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**FOUNDATION INVESTIGATION  
AND DESIGN REPORT  
PROPOSED RETAINING WALLS  
QEW WIDENING  
FROM THIRD LINE TO 1 KM EAST OF TRAGALGAR ROAD  
OAKVILLE, ONTARIO  
G.W.P 189-00-01**

Submitted to:

URS Canada Inc.  
75 Commerce Valley Drive East  
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**GEOCRES No. 30M5-260**

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**PART A**  
**FOUNDATION INVESTIGATION REPORT**  
**PROPOSED RETAINING WALLS**

**QEW WIDENING**  
**FROM THIRD LINE TO 1 KM EAST OF TRAFALGAR ROAD**  
**OAKVILLE, ONTARIO**  
**G.W.P 189-00-01**

## 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation for the detail design of the proposed Retaining Walls along the Queen Elizabeth Way (QEW) between Third Line and 1 km east of Trafalgar Road in Oakville, Ontario. This work forms part of the overall project which includes widening of the QEW, twinning of the Sixteen Mile Creek bridge structure, replacement of the Fourth Line bridge, construction of new high mast light poles and culvert extensions.

This report addresses the foundation investigation of the alignment of proposed retaining walls along the QEW from about Third Line to 1 km east of Trafalgar Road. Foundation investigations were carried out by Golder in 2006/2007 as part of the overall scope of work for the widening of the QEW. For this report, borehole data from the current investigation have been supplemented with information from the following previous geotechnical investigations:

- *Foundation Investigation Report for W.P. 125-66-02 & 03, Site 10-275, QEW District 4, Dorval Drive Underpass, 0.4 mile West of Kerr St. Interchange*, dated 1975. Geocres No. 30M5-101.
- *Geotechnical Investigation – Proposed Watermain Replacement, Oakville, Ontario*, by Golder Associates Ltd., dated November 1999. Report No. 991-1174. \*\*
- *Geotechnical Investigation, North Service Road Watermain Relocation Project (Phase 3), Sixth Line to East of Trafalgar Road, Oakville, Ontario*, prepared by Golder Associates Ltd., dated December 2005. Report No. 04-1111-012B-1. \*\*

\*\* *Permission obtained from the Regional Municipality of Halton to use the geotechnical data.*

The terms of reference for the scope of work are outlined in Golder's proposal P01-1104, dated March 2000, that forms part of the Consultant's Agreement (Number 2005-A-000219) for this project. A digital file of the General Arrangement plan showing the extent and location of the proposed retaining walls was provided to Golder by URS in December 2006.

## 2.0 SITE DESCRIPTION

The project study area extends along the QEW from Third Line to approximately 1 km east of Trafalgar Road in the Town of Oakville. The existing QEW road grade in this area varies from about Elevation 106 m in the vicinity of Trafalgar Road to Elevation 115 m in the vicinity of Dorval Drive and then to Elevation 110 m between Fourth Line and Third Line. It appears that the roadway was constructed generally at the level of the original ground with very little cut or

fill except perhaps adjacent to Dorval Drive. In this area, the original ground surface rises to the north to about Elevation 120 m immediately north of the interchange ramps and there appears to have been some cutting and some filling during the bridge and ramp construction.

### **3.0 INVESTIGATION PROCEDURES**

The borehole investigation program was carried out along the QEW between December 12, 2006 and December 22, 2006, during which time thirty-three boreholes (Boreholes W1 and W2, W4 and W5, W9, W11 and W12, W14 to W16 and W18 to W40) were advanced along the alignments of the proposed retaining walls. In addition, Boreholes F7 and H7 advanced as part of the overall QEW widening have also been incorporated into this report for the proposed retaining walls. The locations of the boreholes are shown on the attached Drawings 1 and 2.

The borehole investigation was carried out using a truck-mounted CME 75 drill rig, supplied and operated by Geo-Environmental Drilling Ltd. of Milton, Ontario. The boreholes were advanced through the overburden using 100 mm outside diameter (O.D.) continuous flight solid stem augers. Soil samples were obtained at 0.76 m and 1.5 m intervals of depth, using 50 mm outer diameter split-spoon samplers driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures.

The boreholes were advanced to depths ranging from 2.5 m to 7.7 m below the existing ground surface. The water level in the open boreholes was observed throughout the drilling operations, and standpipe piezometers were installed in Boreholes W9, W11, W20, W25 and W35 to permit monitoring of the groundwater level at the site. Details of the piezometer installation are shown on the relevant borehole records. Where no piezometer was installed, the boreholes were backfilled using bentonite pellets in accordance with the requirements of Ontario Regulation 903. The water level information upon completion of drilling is presented on the Record of Borehole sheets that follow the text of this report.

The field work was supervised throughout by a member of Golder's technical staff, who located the boreholes, arranged for the clearance of underground service locations, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory classification testing on selected soil samples which includes water contents, Atterberg limits and grain size distributions. All of the laboratory tests were carried out to MTO and/or ASTM Standards as appropriate.

The as-drilled borehole locations and ground surface elevations were measured by Golder relative to survey stakes established in the field by Callon Dietz Inc. The borehole positions are in terms

of MTM NAD83 northing and easting coordinates; this information together with the ground surface elevation (referenced to geodetic datum) are presented on the Records of Borehole sheets that follow the text of this report and on Drawings 1 and 2.

The coordinates (northing and easting) of boreholes from previous investigations have been converted to the MTM NAD83 system, including the boreholes put down for the investigation of the watermain replacement/relocation which were converted from the Region of Halton coordinate system.

## **4.0 SITE GEOLOGY AND STRATIGRAPHY**

### **4.1 Regional Geological**

The site is located in the physiographic region known as the Iroquois Plain. The Iroquois Plain is generally composed of shallow deposits of sand and till covering portions between Hamilton and Toronto<sup>1</sup>. The surface topography slopes down gradually and fairly uniformly towards Lake Ontario. The overburden in the general area of the site consists of a shallow cover of clayey silt till and residual soil which is underlain by bedrock comprised of red shale of the Queenston Formation.

### **4.2 Subsurface Conditions**

The detailed subsurface soil, bedrock and groundwater conditions as encountered in the boreholes advanced during the current investigations, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets and on Figures 1 to 10 following the text of this report. 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. Further, subsurface conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy based on the results of the boreholes are shown on Drawings 3 through 7.

In addition to the current borehole investigation results, use has been made of seven boreholes put down during previous investigations in this area as referenced in Section 1.0 and as noted below. The locations of these boreholes are also shown on Drawings 1 and 2.

- Boreholes 1 to 3, 6 to 8: *1975 Foundation Investigation Report*. Geocres No. 30M5-101.

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<sup>1</sup> Chapman, L.J. and Putnam, D.F., 1984. The Physiography of Southern Ontario, 3<sup>rd</sup> Edition (Ontario Geological Survey, Special Volume 2). Ontario Ministry of Natural Resources.



- Borehole BH1: 1999 *Geotechnical Investigation* by Golder Associates Ltd. Report No. 991-1174.
- Boreholes BH05-1 to BH05-3: 2005 *Geotechnical Investigation*, by Golder Associates Ltd. Report No. 04-1111-012B-1.

In general, the subsoils at the site consist of a layer of asphalt and road base granular fill, underlain by fill materials of varying composition. The fill is typically underlain by clayey silt till, silty sand and gravel till and/or clayey silt residual soil, and shale bedrock of the Queenston Formation.

#### **4.2.1 Asphalt**

The boreholes put down through the existing roadway/shoulder (Boreholes W1 and W2, W4, W11 and W12, W14, W18 to W34, W36, W39 and W40) penetrated between 60 mm and 200 mm of asphalt pavement.

#### **4.2.2 Fill**

A 0.3 m to 2.8 m thick layer of fill of varying composition was encountered either immediately below the asphalt pavement or at ground surface in all of the boreholes except at Borehole W9 where it was encountered below 0.2 m thick layer of topsoil. The base of the fill extends to between Elevation 104.0 m and Elevation 113.6 m. The fill consists of a upper layer of sand and gravel containing trace to some silt and trace organics, to silty sand containing trace to some gravel and brick fragments, and/or sandy silt containing trace gravel and organics. In Boreholes H7, W9, W11, W12, W14, W18, W19, W21, W22, W36 and W39, the sand and gravel and sandy silt fill was underlain by a 0.4 m to 1.5 m thick layer of clayey silt fill. Interlayers of sand and gravel and clayey silt were encountered in Boreholes W11 and W12.

The measured Standard Penetration Test (SPT) 'N' values within the sand and gravel to sandy silt fill typically ranged between 4 and 74 blows per 0.3 m of penetration, indicating a loose to very dense relative density.

The measured SPT 'N' values within the clayey silt fill typically ranged between 4 and 26 blow per 0.3 m of penetration, and as high as 50 blows per 0.13 m of penetration, indicating a soft to hard consistency.

Measured water contents of selected samples of the fill ranged between 3 percent and 22 percent, with the higher water content values measured in the cohesive fill deposits.

Grain size distribution analyses were carried out on a sample of the silty sand fill and a sample of the clayey silt fill and the test results are presented on Figure 1. Atterberg limits testing carried out on two samples of clayey silt fill yielded liquid limits of 28 percent and 31 percent, plastic limits of 18 percent and 20 percent, corresponding plasticity indices of 10 percent and 11 percent, indicating a clayey silt of low plasticity. The test results are plotted on a plasticity chart on Figure 2.

#### **4.2.3 Clayey Silt to Silty Clay**

A 0.7 m to 0.9 m thick clayey silt to silty clay deposit containing trace sand and gravel and occasional shale fragments was encountered underlying the fill materials in Boreholes W15, W16, W37 and W38. The surface of the clayey deposit was encountered between Elevation 105.5 m and Elevation 110.6 m.

The Standard Penetration Test (SPT) 'N' values measured within the clayey deposit ranged between 12 and 47 blows 0.3 m of penetration, with values as high as 60 blows per 0.23 m of penetration, indicating a hard consistency.

Measured water contents of selected samples of clayey deposit ranged between 13 percent and 20 percent. Grain Size distribution analysis was carried out on a sample of clayey silt to silty clay and the test results are presented on Figure 3.

Laboratory tests on a sample of silty clay yielded a water content of about 17 percent, a liquid limit of 47 percent, a plastic limit of 24 percent, corresponding to a plasticity index of 23 percent. The Atterberg limits test results presented on Figure 4 classify this material as a silty clay of medium plasticity.

#### **4.2.4 Silty Sand and Gravel Till**

A 2.0 m to 4.7 m thick deposit of silty sand and gravel till containing trace to some clay was encountered underlying the sand and gravel fill in Boreholes W29, W30, W32 and W33 and underlying clayey silt till in Borehole W31. Cobbles and boulders were noted with the till deposit. The surface of the silty sand and gravel deposit was encountered between Elevation 110.1 m and Elevation 113.6 m.

The Standard Penetration Test (SPT) 'N' values measured within the silty sand and gravel deposit ranged between 4 and 90 blows 0.3 m of penetration with values as high as 50 blows per 0.05 m of penetration, indicating a loose to very dense relative density. Measured water contents of selected samples of the silty sand and gravel till ranged between 3 percent and 17 percent.

In Borehole W4, a 0.7 m thick layer of sandy silt containing trace to some clay and rock fragments was penetrated between the clayey silt till and underlying shale bedrock. The measured Standard Penetration Test (SPT) 'N' value within the sandy silt deposit was 50 blows per 0.1 m of penetration, indicating a very dense consistency. Laboratory testing on one sample of sandy silt yielded a water content of about 5 percent.

The grain size distribution analysis on a sample of the silty sand and gravel till and a sample of the sandy silt are presented on Figure 5 and Figure 6, respectively.

#### **4.2.5 Clayey Silt Till**

A 0.4 m to 2.3 m thick deposit of clayey silt till in places grading to a silty clay till containing trace to some sand and trace gravel was encountered in Boreholes W1, W2, W4, W5, W9, W12, W21 to W28, W31, W34, W39 and W40 overlying sandy silt, clayey silt residual soil and/or the shale bedrock. The surface of the till deposit was encountered between Elevation 104.0 m and Elevation 112.3 m in these boreholes.

Measured SPT 'N' values within the till ranged from 18 to 75 blows per 0.3 m of penetration, indicating a very stiff to hard consistency.

Measured water contents from samples of the clayey silt till ranged between 6 percent and 48 percent. Grain size distribution analysis was carried out on one selected samples of the till and the result is presented on Figure 7. Atterberg limits testing carried out on samples measured liquid limits between 27 percent and 32 percent, plastic limits between 18 percent and 21 percent, and corresponding plasticity indices between 9 percent and 11 percent. The test results, which are presented on Figure 8, classify the till as a clayey silt of low plasticity.

#### **4.2.6 Clayey Silt Residual Soil**

About 0.4 m to 1.5 m thick layer of clayey silt residual soil containing trace to some sand and trace gravel was encountered underlying the fill material and/or the clayey silt till deposit in Boreholes H7, W2, W18, W20, W32 and W34 to W38. Cobbles were encountered at the base of the residual soil layer immediately overlying bedrock in Borehole W32. The surface of the clayey silt residual soil deposit was encountered between Elevation 104.8 m and Elevation 109.2 m in these boreholes.

Measured SPT 'N' values within the clayey silt residual soil deposit ranged from 6 and 58 blows per 0.3 m of penetration, with values as high as and 50 blows per 0.07 m of penetration, indicating a very stiff to hard consistency.

Measured water contents of selected samples of the clayey silt residual soil ranged between 8 percent and 17 percent. Grain size distribution analysis was carried out on one sample of the clayey silt residual soil and the result is presented on Figure 8. Atterberg limits testing carried out on two samples yielded liquid limits of 36 percent and 25 percent, plastic limits of 21 percent and 17 percent, with corresponding plasticity indices of 7 percent and 15 percent. The test results, which are presented on Figure 10, classify the residual soil as a clayey silt of low to medium plasticity.

#### **4.2.7 Bedrock**

Shale bedrock was encountered in all boreholes underlying the fill materials, clayey silt, clayey silt till, silty sand and gravel till, sandy silt and clayey silt residual soil between Elevation 103.4 m and Elevation 110.8 m. Hard limestone/siltstone interbeds were present within the shale bedrock during augering and are noted on the Record of Borehole sheets.

The boreholes were advanced into the shale bedrock by augering and split spoon sampling; SPT 'N' values recorded were generally greater than 50 blows per 0.1 m of penetration.

Measured water contents of samples of the shale bedrock ranged between 1 percent and 10 percent. Atterberg limits testing was carried out on a sample of the shale bedrock, as presented on Figure 11, yielded a liquid limit of 36 percent and a plastic limit of 24 percent, corresponding to a plasticity index of 12 percent, indicating that the shale bedrock breaks down to a clayey silt of low to medium plasticity.

### **4.3 Groundwater Conditions**

The water levels in the boreholes were noted during and upon completion of drilling operations; typically, the open boreholes were dry upon completion of drilling. Standpipe piezometers were installed in Boreholes W9, W11, W20, W25 and W35 to permit monitoring of the groundwater levels at the site. Details of the piezometer installations are shown on the Record of Borehole sheets following the text of the report. Typically the water levels measured in the piezometers vary from about 1.9 m to 3.0 m below ground surface. It should be noted that it was not possible to take a water level reading in piezometer W11 due on February 13, 2007 to the frozen conditions in the tubing. The water levels measured in the piezometers are summarised below:

<i><b>Borehole No.</b></i>	<i><b>Ground Surface Elevation</b></i>	<i><b>Depth to Water Level</b></i>	<i><b>Groundwater Elevation</b></i>	<i><b>Date of Measurement</b></i>
W9	107.3 m	2.1 m	105.2 m	February 13, 2007
W11	113.8 m	Frozen		February 13, 2007
W20	110.0 m	3.0 m	107.0 m	February 13, 2007


<i>Borehole No.</i>	<i>Ground Surface Elevation</i>	<i>Depth to Water Level</i>	<i>Groundwater Elevation</i>	<i>Date of Measurement</i>
W25	111.0 m	2.4 m	108.6 m	February 13, 2007
W35	106.0 m	1.9 m	104.1 m	February 13, 2007

The groundwater level is generally close to the overburden/bedrock surface and tends to slope downward both toward the south as well as toward the Sixteen Mile Creek valley. It should be noted that groundwater levels in the area are subject to seasonal fluctuations and precipitation events and may also be affected by housing development and buried services along the QEW right-of-way.


## 5.0 CLOSURE

The field technician supervising the drilling program was Mr. Chris Radway, CET. This report was prepared by Ms. Nikol Kochmanová, EIT, and Mr. Christopher Ng, P.Eng., an intermediate geotechnical engineer, both with Golder Associates Ltd.; the technical aspects were reviewed by Ms. Anne Poschmann, P.Eng, a Principal with Golder Associates Ltd. Mr. Jorge Costa, P.Eng., a Designated MTO Contact for Golder Associates Ltd., conducted a quality control review of the report.

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## **PART B**

### **FOUNDATION DESIGN REPORT PROPOSED RETAINING WALLS**

**QEW WIDENING  
FROM THIRD LINE TO 1 KM EAST OF TRAFALGAR ROAD  
OAKVILLE, ONTARIO  
G.W.P 189-00-01**

## 6.0 ENGINEERING RECOMMENDATIONS

This section of the report provides geotechnical recommendations for the design of foundations for the proposed retaining walls along the north and south sides of the QEW between Third Line and 1 km east of Trafalgar Road. Geotechnical Recommendations are also provided for the design of associated concrete gravity toe walls (see Section 6.3.3) and a noise barrier wall (Retaining Wall 6) between STA 18+410 and 19+092 (see Section 6.3.4). The foundation design recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation at the retaining wall site. The interpretation and recommendations are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to design the proposed structure foundations. Where comments are made on construction they are provided in order to highlight those aspects which could affect the design of the project, and for which special provisions or operational constraints may be required in the contract documents. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

### 6.1 General

Retaining walls (including associated toe walls and a noise barrier wall), varying in height from about 1.0 m to 3.5 m, are required to separate the QEW from the adjacent North and South Service Roads. The locations, lengths and heights of the proposed retaining walls are presented below.

<i>Retaining Wall</i>	<i>Location</i>	<i>Approximate Length of Wall</i>	<i>Approximate Height of Wall</i>
Retaining Wall 1	STA 16+320 to 17+041 Toronto Bound	721 m	2.5 m to 3.5 m
Retaining Wall 2	STA 9+960 to 10+000 and STA 19+730 to 20+125 Toronto Bound	435 m	2.5 m to 3.5 m
Retaining Wall 3 (Toe Wall)	STA 15+730 to 15+820 Niagara Bound	90 m	1.0 m to 1.8 m
Retaining Wall 4	STA 16+030 to 16+130 Niagara Bound	100 m	2.5 m to 3.0 m
Retaining Wall 5 (Toe Wall)	STA 16+350 to 16+690 Niagara Bound	340 m	1.1 m to 1.8 m
Retaining Wall 6 (Noise Barrier Wall)	STA 18+410 to 19+092 Niagara Bound	682 m	5.0 m
Retaining Wall 7 (Toe Wall)	STA 17+250 to 17+310 Toronto Bound	60 m	1.1 m to 1.2 m
Retaining Wall 8 (Toe Wall)	STA 17+270 to 17+330 Niagara Bound	60 m	1.1 m

## **6.2 Retaining Wall Options**

Two wall types are considered feasible as retaining structures based on the subsurface conditions encountered at this site: retained soil system (RSS) walls and conventional concrete cantilever retaining walls or gravity concrete toe walls.

From a foundations perspective, RSS walls are considered to be the most economical wall type for the subsurface conditions encountered at the site. It is understood, however, that space restrictions may preclude the use of RSS walls given the requirement for encroachment into the travelled lanes of the QEW and/or the service roads for placement of the reinforcing strips. In addition, there may be restrictions associated with the presence of drainage features and the incorporation of proposed traffic barrier walls (jersey walls) on top of the retaining walls. The native deposits are variable along the length of the retaining walls and as such it is considered that concrete retaining walls are the preferred retaining structures and it is recommended that these structures be supported on spread footings founded on the shale bedrock or on deep foundations. If RSS walls are feasible from the perspective of minimum encroachment on travelled lanes and support of traffic barrier walls, then the native soils are considered suitable for the support of the levelling pad and the reinforced earth mass.

The advantages, disadvantages, relative costs and risks/consequences for each of the wall options are summarised in Table 1. Geotechnical recommendations for each wall type are provided in the following sections.

## **6.3 Shallow Foundations**

The proposed retaining walls may be supported on shallow spread footings placed on the surface of the bedrock or on properly prepared engineered fill.

### **6.3.1 Retained Soil System (RSS) Wall**

The use of a mechanically-reinforced soil (retained soil system or RSS ) wall is considered suitable for this site. The RSS wall consists of granular fill placed and compacted in layers and reinforced with metal or fabric strips or grids. A facing material, typically pre-cast concrete panels mechanically fastened to the reinforcing strips or grids, is used to form the face of the reinforced soil structure and to prevent the loss of fill material; these facing panels are supported on a concrete strip footing. Long-term settlements due to the embankment loading are estimated to be less than 25 mm provided that the any loose or soft fill materials are subexcavated.

Prior to construction of the RSS wall, the topsoil and any existing loose or soft fill materials that may be present within the RSS wall footprint should be subexcavated and the subgrade



proofrolled. The subgrade should be inspected following subexcavation/proofrolling to ensure that all loose or soft fill materials have been removed, then the subexcavated area should be replaced with OPSS 1010 Granular “A” or Granular “B” Type II backfill that is placed and compacted in accordance with the requirements of MTO’s Special Provision SP105S10. The facing panel concrete strip footing should be placed on a 150 mm thick levelling pad consisting of compacted Granular “A”.

Assuming that the RSS wall acts as a unit and utilises the full width of the reinforced soil mass, which is taken as 70 percent of the height of the wall, a factored geotechnical resistance at Ultimate Limit States (ULS) of 300 kPa and geotechnical resistance at Serviceability Limit States (SLS) of 250 kPa may be used for the design of the RSS wall founded on properly prepared native deposits or on engineered fill.

The resistance to lateral forces/sliding resistance between the compacted Granular “A” or Granular “B” Type II and the subgrade should be calculated in accordance with Section 6.7.5 of the CHBDC. The coefficient of friction,  $\tan \delta$ , for the cast-in-place concrete footing and properly prepared granular levelling pad/subgrade maybe taken as 0.60. This coefficient of friction represents an unfactored value; in accordance with the *Canadian Highway Bridge Design Code (CHBDC)*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

### 6.3.2 Concrete Retaining Wall Supported on Strip Footings

The recommendation is for the full length of the concrete retaining wall to be founded on the shale bedrock which is generally at relatively shallow depth; however, it may be feasible in some locations to found the concrete retaining wall on the overlying very stiff to hard residual soil/clayey silt till. Along the individual wall lengths the bedrock surface elevation varies as indicated below and therefore the wall footing would have to be stepped along the length of the wall to found within/on the shale bedrock. The required founding level for the wall footings on the shale bedrock has been established based on the bedrock surface elevation at the borehole locations from which the required stepping levels between the boreholes can then be determined. However, it is recommended that some allowance should be made in the design to accommodate variations in the bedrock surface along the wall alignment; the founding level should be taken as at least 0.5 m below the bedrock surface or a constant founding level chosen which is maintained at least 0.3 m below the lowest bedrock surface.

