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FOUNDATION INVESTIGATION AND DESIGN REPORT  
QEW / THIRD LINE UNDERPASS  
QEW INTERCHANGE AT THIRD LINE  
AND THIRD LINE FROM THE QEW NORTHERLY TO  
KING'S COLLEGE DRIVE  
REGIONAL MUNICIPALITY OF HALTON  
GWP 180-00-00



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**PART A**

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Drawings 1 and 2

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## 1.0 INTRODUCTION

Golder Associates Ltd. has been retained by Morrison Hershfield Limited (Morrison Hershfield) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation at the site of the proposed Third Line and QEW Interchange in the Region of Halton, Ontario. The project involves reconstruction of the Third Line and Queen Elizabeth Way (QEW) interchange and Third Line from the QEW northerly to King's College Drive. The project includes new underpass structures to carry Third Line over the QEW and Fourteen Mile Creek, a culvert extension, retaining wall, high embankments and removal and backfill of the existing Third Line overpass. This report addresses the Third Line / QEW underpass structure, retaining wall, high embankments and removal and backfill of the existing overpass structure.

The purpose of the foundation investigation is to determine the subsurface conditions at the site of the proposed structures by drilling boreholes, and carrying out in-situ tests and laboratory tests on selected samples. The terms of reference for the scope of work are outlined in our Total Project Management proposal P01-1321, dated October 2000. The work was carried out in accordance with our Quality Control Plan for Foundation Design Services, Agreement No. 2005-A-000290, dated October 2000.

The General Arrangement plan for the Third Line / QEW underpass structure showing the proposed abutment and pier layout has been provided to us on digital format in September 2001.

## **2.0 SITE DESCRIPTION**

The bridge site is located about 50 m west of the existing QEW and Third Line overpass structure (see Drawing 1). The retaining wall is located north of the QEW on the north side of the North Service Road, west of the existing Third Line (see Drawing 1), in MTO District 4 in the City of Oakville, in the Region of Halton.

The topography of the site area is generally level and gradually slopes downwards towards the south. The existing Third Line has been constructed in cut. Existing culverts carry Fourteen Mile Creek underneath the QEW to the west of Third Line and underneath Third Line south of the QEW. Within the project limits, the vegetation cover generally consists of grass, bushes, and mature trees.



### 3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between February 12 and March 19, 2001. At this time 20 boreholes were put down at the site. Boreholes QEW1, QEW2, 1B, 2B, 3B and 4B were put down within the limits of the proposed foundation units and Boreholes 1, 1D and 5 for the approaches. Boreholes 1C and 2C were put down along the length of the proposed retaining wall west of Third Line at the North Service Road. Boreholes 201 to 203, 300, 301, 401 and 804 to 806 were put down at locations where the embankments are greater than 4.5 m in height along the proposed ramps and proposed Third Line alignment.

The investigation was carried out using a truck-mounted D-90 drill rig (for the boreholes drilled on existing roadways) and bombardier-mounted CME-55 and B-57 drill rigs (for the boreholes drilled elsewhere at the site) supplied and operated by Master Soil Investigation of Toronto. In the boreholes, samples of the overburden were obtained at regular intervals of depth of 0.75 m to 1.5 m using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedures. The boreholes were extended to depths of between 2.1 m and 10.1 m below the existing ground surface. NQ size core samples were obtained in selected boreholes at the retaining wall and bridge sites. Groundwater conditions in the open boreholes were observed throughout the drilling operations. Piezometers were installed in three boreholes to permit monitoring of the groundwater levels at the site. The piezometers consisted of a 200 mm long slotted tip threaded into 12 mm diameter PVC rigid tubing.

The field work was supervised on a full-time basis by a member of our engineering staff who located the boreholes in the field, directed the drilling, sampling and coring operations, and logged the boreholes. The soil samples were identified in the field, placed in labeled containers and transported to our laboratory in Mississauga for further examination. Index and classification tests consisting of grain size analyses, Atterberg Limits tests and water content determinations were carried out on selected samples. In total, 63 soil samples and 37 bedrock samples (obtained by split-spoon procedures) were obtained and 63 natural water content, 11 Atterberg Limits and 5 grain size distribution tests were performed.

