack Length (L) = 3.5 m

Well Radius (r) = 0.025 m

Hole Radius (R) = 0.051 m

Hvorslev Analysis

$$K = \frac{(r^2)\ln(L/R)}{2T_0L} = 5 \times 10^{-5} \text{ cm/s}$$

DATE: May 2008

PROJECT: 08-1111-0014

Golder Associates

prepared by: LE

CHK: SMD

APPENDIX D

WATER QUALITY TEST RESULT

Maxxam Analytics Inc

Driven by service and Science
www.maxxamanalytics.com

Your Project #: 08-1111-0014
Site: PHILLIPS/WATER MAIN/MISS
Your C.O.C. #: 82646-01

Attention: Shannon Palmer
Golder Associates Ltd
Mississauga - Standing Offer
2390 Argentia Rd
Mississauga, ON
L5N 5Z7

Report Date: 2008/05/23

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A849191
Received: 2008/05/15, 09:59

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Alkalinity	1	N/A	2008/05/21	CAM SOP-00448	SM 2320B
Carbonate, Bicarbonate and Hydroxide	1	N/A	2008/05/22		
Chloride by Automated Colourimetry	1	N/A	2008/05/20	CAM SOP-00463	SM 4500 Cl E
Conductivity	1	N/A	2008/05/21	CAM SOP-00448	SM 2510
Dissolved Organic Carbon (DOC)	1	N/A	2008/05/20	CAM SOP-00446	SM 5310 B
Hardness (calculated as CaCO3)	1	N/A	2008/05/23	CAM SOP 0102	SM 2340 B
Dissolved Metals by ICPMS	1	N/A	2008/05/22	CAM SOP-00447	EPA 6020
Ion Balance (% Difference)	1	N/A	2008/05/23		
Anion and Cation Sum	1	N/A	2008/05/23		
Ammonia-N	1	N/A	2008/05/21	CAM SOP-00441	US GS I-2522-90
Nitrate (NO3) and Nitrite (NO2) in Water (1)	1	N/A	2008/05/20	CAM SOP-00440	SM 4500 NO3 I
pH	1	N/A	2008/05/21	CAM SOP-00448	SM 4500H
Orthophosphate	1	N/A	2008/05/20	CAM SOP-00461	SM 4500 P-F
Sat. pH and Langelier Index (@ 20C)	1	N/A	2008/05/23		
Sat. pH and Langelier Index (@ 4C)	1	N/A	2008/05/23		
Sulphate by Automated Colourimetry	1	N/A	2008/05/20	CAM SOP-00464	EPA 375.4
Total Dissolved Solids (TDS calc)	1	N/A	2008/05/23		

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

Encryption Key

Sara Saroop
23 May 2008 14:48:42 -04:00

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

KRISTEN BURMEISTER, Project Manager
Email: Kristen.Burmeister@maxxamanalytics.com
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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CAEAL have approved this reporting process and electronic report format.

For Service Group specific validation please refer to the Validation Signature Page

Total cover pages: 1

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		Y63991		
Sampling Date		2008/05/14		
COC Number		82646-01		
	Units	**WM1**	**RDL**	**QC Batch**
Calculated Parameters				
Anion Sum	me/L	8.75	N/A	1514578
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	304	1	1514670
Calculated TDS	mg/L	485	1	1514674
Carb. Alkalinity (calc. as CaCO3)	mg/L	4	1	1514670
Cation Sum	me/L	8.94	N/A	1514578
Hardness (CaCO3)	mg/L	270	1	1514679
Ion Balance (% Difference)	%	1.06	N/A	1514577
Langelier Index (@ 20C)	N/A	0.911		1514672
Langelier Index (@ 4C)	N/A	0.663		1514673
Saturation pH (@ 20C)	N/A	7.28		1514672
Saturation pH (@ 4C)	N/A	7.53		1514673
Inorganics				
Total Ammonia-N	mg/L	0.53	0.05	1517041
Conductivity	umho/cm	823	2	1517852
Dissolved Organic Carbon	mg/L	2.8	0.1	1516905
Orthophosphate (P)	mg/L	<0.01	0.01	1516138
pH	pH	8.2		1517851
Dissolved Sulphate (SO4)	mg/L	53	1	1516140
Alkalinity (Total as CaCO3)	mg/L	309	1	1517853
Dissolved Chloride (Cl)	mg/L	52	1	1516132
Nitrite (N)	mg/L	<0.01	0.01	1516116
Nitrate (N)	mg/L	<0.1	0.1	1516116
Nitrate + Nitrite	mg/L	<0.1	0.1	1516116
Metals				
Dissolved Aluminum (Al)	ug/L	32	5	1518602
Dissolved Antimony (Sb)	ug/L	<0.5	0.5	1518602
Dissolved Arsenic (As)	ug/L	2	1	1518602
Dissolved Barium (Ba)	ug/L	86	5	1518602
Dissolved Beryllium (Be)	ug/L	<0.5	0.5	1518602
Dissolved Bismuth (Bi)	ug/L	<1	1	1518602
Dissolved Boron (B)	ug/L	280	10	1518602
Dissolved Cadmium (Cd)	ug/L	<0.1	0.1	1518602