<i>Retaining Wall</i>	<i>Borehole</i>	<i>Approximate Station</i>	<i>Depth to Bedrock Surface at Borehole</i>	<i>Bedrock Surface Elevation at Borehole</i>
<b>Retaining Wall 1</b> STA 16+320 to 17+041	W23	16+320	1.1 m	108.3 m
	W24	16+390	1.5 m	108.9 m
	W25	16+465	2.7 m	108.3 m
	W26	16+545	1.5 m	109.8 m

<i>Retaining Wall</i>	<i>Borehole</i>	<i>Approximate Station</i>	<i>Depth to Bedrock Surface at Borehole</i>	<i>Bedrock Surface Elevation at Borehole</i>
	W27	16+615	1.4 m	110.3 m
	W28	16+690	3.0 m	109.1 m
	W29	16+770	2.8 m	110.1 m
	W30	16+840	3.5 m	109.3 m
	W31	16+920	4.3 m	108.8 m
	W32	17+000	5.0 m	108.7 m
	W33	17+040	5.5 m	108.9 m
<b>Retaining Wall 2</b> STA 9+960 to 10+000 and STA 19+730 to 20+125	W34	19+685	2.1 m	104.9 m
	W35	19+760	2.2 m	103.8 m
	W36	19+840	1.9 m	104.4 m
	W37	19+910	2.1 m	104.1 m
	W38	19+990	2.1 m	104.0 m
	W39	20+060	2.8 m	103.4 m
	W40	20+125	2.2 m	104.3 m
<b>Retaining Wall 3 (Toe Wall)</b> STA 15+730 to 15+820	W22	15+730	2.3 m	107.4 m
	W21	15+775	2.2 m	107.6 m
	W20	15+820	2.3 m	107.7 m
<b>Retaining Wall 4</b> STA 16+030 to 16+130	W19	16+030	2.3 m	108.2 m
	W18	16+080	2.1 m	108.4 m
	F7	16+140	0.6 m	109.5 m
<b>Retaining Wall 5 (Toe Wall)</b> STA 16+350 to 16+690	W16	16+350	1.4 m	109.7 m
	W15	16+435	1.4 m	109.5 m
	W14	16+510	2.6 m	108.9 m
	H7	16+600	4.0 m	108.2 m
	W12	16+640	2.5 m	110.2 m
	W11	16+690	3.0 m	110.8 m
<b>Retaining Wall 6 (Noise Barrier Wall)</b> STA 18+410 to 19+092	BH 05-1	18+415	3.7 m	103.6 m
	W9	18+480	3.2 m	104.1 m
	BH 05-2	18+550	2.1 m	105.3 m
	BH1	18+710	2.9 m	104.1 m
	W5	18+785	1.9 m	105.6 m
	W4	18+865	2.2 m	106.6 m
	BH 05-3	18+950	1.5 m	105.5 m
	W2	19+010	1.9 m	104.7 m
	W1	19+090	2.4 m	103.9 m
<b>Retaining Wall 7 (Toe Wall)</b> STA 17+270 to 17+330	3	17+275	3.4 m	112.4 m
	2	17+290	2.5 m	113.2 m
	1	17+310	3.0 m	112.6 m
<b>Retaining Wall 8 (Toe Wall)</b> STA 17+250 to 17+310	8	17+260	3.7 m	110.9 m
	7	17+285	3.7 m	110.8 m
	6	17+300	3.9 m	110.5 m

Wall footings must be placed at least 1.2 m below final grade to provide sufficient cover for protection against frost penetration. For design of strip footings founded on shale bedrock, the factored axial resistance at Ultimate Limit States (ULS) may be taken as 750 kPa. The Serviceability Limit States (SLS) conditions do not apply.

Alternatively, consideration could be given to the use of shallow spread footings founded on engineered fill for the retaining walls where the required design founding elevation is higher than the bedrock surface. The footings should be founded on a compacted Granular "A" pad. A factored geotechnical resistance at ULS of 300 kPa and geotechnical resistance at SLS of 250 kPa may be used for design if subexcavation and replacement of the existing fill and loose or soft native soils is carried out.

The geotechnical resistance values provided above are given under the assumption that the loads will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.7.4 of the *Canadian Highway Bridge Design Code (CHBDC)* and its *Commentary*, using the curve for cohesive soils.

Resistance to lateral forces/sliding resistance between the concrete footings and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. The coefficient of friction,  $\tan \delta$ , for concrete footings and the weathered shale bedrock and concrete footings and properly prepared engineered fill may be taken as 0.70 and 0.60, respectively. This represents an unfactored value; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

### **6.3.3 Toe Walls**

The toe walls should be constructed in accordance to OPSD 3120.100. Consideration could be given to founding the toe walls on engineered fill where the required design founding elevation is higher than the bedrock surface. In this regard, the existing variable fill materials and loose or soft native soils should be subexcavated and the toe walls should be founded on compacted topped with a 150 mm thick Granular 'A' pad. A factored geotechnical resistance at Ultimate Limit States (ULS) of 300 kPa and geotechnical resistance at Serviceability Limit States (SLS) of 250 kPa may be used for design of the walls if subexcavation of the existing fill and loose or soft native soils is carried out and replaced with engineered fill.

Resistance to lateral forces/sliding resistance between the concrete footings and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. The coefficient of friction,  $\tan \delta$ , for concrete footings and the weathered shale bedrock and concrete footings and properly prepared engineered fill, may be taken as 0.70 and 0.60, respectively. This represents an unfactored value; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

### **6.3.4 Noise Barrier Wall**

A noise barrier wall is proposed between STA 18+410 and 19+092 (Retaining Wall 6). It is assumed that the noise barrier wall will be supported on 0.6 m to 0.9 m diameter augered caissons. Design parameters for the soils encountered in the boreholes advanced along the wall alignment between STA 18+410 and 19+092 are given in Table 2. It should be noted that the stratigraphy presented in the table has been simplified for the purposes of the noise barrier wall foundation design. Sloped boundaries between strata, as identified in the table, may be taken as a straight line between the listed coordinates.

For foundation design, full passive resistance will be mobilised only where the width of soil in front of the caissons is equal to or greater than eight caisson diameters. If there is less width of soil for development of passive resistance (i.e. if there is sloping ground adjacent to the noise barrier), the magnitude of the passive resistance may be determined by interpolating between zero passive resistance at ground surface and full passive resistance at the depth where the slope face is greater than eight caisson diameters away from the face of the caisson. In addition, the passive resistance in front of the caisson within the upper 1.2 m below ground surface should be neglected to account for frost action.

## **6.4 Deep Foundations**

Considerations could be given to the use of driven piles or caissons for support of the eastern portion of Retaining Wall 1 between STA 16+839 and 17+041 to reduce the wall height as well as the amount of subexcavation required to found spread footings on the bedrock. In this eastern portion of Retaining Wall 1, the ground surface rises and the depth to bedrock increases to about 5.5 m at the location of Borehole W33.

### **6.4.1 Axial Geotechnical Resistance – Steel H-Piles**

Steel H-piles driven to practical refusal within the shale bedrock may be used for support of this eastern portion of Retaining Wall 1. In this case, it is estimated that the piles could penetrate up to about 1 m into the shale bedrock and the pile tip level should be taken as Elevation 108.0 m. A factored axial resistance at Ultimate Limit States (ULS) of 1400 kN may be used for design for HP 310x110 piles driven into the shale bedrock. Serviceability Limit States (SLS) conditions do not apply for the proposed pile length and founding conditions.

Pile installation should be in accordance with SP903S01. Since hard driving (both within the fill, if cobbles/boulders are encountered, and the shale) is anticipated, the pile tips should be stiffened with MTO flange plates for protection during driving. The pile termination or set criteria will be

dependent on the pile driving hammer type, helmet, selected pile and length of pile. For piles driven into the bedrock, the following note should be used for the drawings:

- “Piles to be driven to bedrock.”

The pile and/or caisson cap should be provided with a minimum of 1.2 m of soil cover for frost protection.

#### **6.4.2 Axial Geotechnical Resistance – Caissons**

The use of caissons socketted into the shale bedrock may also be considered as an alternative for the deep foundations for the eastern portion of Retaining Wall 1. The load carrying capacity for caissons depends on the total length of caissons, the length of the rock socket and the diameter of the caissons. For caissons socketted 1 m into the bedrock, it is recommended that the caissons be designed as end bearing units. In this regard, an axial geotechnical resistance at Ultimate Limit States (ULS) of 2.3 MN may be assumed for the design for 0.9 m diameter caissons and 4 MN for 1.2 m diameter caissons. Serviceability Limits States (SLS) conditions do not apply for the proposed caissons and founding conditions.

The above design capacities assume that the base is thoroughly cleaned of loose material prior to pouring concrete. In accordance with SP903S01, the Contractor should inspect the caissons to determine that the conditions encountered are consistent with the information obtained from the borings, to ensure that the minimum bedrock socket lengths are achieved, and to confirm that the base of the caisson foundations have been adequately prepared/cleaned of loose drill cuttings.

Temporary liners may be required through the fill and granular soil deposits to prevent loss of ground. Groundwater seepage into the caisson excavations through the bedrock and the granular native soils is anticipated. Surface water should be directed away from the caisson excavations to prevent water seepage from entering the excavations.

The caisson cap should be provided with a minimum of 1.2 m of soil cover for frost protection.

#### **6.4.3 Resistance to Lateral Loading**

Lateral loading on the retaining walls could be resisted fully or partially by the use of battered steel H-piles. If vertical piles are used, the resistance to lateral loading will have to be derived from the soil in front of the piles.

The evaluation of the piles subjected to lateral loads should take into account such factors as the relative rigidity of the pile to the surrounding soil, the fixity condition at the head of the pile (pile

cap level), the structural capacity of the pile to withstand bending moment, the soil resistance that can be mobilised, the tolerable lateral deflection at the head of the pile and the pile group effects.

The pile should be modelled as a beam-column supported by springs equivalent to the passive soil reaction distributed along the shaft. The passive resistance developed for lateral deformations, as may be expected for these short piles, should be much less than the passive pressure associated with a full passive resistance. This full passive resistance is calculated from earth pressure theories assuming unlimited deformation of the soil. The lateral resistance of the pile may be limited by the factored structural flexural resistance of the pile rather than the resistance of the soil.

Therefore, in order to develop the full passive resistance, the pile would have to deflect a 'large' amount. For piles 'fixed' within the pile cap, the magnitude of possible deflection is further reduced and the horizontal geotechnical resistance of the pile is some fraction of the full passive resistance occurring at relatively small horizontal displacements.

It can be assumed, based on the shear strength of the soil, that the pile can be considered a laterally supported compression member. The horizontal load capacity of vertical piles may be limited in three different ways:

- The capacity of the soil may be exceeded, resulting in large horizontal movements of the piles and failure of the foundation;
- The bending moments may generate excessive bending stresses in the pile material, resulting in structural failure of the piles; or
- The deflections of the pile heads may be too large to be compatible with the superstructure.

The *Canadian Foundation Engineering Manual (CFEM)* gives two methods by which to assess the lateral capacity of a pile. The first is Brom's Method (1964), which examines failure criteria (i.e. ultimate horizontal resistance) for two types of piles – 'short piles' where the lateral capacity of the soil adjacent to the pile is fully mobilised and 'long piles' where the bending resistance of the pile is fully mobilised.

The second method examines the lateral deflections of the pile by using the horizontal subgrade reaction theory where the soil around a pile is modelled using a series of springs. The spring constant is called the coefficient of horizontal subgrade reaction,  $k_h$  (kN/m<sup>3</sup> or kPa/m). The value of  $k_h$  is used as an input parameter into the elastic soil-structure interaction model.

The resistance to lateral loading in front of a vertical pile may be calculated using subgrade reaction theory. The coefficient of horizontal subgrade reaction,  $k_h$  (kPa/m) for cohesionless soils is derived as:

$$k_h = \frac{n_h z}{B} \quad \text{Where}$$

$n_h$  is the constant of horizontal subgrade reaction (kPa/m)  
 $z$  is the depth (m)  
 $B$  is the pile diameter/width (m)

and for cohesive soils:

$$k_h = \frac{67 s_u}{B} \quad \text{Where}$$

$s_u$  is the undrained shear strength of the soil (kPa)  
 $B$  is the pile diameter width (m)

Since the potential penetration of the piles into the bedrock cannot be predicted but is estimated to be only about 1 m, it is recommended that only the lateral resistance derived from the length of the pile within the fill/native soils should be used in the design. The value of  $n_h$  to be assumed in the structural analysis is given below.

<i>Location</i>	<i>Soil Unit</i>	<i><math>n_h</math></i>
Retaining Wall 1 (between STA 16+839 and 17+041)	Existing Fill / Native Soils	6.6 MN/m <sup>3</sup>

Group action for lateral loading should also be considered when the pile spacing in the direction of the loading is less than six to eight pile diameters. Group action can be evaluated by reducing the coefficient of horizontal subgrade reaction in the direction of loading by a reduction factor,  $R$ , as follows:

<i>Pile Spacing in Direction of Loading <math>d</math> = Pile Diameter</i>	<i>Subgrade Reaction Reduction Factor</i>
8d	1.00
6d	0.70
4d	0.40
3d	0.25

## 6.5 Lateral Earth Pressures for Design

The lateral earth pressures acting on concrete retaining walls, will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill, on the

magnitude of surcharge including construction loadings, on the freedom of lateral movement of the structure, and on the drainage conditions behind the walls.

The following recommendations are made concerning the design of the walls. It should be noted that these design recommendations and parameters assume level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select free-draining granular fill meeting the specifications of Ontario Provincial Standard Specifications (OPSS) Granular 'A' or Granular 'B' Type II but with less than 5 per cent passing the 200 sieve should be used as backfill behind the walls. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Other aspects of the granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD 3501.00 and 3504.00.
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the wall stem, in accordance with *CHBDC* Section 6.9.3 and Figure 6.9.3. Placement and compaction of fill and use of compaction equipment should be in accordance with MTO's Special Provision SP105S10. Other surcharge loadings should be accounted for in the design, as required.
- The granular fill may be placed either in a zone with width equal to at least 1.2 m behind the back of the wall stem (Case I in Figure C6.9.1(I) of the *Commentary to the CHBDC*) or within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (Case II in Figure C6.9.1(I) of the *Commentary to the CHBDC*).
- For Case I, the pressures are based on the proposed backfill material and the existing fill/native soil and the following parameters (unfactored) may be assumed:

Soil unit weight:	20 kN/m <sup>3</sup>
Coefficients of lateral earth pressure:	
Active, $K_a$	0.35
At rest, $K_o$	0.50

- For Case II, the pressures are based on the granular fill as placed and the following parameters (unfactored) may be assumed:

	<b>Granular 'A'</b>	<b>Granular 'B' Type II</b>
Soil unit weight:	22 kN/m <sup>3</sup>	21 kN/m <sup>3</sup>
Coefficients of lateral earth pressure:		
Active, $K_a$	0.27	0.27
At rest, $K_o$	0.43	0.43



- If the wall support allows lateral yielding of the stem, active earth pressures may be used in the geotechnical design of the structure. If the wall support does not allow lateral yielding, at-rest earth pressures should be assumed for geotechnical design.

## **6.6 Design and Construction Considerations**

The following sections are intended to highlight conditions or operations that may pose construction difficulties, such as excavations and temporary cut slopes, bedrock excavation, groundwater and surface water control and obstructions.

### **6.6.1 Groundwater and Surface Water Control for Footings and Caissons**

In general, the excavations for shallow footings and/or excavations of caissons foundations will be advanced through overburden and into the shale bedrock. The use of a temporary liner is recommended for advancement of the auger holes for caissons in order minimize the potential for ground loss into the caisson excavations. Based on the water level observations at the completion of borehole drilling, the augered holes will generally be dry if extended into the clayey silt till. However, natural fluctuations in the groundwater table at the time of construction may increase the level of water encountered in the holes. Seepage of groundwater into the holes should be expected.

It is recommended that a Non-Standard Special Provision (NSSP), such as presented in Appendix D, be included in the Contract Documents to warn the Contractor of the control of overburden soils and groundwater which is expected to affect the installation of the caisson foundations at this site:

- **Control of overburden soils and groundwater:** Lenses or layers of water-bearing cohesionless soils should be expected to be present within the fill and native soil deposits such as the sand and gravel till and clayey silt till. Cohesionless soils and cohesionless lenses within the tills should be expected to be unstable below the groundwater level. If cohesionless soil layers or lenses are encountered within the fill and/or native soils, the caisson holes may have to be advanced using a temporary liner in order to minimise ground loss during drilling and concrete placement.

### **6.6.2 Obstructions**

The Contractor's proposed excavation techniques should be able to accommodate removal or breaking up of cobbles/boulders which are expected to be encountered in the fill and the clayey silt till and sand and gravel materials.

It is recommended that a Non-Standard Special Provision (NSSP), such as presented in Appendix D, be included in the Contract Documents to warn the Contractor of the following items which are expected to affect the installation of the retaining wall foundations at this site:

- **Cobbles and boulders:** The fill and till deposits are expected to contain cobbles and boulders. Appropriate equipment and procedures will be required to penetrate these obstructions during excavation for the retaining wall footings.
- **Presence of stronger interlayers of limestone/siltstone within the shale bedrock:** Shale bedrock was encountered within the potential depth for caisson foundations throughout most of the site. The shale bedrock in the area is known to contain stronger limestone and siltstone interlayers. Consideration of the presence of the stronger limestone and siltstone interlayers must be made in the selection of caisson installation equipment at these locations, if the foundation design requires that caissons be extended into the bedrock.

### **6.6.3 Excavations and Temporary Roadway Protection**

Where temporary roadway protection is required, the temporary excavation support system should be designed and constructed in accordance with MTO's Special Provision SP105S19. The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in SP105S19, provided that any utilities that may be present along the QEW adjacent to the excavation areas can tolerate 25 mm of deformation.

Local subexcavation will be required for the construction of the retaining walls. The excavations will extend through the existing loose or soft fill material, clayey silt and sand and gravel tills and residual soil deposits. Temporary open-cut excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities. The fill materials at the site are classified as Type 3 soils whereas the native subsoils at the site are classified as Type 2 soil, according to the OHSA. Where space permits, temporary slopes maintained through these materials should be made with side slopes not steeper than 1H:1V.

### **6.6.4 Subgrade Protection**

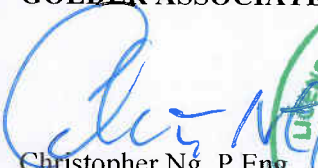
The clayey silt and sand and gravel tills and the residual soil deposit as well as the shale bedrock that is exposed at the founding subgrade level will be susceptible to weathering and disturbance due to construction traffic and/or ponded water. Surface water should be directed away from the excavation area, to prevent ponding of water that could result in disturbance and weakening of the foundation subgrade.

A Non-Standard Special Provision (NSSP), such as presented in Appendix D, should be included in the Contract Documents to warn the contractor of this effect and limit detrimental conditions; in this regard, a working mat of lean concrete should be placed immediately after preparation and inspection of the footing subgrade.


## 7.0 CLOSURE

This report was prepared by Ms. Nikol Kochmanová, EIT, and Mr. Christopher Ng, P.Eng., an intermediate geotechnical engineer, both with Golder Associates Ltd.; the technical aspects were reviewed by Ms. Anne Poschmann, P.Eng., a Principal and geotechnical engineer with Golder Associates Ltd. Mr. Jorge Costa, P.Eng., a Designated MTO Contact for Golder Associates Ltd., conducted a quality control review of the report.

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**TABLE 1**  
**EVALUATION OF RETAINING WALL FOUNDATION ALTERNATIVES**  
**QEW WIDENING**  
**FROM THIRD LINE TO 1 KM EAST OF TRAFALGAR ROAD**  
**OAKVILLE, ONTARIO**  
**G.W.P. 189-00-01**

<i>Option</i>	<i>Rank/ Option</i>	<i>Advantages</i>	<i>Disadvantages</i>	<i>Relative Costs</i>	<i>Risks/Consequences</i>
Retained Soil System (RSS) Wall	2	<ul style="list-style-type: none"> <li>Relative ease of construction; foundation placed on prepared native bedrock;</li> <li>Sub-excavation is not required.</li> </ul>	<ul style="list-style-type: none"> <li>Low bearing capacity and differential post-construction settlements due to variable foundation soil conditions;</li> <li>Requires roadway protection;</li> <li>Potential encroachment into the travelled lanes;</li> <li>Proprietary system design and construction;</li> <li>Restriction due to local drainage features and traffic barrier walls on top.</li> </ul>	<ul style="list-style-type: none"> <li>Comparable cost to Concrete Cantilever Wall on Spread Footing;</li> <li>Increase in cost if granular fill is required to raise the founding elevation of the RSS Wall.</li> </ul>	<ul style="list-style-type: none"> <li>Differential post-construction settlement should be anticipated along length of wall due to variable foundation soil conditions</li> <li>May require extensive reconstruction of travelled lanes with corresponding lane closures.</li> </ul>
Concrete Cantilever Wall on Spread Footing	1	<ul style="list-style-type: none"> <li>Relative ease of construction; foundation placed on prepared bedrock;</li> <li>Minimal post-construction settlement.</li> </ul>	<ul style="list-style-type: none"> <li>Sub-excavation of fill and clayey silt till/residual soils are required to reach design founding levels;</li> <li>Requires roadway protection.</li> </ul>	<ul style="list-style-type: none"> <li>Comparable cost to RSS Wall option;</li> <li>Increase in cost if granular fill is required to raise the founding elevation of the Concrete Cantilever Wall.</li> </ul>	
Steel H-Piles Driven to Shale Bedrock	3	<ul style="list-style-type: none"> <li>Relative ease of construction;</li> <li>Negligible post-construction settlement;</li> <li>Sub-excavation is not required.</li> </ul>	<ul style="list-style-type: none"> <li>Downdrag loads may have to be considered;</li> <li>Pre-augering required to penetrate cobbles and boulders;</li> <li>Requires roadway protection</li> <li>Not practical due to shallow depth to bedrock at most locations.</li> </ul>	<ul style="list-style-type: none"> <li>Increased cost associated with pre-augering at pile locations.</li> </ul>	<ul style="list-style-type: none"> <li>All piles would require pre-augering to permit pile installation;</li> <li>Difficulty may be encountered with advancing pre-augered holes through the clayey silt till/residual soil if boulders are encountered.</li> </ul>
Caissons Socketted into Shale Bedrock	4	<ul style="list-style-type: none"> <li>Relative ease of construction;</li> <li>Negligible post-construction settlement;</li> <li>Sub-excavation is not required.</li> </ul>	<ul style="list-style-type: none"> <li>Temporary liners will be required for groundwater control. Socketting into bedrock may require rock coring or churn drilling techniques;</li> <li>Requires roadway protection.</li> </ul>	<ul style="list-style-type: none"> <li>Increased cost of socketting into bedrock.</li> </ul>	<ul style="list-style-type: none"> <li>Difficulty may be encountered socketting liner to seal off water;</li> <li>Difficulty may be encountered with advancing caissons through the clayey silt till/residual soil if boulders are encountered.</li> </ul>

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**TABLE 2**  
**DESIGN PARAMETERS FOR NOISE BARRIER WALL FOUNDATION**  
**QEW WIDENING**  
**FROM THIRD LINE TO 1 KM EAST OF TRAFALGAR ROAD**  
**OAKVILLE, ONTARIO**  
**G.W.P 189-00-01**

Approximate HML Location	Reference Borehole No.	Borehole Location	Stratum	Depth (m)	Elevation (m)	Groundwater Elevation (m)	Design Parameters <sup>1</sup>		
							$\phi'$	$\gamma$	$\gamma'$
Station 18+415	BH05-1	N 4812766.4 E 289268.9	Fill	0.0 – 1.8	107.3 – 105.4	105.5	28	19	-
			Clayey Silt Till	1.8 – 3.7	105.4 – 103.6		32	21	11
			Shale Bedrock	3.7 – 5.2	103.6 – 102.1		38	22	12
Station 18+450	W9	N 4812803.2 E 289325.0	Fill	0.0 – 2.2	107.3 – 105.1	105.5	28	19	9
			Clayey Silt Till	2.2 – 3.2	105.1 – 104.1		32	21	11
			Shale Bedrock	3.2 – 4.8	104.1 – 102.5		38	22	12
Station 18+550	BH05-2	N 4812866.8 E 289364.8	Fill	0.0 – 0.8	107.5 – 106.7	105.5	28	19	-
			Clayey Silt Till	0.8 – 2.1	106.7 – 105.3		32	21	11
			Shale Bedrock	2.1 – 4.3	105.3 – 103.2		38	22	12
Station 18+785	BH1	N 4812979.5 E 289475.4	Fill	0.0 – 1.5	107.0 – 105.5	105.5	28	19	-
			Silty Clay Till	1.5 – 2.9	105.5 – 104.1		32	21	11
			Shale Bedrock	2.9 – 3.7	104.1 – 103.3		38	22	12
Station 18+865	W5	N 4813038.0 E 289523.3	Fill	0.0 – 1.4	107.5 – 106.1	105.5	28	19	-
			Clayey Silt Till	1.4 – 1.9	106.1 – 105.6		32	21	-
			Shale Bedrock	1.9 – 2.5	105.6 – 105.0		38	22	12
Station 18+865	W4	N 4813098.4 E 289571.9	Fill	0.0 – 0.9	108.8 – 107.9	105.5	28	19	-
			Clayey Silt Till	0.9 – 1.5	107.9 – 107.3		32	21	-
			Sandy Silt	1.5 – 2.2	107.3 – 106.6		30	20	-
			Shale Bedrock	2.2 – 4.6	106.6 – 104.2		38	22	12
Station 18+950	BH05-3	N 4813177.3 E 289609.9	Fill	0.0 – 0.9	107.0 – 106.1	105.5	28	19	-
			Silty Clay Residual Soil	0.9 – 1.5	106.1 – 105.5		32	21	-
			Shale Bedrock	1.5 – 4.7	105.5 – 102.3		38	22	12

**TABLE 2 (continued)**  
**DESIGN PARAMETERS FOR NOISE BARRIER WALL FOUNDATION**  
**QEW WIDENING**  
**FROM THIRD LINE TO 1 KM EAST OF TRAFALGAR ROAD**  
**OAKVILLE, ONTARIO**  
**G.W.P 189-00-01**

Approximate HML Location	Reference Borehole No.	Borehole Location	Stratum	Depth (m)	Elevation (m)	Groundwater Elevation (m)	Design Parameters <sup>1</sup>		
							$\phi'$	$\gamma$	$\gamma'$
Station 19+010	W2	N 4813211.6 E 289661.9	Fill	0.0 – 0.7	106.6 – 105.9	105.5	28	19	-
			Silty Clay Till	0.7 – 1.5	105.9 – 105.1		32	21	11
			Clayey Silt Residual Soil	1.5 – 1.9	105.1 – 104.7		32	21	11
			Shale Bedrock	1.9 – 4.7	104.7 – 101.9		38	22	12
Station 19+090	W1	N 4813284.1 E 289704.1	Fill	0.0 – 0.7	106.3 – 105.6	105.5	28	19	-
			Clayey Silt Till	0.7 – 2.4	105.6 – 103.9		32	21	11
			Shale Bedrock	2.4 – 4.6	103.9 – 101.7		38	22	12

**NOTES:**

Design parameters:

 $\phi'$  = effective friction angle (degrees); $\gamma$  = bulk unit weight (kN/m<sup>3</sup>); $\gamma'$  = effective unit weight below the groundwater level (kN/m<sup>3</sup>)

## LIST OF ABBREVIATIONS

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

### I. SAMPLE TYPE

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

### 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

### 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.)

#### Consistency

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

#### 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<sup>2</sup> 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.