The limits of the proposed bridge abutments along with centreline chainages of the proposed Third Line and ramps were staked in the field by Morrison Hershfield. Based on the information provided, the northing and easting co-ordinates of the borehole locations are given in UTM, and the borehole elevations are referenced to the Geodetic Datum. The co-ordinates of the boreholes are indicated on the Record of Borehole sheets and the locations of the boreholes are shown on Drawings 1 and 2.

## **4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY**

### **4.1 Site Geology**

The site is located in the physiographic region known as the Iroquois Plain. The Iroquois Plain is generally composed of a shallow cover of sand and till covering portions between Hamilton and Toronto (Chapman and Putnam, "The Physiography of Southern Ontario", 3<sup>rd</sup> Edition, 1984). The surface topography slopes gradually and fairly uniformly towards Lake Ontario. The overburden at the site consists of a shallow cover of residual soil which is underlain by bedrock comprised of red shale of the Queenston Formation.

### **4.2 Site Stratigraphy**

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets following the text of this report. The stratigraphic boundaries shown on the borehole sheets are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsoils at the site generally consist of 0.3 m to 4.9 m of topsoil and clayey silt to silty clay fill underlain by a 0.3 m to 1.6 m thick deposit of clayey silt residual soil. The fill or residual soil is directly underlain by shale bedrock of the Queenston Formation.

Locations and elevations of all the borings are shown on Drawing 1. The locations and elevations of the borings at the bridge site together with the interpreted stratigraphical profile and sections are shown on the attached Drawing 2. A detailed description of the subsurface conditions encountered in the boreholes for this investigation is provided in the following sections.

#### **4.2.1 Topsoil**

A surficial layer of topsoil, between 100 mm and 900 mm thick, was encountered in Boreholes 5, 1D, 202, 203, 300, 401, 805 and 806. The topsoil consists of black clayey silt containing some sand, trace gravel and shale fragments, grass and organics. Measured Standard Penetration Test (SPT) 'N' values range between 6 and 17 blows per 0.3 m of penetration indicating a firm to very stiff consistency. The natural water content measured on selected samples of the topsoil range from 28 and 58 percent.



#### **4.2.2 Road Base Fill**

Boreholes QEW1 and QEW2 were drilled through the paved median shoulder of the QEW and Borehole 2C was drilled through the gravel shoulder of the North Service Road. The asphalt thickness was 200 mm (Boreholes QEW1 and QEW2) and the crushed limestone (sand and gravel sizes) road base was between 400 mm and 800 mm thick. The SPT 'N' values on two samples of the sand and gravel were 15 and 17 blows per 0.3 m of penetration indicating that the material is compact. The natural water content measured on one sample of the sand and gravel was 7 percent.

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

A 0.6 m to 4.6 m thick deposit of red brown to black brown to grey clayey silt to silty clay fill was encountered below the ground surface, topsoil or road base fill in all boreholes except Borehole 5 and 806. The fill contains trace to with sand, trace to some gravel, trace organics and trace shale fragments. The deeper fills are associated with the two boreholes put down for the proposed retaining wall. Measured SPT 'N' values on samples of the fill range between 7 and 42 blows per 0.3 m of penetration indicating a firm to hard consistency. Occasional grinding during augering through the fill was noted. Grain size distribution curves for selected samples of the fill are shown on Figure 1. Atterberg Limits testing was carried out on selected samples of the fill. The liquid limits were between 26 and 31 percent and the plasticity indices were between 11 and 14 percent, indicating that the fill is of low plasticity. The test results are shown on the plasticity chart on Figure 2. The natural water content measured on selected samples of the fill ranged from about 7 to 25 percent.

In Boreholes 2C and 201, a 0.8 m thick zone with a high concentration of organics was noted within the fill just above the residual soil or bedrock surface about Elevation 113.0 m and 103.6 m, respectively.

In Boreholes 202, 301, 804, 805, 1C, 2C, 1D and QEW2, the fill directly overlies the bedrock surface.

#### **4.2.4 Clayey Silt Residual Soil**

A 0.3 m to 1.6 m thick deposit of residual soil containing sand, occasional trace gravel and trace shale fragments was encountered below the fill or topsoil in Boreholes 1B, 2B, 3B, 4B, QEW1, 1, 5, 806, 201, 203, 300 and 401. The residual soil is derived through weathering of the shale

bedrock and is essentially comprised of clayey silt. This deposit generally has a till-like structure but can contain zones of rock-like structure. The deposit was encountered below Elevations 102.8 m to 105.5 m in the borings drilled for the high embankments and below Elevations 107.0 m and 107.4 m in the borings drilled for the bridge structure and approaches.