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: A849191
Report Date: 2008/05/23

Golder Associates Ltd
Client Project #: 08-1111-0014
Project name: PHILLIPS/WATER MAIN/MISS

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		Y63991		
Sampling Date		2008/05/14		
COC Number		82646-01		
	Units	WM1	RDL	QC Batch
Dissolved Calcium (Ca)	ug/L	49000	200	1518602
Dissolved Chromium (Cr)	ug/L	<5	5	1518602
Dissolved Cobalt (Co)	ug/L	1.4	0.5	1518602
Dissolved Copper (Cu)	ug/L	2	1	1518602
Dissolved Iron (Fe)	ug/L	<100	100	1518602
Dissolved Lead (Pb)	ug/L	<0.5	0.5	1518602
Dissolved Magnesium (Mg)	ug/L	34000	50	1518602
Dissolved Manganese (Mn)	ug/L	120	2	1518602
Dissolved Molybdenum (Mo)	ug/L	8	1	1518602
Dissolved Nickel (Ni)	ug/L	<1	1	1518602
Dissolved Phosphorus (P)	ug/L	<100	100	1518602
Dissolved Potassium (K)	ug/L	5700	200	1518602
Dissolved Selenium (Se)	ug/L	<2	2	1518602
Dissolved Silicon (Si)	ug/L	12000	50	1518602
Dissolved Silver (Ag)	ug/L	<0.1	0.1	1518602
Dissolved Sodium (Na)	ug/L	79000	100	1518602
Dissolved Strontium (Sr)	ug/L	670	1	1518602
Dissolved Thallium (Tl)	ug/L	<0.05	0.05	1518602
Dissolved Titanium (Ti)	ug/L	<5	5	1518602
Dissolved Uranium (U)	ug/L	6.2	0.1	1518602
Dissolved Vanadium (V)	ug/L	<1	1	1518602
Dissolved Zinc (Zn)	ug/L	<5	5	1518602

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Package 1	10.3°C

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

GENERAL COMMENTS

Results relate only to the items tested.

Golder Associates Ltd
Attention: Shannon Palmer
Client Project #: 08-1111-0014
P.O. #:
Project name: PHILLIPS/WATER MAIN/MISS