### 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 <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	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 <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	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

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

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\epsilon$	linear strain
$\epsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	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
$\gamma'$	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
$\sigma'_p$	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

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

- Notes:**
- 1  $\tau = c' + \sigma' \tan \phi'$
  - 2 shear strength  $= (\text{compressive strength})/2$
  - \* density symbol is  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density x acceleration due to gravity)



PROJECT 011-1128			RECORD OF BOREHOLE No F7			1 OF 1 METRIC												
G.W.P. 189-00-01			LOCATION N 4810992.0 ; E 287842.0			ORIGINATED BY SB												
DIST 4 HWY QEW			BOREHOLE TYPE CME 75, 100mm O.D. Solid Stem Auger			COMPILED BY SEP												
DATUM Geodetic			DATE November 29, 2001			CHECKED BY ASP												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) W <sub>p</sub> — W — W <sub>L</sub>			γ		
110.1	GROUND SURFACE							20 40 60 80 100										
109.5	TOPSOIL Silty clay (FILL) Brown																	
109.5	Weathered, red-brown and grey SHALE BEDROCK (Queenston Formation) with occasional limestone siltstone layers		1	SS	86/25													
109.5			2	SS	50/13													
108.5	Augers grinding at depths of 1.2 m and 2.3 m for 25 mm.																	
107.5			3	SS	50/08													
106.5	Augers grinding at depths of 3.6 m and 4.0 m for 50 mm.																	
105.5	END OF BOREHOLE		4	SS	50/08													
105.5	Notes: 1. Water level in open borehole at a depth of 1.7 m (Elev.108.4 m) upon completion of drilling.																	

PROJECT 011-1128			RECORD OF BOREHOLE No H7			1 OF 1 METRIC									
G.W.P. 189-00-01			LOCATION N 4811344.0 ; E 288142.0			ORIGINATED BY ANB									
DIST 4 HWY QEW			BOREHOLE TYPE CME 75, 100mm O.D. Solid Stem Auger			COMPILED BY SEP									
DATUM Geodetic			DATE December 14, 2001			CHECKED BY ASP									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
112.2 0.0	GROUND SURFACE ASPHALT		1	AS											
	Crushed gravel (FILL) Brown														
111.4 0.8	Silty sand, trace gravel (FILL) Brown Moist		2	SS	11										
	Clayey silt, trace to some sand, trace gravel (FILL) Stiff to very stiff Brown to red-brown Moist		3	SS	16										
110.1 2.1	CLAYEY SILT, trace sand to some shale fragments (Residual Soil) Firm to stiff Red-brown Moist		4	SS	6										
			5	SS	10										
108.2 4.0	SHALE BEDROCK (Queenston Formation) with occasional grey limestone/siltstone fragments Red-brown and grey		6	SS	50/05										
			7	SS	50/02										
			8	SS	50/02										
104.6 7.6	END OF BOREHOLE		9	SS	50/02										
Notes: 1. Borehole caved at a depth of 3.6 m upon completion of drilling. 2. Water level in open borehole at a depth of 3.3 m (Elev.108.9 m) upon completion of drilling.															

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PROJECT 011-1128			RECORD OF BOREHOLE No W1			1 OF 1 METRIC											
G.W.P. 189-00-01			LOCATION N 4813284.1 ; E 289704.1			ORIGINATED BY CR											
DIST 4 HWY QEW			BOREHOLE TYPE CME 75, 100mm O.D. Solid Stem Auger			COMPILED BY NK											
DATUM Geodetic			DATE December 14, 2006			CHECKED BY CN											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED			WATER CONTENT (%) W <sub>p</sub> — W — W <sub>L</sub>			γ kN/m <sup>3</sup>	GR SA SI CL		
							20 40 60 80 100				10 20 30						
106.3	GROUND SURFACE																
0.0	ASPHALT																
0.2	Sand and gravel, trace silt (FILL) Compact		1	SS	19		106										
105.6	Reddish brown																
0.7	Moist CLAYEY SILT, some to trace sand, trace gravel, containing sand seams (TILL) Very stiff to hard Reddish brown to grey, mottled Moist		2	SS	22		105										
			3	SS	33												
103.9	Grinding of augers noted at a depth of 2.29 m		4	SS	50/0.08		104										
2.4	SHALE BEDROCK Reddish to grey		5	SS	50/0.13		103										
101.7							102										
4.6	END OF BOREHOLE		6	SS	50/0.08												
Notes: 1. Open borehole dry upon completion of drilling.																	

PROJECT 011-1128			RECORD OF BOREHOLE No W2			1 OF 1 METRIC						
G.W.P. 189-00-01			LOCATION N 4813211.6 ; E 289661.9			ORIGINATED BY CR						
DIST 4 HWY QEW			BOREHOLE TYPE CME 75, 100mm O.D. Solid Stem Auger			COMPILED BY NK						
DATUM Geodetic			DATE December 14, 2006			CHECKED BY CN						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W <sub>p</sub> — W — W <sub>L</sub>	WATER CONTENT (%)	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES							
106.6	GROUND SURFACE											
0.0	ASPHALT											
0.2	Sand and gravel, some silt (FILL)		1	SS	11							
105.9	Compact											
0.7	Reddish brown											
	Moist											
105.1	SILTY CLAY, trace to some sand, some gravel (TILL)		2	SS	33							
	Stiff											
104.7	Reddish brown, grey, mottled		3	SS	72/0.20							
	Moist											
104.7	CLAYEY SILT, some sand, trace gravel (Residual Soil)											
1.9	Hard		4	SS	50/0.13							
	Reddish-brown, mottled											
	Moist											
	SHALE BEDROCK		5	SS	50/0.08							
	Reddish brown											
	Grinding of augers noted from depths 3.20 m to 3.25 m, 3.81 m to 3.88 m and 4.26 m to 4.29 m											
101.9												
4.7	END OF BOREHOLE		6	SS	50/0.10							
	Notes:  1. Water level in open borehole at a depth of 4.3 m (Elev. 102.3 m) upon completion of drilling.											

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PROJECT <u>011-1128</u>		<b>RECORD OF BOREHOLE No W4</b>		1 OF 1 <b>METRIC</b>	
G.W.P. <u>189-00-01</u>		LOCATION <u>N 4813098.4 ; E 289571.9</u>		ORIGINATED BY <u>CR</u>	
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>		COMPILED BY <u>NK</u>	
DATUM <u>Geodetic</u>		DATE <u>December 14, 2006</u>		CHECKED BY <u>CN</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								<div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div><div></div><div></div></div>		
108.8	GROUND SURFACE													
0.0	ASPHALT		1	SS	9									
0.2	Silty sand, trace to some gravel, contains brick fragments (FILL) Loose													
107.9	Brown to dark brown Moist		2	SS	36									
0.9	CLAYEY SILT, trace sand, trace gravel, contains cobbles (TILL) Hard		3	SS	50/0.10									
107.3	Moist													
1.5	SANDY SILT, trace to some clay, contains rock fragments Very dense		4	SS	50/0.08									
106.6	Brown Moist													
2.2	Grinding of augers noted at depths of 1.82 m to 1.98 m and 2.13 m to 2.18 m		5	SS	50/0.13									
	SHALE BEDROCK Reddish brown													
	Grinding of augers noted at a depth of 2.89 m													
104.2	END OF BOREHOLE		6	SS	50/0.05									
4.6	Notes:  1. Open borehole dry upon completion of drilling.													

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PROJECT <u>011-1128</u>		<b>RECORD OF BOREHOLE No W5</b>		1 OF 1 <b>METRIC</b>	
G.W.P. <u>189-00-01</u>		LOCATION <u>N 4813038.0 ; E 289523.3</u>		ORIGINATED BY <u>CR</u>	
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>		COMPILED BY <u>NK</u>	
DATUM <u>Geodetic</u>		DATE <u>December 12, 2006</u>		CHECKED BY <u>CN</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT  w <sub>p</sub>	NATURAL MOISTURE CONTENT  w	LIQUID LIMIT  w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED									
107.5	GROUND SURFACE																			
0.0	Silty sand and gravel (FILL) Loose to compact Brown Moist		1	SS	5															
106.4			2	SS	10															
106.1	Sandy silt, trace gravel, contains topsoil (FILL) Compact																			
1.4	Brown to dark brown Moist to wet		3	SS	50															
105.6	CLAYEY SILT, trace sand, trace gravel (TILL) Hard		4	SS	55/0.13															
1.9	Reddish brown to grey, mottled Moist to wet																			
105.0	SHALE BEDROCK Reddish brown																			
2.5	Grinding of augers noted at depths 1.98 to 2.08 m END OF BOREHOLE																			
	Notes:  1. Water level in open borehole at a depth of 1.8 m (perched) during drilling.  2. Water level in open borehole at a depth of 1.8 m (Elev. 105.7 m) upon completion of drilling.																			

PROJECT 011-1128			RECORD OF BOREHOLE No W9			1 OF 1 METRIC												
G.W.P. 189-00-01			LOCATION N 4812803.2; E 289325.0			ORIGINATED BY CR												
DIST 4 HWY QEW			BOREHOLE TYPE CME 75, 100mm O.D. Solid Stem Auger			COMPILED BY NK												
DATUM Geodetic			DATE December 12, 2006			CHECKED BY CN												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED			WATER CONTENT (%) W <sub>p</sub> — W — W <sub>L</sub>			γ				
107.3 0.0	GROUND SURFACE TOPSOIL		1	SS	8		107											
106.8 0.6	Sandy silt, trace gravel, trace organics (FILL) Loose Brown Moist Clayey silt, trace to some sand, some gravel, contains topsoil (FILL) Firm Brown Moist to wet		2	SS	7		106											
105.1 2.2	CLAYEY SILT, some sand, some gravel, contains cobbles (TILL) Hard Reddish brown Wet		3	SS	50/0.13		105											
104.1 3.2	SHALE BEDROCK Reddish brown		4	SS	46		104											
102.5 4.8	Grinding of augers noted at depths 4.57 m to 4.65 m Auger refusal at a depth of 4.78 m END OF BOREHOLE		5	SS	55/0.08		103											
	Notes: 1. Water level in open borehole at a depth of 1.5 m during drilling. 2. Water level in open borehole at a depth of 2.1 m (Elev. 105.2 m) upon completion of drilling. 3. Water level in piezometer at a depth of 2.1 m (Elev. 105.2 m) on February 13, 2007.		6	SS	50/0.08													

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PROJECT 011-1128			RECORD OF BOREHOLE No W11			1 OF 1 METRIC																
G.W.P. 189-00-01			LOCATION N 4811415.8 ; E 288196.7			ORIGINATED BY CR																
DIST 4 HWY QEW			BOREHOLE TYPE CME 75, 100mm O.D. Solid Stem Auger			COMPILED BY NK																
DATUM Geodetic			DATE December 19, 2006			CHECKED BY CN																
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) W <sub>p</sub> — W — W <sub>L</sub>			γ						
113.8 0.0	GROUND SURFACE ASPHALT							20 40 60 80 100														
113.3 0.5	Sand and gravel (FILL) Compact Brown Moist		1	SS	33		113															
112.3 1.5	Clayey silt, some sand, contains topsoil (FILL) Firm Reddish brown Wet		2	SS	6		112															
111.5 2.3	Silty sand, trace to some gravel (FILL) Loose Reddish brown Wet		3	SS	4		111															
110.8 3.0	Clayey silt, some sand, some gravel (FILL) Very stiff Brown to reddish brown Wet		4	SS	18		110															
	SHALE BEDROCK Reddish brown to grey, contains limestone inclusions		5	SS	50/0.1		109															
			6	SS	50/0.07		108															
107.7 6.2	END OF BOREHOLE		7	SS	50/0.06																	
Notes: 1. Water level in open borehole at a depth of 0.8 m (perched) during of drilling. 2. Water level in open borehole at a depth of 0.8 m (Elev. 113.0 m) upon completion of drilling. 3. Tubing frozen on February 13, 2007.																						

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PROJECT <u>011-1128</u>			<b>RECORD OF BOREHOLE No W12</b>			1 OF 1 <b>METRIC</b>		
G.W.P. <u>189-00-01</u>			LOCATION <u>N 4811376.0 ; E 288165.0</u>			ORIGINATED BY <u>CR</u>		
DIST <u>4</u> HWY <u>QEW</u>			BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>			COMPILED BY <u>NK</u>		
DATUM <u>Geodetic</u>			DATE <u>December 19, 2006</u>			CHECKED BY <u>CN</u>		









  

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE "N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   x REMOULDED		WATER CONTENT (%) W <sub>p</sub> W   W <sub>L</sub>				
112.7 0.0	GROUND SURFACE ASPHALT												
112.2 0.5	Sand and Gravel, (FILL) Compact Brown Moist		1	SS 27									
111.2 1.5	Clayey silt, with gravel, some sand, some cobbles (FILL) Very stiff Dark brown Moist		2	SS 26									
110.6 2.5	Silty sand, some clay, some gravel (FILL) Stiff Reddish brown Moist		3	SS 9									
110.2 2.5	CLAYEY SILT, some sand, trace gravel, contains cobbles (TILL) Stiff Reddish brown Moist		4	SS 65/0.29									
	SHALE BEDROCK Grey to reddish brown		5	SS 50/0.07									
108.1 4.6	END OF BOREHOLE		6	SS 50/0.05									
Notes: 1. Open borehole dry upon completion of drilling.													

PROJECT <u>011-1128</u>		<b>RECORD OF BOREHOLE No W14</b>		1 OF 1 <b>METRIC</b>	
G.W.P. <u>189-00-01</u>		LOCATION <u>N 4811278.5 ; E 288084.8</u>		ORIGINATED BY <u>CR</u>	
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>		COMPILED BY <u>NK</u>	
DATUM <u>Geodetic</u>		DATE <u>December 19, 2006</u>		CHECKED BY <u>CN</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>					
111.5	GROUND SURFACE																			
0.0	ASPHALT																			
0.2	Sand and gravel (FILL) Compact Brown Moist		1	SS	22															
			2	SS	9															
110.1																				
1.4	Clayey silt, some sand, some gravel, contains topsoil (FILL) Very stiff to hard Brown to dark-brown Moist		3	SS	17												19	20 43 18		
			4A																	
108.9			4B	SS	43															
2.6	SHALE BEDROCK, occasional limestone inclusions Grey to reddish brown		5	SS	50/0.07															
	Grinding of augers noted at depths 3.96 m, 4.06 m, 4.47 and 4.87 m		6	SS	50/0.07															
	Grinding of augers noted at depths 5.64 m and 5.79 m																			
105.4			7	SS	50/0.08															
6.2	END OF BOREHOLE																			
	Notes:  1. Water level in open borehole at a depth of 2.3 m (perched) during drilling.  2. Open borehole dry upon completion of drilling.																			

PROJECT <u>011-1128</u>		<b>RECORD OF BOREHOLE No W15</b>		1 OF 1 <b>METRIC</b>	
G.W.P. <u>189-00-01</u>		LOCATION <u>N 4811217.7 ; E 288034.7</u>		ORIGINATED BY <u>CR</u>	
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>		COMPILED BY <u>NK</u>	
DATUM <u>Geodetic</u>		DATE <u>December 19, 2006</u>		CHECKED BY <u>CN</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT   NATURAL MOISTURE   LIQUID CONTENT   LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × REMOULDED				w <sub>p</sub> w   w <sub>L</sub>				
110.9	GROUND SURFACE						20	40	60	80	100					
0.0	Sand and Gravel, (FILL) Compact Brown Moist		1	SS	20											
110.4	CLAYEY SILT, trace sand Hard Reddish brown, mottled Moist		2	SS	47								○			
109.5	SHALE BEDROCK Grey to reddish brown		3	SS	50/0.11								○			
1.4			4	SS	50/0.13											
			5	SS	50/0.07								○			
																
																
106.3	END OF BOREHOLE		6	SS	50/0.05											
4.6	Notes:  1. Open borehole dry upon completion of drilling.															

PROJECT <u>011-1128</u>			<b>RECORD OF BOREHOLE No W16</b>			1 OF 1 <b>METRIC</b>		
G.W.P. <u>189-00-01</u>			LOCATION <u>N 4811151.7 ; E 287984.2</u>			ORIGINATED BY <u>CR</u>		
DIST <u>4</u> HWY <u>QEW</u>			BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>			COMPILED BY <u>NK</u>		
DATUM <u>Geodetic</u>			DATE <u>December 19, 2006</u>			CHECKED BY <u>CN</u>		

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa				WATER CONTENT (%)				
							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
111.1	GROUND SURFACE															
0.0	Sand and gravel (FILL)		1	SS	16											
110.6	Compact Brown Moist															
0.5	CLAYEY SILT to SILTY CLAY, trace sand		2	SS	33								o			0 5 65 30
109.7	Hard Reddish brown to grey Moist		3	SS	50/0.13											
1.4	SHALE BEDROCK, occasional limestone inclusions Grey to reddish brown		4	SS	50/0.13											
			5	SS	71/0.25								o			
	Grinding of augers noted at depths 4.11 m to 4.26 m depth															
106.5	END OF BOREHOLE		6	SS	50/0.08											
4.7	Notes:  1. Water level in open borehole at a depth of 2.7 m (Elev. 108.4 m) upon completion of drilling.															

PROJECT		011-1128		<b>RECORD OF BOREHOLE No W18</b>				1 OF 1 <b>METRIC</b>						
G.W.P.		189-00-01		LOCATION		N 4810943.8 ; E 287813.3		ORIGINATED BY CR						
DIST		4 HWY QEW		BOREHOLE TYPE		CME 75, 100mm O.D. Solid Stem Auger		COMPILED BY NK						
DATUM		Geodetic		DATE		December 17, 2006		CHECKED BY CN						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
110.4	GROUND SURFACE													
0.0	ASPHALT													
0.2	Sand and gravel (FILL)		1	SS	35									
0.6	Compact Brown Moist													
109.8	Clayey silt, trace to some sand, trace gravel, contains topsoil (FILL)		2	SS	12									
109.0	Very stiff to stiff													
1.4	Reddish brown, grey, mottled Moist		3	SS	71/0.29									
108.3	CLAYEY SILT, trace to some sand, trace gravel (Residual Soil)													
2.1	Hard Reddish brown Moist		4	SS	50/0.13									
	SHALE BEDROCK													
	Reddish brown		5	SS	50/0.08									
105.7	END OF BOREHOLE		6	SS	50/0.08									
4.7	Notes: 1. Water level in open borehole at a depth of 2.7 m during drilling. 2. Water level in open borehole at a depth of 2.7 m (Elev. 107.7 m) upon completion of drilling.													

PROJECT <u>011-1128</u>		<b>RECORD OF BOREHOLE No W19</b>		1 OF 1 <b>METRIC</b>	
G.W.P. <u>189-00-01</u>		LOCATION <u>N 4810904.9 ; E 287778.8</u>		ORIGINATED BY <u>CR</u>	
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>		COMPILED BY <u>NK</u>	
DATUM <u>Geodetic</u>		DATE <u>December 17, 2006</u>		CHECKED BY <u>CN</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)					
								20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>				
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x REMOULDED									
110.5	GROUND SURFACE														
0.0	ASPHALT		1	SS	18										
0.2	Sand and gravel (FILL) Compact to loose Brown														
109.7	Moist														
0.8	Clayey silt to silty clay, contains topsoil (FILL) Firm to stiff Reddish brown, grey, mottled Moist		2	SS	7										
			3	SS	12										
108.2															
2.3	SHALE BEDROCK, contains limestone inclusions Reddish brown to grey		4	SS	50/0.08										
			5	SS	50/0.15										
105.8	Grinding of augers noted at a depth of 4.27 m														
4.7	END OF BOREHOLE		6	SS	50/0.08										
	Notes:  1. Open borehole dry upon completion of drilling.														

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PROJECT		011-1128		<b>RECORD OF BOREHOLE No W20</b>		1 OF 1 <b>METRIC</b>								
G.W.P.		189-00-01		LOCATION		N 4810742.6 ; E 287646.8								
DIST		4 HWY QEW		BOREHOLE TYPE		CME 75, 100mm O.D. Solid Stem Auger								
DATUM		Geodetic		DATE		December 18, 2006								
						ORIGINATED BY CR								
						COMPILED BY NK								
						CHECKED BY CN								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
110.0	GROUND SURFACE													
0.0	ASPHALT													
109.5	Sand and gravel (FILL) Compact Brown Moist		1	SS	23									
0.8	Silty sand, trace clay, some gravel (FILL) Compact Brown Moist		2	SS	19									
			3	SS	81/0.23									
107.7	CLAYEY SILT, trace sand, contains shale fragments below 1.52 m (Residual Soil) Very stiff to hard Grey-reddish brown, mottled Moist		4	SS	50/0.05									
2.3	SHALE BEDROCK contains limestone inclusions Reddish brown to grey		5	SS	50/0.05									
	Grinding of augers noted at depths of 2.74 m to 2.79 m													
			6	SS	50/0.08									
	Grinding of augers noted at depths of 4.72 m, 5.18 m, 5.64 m and 5.79 m													
			7	SS	50/0.06									
102.4	END OF BOREHOLE													
7.6	Notes:  1. Water level in open borehole at a depth of 3.4 m (perched) during drilling.  2. Water level in open borehole at a depth of 4.6 m (Elev. 105.4 m) upon completion of drilling.  3. Water level in piezometer at a depth of 3.0 m depth (Elev. 107.0 m) on February 13, 2007.													