Measured SPT 'N' values on samples of the residual soil were between 50 blows and greater than 100 blows per 0.3 m of penetration, indicating a hard consistency. Occasional grinding during augering through the residual soil was noted. Grain size distribution curves for selected samples of the residual soil are shown on Figure 3. Atterberg Limits testing was carried out on selected samples of the residual soil. The liquid limits were between 26 and 33 percent and the plasticity indices were between 9 and 15 percent indicating that the clayey silt is of low plasticity. The test results are shown on the plasticity chart on Figure 4. The natural water content measured on selected samples of the residual soil ranged from about 8 to 17 percent. Where encountered, the residual soil directly overlies the shale bedrock.

#### 4.2.5 Bedrock

The shale bedrock surface was encountered in all boreholes. The bedrock was augered for lengths of 0.1 m to 2.8 m in all the boreholes prior to rock coring. Occasional grinding during augering through the bedrock was noted. The shale bedrock surface was encountered at the elevations shown in the table below:

<i>Borehole</i>	<i>Location</i>	<i>Ground Surface Elevation (m)</i>	<i>Depth (m)</i>	<i>Elevation (m)</i>
1	North Approach	108.9	3.0	105.9
1D		109.1	1.2	107.9
1B	North Abutment	108.9	3.1	105.8
2B		108.7	3.1	105.6
3B	South Abutment	108.0	1.1	106.9
4B		108.1	1.5	106.6
QEW1	Central Pier	108.5	2.4	106.1
QEW2		108.4	1.5	106.9
5	South Approach	107.9	1.5	106.4



<i>Borehole</i>	<i>Location</i>	<i>Ground Surface Elevation (m)</i>	<i>Depth (m)</i>	<i>Elevation (m)</i>
201	High Embankments	105.9	3.8	102.1
202		106.5	3.8	102.7
203		107.2	3.1	104.1
300		107.0	2.3	104.7
301		106.1	2.3	103.8
401		107.3	3.0	104.3
804		109.6	1.2	108.4
805		107.4	1.4	106.0
806		104.4	0.8	103.6
1C	Retaining Wall	116.9	4.6	112.3
2C		116.8	4.8	112.0

The shale bedrock was cored in Boreholes 1B, 2B, 3B, 4B, QEW1, QEW2, 1C and 2C. The bedrock is described as moderately to highly weathered, red brown, thinly laminated, fine-grained, very weak to weak, calcareous shale of the Queenston Formation. Rock Quality Designation (RQD) values were measured between 0 and 74 percent indicating rock of very poor to fair quality. The rock quality generally improved below about Elevation 103 m at the proposed bridge foundation units and below about Elevation 109 m at the proposed retaining wall location. Seams of slightly less weathered, grey shale was encountered within the core samples. Zones of residual soil between 50 mm and 75 mm thick were encountered within the core samples from Boreholes 3B, 4B and QEW1.

In terms of the strength classification as noted above, weak rock encompasses rock with unconfined compressive strength between 5 MPa and 25 MPa. Based on the core samples obtained, the calcareous shale typically has strength closer to the upper limit of the range. Uniaxial compression strength testing was carried out on two samples obtained from a previous borehole investigation carried out by Golder Associates (Report No. 871-1526, dated April 1988). The tests indicate uniaxial compressive strengths of 27 MPa and 46 MPa. This would classify the rock as having medium strength, where medium strong rock encompasses rock with unconfined compressive strength between 25 MPa and 50 MPa.

A faint hydrocarbon odour was noted at 1.5 m depth in Borehole 4B at the surface of the shale bedrock.

### 4.3 Groundwater Conditions

Water levels were noted in the open boreholes during and upon completion of the drilling operation; these levels are shown on the attached Record of Borehole sheets. Piezometers were sealed into the bedrock in Boreholes 1B, 3B and 2C to permit the monitoring of the groundwater levels across the site. Details of the piezometer installations and water level measurements are shown on the attached Record of Borehole sheets.

All of the open boreholes were dry upon completion of overburden drilling operations. A summary of the water level monitoring results are provided in the following table.