Quality Assurance Report

Maxxam Job Number: MA849191

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
1516116 CCI	MATRIX SPIKE	Nitrite (N)	2008/05/20		NC (1)	%	75 - 125
		Nitrate (N)	2008/05/20		93	%	75 - 125
	Spiked Blank	Nitrite (N)	2008/05/20		103	%	80 - 120
		Nitrate (N)	2008/05/20		87	%	80 - 120
	Method Blank	Nitrite (N)	2008/05/20	<0.01		mg/L	
		Nitrate (N)	2008/05/20	<0.1		mg/L	
		Nitrate + Nitrite	2008/05/20	<0.1		mg/L	
	RPD	Nitrite (N)	2008/05/20	3.0		%	25
		Nitrate (N)	2008/05/20	0.4		%	25
		Nitrate + Nitrite	2008/05/20	0.5		%	25
1516132 DRM	MATRIX SPIKE [Y63991-01]	Dissolved Chloride (Cl)	2008/05/20		NC (1)	%	75 - 125
	Spiked Blank	Dissolved Chloride (Cl)	2008/05/20		103	%	80 - 120
	Method Blank	Dissolved Chloride (Cl)	2008/05/20	<1		mg/L	
	RPD [Y63991-01]	Dissolved Chloride (Cl)	2008/05/20	0.06		%	20
1516138 C_N	MATRIX SPIKE [Y63991-01]	Orthophosphate (P)	2008/05/20		110	%	75 - 125
	Spiked Blank	Orthophosphate (P)	2008/05/20		102	%	80 - 120
	Method Blank	Orthophosphate (P)	2008/05/20	<0.01		mg/L	
	RPD [Y63991-01]	Orthophosphate (P)	2008/05/20	NC		%	25
1516140 DRM	MATRIX SPIKE [Y63991-01]	Dissolved Sulphate (SO4)	2008/05/20		NC (1)	%	75 - 125
	Spiked Blank	Dissolved Sulphate (SO4)	2008/05/20		104	%	80 - 120
	Method Blank	Dissolved Sulphate (SO4)	2008/05/20	<1		mg/L	
	RPD [Y63991-01]	Dissolved Sulphate (SO4)	2008/05/20	1.4		%	25
1516905 AHA	MATRIX SPIKE	Dissolved Organic Carbon	2008/05/20		98	%	75 - 125
	Spiked Blank	Dissolved Organic Carbon	2008/05/20		102	%	75 - 125
	Method Blank	Dissolved Organic Carbon	2008/05/20	<0.1		mg/L	
	RPD	Dissolved Organic Carbon	2008/05/20	0		%	20
1517041 ADB	MATRIX SPIKE	Total Ammonia-N	2008/05/21		98	%	80 - 120
	Spiked Blank	Total Ammonia-N	2008/05/21		105	%	80 - 120
	Method Blank	Total Ammonia-N	2008/05/21	<0.05		mg/L	
	RPD	Total Ammonia-N	2008/05/21	NC		%	25
1517852 JDE	QC STANDARD	Conductivity	2008/05/21		102	%	85 - 115
	Method Blank	Conductivity	2008/05/21	<2		umho/cm	
	RPD	Conductivity	2008/05/21	0.2		%	25
1517853 JDE	QC STANDARD	Alkalinity (Total as CaCO3)	2008/05/21		99	%	85 - 115
	Method Blank	Alkalinity (Total as CaCO3)	2008/05/21	<1		mg/L	
	RPD	Alkalinity (Total as CaCO3)	2008/05/21	0.04		%	25
1518602 HRE	MATRIX SPIKE	Dissolved Aluminum (Al)	2008/05/22		91	%	80 - 120
		Dissolved Antimony (Sb)	2008/05/22		101	%	80 - 120
		Dissolved Arsenic (As)	2008/05/22		102	%	80 - 120
		Dissolved Barium (Ba)	2008/05/22		98	%	80 - 120
		Dissolved Beryllium (Be)	2008/05/22		103	%	80 - 120
		Dissolved Bismuth (Bi)	2008/05/22		94	%	80 - 120
		Dissolved Boron (B)	2008/05/22		104	%	80 - 120
		Dissolved Cadmium (Cd)	2008/05/22		101	%	80 - 120
		Dissolved Calcium (Ca)	2008/05/22		NC (1)	%	80 - 120
		Dissolved Chromium (Cr)	2008/05/22		98	%	80 - 120
		Dissolved Cobalt (Co)	2008/05/22		96	%	80 - 120
		Dissolved Copper (Cu)	2008/05/22		97	%	80 - 120
		Dissolved Iron (Fe)	2008/05/22		101	%	80 - 120
		Dissolved Lead (Pb)	2008/05/22		95	%	80 - 120
		Dissolved Magnesium (Mg)	2008/05/22		96	%	80 - 120
		Dissolved Manganese (Mn)	2008/05/22		NC	%	80 - 120

Quality Assurance Report (Continued)