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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



PROJECT <u>011-1128</u>			<b>RECORD OF BOREHOLE No W22</b>			1 OF 1 <b>METRIC</b>		
G.W.P. <u>189-00-01</u>			LOCATION <u>N 4810674.5 ; E 287584.4</u>			ORIGINATED BY <u>CR</u>		
DIST <u>4</u> HWY <u>QEW</u>			BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>			COMPILED BY <u>NK</u>		
DATUM <u>Geodetic</u>			DATE <u>December 17, 2006</u>			CHECKED BY <u>CN</u>		

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE "N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W   W <sub>L</sub>	10 20 30			
109.7	GROUND SURFACE												
0.0	ASPHALT												
	Sand and gravel (FILL)		1	SS	14								
108.9	Compact Brown Moist												
0.8	Clayey silt, some sand, some gravel (FILL)		2	SS	14								
	Stiff Reddish brown, mottled Moist												
	CLAYEY SILT, some sand, trace gravel (TILL)		3	SS	44								
107.4	Stiff to hard Reddish brown to grey, mottled Moist		4	SS	50/0.13								
2.3	Grinding of augers noted at a depth of 2.29 m		5	SS	50/0.10								
	SHALE BEDROCK contains limestone inclusions Reddish brown to grey Moist		6	SS	50/0.07								
	Grinding of augers noted at a depth of 3.81 m												
105.0			7	SS	50/0.07								
4.7	END OF BOREHOLE												
Notes: 1. Water level in open borehole at a depth of 0.5 m (perched) during drilling. 2. Water level in open borehole at a depth of 0.5 m (Elev. 109.2 m) upon completion of drilling.													

PROJECT <u>011-1128</u>			<b>RECORD OF BOREHOLE No W23</b>			1 OF 1 <b>METRIC</b>		
G.W.P. <u>189-00-01</u>			LOCATION <u>N 4811095.8 ; E 288003.9</u>			ORIGINATED BY <u>CR</u>		
DIST <u>4</u> HWY <u>QEW</u>			BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>			COMPILED BY <u>NK</u>		
DATUM <u>Geodetic</u>			DATE <u>December 20, 2006</u>			CHECKED BY <u>CN</u>		

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE "N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED						
109.4	GROUND SURFACE												
0.0	ASPHALT												
0.1	Sand and gravel (FILL)		1	SS 25									
0.6	Compact Grey-brown Moist												
0.8			2	SS 75/0.25									
1.1	CLAYEY SILT, some sand, trace gravel (TILL) Hard Reddish brown Moist												
	SHALE BEDROCK Reddish brown		3	SS 78/0.28									
			4	SS 50/0.13									
	Grinding of augers noted at a depth of 3.05 m		5	SS 50/0.13									
	Grinding of augers noted at a depth of 3.96 m												
104.7			6	SS 50/0.10									
4.7	END OF BOREHOLE												
Notes: 1. Open borehole dry upon completion of drilling.													

PROJECT <u>011-1128</u>			<b>RECORD OF BOREHOLE No W24</b>			1 OF 1 <b>METRIC</b>		
G.W.P. <u>189-00-01</u>			LOCATION <u>N 4811151.2; E 288049.9</u>			ORIGINATED BY <u>CR</u>		
DIST <u>4</u> HWY <u>QEW</u>			BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>			COMPILED BY <u>NK</u>		
DATUM <u>Geodetic</u>			DATE <u>December 20, 2006</u>			CHECKED BY <u>CN</u>		

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE "N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED								
110.4	GROUND SURFACE														
0.0	ASPHALT														
109.9	Sand and gravel (FILL) Compact Brown		1	SS 24											
0.5	Moist CLAYEY SILT, some sand, trace gravel (TILL) Very stiff		2	SS 24											
108.9	Reddish brown Moist		3	SS 50/0.13											
1.5	SHALE BEDROCK, contains limestone inclusions Reddish brown to grey		4	SS 50/0.13											
	Grinding of augers noted at depths of 3.20 m to 3.25 m and 3.51		5	SS 50/0.13											
	Grinding of augers noted at a depth of 3.96 m														
105.8	END OF BOREHOLE		6	SS 50/0.08											
4.7	Notes:  1. Open borehole dry upon completion of drilling.														

PROJECT		RECORD OF BOREHOLE		No W25		1 OF 1		METRIC					
G.W.P. 189-00-01		LOCATION		N 4811210.8; E 288097.5		ORIGINATED BY		CR					
DIST 4 HWY QEW		BOREHOLE TYPE		CME 75, 100mm O.D. Solid Stem Auger		COMPILED BY		NK					
DATUM Geodetic		DATE		December 21, 2006		CHECKED BY		CN					
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	GR SA SI CL
111.0	GROUND SURFACE		1	SS	50/0.13								
0.0	ASPHALT												
0.2	Sand and gravel, trace silt, zones of clayey silt, contains cobbles (FILL)												
110.4	Compact to loose												
0.6	Brown Moist CLAYEY SILT, some sand, trace gravel, contains shale fragments (TILL)		2	SS	18		110						
	Firm to very stiff Reddish brown Moist		3	SS	9		109						
	Cobbles encountered at 0.41 m to 0.61 m, 0.76 m to 1.37 m depth		4	SS	4								
108.3	SHALE BEDROCK, contains limestone inclusions Reddish brown to grey		5	SS	50/0.13		108						
2.7	Grinding of augers noted at depths of 3.66 m, 3.81 m and 3.96 m						107						
106.3	END OF BOREHOLE		6	SS	50/0.13								
4.7	Notes: 1. Water level in open borehole at a depth of 0.8 m during drilling. 2. Open borehole dry upon completion of drilling. 3. Water level in piezometer at a depth of 2.4 m (Elev. 108.6 m) on February 13, 2007												

PROJECT <u>011-1128</u>		<b>RECORD OF BOREHOLE No W26</b>				1 OF 1 <b>METRIC</b>	
G.W.P. <u>189-00-01</u>		LOCATION <u>N 4811270.5 ; E 288147.2</u>				ORIGINATED BY <u>CR</u>	
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>				COMPILED BY <u>NK</u>	
DATUM <u>Geodetic</u>		DATE <u>December 21, 2006</u>				CHECKED BY <u>CN</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
							20 40 60 80 100			W <sub>p</sub>	W	W <sub>L</sub>		
							20 40 60 80 100							
111.3	GROUND SURFACE													
0.0	ASPHALT													
0.1	Sand and gravel (FILL)		1	SS	30									
110.7	Dense Brown Moist													
0.6	CLAYEY SILT, trace sand, trace gravel (TILL)		2	SS	13									
109.8	Stiff Reddish brown Moist		3	SS	75/0.25									
1.5	SHALE BEDROCK, contains limestone inclusions Grey to reddish brown		4	SS	50/0.13									
			5	SS	50/0.14									
106.7														
4.7	END OF BOREHOLE		6	SS	50/0.08									
Notes: 1. Open borehole dry upon completion of drilling.														

PROJECT <u>011-1128</u>			<b>RECORD OF BOREHOLE No W27</b>			1 OF 1 <b>METRIC</b>		
G.W.P. <u>189-00-01</u>			LOCATION <u>N 4811323.6 ; E 288190.2</u>			ORIGINATED BY <u>CR</u>		
DIST <u>4</u> HWY <u>QEW</u>			BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>			COMPILED BY <u>NK</u>		
DATUM <u>Geodetic</u>			DATE <u>December 21, 2006</u>			CHECKED BY <u>CN</u>		

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	"N" VALUES			SHEAR STRENGTH kPa						
						○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED							
111.7	GROUND SURFACE												
0.0	ASPHALT												
111.2	Sand and gravel, trace silt (FILL)		1	SS 20									
0.5	Compact Brown Moist												
110.3	CLAYEY SILT, some sand, trace gravel (TILL)		2	SS 34									0 4 70 26
1.4	Hard Reddish brown Moist		3	SS 50/0.13									
	SHALE BEDROCK, contains limestone inclusions												
	Grey to reddish-brown		4	SS 50/0.15									
	Grinding of augers noted at depths of 2.74 m and 2.89 m												
			5	SS 50/0.08									
	Grinding of augers noted at depths of 3.35 m and 3.51 m depth												
107.0													
4.7	END OF BOREHOLE		6	SS 50/0.10									
Notes: 1. Open borehole dry upon completion of drilling.													

PROJECT <u>011-1128</u>		<b>RECORD OF BOREHOLE No W28</b>		1 OF 1 <b>METRIC</b>	
G.W.P. <u>189-00-01</u>		LOCATION <u>N 4811384.0 ; E 288240.1</u>		ORIGINATED BY <u>CR</u>	
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>		COMPILED BY <u>NK</u>	
DATUM <u>Geodetic</u>		DATE <u>December 21, 2006</u>		CHECKED BY <u>CN</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20	40	60	80	100			W <sub>p</sub>	W	W <sub>L</sub>
112.1	GROUND SURFACE																
0.0	ASPHALT																
0.2	Sand and gravel (FILL) Very dense Brown		1	SS	74												
111.3	Moist		2	SS	81/0.25												
0.8	CLAYEY SILT, some sand, some gravel, contains shale fragments (TILL) Firm to hard Reddish brown Moist		3	SS	21												
	Cobbles encountered at depths 0.91 m to 1.22 m and 1.98 m to 2.13 m		4	SS	7												
109.1			5	SS	50/0.15												
3.0	SHALE BEDROCK, contains limestone inclusions Reddish brown																
	Grinding of augers noted at depths of 3.66 m and 4.11 m																
107.4																	
4.7	END OF BOREHOLE		6	SS	50/0.1												
	Notes:  1. Water level in open borehole at a depth of 1.8 m (perched) during drilling.  2. Open borehole dry upon completion of drilling.																

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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



PROJECT 011-1128			RECORD OF BOREHOLE No W30			1 OF 1 METRIC													
G.W.P. 189-00-01			LOCATION N 4811495.8 ; E 288334.1			ORIGINATED BY CR													
DIST 4 HWY QEW			BOREHOLE TYPE CME 75, 100mm O.D. Solid Stem Auger			COMPILED BY NK													
DATUM Geodetic			DATE December 21, 2006			CHECKED BY CN													
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								WATER CONTENT (%)			
112.8	GROUND SURFACE						20	40	60	80	100								
0.0	ASPHALT																		
0.2	Sand and gravel (FILL)		1	SS	32														
112.2	Dense																		
0.6	Brown																		
	Moist																		
	Silty SAND AND GRAVEL, trace to some clay, contains shale fragments (TILL)		2	SS	31														
	Loose to dense																		
	Brown to reddish brown		3	SS	8														
	Moist																		
	Cobbles encountered at depths of 1.22 m to 1.37 m, 1.52 m to 2.13 m and 2.28 m to 2.89 m		4	SS	5											26	42	23	9
109.3			5	SS	7														
3.5	SHALE BEDROCK, contains limestone inclusions																		
	Reddish brown to grey																		
	Grinding of augers noted at depths of 4.72 m and 4.88 m		6	SS	50/0.02														
106.7																			
6.2	END OF BOREHOLE		7	SS	50/0.05														
	Notes:																		
	1. Water level in open borehole at a depth of 2.3 m (perched) during drilling.																		
	2. Open borehole dry upon completion of drilling.																		

PROJECT		011-1128		<b>RECORD OF BOREHOLE No W31</b>		1 OF 1 <b>METRIC</b>							
G.W.P.		189-00-01		LOCATION		N 4811557.1 ; E 288388.5							
DIST		4 HWY QEW		BOREHOLE TYPE		CME 75, 100mm O.D. Solid Stem Auger							
DATUM		Geodetic		DATE		December 21, 2006							
						ORIGINATED BY CR							
						COMPILED BY NK							
						CHECKED BY CN							
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
113.1	GROUND SURFACE												
0.0	ASPHALT												
0.2	Sand and gravel, some silt, occasional cobbles (FILL)		1	SS	55								
112.3	Very dense												
0.8	Brown Moist		2	SS	18								
	CLAYEY SILT, some sand, some gravel, occasional cobbles (TILL)												
	Very stiff to hard		3	SS	22								
	Brown to reddish brown												
	Moist												
	Cobbles encountered at depths of 1.98 m to 2.44 m, 2.29 m to 2.89 m, 3.05 m to 3.1 m		4	SS	50/0.15								
110.1													
3.1	Silty SAND AND GRAVEL, trace clay, occasional cobbles (TILL)		5	SS	90								
	Very dense												
	Brown												
	Moist												
108.8	Cobbles encountered at depths of 3.1 m to 3.5 m												
4.3	SHALE BEDROCK		6	SS	50/0.05								
	Reddish brown												
	Grinding of augers noted at depths of 4.57 m to 4.78 m												
106.9													
6.2	END OF BOREHOLE		7	SS	50/0.05								
Notes: 1. Water level in open borehole at a depth of 4.3 m during drilling. 2. Water level in open borehole at a depth of 4.9 m (Elev. 108.2 m) upon completion of drilling.													

PROJECT 011-1128			RECORD OF BOREHOLE No W32			1 OF 1 METRIC								
G.W.P. 189-00-01		LOCATION N 4811615.5 ; E 288440.3		ORIGINATED BY CR										
DIST 4 HWY QEW		BOREHOLE TYPE CME 75, 100mm O.D. Solid Stem Auger		COMPILED BY NK										
DATUM Geodetic		DATE December 22, 2006		CHECKED BY CN										
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						
113.7	GROUND SURFACE													
0.0	ASPHALT													
0.2	Sand and gravel (FILL) Very dense Brown Moist		1	SS	51									
112.9														
0.8	Silty SAND AND GRAVEL, trace clay, occasional cobbles and boulders (TILL) Very dense Brown to reddish brown Moist		2	SS	50									
	Encountered cobbles at depths of 1.07 m to 1.22 m, 1.52 m to 2.13 m, 2.28 m to 2.3 m, 2.3 m to 2.89 m, 3.35 m to 3.51 m and 3.76 m to 3.96 m		3	SS	58									
			4	SS	50/0.05									
			5	SS	34									
109.7														
4.0	CLAYEY SILT, trace to some sand, some gravel (Residual Soil) Very stiff Reddish brown Moist													
108.7														
5.0	Encountered cobbles at depths of 4.57 m to 5.0 m SHALE BEDROCK Grey to reddish brown		6	SS	24									
107.6														
6.2	END OF BOREHOLE		7	SS	50/0.07									
	Notes:  1. Open borehole dry upon completion of drilling.													

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PROJECT 011-1128		RECORD OF BOREHOLE No W33				1 OF 1 METRIC										
G.W.P. 189-00-01		LOCATION N 4811645.1 ; E 288469.2		ORIGINATED BY CR												
DIST 4 HWY QEW		BOREHOLE TYPE CME 75, 100mm O.D. Solid Stem Auger		COMPILED BY NK												
DATUM Geodetic		DATE December 22, 2006		CHECKED BY CN												
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa							WATER CONTENT (%)	
114.4	GROUND SURFACE						20	40	60	80	100					
0.0	ASPHALT															
0.2	Sand and gravel, trace clay, contains clayey silt pockets, contains cobbles (FILL)		1	SS	20											
113.6	Compact Brown to reddish brown Moist		2	SS	50/0.15											
0.8	Silty SAND AND GRAVEL, trace clay, occasional cobbles (TILL) Compact to very dense Brown Moist		3	SS	60											
	Encountered cobbles at depths of 1.07 m to 1.37 m, 1.52 m to 2.13 m, 1.98 m to 2.29 m and 2.29 m to 2.82 m		4	SS	71											
	Grinding of augers noted at depths of 3.65 m to 3.96 m		5	SS	90											
	Grinding of augers noted at depths of 4.27 m to 4.42 m		6	SS	17											
108.9	SHALE BEDROCK Gray to reddish brown Moist															
5.5	Grinding of augers noted at a depth of 5.64 m		7	SS	50/0.13											
106.7	END OF BOREHOLE		8	SS	50/0.08											
7.7	Notes: 1. Open borehole dry upon completion of drilling.															

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PROJECT <u>011-1128</u>			<b>RECORD OF BOREHOLE No W34</b>			1 OF 1 <b>METRIC</b>		
G.W.P. <u>189-00-01</u>			LOCATION <u>N 4813711.4 ; E 290128.5</u>			ORIGINATED BY <u>CR</u>		
DIST <u>4</u> HWY <u>QEW</u>			BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>			COMPILED BY <u>NK</u>		
DATUM <u>Geodetic</u>			DATE <u>December 15, 2006</u>			CHECKED BY <u>CN</u>		

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
						○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED				WATER CONTENT (%)						
						20	40	60	80	100	10	20	30			
107.0	GROUND SURFACE															
0.0	ASPHALT															
0.2	Sand and gravel, trace silt (FILL)		1	SS	16						○					
106.2	Compact Brown Moist															
0.8	CLAYEY SILT, some sand, trace gravel (TILL)		2	SS	18											
105.5	Very stiff Reddish brown to grey, mottled Moist															
1.5	CLAYEY SILT, some sand (Residual Soil)		3	SS	39							○				4 5 63 28
104.9	Hard Reddish brown Moist		4	SS	50/0.13											
2.1	SHALE BEDROCK contains limestone inclusions Reddish brown to grey		5	SS	50/0.07											
	Grinding of augers noted at depths of 2.13 m to 2.29 m, 2.29 m to 2.57 m, 2.89 m to 3.05 m, 3.20 m to 3.25 m, 3.96 m, 4.11 m, 4.47 m		6	SS	50/0.13							○				
102.3																
4.7	END OF BOREHOLE		7	SS	50/0.15											
Notes: 1. Water level in open borehole at a depth of 3.1 m during drilling. 2. Water level in open borehole at a depth of 4.4 m (Elev. 102.6 m) upon completion of drilling.																

PROJECT <u>011-1128</u>		<b>RECORD OF BOREHOLE No W35</b>		1 OF 1 <b>METRIC</b>	
G.W.P. <u>189-00-01</u>		LOCATION <u>N 4813772.1 ; E 290171.4</u>		ORIGINATED BY <u>CR</u>	
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>		COMPILED BY <u>NK</u>	
DATUM <u>Geodetic</u>		DATE <u>December 15, 2006</u>		CHECKED BY <u>CN</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>		
106.0	GROUND SURFACE													
0.0	Sand and gravel, some silt (FILL) Compact Brown Moist		1	SS	16									
105.3														
0.7	CLAYEY SILT, trace sand, trace gravel (Residual Soil) Very stiff to hard Reddish brown to grey Moist		2	SS	24									
			3	SS	58									
103.8														
2.2	SHALE BEDROCK contains limestone inclusions Reddish brown to grey  Grinding of augers noted at depths of 2.20 m to 2.90m, 3.35 m to 3.51 m, 3.66 m to 3.76 m, 4.27 m to 4.37 m, 4.57 m to 4.57 m		4	SS	50/0.13									
			5	SS	50/0.13									
101.4														
4.6	END OF BOREHOLE		6	SS	50/0.09									
	Notes:  1. Water level in open borehole at a depth of 1.5 m during drilling.  2. Water level in open borehole at a depth of 1.5 m (Elev. 104.5 m) upon completion of drilling.  3. Water level in piezometer at a depth of 1.9 m (Elev. 104.1 m) on February 13, 2007.													





PROJECT <u>011-1128</u>			<b>RECORD OF BOREHOLE No W36</b>			1 OF 1 <b>METRIC</b>		
G.W.P. <u>189-00-01</u>			LOCATION <u>N 4813830.8 ; E 290214.4</u>			ORIGINATED BY <u>CR</u>		
DIST <u>4</u> HWY <u>QEW</u>			BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>			COMPILED BY <u>NK</u>		
DATUM <u>Geodetic</u>			DATE <u>December 15, 2006</u>			CHECKED BY <u>CN</u>		

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE "N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × REMOULDED		WATER CONTENT (%) W <sub>p</sub> W   W <sub>L</sub>				
106.3	GROUND SURFACE												
0.0	ASPHALT												
0.2	Sand and gravel, trace silt (FILL)		1	SS	15								
105.6	Compact Brown												
0.7	Moist												
104.9	Clayey silt, some sand, trace gravel, trace organics (FILL)		2	SS	26								
1.4	Very stiff												
104.4	Reddish brown to grey		3	SS	50/0.13								
1.9	Moist												
	CLAYEY SILT, some sand, trace gravel (Residual Soil)												
	Hard		4	SS	50/0.08								
	Reddish brown to grey												
	Moist												
	SHALE BEDROCK, contains limestone inclusions		5	SS	50/0.08								
	Reddish brown to grey												
	Grinding of augers noted at depths of 1.88 m to 1.98 m, 2.13 m, 2.29 m to 2.46 m, 2.84 m, 2.95 m to 2.99 m, 3.96 m to 4.06 m and 4.42 m to 4.47 m												
101.7													
4.6	END OF BOREHOLE		6	SS	50/0.02								
Notes: 1. Water level in open borehole at a depth of 2.4 m during drilling. 2. Water level in open borehole at depth of 2.5 m (Elev. 103.8 m) upon completion of drilling.													

PROJECT <u>011-1128</u>			<b>RECORD OF BOREHOLE No W37</b>				1 OF 1 <b>METRIC</b>	
G.W.P. <u>189-00-01</u>			LOCATION <u>N 4813890.6 ; E 290260.4</u>				ORIGINATED BY <u>CR</u>	
DIST <u>4</u> HWY <u>QEW</u>			BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>				COMPILED BY <u>NK</u>	
DATUM <u>Geodetic</u>			DATE <u>December 15, 2006</u>				CHECKED BY <u>CN</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub>	W	W <sub>L</sub>		
							20 40 60 80 100							
106.2	GROUND SURFACE													
0.0	Sand and gravel, some silt (FILL) Compact Brown Moist		1	SS	21									
105.5														
0.7	SILTY CLAY, some sand Stiff Reddish brown to grey, mottled Moist		2	SS	12								47	
104.8														
1.4	CLAYEY SILT, some sand, trace gravel (Residual Soil) Hard Reddish brown to grey, mottled Moist		3	SS	40									
104.1														
2.1	SHALE BEDROCK contains limestone inclusions Grey to reddish brown		4	SS	50/0.1									
	Grinding of augers noted at depths of 2.13 m to 2.18 m		5	SS	50/0.07									
	Grinding of augers noted at depths of 2.59 m to 2.64 m, 2.79 m to 2.89 m, and 3.66 m to 3.71 m													
	Grinding of augers noted at depths of 4.27 m to 4.37 m													
101.5														
4.7	END OF BOREHOLE													
	Notes:  1. Water level in open borehole at a depth of 2.6 m during drilling.  2. Water level in open borehole at a depth of 2.4 m (Elev. 103.8 m) upon completion of drilling.													