Borehole	On Completion of Overburden Drilling		Water Level in Piezometer			
			March 23, 2001		April 30, 2001	
	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)
1B	Dry	--	3.6	105.3	4.0	104.9
3B	Dry	--	2.0	106.0	2.5	105.5
2C	Dry	--	4.7	112.1	4.8	112.0

These levels indicated that the groundwater level generally slopes downward toward the south, following the ground surface topography. It should be noted that groundwater levels are expected to fluctuate seasonally and are expected to be higher during wet periods of the year.

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**PART B**

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## **5.0 ENGINEERING RECOMMENDATIONS**

### **5.1 General**

This section of the report provides our recommendations on the geotechnical aspects of design of proposed QEW / Third Line Overpass, the retaining wall at the North Service Road and high embankments based on our interpretation of the factual information obtained during the investigation. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

It is understood that the proposed Third Line alignment will be carried over the QEW and will involve embankments up to 8 m in height. A retaining wall is proposed to separate the North Service Road from the small creek to the north of the North Service Road. The existing QEW overpass at Third Line will have to be partially removed and fully backfilled.

### **5.2 Bridge Foundations**

The subsoils encountered in the boreholes put down during the present investigation typically consist of fill and hard clayey silt residual soil overlying shale bedrock. The groundwater table is at about Elevation 106.0 m in the immediate vicinity of the proposed abutments.

Based on the subsurface information above, consideration may be given to support on shallow spread footings placed on the hard residual soil deposit or the surface of the weathered shale bedrock. Consideration may also be given to supporting the structure on steel piles driven to practical refusal within the weathered shale or on H-piles or caissons socketted into the shale bedrock. In order to achieve the minimum pile length of 5 m, pre-augering through the shale bedrock of the full depth will likely be required to advance the driven piles.

#### **5.2.1 Shallow Foundations**

Shallow spread footings may be used to support the abutments and central pier for the proposed bridge. Consideration can be given to placing the footings on the hard residual soil, at the surface of the weathered bedrock or at depth on the more competent bedrock.

### 5.2.1.1 Geotechnical Bearing Resistance

The highest recommended founding level for spread footings founded on the hard clayey silt residual soil, the surface of the weathered shale bedrock or at depth within the bedrock (to be below the upper weathered / fractured zone) are given in the table below. The design bearing resistances for the three options are also given.

<i>Design Founding Levels for Spread Footings Founding Option</i>	<i>QEW / Third Line Underpass</i>			<i>Bearing Resistance</i>
	<i>North Abutment</i>	<i>Central Pier</i>	<i>South Abutment</i>	
Spread Footings on Residual Soil	107.2 m	107.0 m	107.2 m	600 kPa (ULS) 500 kPa (SLS)
Spread Footings on Surface of Weathered Shale Bedrock	105.7 m	106.1	106.6 m	750 kPa (ULS) 600 kPa (SLS)
Spread Footings Within Shale Bedrock Below Upper Fractured Portion	103 m	104 m	103 m	1,500 kPa (ULS)*

\* SLS not applicable.

Spread footings for the abutments should be a cost-effective foundation as suitable bearing soil, either the residual soil or the weathered shale bedrock is at a relatively shallow depth. The founding level for the footings placed on the residual soil or the surface of the bedrock is above the groundwater level. The above geotechnical bearing resistances assume that appropriate construction procedures are adopted to handle any seepage inflow during footing construction to ensure that the hard residual soil / weathered bedrock is not softened / disturbed prior to concrete placement.

### 5.2.1.2 Resistance to Lateral Forces

Resistance to lateral forces / sliding resistance between the concrete spread footings and subsoil should be calculated in accordance with Section 6-8.4.3 of the OHBDC assuming the following coefficients of friction between the concrete and the founding soils:

Footings on hard residual soil	0.50
Footings on weathered shale	0.45

### **5.2.1.3 Frost Protection**

All footings should be provided with a minimum of 1.2 m of earth cover for frost protection purposes.

### **5.2.1.4 Construction Considerations**

For the alternative founding levels for the bridge abutments and pier footings placed on the hard residual soil at about Elevation 107 m or at the surface of the weathered shale at about Elevation 106 m, the footing excavations will be at or above the groundwater level. For the alternative of founding deeper within the bedrock, the footing excavations will be extended below the groundwater level. Some water seepage into footing excavations should be expected for excavations extended below Elevation 106 m and significant water flow could be encountered through the fractured shale. Pumping from well-filtered sumps placed at the base of the excavation should provide sufficient groundwater control during foundation excavations. Sumps should be maintained outside of the footing area.