Maxxam Job Number: MA849191

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
1518602 HRE	MATRIX SPIKE	Dissolved Molybdenum (Mo)	2008/05/22		103	%	80 - 120
		Dissolved Nickel (Ni)	2008/05/22		97	%	80 - 120
		Dissolved Phosphorus (P)	2008/05/22		104	%	80 - 120
		Dissolved Potassium (K)	2008/05/22		101	%	80 - 120
		Dissolved Selenium (Se)	2008/05/22		99	%	80 - 120
		Dissolved Silicon (Si)	2008/05/22		99	%	80 - 120
		Dissolved Silver (Ag)	2008/05/22		96	%	80 - 120
		Dissolved Sodium (Na)	2008/05/22		99	%	80 - 120
		Dissolved Strontium (Sr)	2008/05/22		101	%	80 - 120
		Dissolved Thallium (Tl)	2008/05/22		94	%	80 - 120
		Dissolved Titanium (Ti)	2008/05/22		101	%	80 - 120
		Dissolved Uranium (U)	2008/05/22		97	%	80 - 120
		Dissolved Vanadium (V)	2008/05/22		99	%	80 - 120
		Dissolved Zinc (Zn)	2008/05/22		99	%	80 - 120
	Spiked Blank	Dissolved Aluminum (Al)	2008/05/22		96	%	85 - 115
		Dissolved Antimony (Sb)	2008/05/22		100	%	85 - 115
		Dissolved Arsenic (As)	2008/05/22		102	%	85 - 115
		Dissolved Barium (Ba)	2008/05/22		101	%	85 - 115
		Dissolved Beryllium (Be)	2008/05/22		103	%	85 - 115
		Dissolved Bismuth (Bi)	2008/05/22		96	%	85 - 115
		Dissolved Boron (B)	2008/05/22		107	%	85 - 115
		Dissolved Cadmium (Cd)	2008/05/22		100	%	85 - 115
		Dissolved Calcium (Ca)	2008/05/22		103	%	85 - 115
		Dissolved Chromium (Cr)	2008/05/22		99	%	85 - 115
		Dissolved Cobalt (Co)	2008/05/22		98	%	85 - 115
		Dissolved Copper (Cu)	2008/05/22		99	%	85 - 115
		Dissolved Iron (Fe)	2008/05/22		103	%	85 - 115
		Dissolved Lead (Pb)	2008/05/22		97	%	85 - 115
		Dissolved Magnesium (Mg)	2008/05/22		100	%	85 - 115
		Dissolved Manganese (Mn)	2008/05/22		99	%	85 - 115
		Dissolved Molybdenum (Mo)	2008/05/22		101	%	85 - 115
		Dissolved Nickel (Ni)	2008/05/22		98	%	85 - 115
		Dissolved Phosphorus (P)	2008/05/22		94	%	85 - 115
		Dissolved Potassium (K)	2008/05/22		101	%	85 - 115
		Dissolved Selenium (Se)	2008/05/22		100	%	85 - 115
		Dissolved Silicon (Si)	2008/05/22		103	%	85 - 115
		Dissolved Silver (Ag)	2008/05/22		97	%	85 - 115
		Dissolved Sodium (Na)	2008/05/22		102	%	85 - 115
		Dissolved Strontium (Sr)	2008/05/22		102	%	85 - 115
		Dissolved Thallium (Tl)	2008/05/22		95	%	85 - 115
		Dissolved Titanium (Ti)	2008/05/22		102	%	85 - 115
		Dissolved Uranium (U)	2008/05/22		98	%	85 - 115
		Dissolved Vanadium (V)	2008/05/22		101	%	85 - 115
		Dissolved Zinc (Zn)	2008/05/22		100	%	85 - 115
	Method Blank	Dissolved Aluminum (Al)	2008/05/22	<5		ug/L	
		Dissolved Antimony (Sb)	2008/05/22	<0.5		ug/L	
		Dissolved Arsenic (As)	2008/05/22	<1		ug/L	
		Dissolved Barium (Ba)	2008/05/22	<5		ug/L	
		Dissolved Beryllium (Be)	2008/05/22	<0.5		ug/L	
		Dissolved Bismuth (Bi)	2008/05/22	<1		ug/L	
		Dissolved Boron (B)	2008/05/22	<10		ug/L	
		Dissolved Cadmium (Cd)	2008/05/22	<0.1		ug/L	
		Dissolved Calcium (Ca)	2008/05/22	<200		ug/L	
		Dissolved Chromium (Cr)	2008/05/22	<5		ug/L	
		Dissolved Cobalt (Co)	2008/05/22	<0.5		ug/L	