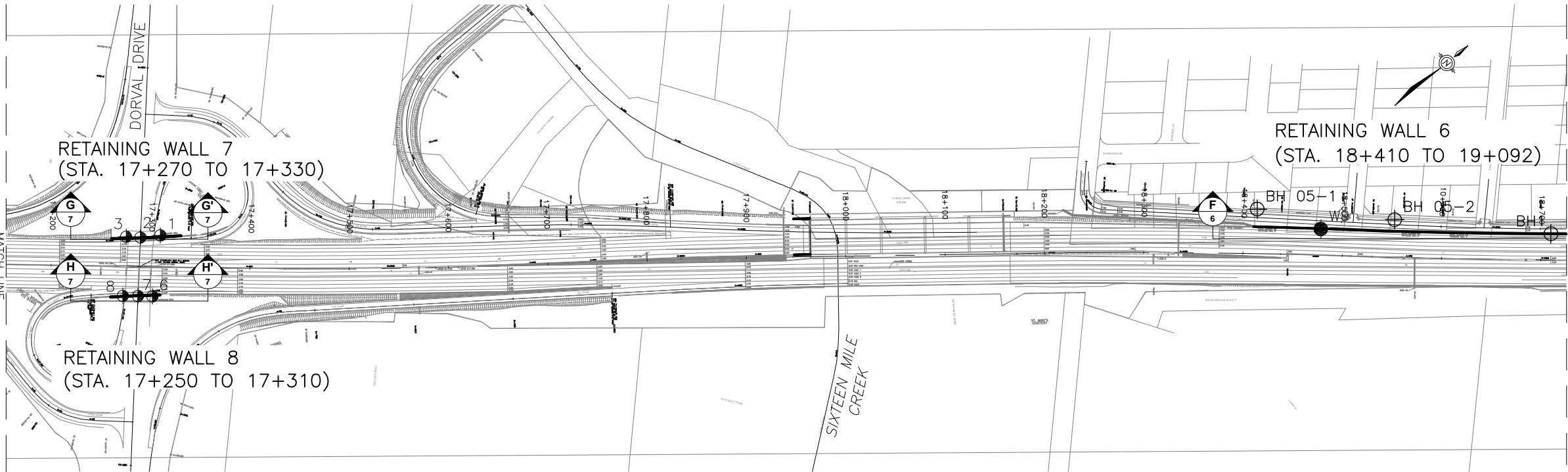
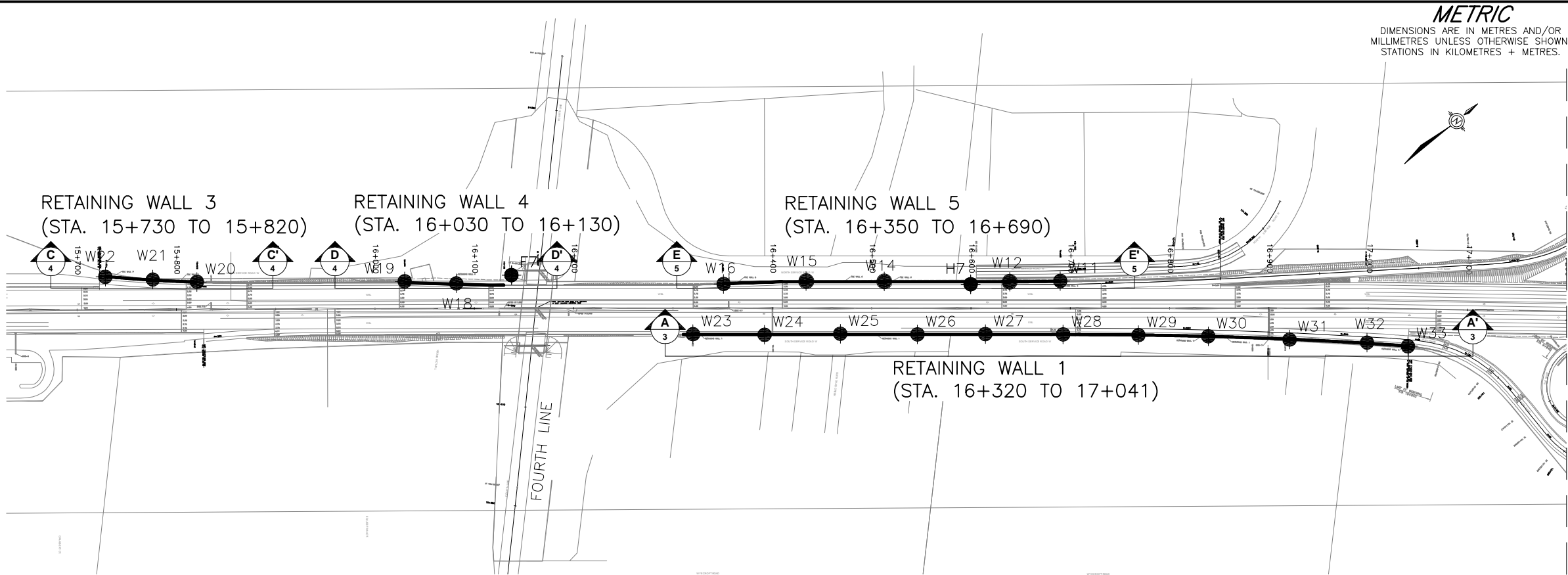


PROJECT		RECORD OF BOREHOLE				No W38		1 OF 1		METRIC					
G.W.P. 189-00-01		LOCATION		N 4813957.8 ; E 290313.0		ORIGINATED BY		CR							
DIST 4 HWY QEW		BOREHOLE TYPE		CME 75, 100mm O.D. Solid Stem Auger		COMPILED BY		NK							
DATUM Geodetic		DATE		December 15, 2006		CHECKED BY		CN							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
106.1	GROUND SURFACE														
105.8	Silty sand and gravel, contains clayey silt pockets, asphalt fragments (FILL)		1	SS	17										
105.0	Compact Brown Moist		2	SS	60/0.23										
104.0	CLAYEY SILT, some sand Hard Reddish brown-gray mottled Moist		3	SS	50/0.07										
104.0	CLAYEY SILT, trace sand, some to trace gravel (Residual Soil) Hard Reddish brown Moist		4	SS	50/0.07										
103.0	SHALE BEDROCK, contains limestone inclusions Reddish brown to grey		5	SS	50/0.13										
101.5	Grinding of augers noted at depths of 3.35 m to 3.43 m, 3.86 m to 3.94 m, 3.96 m to 4.01 m and 4.11 m														
101.5	END OF BOREHOLE		6	SS	50/0.04										
4.6	Notes:  1. Water level in open borehole at a depth of 2.4 m during drilling.  2. Water level in open borehole at a depth of 4.5 m (Elev. 101.6 m) upon completion of drilling.														

PROJECT 011-1128			RECORD OF BOREHOLE No W39			1 OF 1 METRIC										
G.W.P. 189-00-01			LOCATION N 4814013.0 ; E 290357.6			ORIGINATED BY CR										
DIST 4 HWY QEW			BOREHOLE TYPE CME 75, 100mm O.D. Solid Stem Auger			COMPILED BY NK										
DATUM Geodetic			DATE December 20, 2006			CHECKED BY CN										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
106.2	GROUND SURFACE															
0.0	ASPHALT															
0.2	Sand and gravel, some silt (FILL) Dense to compact Brown Moist		1	SS	36											
			2	SS	13											
104.8																
1.4	Clayey silt to silty clay, trace gravel (FILL) Stiff Reddish brown to grey, mottled Moist		3	SS	14											
104.0																
2.2	CLAYEY SILT, trace sand, trace gravel (TILL) Hard Moist		4	SS	49											
103.4																
2.8	SHALE BEDROCK, contains limestone inclusions Grey  Grinding of augers noted at depths of 3.51 m to 3.66 m, 3.96 m to 4.06 m and 4.32 m to 4.42 m		5	SS	50/0.15											
			6	SS	50/0.07											
100.0																
6.2	END OF BOREHOLE		7	SS	50/0.05											
	Notes:  1. Water level in open borehole at a depth of 4.0 m during drilling.  2. Water level in open borehole at a depth of 3.3 m (Elev. 102.9 m) upon completion of drilling.															

PROJECT <u>011-1128</u>		<b>RECORD OF BOREHOLE No W40</b>		1 OF 1 <b>METRIC</b>	
G.W.P. <u>189-00-01</u>		LOCATION <u>N 4814057.8 ; E 290391.4</u>		ORIGINATED BY <u>CR</u>	
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>CME 75, 100mm O.D. Solid Stem Auger</u>		COMPILED BY <u>NK</u>	
DATUM <u>Geodetic</u>		DATE <u>December 20, 2006</u>		CHECKED BY <u>CN</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE   LIQUID CONTENT   LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20   40   60   80   100	W <sub>p</sub> W   W <sub>L</sub>					
SHEAR STRENGTH kPa								WATER CONTENT (%)						
							○ UNCONFINED   + FIELD VANE							
							● QUICK TRIAXIAL   × REMOULDED							
106.5 0.0	GROUND SURFACE ASPHALT		1	SS	19									
106.0 0.6	Sand and gravel (FILL) Compact Brown Moist		2	SS	14									
105.1 1.4	Clayey silt to silty clay, some sand, contains sand pockets (FILL) Stiff Reddish brown to grey Moist		3	SS	60									
104.3 2.2	CLAYEY SILT, trace sand, trace gravel (TILL) Hard Moist		4	SS	50/0.15									
	SHALE BEDROCK, contains limestone inclusions Grey		5	SS	50/0.08									
102.7 3.8	Grinding of augers noted at depths of 2.74 m to 2.89 m, 2.95 m to 2.99 m, 3.2 m to 3.30 m, 3.40 m to 3.50 m and 3.61 m to 3.81 m END OF BOREHOLE		6	SS	50/0.04									
Notes:  1. Open borehole dry upon completion of drilling.														



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

CONT No.  
GWP No. 189-00-01

RETAINING WALLS  
QEW WIDENING FROM THIRD LINE TO  
1 KM EAST OF TRAFALGAR ROAD  
BOREHOLE LOCATIONS



SHEET



**Golder Associates Ltd.**  
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE  
800 0 800 m

LEGEND

- Borehole - Current Investigation
- Borehole - Previous Golder Investigation
- Borehole - Previous Investigation by Others

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
BH1	107.0	4812979.5	289475.4
BH 05-1	107.3	4812766.4	289268.9
BH 05-2	107.5	4812866.8	289364.8
F7	110.1	4810992.0	287842.0
H7	112.2	4811344.0	288142.0
W9	107.3	4812803.2	289325.0
W11	113.8	4811415.8	288196.7
W12	112.7	4811376.0	288165.0
W14	111.5	4811278.5	288084.8
W15	110.9	4811217.7	288034.7
W16	111.1	4811151.7	287984.2
W18	110.4	4810943.8	287813.3
W19	110.5	4810904.9	287778.8
W20	110.0	4810742.6	287646.8
W21	109.8	4810709.7	287616.7
W22	109.7	4810674.5	287584.4
W23	109.4	4811095.8	288003.9
W24	110.4	4811151.2	288049.9
W25	111.0	4811210.8	288097.5
W26	111.3	4811270.5	288147.2
W27	111.7	4811323.6	288190.2
W28	112.1	4811384.0	288240.1
W29	112.9	4811442.2	288288.7
W30	112.8	4811495.8	288334.1
W31	113.1	4811557.1	288388.5
W32	113.7	4811615.5	288440.3
W33	114.4	4811645.1	288469.2
1	115.7	4811895.1	288589.8
2	115.7	4811878.2	288578.7
3	115.8	4811867.5	288569.0
6	114.5	4811850.1	288632.2
7	114.5	4811839.1	288622.8
8	114.6	4811827.2	288612.8

NOTES

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REFERENCE

Base plans provided in digital format by URS, drawing file no. QEW-EL-LS-MTO-60% and QEW Plan, received on December 20, 2006.

NO.	DATE	BY	REVISION
Geocres No. 30M5-260			
HWY. QEW	PROJECT NO. 011-1128		DIST.
SUBM'D. NK	CHKD. CN	DATE: MAR 2007	SITE:
DRAWN: MSM	CHKD. ASP	APPD. JMAC	DWG. 1

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

CONT No.  
GWP No. 189-00-01

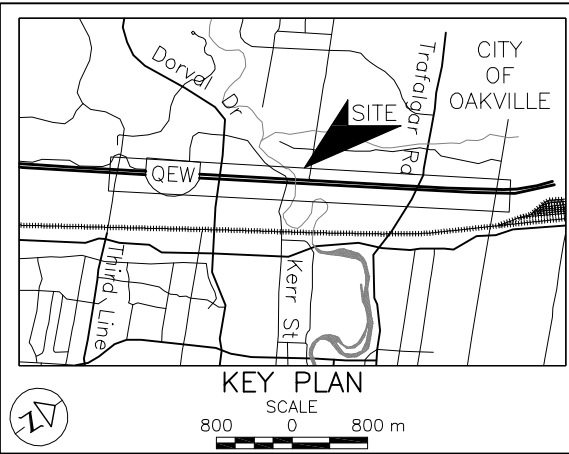


RETAINING WALLS  
QEW WIDENING FROMTHIRD LINE TO  
1 KM EAST OF TRAFALGAR ROAD  
BOREHOLE LOCATIONS

SHEET



**Golder Associates Ltd.**  
MISSISSAUGA, ONTARIO, CANADA



LEGEND

- Borehole - Current Investigation
- ⊕ Borehole - Previous Golder Investigation

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
BH1	107.0	4812979.5	289475.4
BH 05-3	107.0	4813177.3	289609.9
W1	106.3	4813284.1	289704.1
W2	106.6	4813211.6	289661.9
W4	108.8	4813098.4	289571.9
W5	107.5	4813038.0	289523.3
W34	107.0	4813711.4	290128.5
W35	106.0	4813772.1	290171.4
W36	106.3	4813830.8	290214.4
W37	106.2	4813890.6	290260.4
W38	106.1	4813957.8	290313.0
W39	106.2	4814013.0	290357.6
W40	106.5	4814057.8	290391.4

NOTES

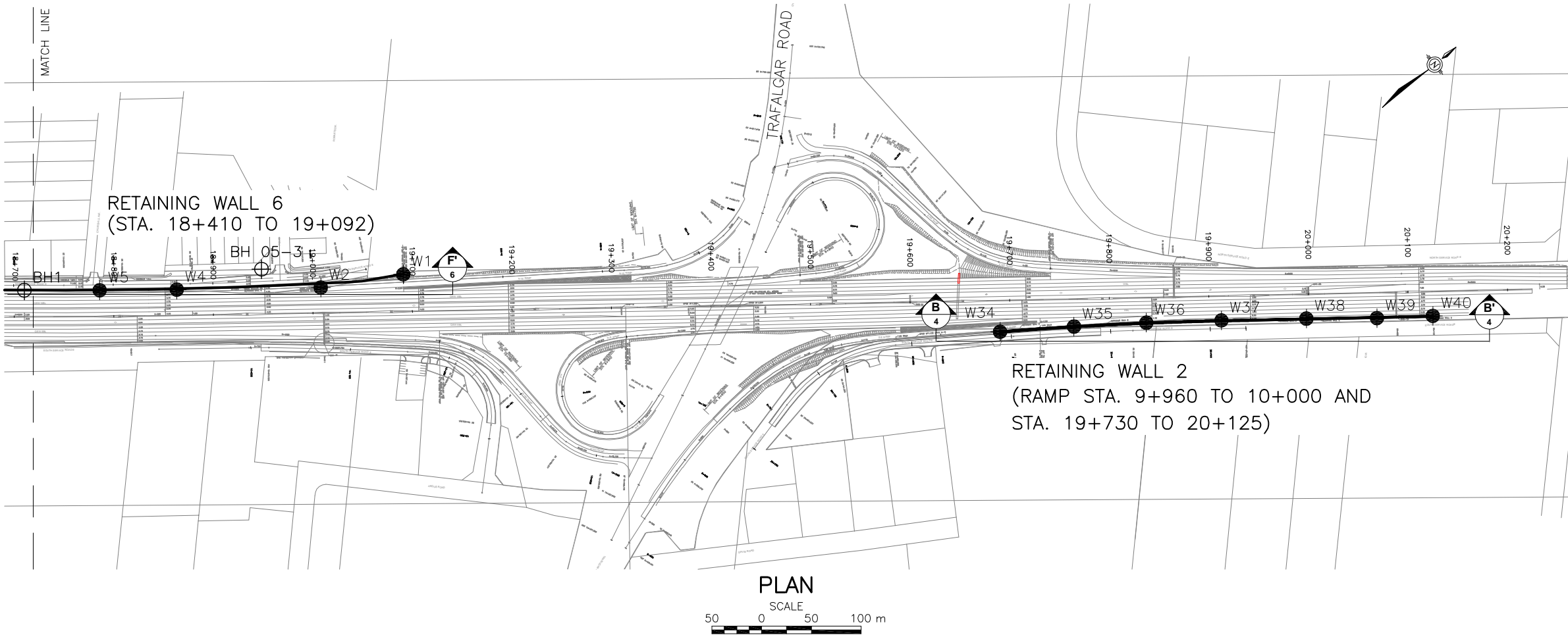
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REFERENCE

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NO.	DATE	BY	REVISION
Geocres No. 30M5-260			
HWY. QEW	PROJECT NO. 011-1128		DIST.
SUBM'D. NK	CHKD. CN	DATE: MAR 2007	SITE:
DRAWN: MSM	CHKD. ASP	APPD. JMAC	DWG. 2



PLAN

SCALE  
50 0 50 100 m

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

CONT No.  
GWP No. 189-00-01

RETAINING WALL 1  
(STA. 16+320 TO 17+041)  
SOIL STRATA

SHEET



**Golder Associates Ltd.**  
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN  
SCALE  
800 0 800 m

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 Feb. 13, 2007
- ≡ WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
W23	109.4	4811095.8	288003.9
W24	110.4	4811151.2	288049.9
W25	111.0	4811210.8	288097.5
W26	111.3	4811270.5	288147.2
W27	111.7	4811323.6	288190.2
W28	112.1	4811384.0	288240.1
W29	112.9	4811442.2	288288.7
W30	112.8	4811495.8	288334.1
W31	113.1	4811557.1	288388.5
W32	113.7	4811615.5	288440.3
W33	114.4	4811645.1	288469.2

NOTES

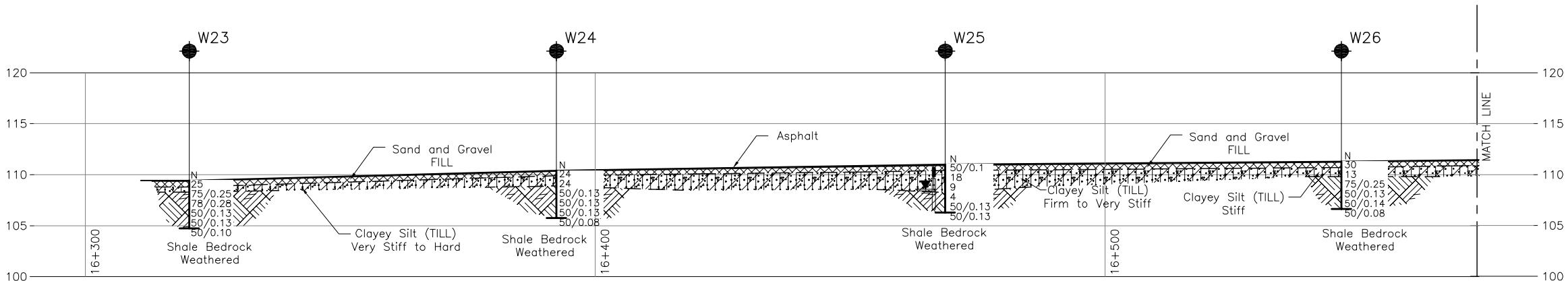
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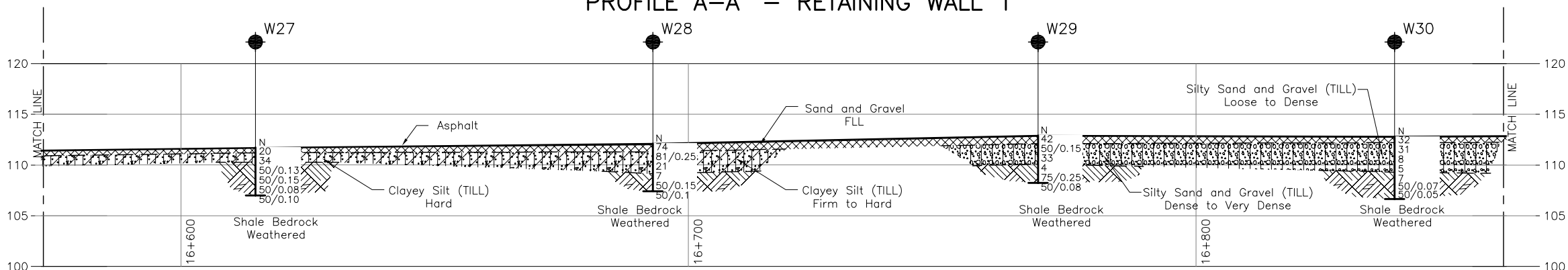
REFERENCE

Base plans provided in digital format by URS, drawing file no. QEW-EL-LS-MT0-60% and QEW Plan, received on December 20, 2006.

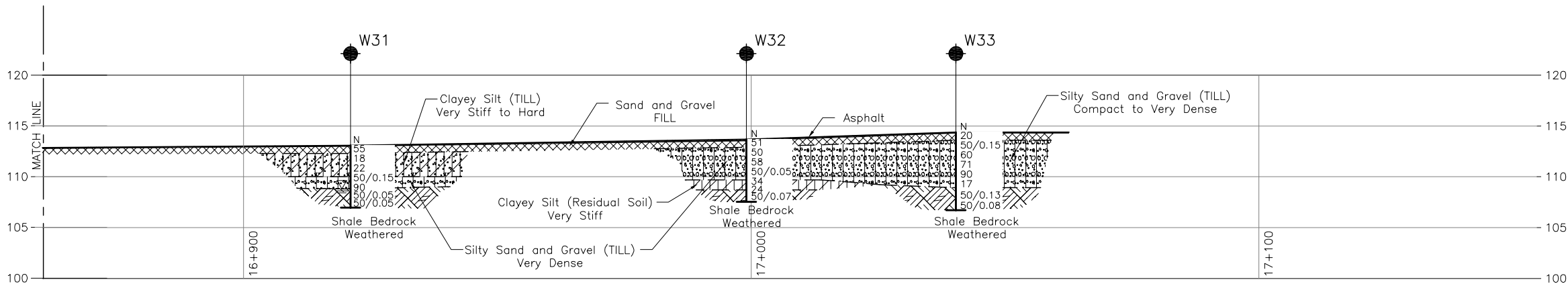
NO.	DATE	BY	REVISION
Geocres No. 30M5-260			
HWY. QEW	PROJECT NO. 011-1128		DIST.
SUBM'D. NK	CHKD. CN	DATE: MAR 2007	SITE:
DRAWN: MSM	CHKD. ASP	APPD. JMAC	DWG. 3



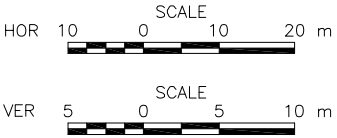
PROFILE A-A' - RETAINING WALL 1



PROFILE A-A' - RETAINING WALL 1 (CONTINUED)



PROFILE A-A' - RETAINING WALL 1 (CONTINUED)





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

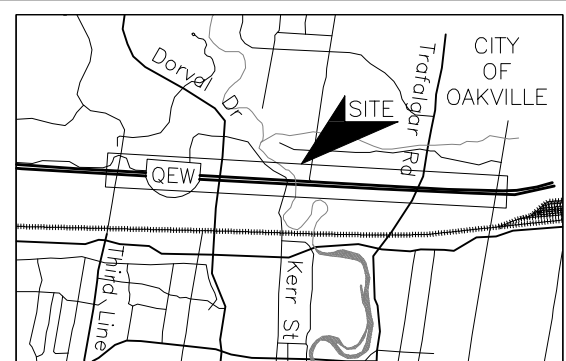
CONT No.  
GWP No. 189-00-01

RETAINING WALLS 2, 3 AND 4  
RW2 (RAMP STA. 9+960 TO 10+000 AND  
STA. 19+730 TO 20+125)  
RW3 (STA. 15+730 TO 15+820)  
RW4 (STA. 16+030 TO 16+130)  
SOIL STRATA

SHEET



**Golder Associates Ltd.**  
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN  
SCALE  
800 0 800 m

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 Feb. 13, 2007
- ≡ WL upon completion of drilling

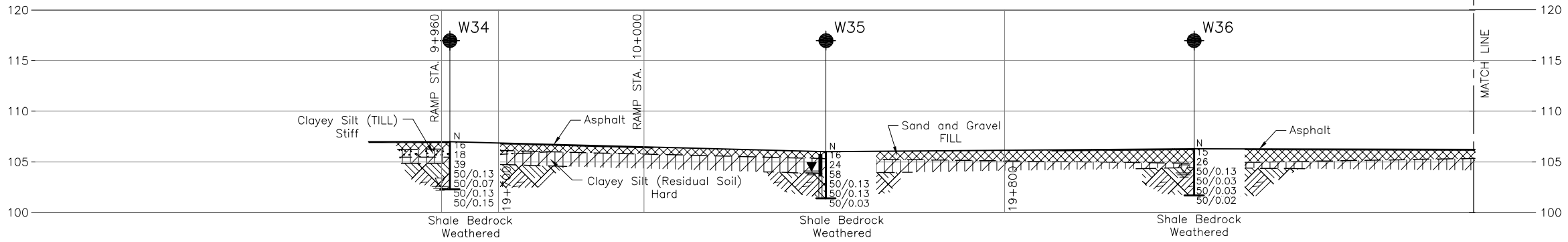
No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
F7	110.1	4810992.0	287842.0
W18	110.4	4810943.8	287813.3
W19	110.5	4810904.9	287778.8
W20	110.0	4810742.6	287646.8
W21	109.8	4810709.7	287616.7
W22	109.7	4810674.5	287584.4
W34	107.0	4813711.4	290128.5
W35	106.0	4813772.1	290171.4
W36	106.3	4813830.8	290214.4
W37	106.2	4813890.6	290260.4
W38	106.1	4813957.8	290313.0
W39	106.2	4814013.0	290357.6
W40	106.5	4814057.8	290391.4