The founding strata (including the shale bedrock) are sensitive to disturbance and softening due to water seepage or ponding. Any water should be directed away from the footing area at all times. Placement of a lean concrete mud coat will be required at the base of the excavation for the footing area. The cleaned excavation base should be inspected by qualified geotechnical personnel. The mud coat should be placed within four hours after footing inspection. It should be noted that the water levels could be higher during wet periods of the year.

## **5.2.2 Deep Foundations**

Consideration could be given to the use of driven or socketed H-piles (in the case of integral abutments) or the use of caissons for support of the bridge abutments and central pier.

### **5.2.2.1 Geotechnical Resistance – Driven Steel H-Piles**

Depending on the proposed road grade, support of the structures on driven steel piles is probably not practical due to the shallow depth to shale bedrock. If the option of steel H-piles is to be considered, pre-augering through the residual soil and shale bedrock for the full depth of the pile will be required. Steel H-piles could then be installed within the preaugered hole and driven to



practical refusal within the shale bedrock which was encountered at about Elevation 106 m. For design, the factored axial resistance at Ultimate Limit States for HP 310 x 110 piles driven to practical refusal on shale bedrock may be taken at 2,000 kN. The axial resistance at Serviceability Limit States (SLS) for 25 mm of settlement may be taken at 1,600 kN.

The H-piles should be driven to a final set of no less than 15 blows per 25 mm of penetration using a hammer with rated energy of about 50 kJ but not exceeding 60 kJ. Provision should be made to re-tap the piles to confirm the set after adjacent piles have been driven in accordance with Special Provision 903S01. The pile toes should be stiffened with MTO flange plates for protection during driving.

#### **5.2.2.2 Geotechnical Resistance – Socketted H-Piles**

Consideration can be given to socketting H-piles into the shale bedrock to achieve the minimum pile length and installing the piles without driving. It is understood that two options are being considered with respect to the founding level for the pile socket; founding within the upper fractured shale at Elevation 105 m, or founding within the less fractured shale at Elevation 102 m. It is assumed that the load will be transferred down the H-pile (which is placed in the augered hole) and over the full socket diameter at the base. It is also assumed that the socket length will be 1 m, formed of mass concrete, and the remainder of the pile placed within a steel casing filled with sand to allow lateral movement.

For the first option with founding level at Elevation 105 m within the fractured shale, a geotechnical axial resistance at Ultimate Limit States (ULS) of 1,500 kPa for end-bearing may be used. This results in a capacity of 425 kN for 0.6 m diameter sockets and 850 kN for 0.9 m diameter sockets.

For the second option with founding level at Elevation 102 m within the less fractured shale, a geotechnical axial resistance at Ultimate Limit States (ULS) of 3,000 kPa for end-bearing may be used. This results in a capacity of 850 kN for 0.6 m diameter sockets and 1,900 kN for 0.9 m diameter sockets.

#### **5.2.2.3 Geotechnical Resistance - Caissons**

The use of caissons socketted into the shale bedrock below the upper fractured portion (below about Elevation 104 m) may also be considered as an alternative for the foundations. The load carrying capacity for caissons depends on the total length of the caissons, the length of the rock socket and

the diameter of the caissons. Where the length to diameter ratio is less than 5, it is recommended that the caissons be designed as end-bearing units. For design, an axial geotechnical resistance at ULS of 3.4 MN and 5.3 MN may be assumed for 1.2 m and 1.5 m diameter caissons, respectively, assuming a rock socket length of 2 m. Serviceability Limit States (SLS) does not apply for caissons founded within the unweathered shale bedrock at this site.

The use of caissons at the centre pier has the advantage of speed of operation and limited space requirements for installation.

#### 5.2.2.4 Resistance of Lateral Loads

The lateral loading could be resisted fully or partially by the use of battered piles. If integral abutments are considered, the vertical piles must provide the resistance to the lateral loading. In this case, the horizontal reaction to the pile can be estimated using the following equation and the range in values given in the table below where:

$K_h$  = coefficient of horizontal subgrade reaction (MPa/m) =  $K_{SI}/5d$

$d$  = pile width or diameter (m)

$K_{SI}$  = constant of horizontal subgrade reaction (MPa/m)

<i>Soil Type</i>	<i><math>K_{SI}</math> (MPa/m)</i>
Hard Residual Soil	50 to 80
Weathered Shale Bedrock	100 to 150

The resistance should be checked for the range of values as given and the design be based on the least or greatest resistance as appropriate.