Quality Assurance Report (Continued)

Maxxam Job Number: MA849191

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
1518602 HRE	Method Blank	Dissolved Copper (Cu)	2008/05/22	<1		ug/L	
		Dissolved Iron (Fe)	2008/05/22	<100		ug/L	
		Dissolved Lead (Pb)	2008/05/22	<0.5		ug/L	
		Dissolved Magnesium (Mg)	2008/05/22	<50		ug/L	
		Dissolved Manganese (Mn)	2008/05/22	<2		ug/L	
		Dissolved Molybdenum (Mo)	2008/05/22	<1		ug/L	
		Dissolved Nickel (Ni)	2008/05/22	<1		ug/L	
		Dissolved Phosphorus (P)	2008/05/22	<100		ug/L	
		Dissolved Potassium (K)	2008/05/22	<200		ug/L	
		Dissolved Selenium (Se)	2008/05/22	<2		ug/L	
		Dissolved Silicon (Si)	2008/05/22	<50		ug/L	
		Dissolved Silver (Ag)	2008/05/22	<0.1		ug/L	
		Dissolved Sodium (Na)	2008/05/22	<100		ug/L	
		Dissolved Strontium (Sr)	2008/05/22	<1		ug/L	
		Dissolved Thallium (Tl)	2008/05/22	<0.05		ug/L	
		Dissolved Titanium (Ti)	2008/05/22	<5		ug/L	
		Dissolved Uranium (U)	2008/05/22	<0.1		ug/L	
		Dissolved Vanadium (V)	2008/05/22	<1		ug/L	
		Dissolved Zinc (Zn)	2008/05/22	<5		ug/L	
	RPD	Dissolved Aluminum (Al)	2008/05/22	NC		%	25
		Dissolved Antimony (Sb)	2008/05/22	NC		%	25
		Dissolved Arsenic (As)	2008/05/22	NC		%	25
		Dissolved Barium (Ba)	2008/05/22	NC		%	25
		Dissolved Beryllium (Be)	2008/05/22	NC		%	25
		Dissolved Boron (B)	2008/05/22	NC		%	25
		Dissolved Cadmium (Cd)	2008/05/22	NC		%	25
		Dissolved Calcium (Ca)	2008/05/22	1		%	25
		Dissolved Chromium (Cr)	2008/05/22	NC		%	25
		Dissolved Cobalt (Co)	2008/05/22	NC		%	25
		Dissolved Copper (Cu)	2008/05/22	NC		%	25
		Dissolved Iron (Fe)	2008/05/22	0.1		%	25
		Dissolved Lead (Pb)	2008/05/22	NC		%	25
		Dissolved Manganese (Mn)	2008/05/22	0.4		%	25
		Dissolved Molybdenum (Mo)	2008/05/22	NC		%	25
		Dissolved Nickel (Ni)	2008/05/22	NC		%	25
		Dissolved Selenium (Se)	2008/05/22	NC		%	25
		Dissolved Silver (Ag)	2008/05/22	NC		%	25
		Dissolved Sodium (Na)	2008/05/22	1.1		%	25
		Dissolved Thallium (Tl)	2008/05/22	NC		%	25
		Dissolved Vanadium (V)	2008/05/22	NC		%	25
		Dissolved Zinc (Zn)	2008/05/22	NC		%	25

NC = Non-calculable
RPD = Relative Percent Difference
QC Standard = Quality Control Standard
SPIKE = Fortified sample
(1) The recovery in the matrix spike was not calculated (NC). Because of the high concentration of this analyte in the parent sample, the relative difference between the spiked and unspiked concentrations is not sufficiently significant to permit a reliable recovery calculation.

Validation Signature Page

Maxxam Job #: A849191

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

Cristina Nervo

CHRISTINA NERVO, Scientific Services

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