NOTES

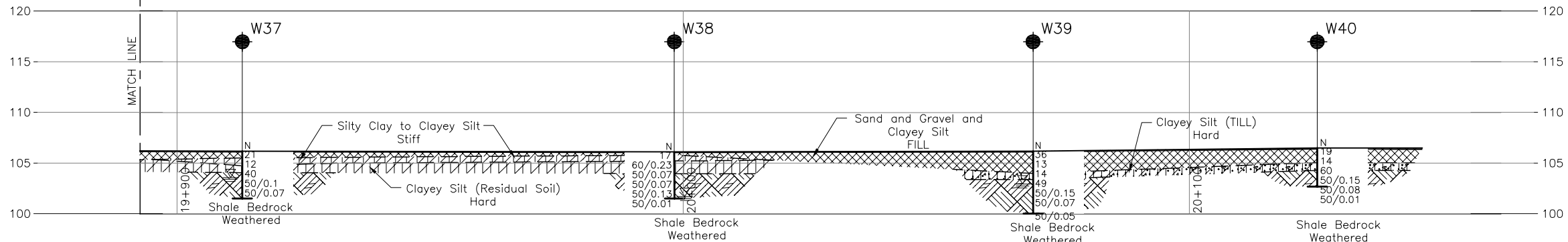
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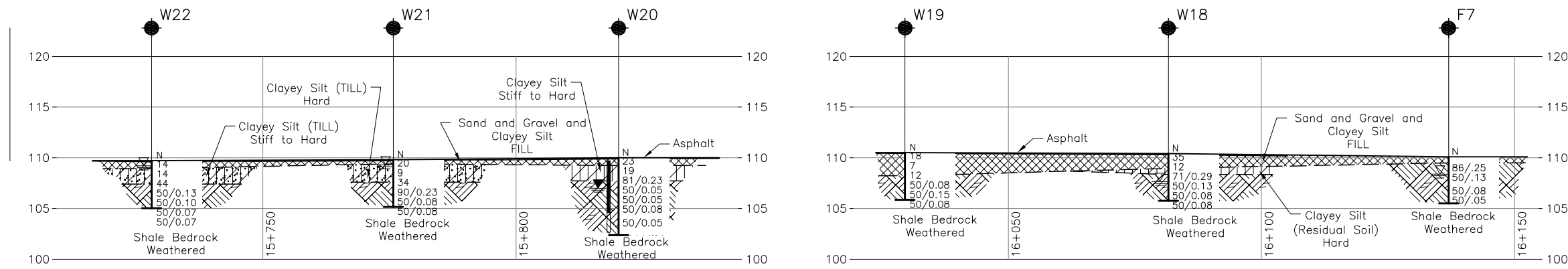
NO.	DATE	BY	REVISION
Geocres No. 30M5-260			
HWY. QEW	PROJECT NO. 011-1128		DIST.
SUBM'D. NK	CHKD. CN	DATE: MAR 2007	SITE:
DRAWN: MSM	CHKD. ASP	APPD. JMAC	DWG. 4



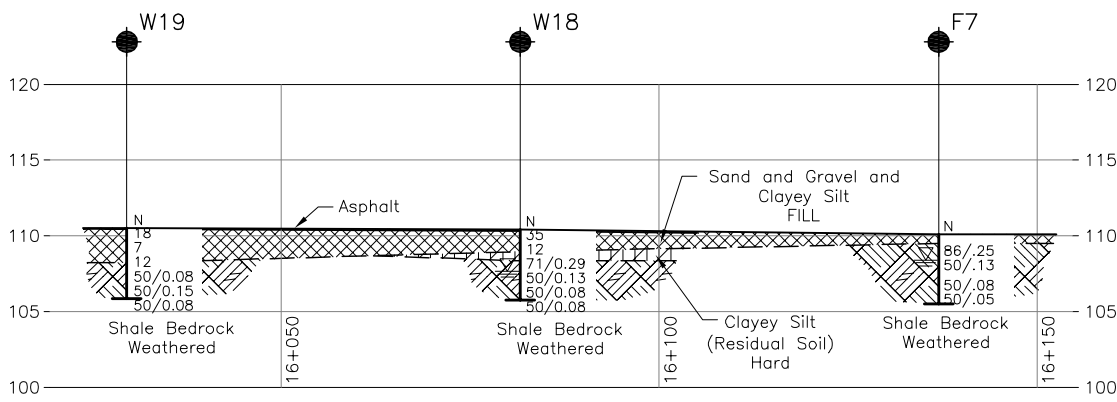
PROFILE B-B' - RETAINING WALL 2



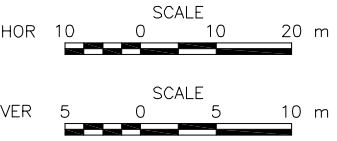
PROFILE B-B' - RETAINING WALL 2 (CONTINUED)



PROFILE C-C' - RETAINING WALL 3



PROFILE D-D' - RETAINING WALL 4



REFERENCE

Base plans provided in digital format by URS, drawing file no. QEW-EL-LS-MTO-60% and QEW Plan, received on December 20, 2006.

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

CONT No.  
GWP No. 189-00-01

RETAINING WALL 5  
(STA. 16+350 TO 16+690)  
SOIL STRATA

SHEET



Golder Associates Ltd.  
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN  
SCALE  
0 800 m

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 Feb. 13, 2007
- WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
H7	112.2	4811344.0	288142.0
W11	113.8	4811415.8	288196.7
W12	112.7	4811376.0	288165.0
W14	111.5	4811278.5	288084.8
W15	110.9	4811217.7	288034.7
W16	111.1	4811151.7	287984.2

NOTES

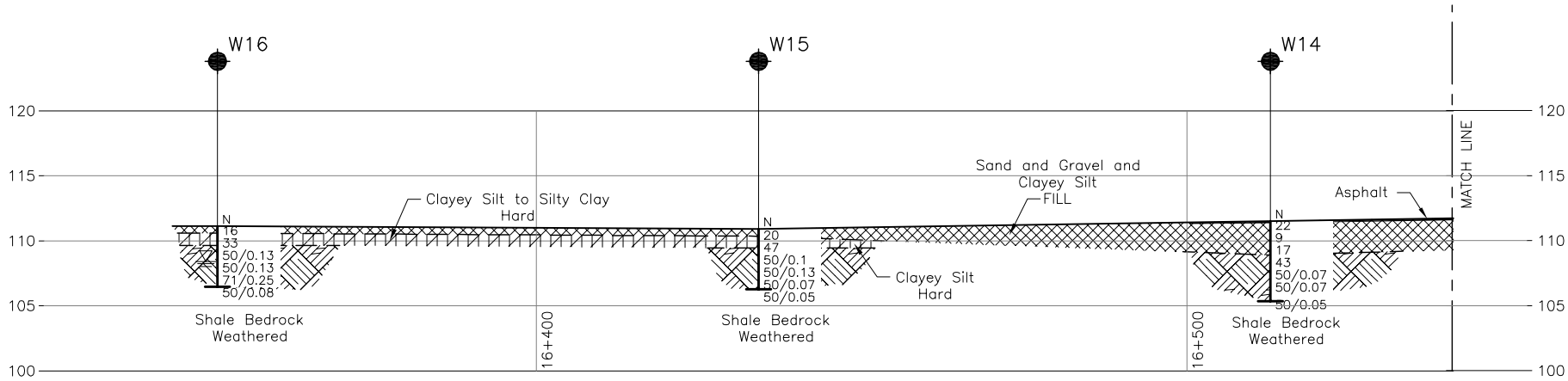
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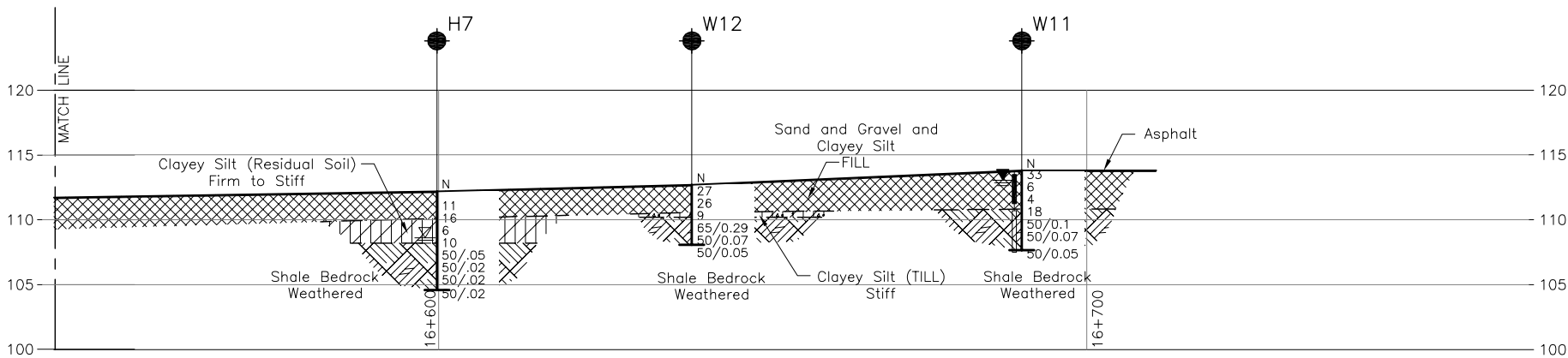
REFERENCE

Base plans provided in digital format by URS, drawing file no. QEW-EL-LS-MT0-60% and QEW Plan, received on December 20, 2006.

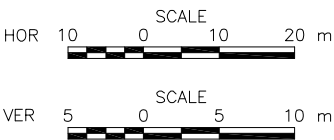
NO.	DATE	BY	REVISION
Geocres No. 30M5-260			
HWY.	QEW	PROJECT NO.	011-1128
SUBM'D.	NK	CHKD.	CN
DATE:	MAR 2007	SITE:	
DRAWN:	MSM	CHKD.	ASP
APPD.	JMAC	DWG.	5



PROFILE E-E' - RETAINING WALL 5



PROFILE E-E' - RETAINING WALL 5 (CONTINUED)





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

CONT No.  
GWP No. 189-00-01

RETAINING WALL 6  
(STA. 18+410 TO 19+092)  
SOIL STRATA

SHEET



**Golder Associates Ltd.**  
MISSISSAUGA, ONTARIO, CANADA



**KEY PLAN**  
SCALE  
0 800 m

**LEGEND**

- Borehole - Current Investigation
- Borehole - Previous Golder Investigation
- Seal
- Piezometer
- Standard Penetration Test Value
- Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on Feb. 13, 2007
- WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
BH1	107.0	4812979.5	289475.4
BH 05-1	107.3	4812766.4	289268.9
BH 05-2	107.5	4812866.8	289364.8
BH 05-3	107.0	4813177.3	289609.9
W1	106.3	4813284.1	289704.1
W2	106.6	4813211.6	289661.9
W4	108.8	4813098.4	289571.9
W5	107.5	4813038.0	289523.3
W9	107.3	4812803.2	289325.0

**NOTES**

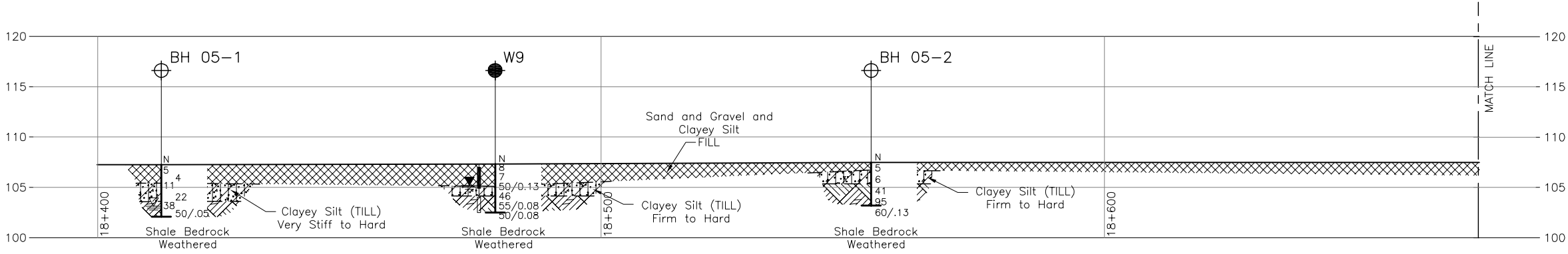
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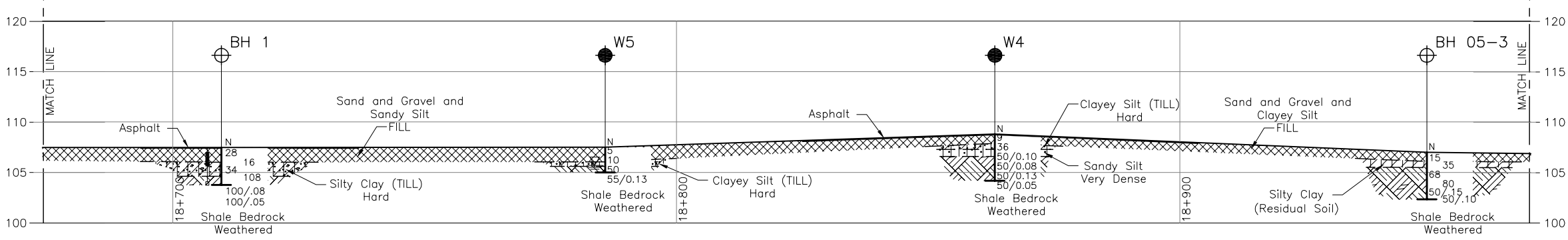
**REFERENCE**

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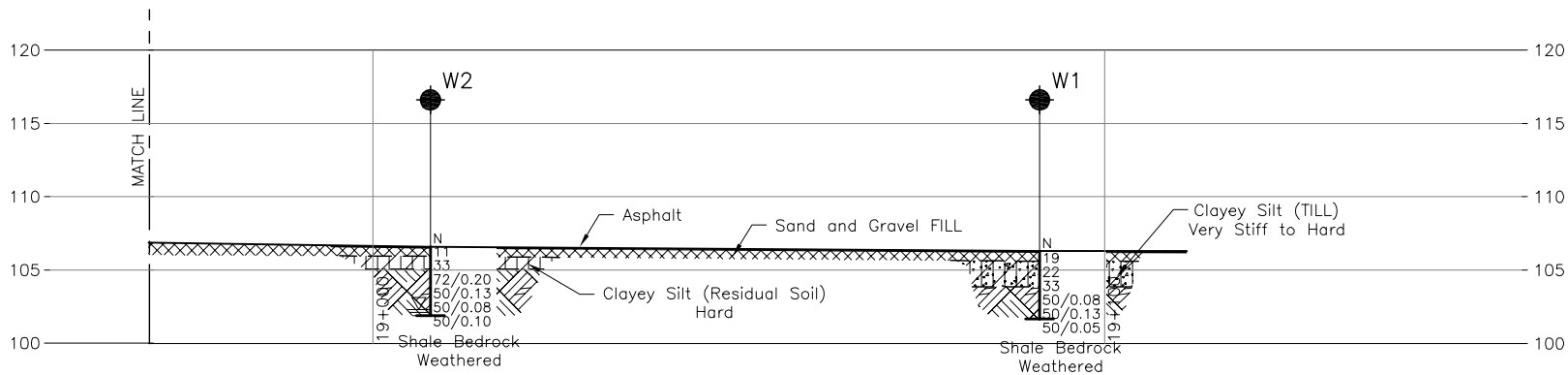
NO.	DATE	BY	REVISION
Geocres No. 30M5-260			
HWY. QEW	PROJECT NO. 011-1128		DIST.
SUBM'D. NK	CHKD. CN	DATE: MAR 2007	SITE:
DRAWN: MSM	CHKD. ASP	APPD. JMAC	DWG. 6



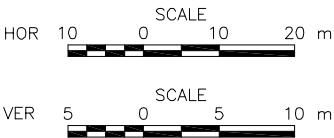
PROFILE F-F' - RETAINING WALL 6



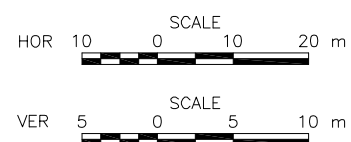
PROFILE F-F' - RETAINING WALL 6 (CONTINUED)



PROFILE F-F' - RETAINING WALL 6 (CONTINUED)

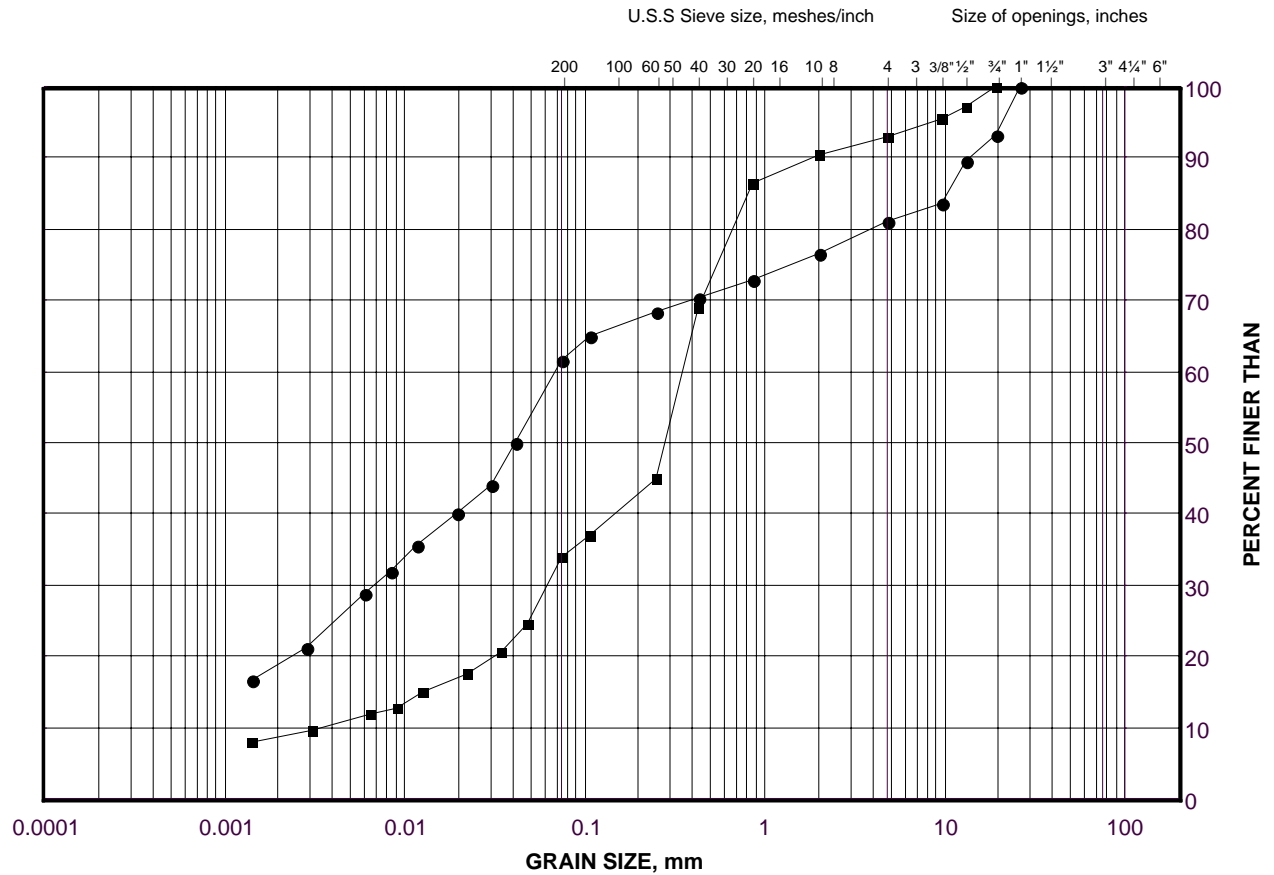


<h2 style="text-align: center;">REFERENCE</h2> <p>Base plans provided in digital format by URS, drawing file no. QEW-EL-LS-MTO-60% and QEW Plan, received on December 20, 2006.</p>			
NO.	DATE	BY	REVISION
Geocres No. 30M5-260			
HWY. QEW		PROJECT NO. 011-1128	DIST.
SUBM'D. N/K	CHKD. CN	DATE: MAR 2007	SITE:
DRAWN: MSM	CHKD. ASP	APPD. JMAC	DWG. 7



### Clayey Silt to Silty Sand (Fill)

FIGURE 1



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

## LEGEND

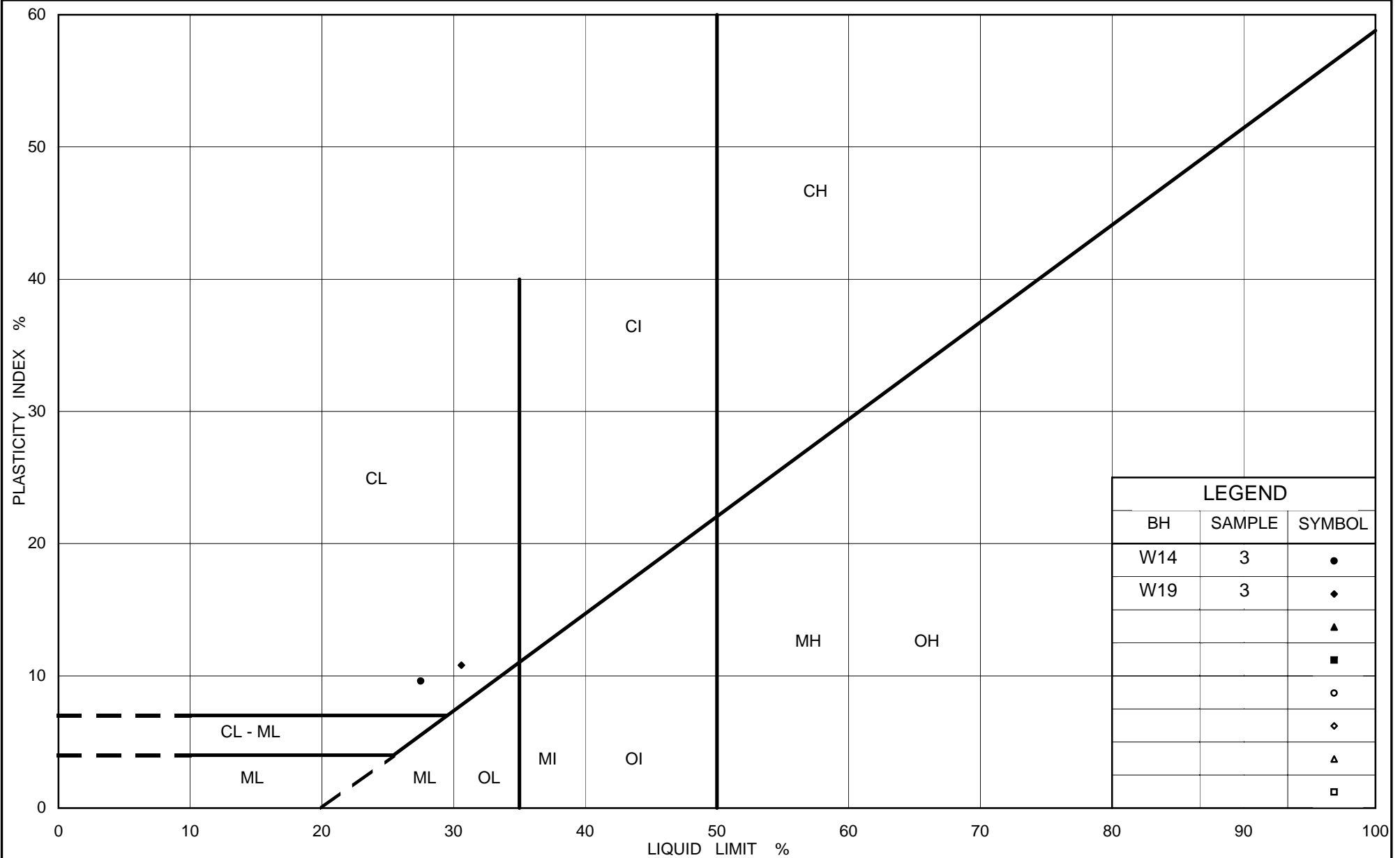
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	W14	3	109.7
■	W11	3	112.0