Group action for lateral loading should 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 lateral subgrade reaction in the direction of loading by a reduction factor  $R$  as follows:

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

#### 5.2.2.5 Frost Protection

The pile caps should be provided with 1.2 m soil cover for frost protection.

### 5.3 Lateral Earth Pressures

The lateral pressures acting on the bridge abutments will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill and on the subsequent lateral movement of the structure. The following recommendations are made concerning the design of the abutments and the retaining walls in accordance with OHBDC:

- Select free-draining granular fill meeting the specifications of OPSS Granular 'A' or Granular 'B' but with less than 5 percent passing the 200 sieve should be used as backfill behind the walls. All granular fill should be compacted in lifts of loose thickness not greater than 200 mm to 95 percent of the material's Standard Proctor maximum dry density in accordance with OPSS501.
- Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill.
- The granular fill may be placed either in a zone with width equal to at least 1.2 m behind the back of the stem (Case I from OHBDC Figure 6-7.4.1) or within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical up and back from the bottom of the rear face of the footing (Case II from OHBDC Figure 6-7.4.4).
- If the wall support allows lateral yielding of the stem (unrestrained structure), active earth pressures may be used in the geotechnical design of the structure. If the abutment support does not allow lateral yielding (restrained structure), at-rest pressures should be assumed for geotechnical design.
- A compaction surcharge equal to 16 kPa should be included in the lateral earth pressures for the structural design of the abutment wall in accordance with OHBDC Figure 6-7.4.3. Compaction equipment should be used in accordance with OPSS 501.06.



- For Case I, the pressures are based on the existing and proposed embankment fill materials and the following parameters (unfactored) may be assumed:

Soil unit weight (assuming clean earth fill)	20 kN/m <sup>3</sup>
Coefficients of lateral earth pressure:	
'active'	0.43
'at rest'	0.50

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

	Granular 'A'	Granular 'B' Type II
Soil Unit Weight	22 kN/m <sup>3</sup>	21 kN/m <sup>3</sup>
Coefficients of Lateral Earth Pressure		
'active'	0.27	0.31
'at rest'	0.43	0.47

It should be noted that the above design parameters assume level backfill and ground surface behind the wall. Other aspects of the abutment granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD-3501.00.

## 5.4 Embankments

The proposed Third Line alignment and associated ramps will be constructed entirely in fill and will involve embankment heights of up to about 9.5 m.

### 5.4.1 Embankment Design

The embankment subgrade soils consist of a surficial layer of firm to hard clayey silt to silty clay fill underlain by hard clayey silt residual soil underlain by weathered shale bedrock. Providing that topsoil is stripped from the embankment subgrade and the exposed surface proof-rolled, the embankment with side slopes maintained at 2 horizontal to 1 vertical would be stable. Settlement below the embankment is expected to be negligible. Settlement of the new embankment fill itself will occur and is expected to be less than 75 mm. The use of granular fill for embankment construction will reduce the amount of settlement since the majority of settlement of granular fills

will occur during construction. The majority of the settlement of cohesive embankment fills would occur after construction.

Where the proposed embankment height is greater than 8 m, a mid-height bench with a platform width of 2.0 m will be required on both sides of the embankment. The 2.0 m wide platform is not required in front of the abutments since there is a reduced embankment height and concrete slope paving will be present. If space restrictions preclude the use of benching within the embankment slope, consideration could be given to the use of an RSS slope which would involve incorporation of geogrid within the 2H:1V slopes. The geogrid would enhance the surficial stability of embankment slopes greater than 8 m.

#### **5.4.2 Embankment Construction**

Topsoil and fill deposits should be stripped from below the fill embankment areas and all subgrade soils proof-rolled to aid fill placement. Construction of the embankment above the prepared subgrade may be carried out using clean earth fill meeting the specifications of OPSS 212 or Select Subgrade Material meeting the specifications of OPSS 1010, depending on material availability. All embankment fill should be placed in regular lifts with loose thickness not exceeding 300 mm, and be compacted to at least 95 percent of the material's Standard Proctor maximum dry density. The final lift prior to placement of the granular subbase or base course should be compacted to 100 percent of the Standard Proctor maximum dry density. Inspection and field density testing should be carried out by qualified geotechnical personnel during all fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved. The permanent soil slopes of the embankment should be maintained not steeper than 2 horizontal to 1 vertical (2H:1V). Vegetation cover should be established on all soil slopes, including RSS slopes, to protect embankment fill against surficial erosion, as per OPSS 572.