Project Number: 011-1128

Checked By: \_\_\_\_\_

## Golder Associates

Date: 09-Mar-07



Ministry of Transportation

Ontario

## PLASTICITY CHART

### Clayey Silt (Fill)

Figure No. 2

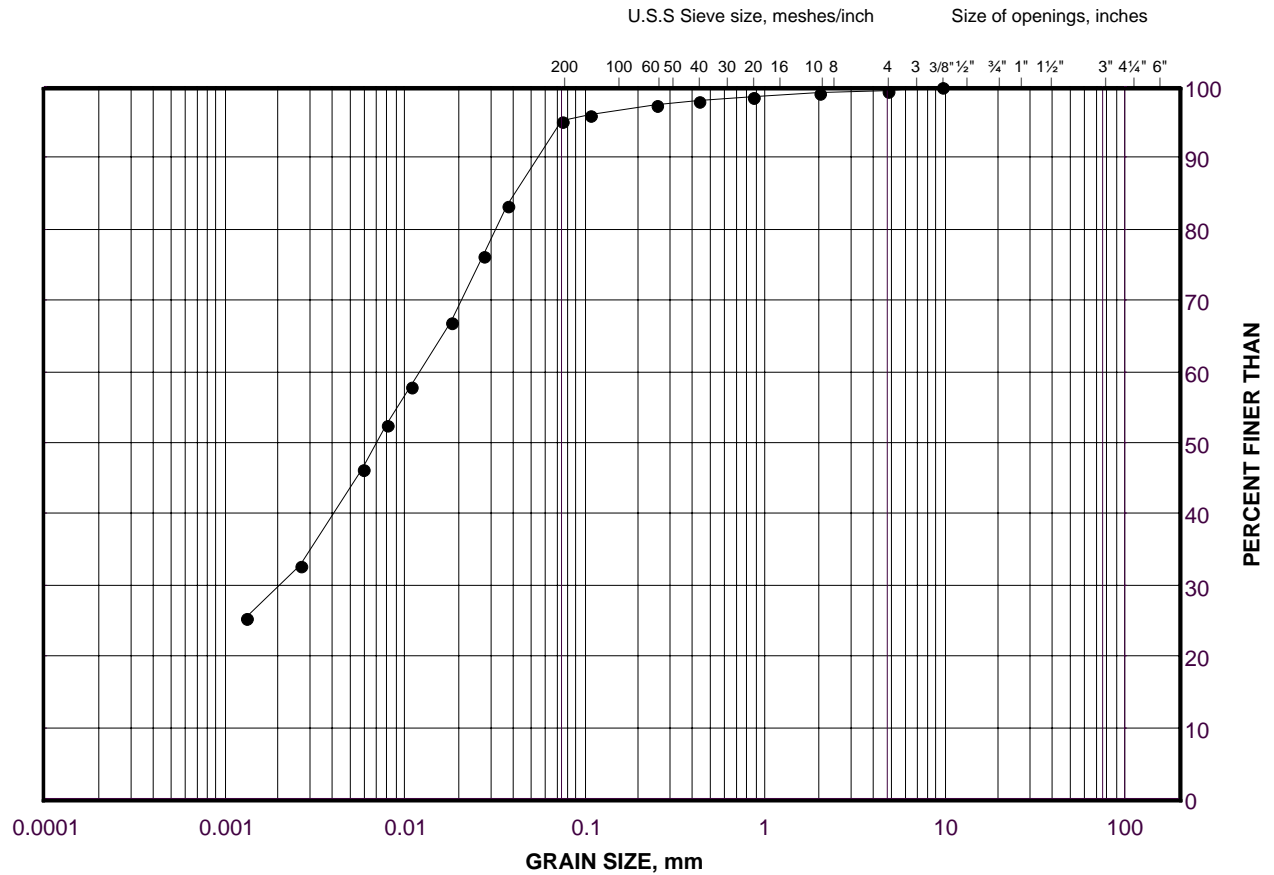
Project No. 011-1128

Checked By:

# GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay

FIGURE 3



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

## LEGEND

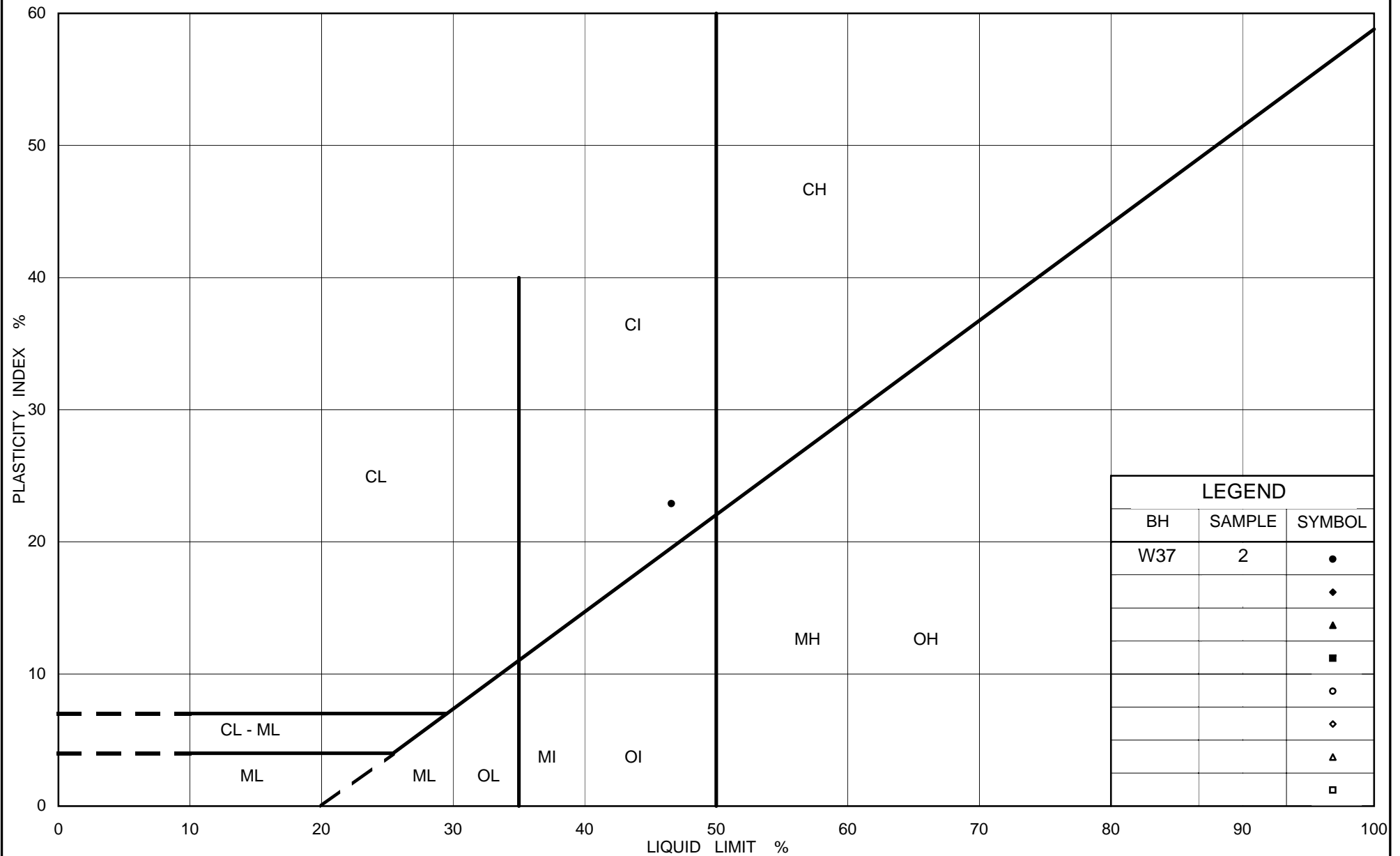
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	W16	2	110.0

Project Number: 011-1128

Checked By: \_\_\_\_\_

**Golder Associates**

Date: 09-Mar-07



Ministry of Transportation

Ontario

## PLASTICITY CHART

### Silty Clay

Figure No. 4

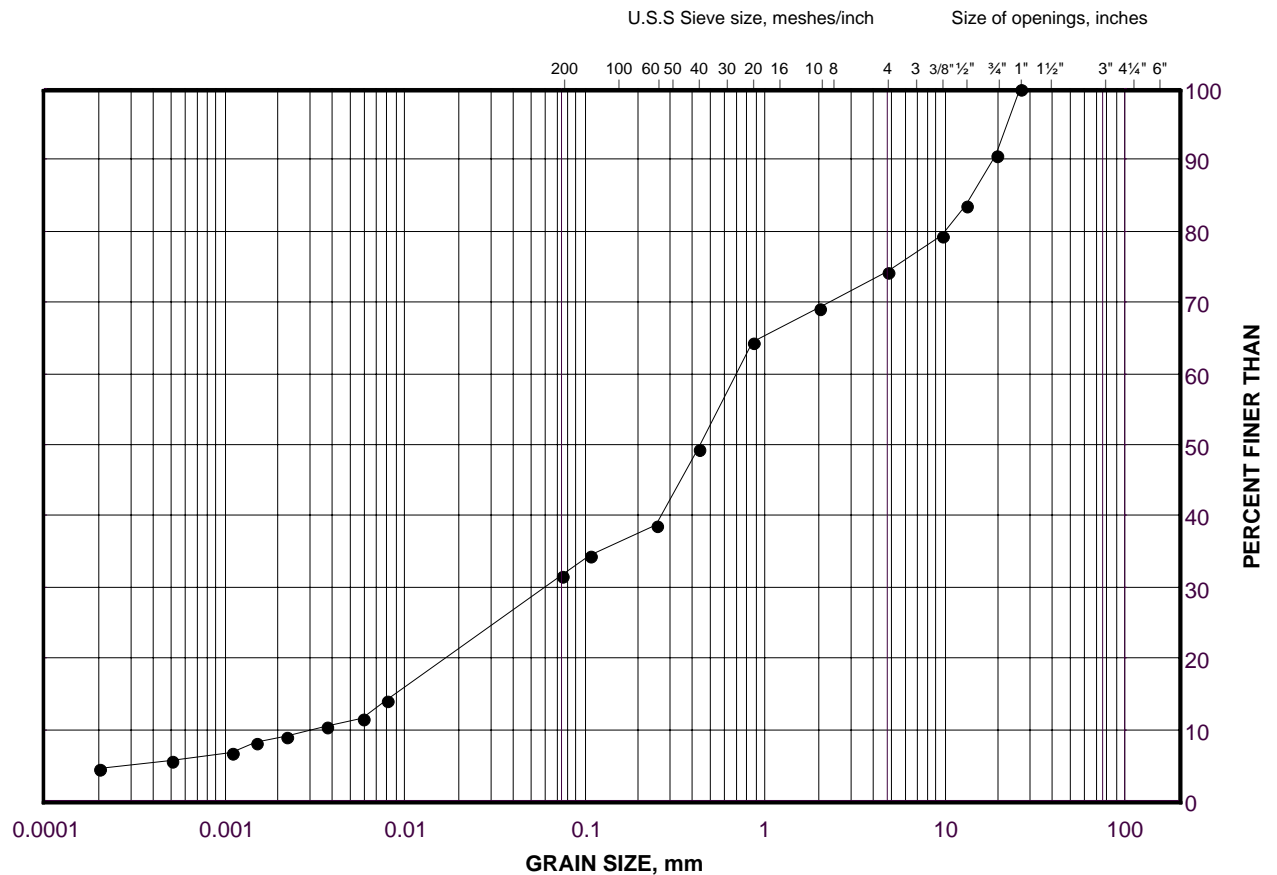
Project No. 011-1128

Checked By:

# GRAIN SIZE DISTRIBUTION

Silty Sand and Gravel (Till)

FIGURE 5



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	W30	4	110.2

Project Number: 011-1128

Checked By: \_\_\_\_\_

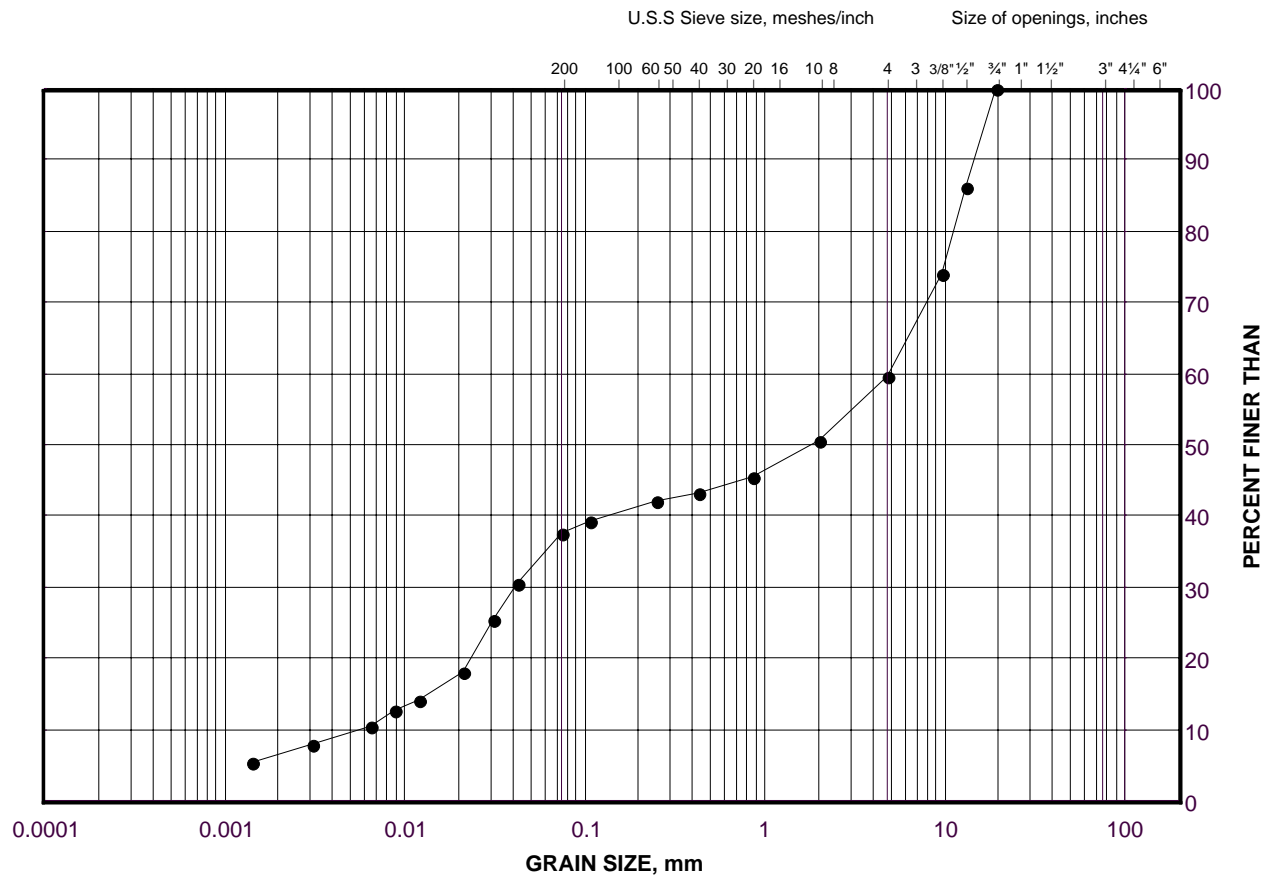
**Golder Associates**

Date: 09-Mar-07

# GRAIN SIZE DISTRIBUTION

Sandy Silt

FIGURE 6



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	W4	3	107.2

Project Number: 011-1128

Checked By: \_\_\_\_\_

**Golder Associates**

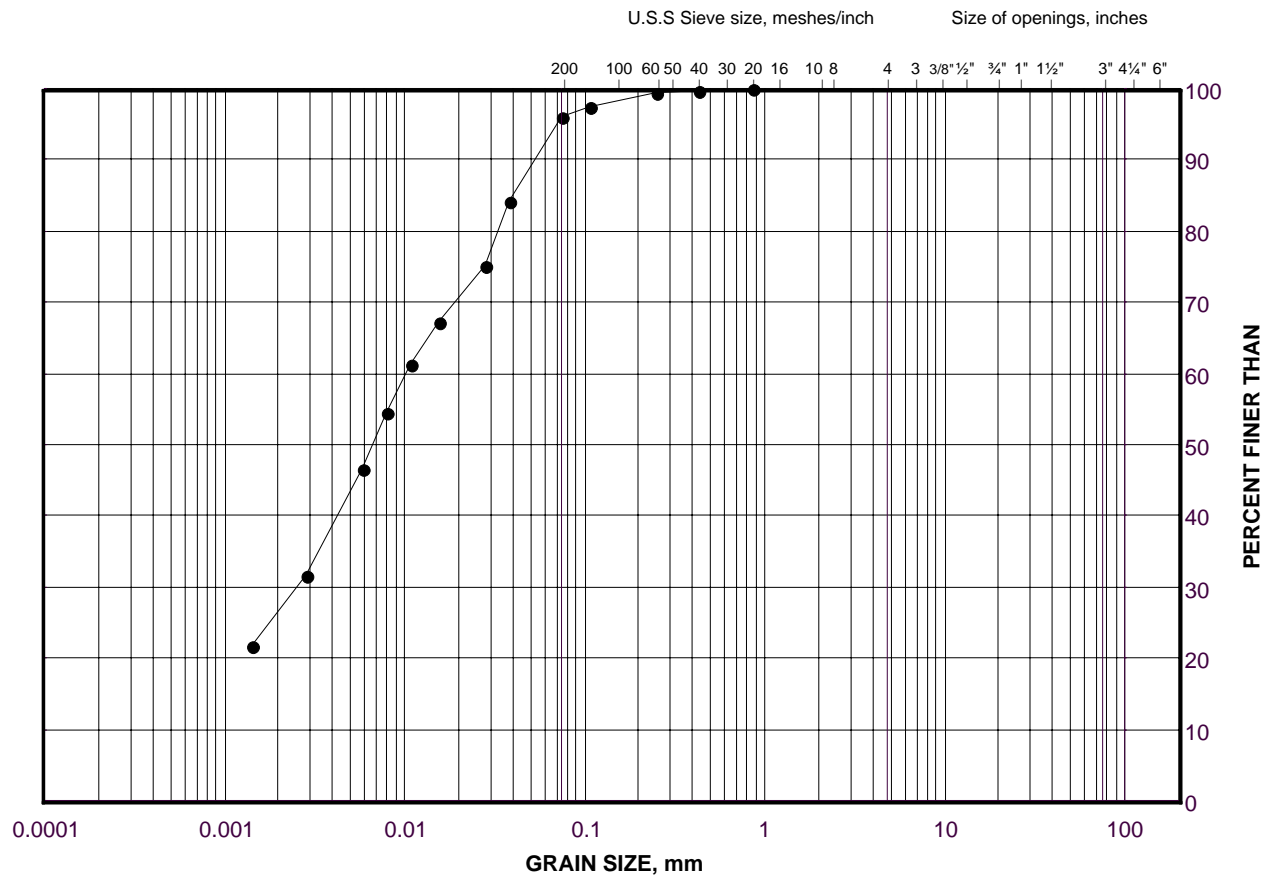
Date: 09-Mar-07



# GRAIN SIZE DISTRIBUTION

Clayey Silt (Till)

FIGURE 7



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

## LEGEND

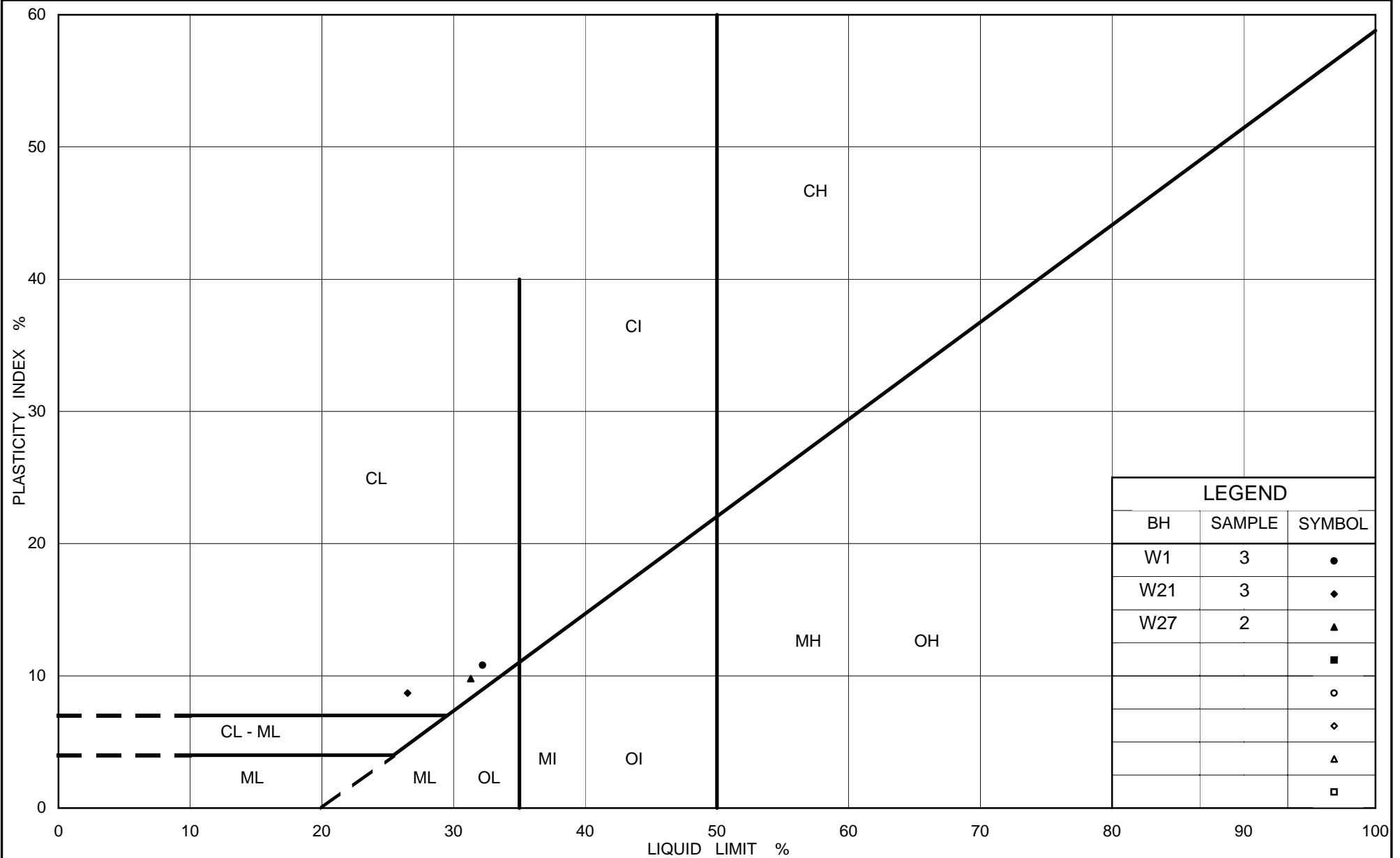
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	W27	2	110.6

Project Number: 011-1128

Checked By: \_\_\_\_\_

**Golder Associates**

Date: 09-Mar-07



Ministry of Transportation

Ontario

## PLASTICITY CHART

### Clayey Silt (Till)

Figure No. 8

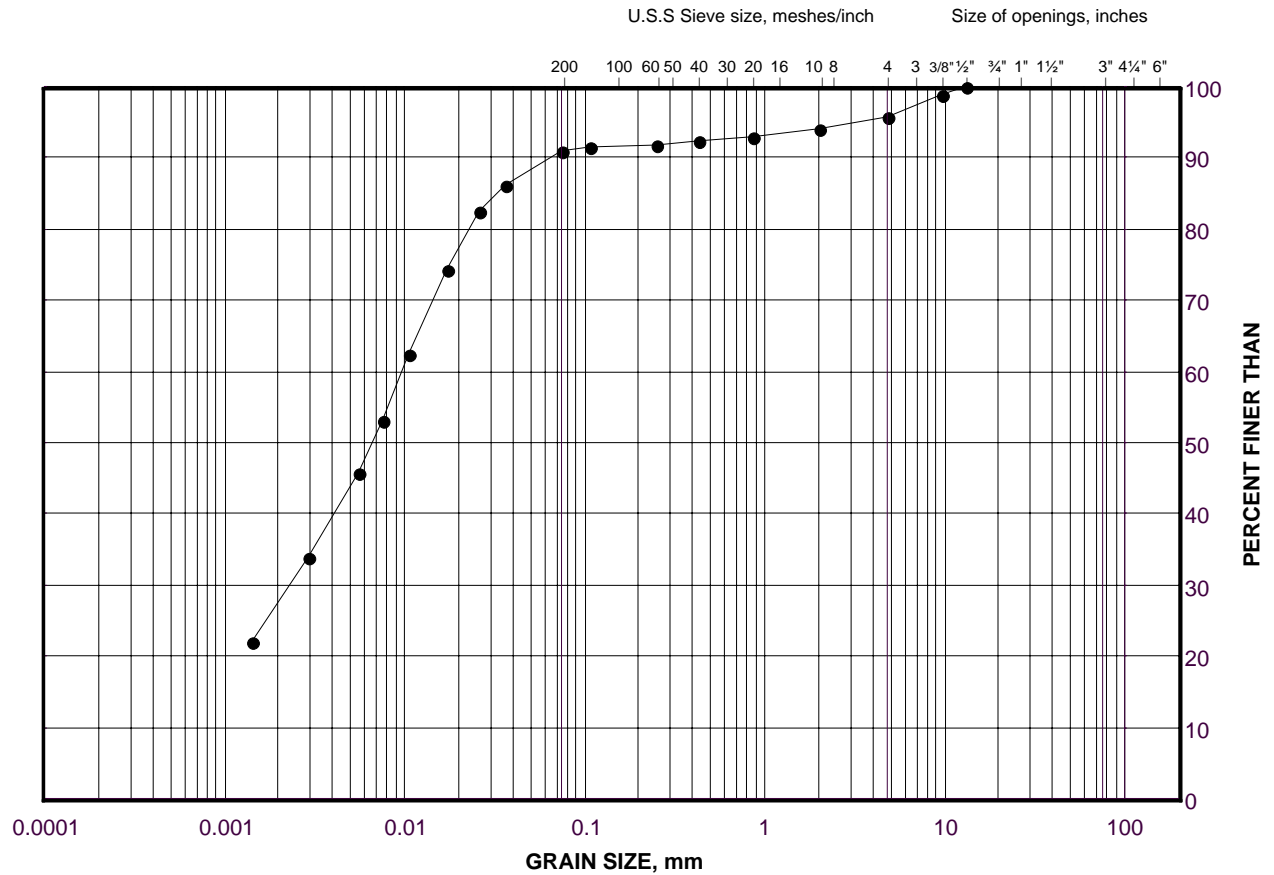
Project No. 011-1128

Checked By:

# GRAIN SIZE DISTRIBUTION

Clayey Silt (Residual Soil)

FIGURE 9



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

## LEGEND

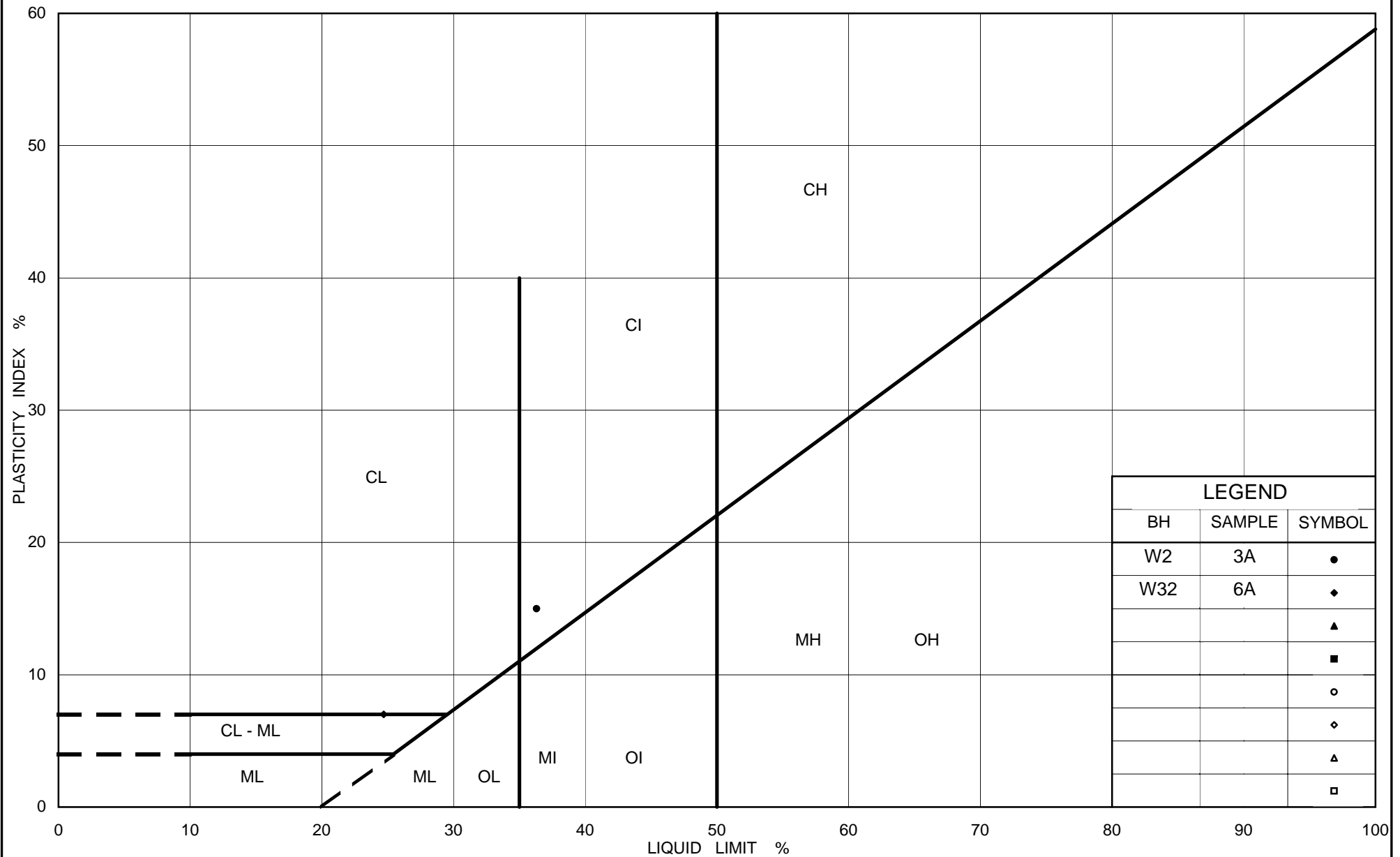
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	W34	3	105.2

Project Number: 011-1128

Checked By: \_\_\_\_\_

**Golder Associates**

Date: 06-Mar-07



Ministry of Transportation

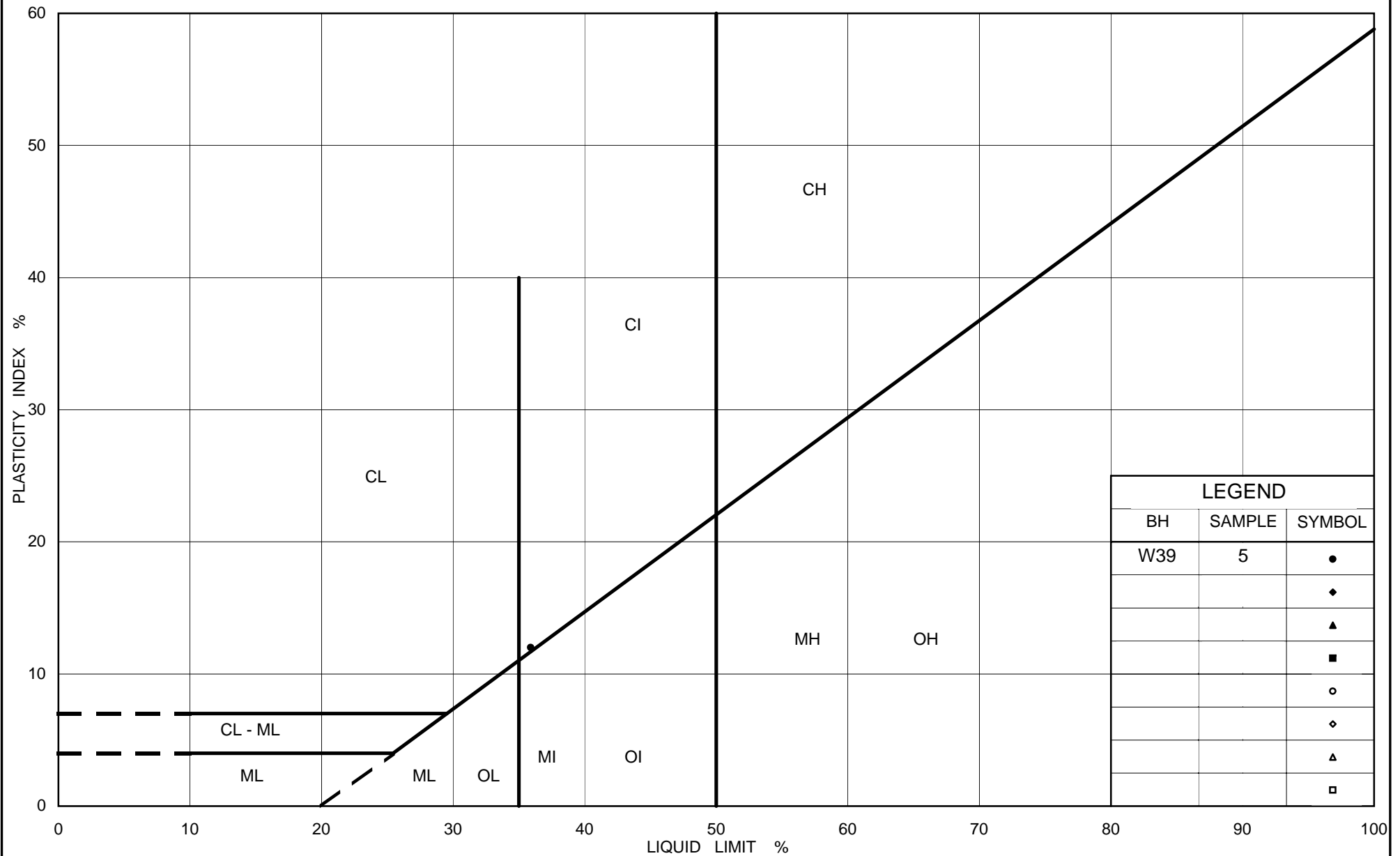
# PLASTICITY CHART Clayey Silt (Residual Soil)

Ontario

Figure No. 10

Project No. 011-1128

Checked By:



Ministry of Transportation

Ontario

## PLASTICITY CHART

### Shale Bedrock

Figure No. 11

Project No. 011-1128

Checked By:

## **APPENDIX A**

**RECORDS OF BOREHOLES 1 TO 3 AND 6 TO 8, 1975 INVESTIGATION BY MTO  
GEOCRES NO. 30M5-101**

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO  
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 1

WP 125-66-02 LOCATION Co-ords. 786,312 N; 946,765 E. ORIGINATED BY PJS  
DIST 4 HWY QEW BORING DATE December 17, 1975 COMPILED BY PJS  
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & BXL CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$ $w_p$ — $w$ — $w_L$ WATER CONTENT % 10 20 30	UNIT WEIGHT $\gamma$	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES					
379.5	Ground Level									
0.0	Sand & gravel with silt, trace of clay (Glacial Till)		1	SS	8					
369.5	Loose		2	SS	100	370				
10.0	(Red) Shale, severely to moderately weathered		3	BXL	90					
363.5										
16.0	End of Borehole					360				

20  
15  $\phi$  5 % STRAIN AT FAILURE  
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO  
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 2

WP 125-66-02 LOCATION Co-ords. 786,271 N; 946,728 E. ORIGINATED BY PJS  
DIST 4 HWY QEW BORING DATE December 17, 1975 COMPILED BY PJS  
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$ $w_p$ — $w$ — $w_L$ WATER CONTENT % 10 20 30	UNIT WEIGHT $\gamma$	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES					
379.6	Ground Level									
0.0	Sand & gravel with silt, trace of clay (Glacial Till)		1	SS	6					
371.6	Loose		2	SS	80					
8.0	(Red) Shale, severely to moderately weathered		3	SS	8876"	370				
364.4			4	SS	1006"					
15.2	End of Borehole		5	SS	7573"					
						360				

20  
15  $\phi$  5 % STRAIN AT FAILURE  
10



RECORD OF BOREHOLE NO 3

WP 125-66-02 LOCATION Co-ords. 786,236 N; 946,700 E. ORIGINATED BY PJS  
 DIST 4 HWY QEW BORING DATE December 16, 1975 COMPILED BY PJS  
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	LIQUID LIMIT $W_L$ PLASTIC LIMIT $W_P$ WATER CONTENT $W$ $W_P$ $W$ $W_L$	UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES					
379.9	Ground Level									
0.0	Sand & gravel with silt, trace of clay (Glacial Till) Compact to Very Dense		1	SS	31					
8.5			2	SS	15					
368.9			3	SS	59					
11.0	Red Shale		4	SS	100	4"				
365.7			5	SS	100	3"				
14.2	End of Borehole									

## RECORD OF BOREHOLE No. 6

SOIL PROFILE		SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$ $w_p$ — $w$ — $w_L$	UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE					
375.5	Ground Level								
0.0	Gravel & sand, some silt, trace of clay numerous boulders (Glacial Till)		1	SS	95				
			2	SS					
	Compact to Very Dense		3	SS	10				
362.8	(Red) Shale		4	SS	50/3				
12.7	End of Borehole								

OFFICE REPORT ON SOIL EXPLORATION

## RECORD OF BOREHOLE No 7

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT — $w_L$	PLASTIC LIMIT — $w_p$	UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20 40 60 80 100	WATER CONTENT — $w$	WATER CONTENT % $w_p \quad w \quad w_L$ 10 20 30		
375.7	Ground Level										
0.0	Gravel & sand, some silt, trace of clay, numerous boulders (Glacial Till)		1	SS	50	" 370					
			2	SS	58						
363.7	Compact to Very Dense		3	SS	24						
12.0	(Red) Shale		4	SS	75	No further progress with auger possible					
361.3											
14.4	End of Borehole					360					

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO  
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 8

WP 125-66-02 LOCATION Co-ords. 786,108 N: 946,836 E. ORIGINATED BY PJS  
DIST 4 HWY QEW BORING DATE December 21, 1975 COMPILED BY PJS  
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & BXL Core CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$			UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100	$w_p$	$w$	$w_L$		
376.0	Ground Level															
0.0	Gravel & sand, some silt, trace of clay, numerous boulders (Glacial Till) Very Dense		1	SS	53	370										
			2	SS	25/2	"										
36.0			3	SS	79											
12.0	(Red) Shale, severely to moderately weathered		4	BXL	90%	360										
359.6																
16.4	End of Borehole															

20  
15  $\phi$  5 % STRAIN AT FAILURE  
10

## **APPENDIX B**

### **RECORD OF BOREHOLE BH1, 1999 INVESTIGATION BY GOLDER ASSOCIATES**

PROJECT: 991-1174

## RECORD OF BOREHOLE: BH1

SHEET 1 OF 1

LOCATION: Refer to Figure 2

BORING DATE: 6/10/99

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION										
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT PERCENT													
								20		40		60				80		10 <sup>-2</sup>		10 <sup>-4</sup>		10 <sup>-6</sup>		10 <sup>-8</sup>	
								SHEAR STRENGTH Cu, kPa		nat V. + rem V. ⊗		Q - ● U - ○				Wp ——— W ——— Wt									
							20	40	60	80					10	20	30	40							
0	D-50 TRUCK MOUNT 114mm SOLID STEM AUGER	Ground Surface		0.00																					
		ASPHALT		0.11	1	SD	28														CONCRETE				
		Compact, moist, brown sand and gravel, trace silt. (Granular FILL)		0.81																					
		Compact, moist, brown silty sand, trace to some gravel, occ. organics. (FILL)		0.81	2	SD	16														BENTONITE SEAL				
1				1.45																					
		Hard, moist, reddish brown SILTY CLAY, trace to some sand, trace gravel, occ. shale fragments. (TILL)		1.45	3	SD	34																		
2					4	SD	108																		
				2.86																					
		Weathered, red SHALE, occ. weathered siltstone/ limestone interlayers. (BEDROCK)		2.86	5	SD	100/														SAND				
3				3.71																					
		END OF BOREHOLE		3.71	50	DO	100/																		
4																									
5																									
6																									
7																									
8																									
9																									
10																									

Note: 1. Open  
borehole dry  
upon completion  
of drilling.  
2. Piezometer  
dry on October  
27/99.

Note: 1. Open borehole dry upon completion of drilling.  
2. Piezometer dry on October 27/99.

BOREHOLE 991-1174 GPJ GLDR CAN.GDT 29/10/99 PS

DEPTH SCALE

1 : 50



LOGGED: DKB

CHECKED: ASP

## **APPENDIX C**

### **RECORDS OF BOREHOLES BH05-1 AND BH05-3, 2005 INVESTIGATION BY GOLDER ASSOCIATES**

PROJECT: 04-1111-012B

## RECORD OF BOREHOLE: BH 05-1

SHEET 1 OF 1

LOCATION: N 4812134.7 ; E 605832.4

BORING DATE: January 11, 2005

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT PERCENT					
								SHEAR STRENGTH				WATER CONTENT PERCENT					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>	10 <sup>-4</sup>			10 <sup>-3</sup>
															</		

DEPTH SCALE

1 : 50



LOGGED: PKS

CHECKED: SLP

MISS BHS 041111012BAAGDR.GPJ GLDR CAN GDT 21/12/05 DD



PROJECT: 04-1111-012B

## RECORD OF BOREHOLE: BH 05-2

SHEET 1 OF 1




LOCATION: N 4812236.8 ;E 605926.5

BORING DATE: January 10, 2005

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa				WATER CONTENT PERCENT					
								20	40	60	80	10 <sup>-6</sup>	10 <sup>-5</sup>			10 <sup>-4</sup>	10 <sup>-3</sup>
								nat V. + Q - ●	rem V. ⊗ U - ○								
								20	40	60	80	10	20	30	40		
0		GROUND SURFACE		107.47													
	Power Auger 108 mm O.D. Solid Stem Augers	Loose, wet, brown sand, some gravel, some silt, trace clay (FILL)		0.00	1	50 DO	5										
1		Firm to hard, moist, brown/red CLAYEY SILT, some sand, trace gravel and shale fragments (TILL/RESIDUAL SOIL)		106.71 0.76	2	50 DO	6										
2						3	50 DO	41									
		Weathered, red SHALE (Bedrock) contains limestone/siltstone interbeds		105.34 2.13	4	50 DO	95										
3					5	50 DO	60/.13										
4																	
5		END OF BOREHOLE AUGER REFUSAL		103.20 4.27													
6		Note: 1. Open borehole dry upon completion of drilling operations.															
7																	
8																	
9																	
10																	

DEPTH SCALE

1 : 50



LOGGED: PKS

CHECKED: SLP

MISS BHS 041111012BAGDR.GPJ GLDR\_CAN.GDT 21/12/05 DD

PROJECT: 04-1111-012B

## RECORD OF BOREHOLE: BH 05-3

SHEET 1 OF 1




LOCATION: N 4812551.5 ;E 606166.1

BORING DATE: January 10, 2005

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa				WATER CONTENT PERCENT						
								20	40	60	80	nat V. rem V.	+ -	Q - U -	● ○			10 <sup>-6</sup>
								20	40	60	80							
0		GROUND SURFACE		107.01														
	Power Auger 108 mm O.D. Solid Stem Augers	Very stiff, moist, brown clayey silt, some sand, trace gravel (FILL)		0.00	1	50 DO	15											
1		Hard, red SILTY CLAY, trace sand, trace gravel and limestone fragments (RESIDUAL SOIL)		0.91	2	50 DO	35											MH
		Weathered, red SHALE (Bedrock) contains limestone/siltstone interbeds		1.52	3	50 DO	66											
2					4	50 DO	80											
3					5	50 DO	50/.15											
4																		
5		END OF BOREHOLE		102.34	6	50 DO	50/.15											
				4.87														
5		Note:																
		1. Open borehole dry upon completion of drilling operations.																
6																		
7																		
8																		
9																		
10																		

DEPTH SCALE

1:50



LOGGED: PKS

CHECKED: SLP

MISS BHS 041111012BAAGDR.GPJ GLDR CAN.GDT 21/12/05 DD

**APPENDIX D**  
**NON-STANDARD SPECIAL PROVISIONS**

**CONTROL OF OVERBURDEN SOILS AND GROUNDWATER DURING RETAINING  
WALL FOUNDATION INSTALLATION - Item No.**

---

**Non-Standard Special Provision**

---

Excavations for the retaining wall foundations will be advanced through fill of varying composition and native soils such as sand and gravel till, silty sand and clayey silt till/residual soils. In addition, lenses or layers of water-bearing cohesionless soils should be expected to be present within the fill and till. Where cohesionless soil layers or lenses are encountered above or within the fill and till, the caisson holes may have to be advanced using a temporary liner in order to minimise ground loss during drilling and concrete placement.

**Basis of Payment**

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

END OF SECTION

**BOULDERS/OBSTRUCTIONS DURING RETAINING WALL FOUNDATION  
INSTALLATION - Item No.**

---

**Non-Standard Special Provision**

---

The clayey silt and sand and gravel till deposits at the site is glacially-derived and should be expected to contain cobbles and boulders. In addition, similar obstructions may be present within the existing fill. Appropriate equipment and procedures will be required to penetrate these obstructions during excavation for the retaining wall foundations.

**Basis of Payment**

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

END OF SECTION

**PRESENCE OF STRONGER INTERLAYERS OF LIMESTONE/SILTSTONE WITHIN  
SHALE BEDROCK DURING RETAINING WALL FOUNDATION INSTALLATION -  
Item No.**

---

Non-Standard Special Provision

---

Shale bedrock will be encountered within the depth of caisson foundations at all of the retaining wall locations. The shale bedrock in this area is known to contain stronger interlayers of limestone and siltstone. Consideration of the presence of the stronger interlayers must be made in the selection of caisson installation equipment at these locations.

**Basis of Payment**

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

END OF SECTION

**SUBGRADE PROTECTION OF BEARING STRATUM - Item No.**

---

**Non-Standard Special Provision**

---

If required, supply and installation of the lean concrete (i.e. mud mat) to prevent erosion and/or disturbance to the foundation soils should be considered. If the concrete for the footings on the shale bedrock cannot be poured immediately after excavation and inspection, a working mat of lean concrete should be placed on the base of the excavation to protect the integrity of the bearing stratum.

Lean concrete shall have a compressive strength of at least 5 MPa and will be placed in accordance with OPSS 904. A minimum thickness of 75 mm is recommended.

**Basis of Payment**

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

END OF SECTION