#### **5.5 Retaining Wall**

The proposed retaining wall, about 70 m in length, will be located west of Third Line along the north side of the North Service Road and separate the North Service Road from the creek.

The subsoils encountered in the boreholes put down during the present investigation for the walls typically consist of about 4.6 m to 4.8 m of firm to hard clayey silt to silty clay fill overlying weathered shale bedrock. The groundwater level measured in one piezometer at the wall location is at about Elevation 112.0 m; consistent with the water level in the creek and coincident with the bedrock surface.

It is understood that two concepts are under consideration for the retaining wall:

- mechanically reinforced soil retaining wall system; and
- cantilever cast-in-place concrete retaining wall.

The fill materials are variable and are not considered suitable for the support of a concrete cantilever retaining wall. The concrete cantilever retaining wall may be founded on the surface of the weathered shale bedrock at or below Elevation 112.0 m (about 4.6 m below ground surface). The reinforced earth wall, which is more tolerant of settlement, may be supported on the fill materials; therefore reducing the amount of excavation required.

To provide protection against frost, the backfill material to a horizontal minimum distance of 1.2 m behind the face of the wall must consist of granular fill such as OPSS Granular A or Granular B Type II.

<i>Fill Materials</i>	<i>Granular A</i>	<i>Granular B, Type II</i>
Soil Unit Weight	22 kN/m <sup>3</sup>	21 kN/m <sup>3</sup>
Angle of friction (unfactored)	35°	32°

### 5.5.1 Mechanically Reinforced Soil Retaining Wall System

A mechanically reinforced soil retaining wall system consists of soil reinforced with metal or fabric strips or grids integrated with suitable granular fill which is placed and compacted in layers. 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. Consideration could be given to founding the RSS wall on the weathered shale bedrock at Elevation 112.0 m or higher up within the fill material (to reduce excavation quantities).

For the reinforced earth mass founded on the fill material, the design values for geotechnical bearing resistances are given in the table below:



<i>Founding Elevation (m)</i>	<i>Assumed Height of Wall (m)</i>	<i>Factored Geotechnical Bearing Resistance (ULS)</i>	<i>Geotechnical Bearing Resistance (SLS)</i>
114.8 m	2.0 m	75 kPa	75 kPa
113.8 m	3.0 m	110 kPa	150 kPa

Note that values in the table for SLS are based on 25 mm of settlement and for an RSS wall founded on the fill, the ULS values will govern design.

Differential settlement will occur along the length of the RSS wall if founded on the fill as a result of the variability of the fill. The magnitude of the differential settlement is unquantifiable due to the variability of the fill and the presence of organic material within the fill.

For the RSS wall founded on the surface of the weathered shale at about Elevation 112.0 m, the maximum height of the wall is anticipated to be about 4.6 m. For the reinforced earth mass founded on the weathered shale bedrock, the factored geotechnical bearing resistance bearing at ULS of 400 kPa may be used for design. The corresponding geotechnical resistance at SLS may be taken as 275 kPa. For the RSS wall founded on the weathered shale, all topsoil, existing fill and loose / soft materials should be removed prior to placing the granular for the reinforced soil system.

A coefficient of friction equal to 0.5 may be assumed between the granular fill of the RSS wall and the clayey silt to silty clay fill founding soils. For an RSS wall founded on weathered shale, a coefficient of friction of 0.6 should be used.

The internal stability of the mechanically-reinforced soil wall should be checked by the RSS supplier / designer. The factor of safety related to global stability for properly design and constructed RSS walls at this site will be greater than 1.3.

The subgrade should be inspected by qualified geotechnical personnel prior to placement of the granular materials.

### 5.5.2 Cantilever Cast-in-place Concrete Retaining Wall

For the cantilever wall option, the concrete wall may be supported on spread footings founded on the surface of the weathered shale bedrock at about Elevation 112 m. Factored geotechnical bearing resistances are given in the table below.

<i>Assumed Footing Width (m)</i>	<i>Factored Geotechnical Bearing Resistance (ULS)</i>	<i>Geotechnical Bearing Resistance (SLS)</i>
2.0	650	450
2.5	750	500
3.0	825	550

The SLS values provided are for 25 mm of settlement. A minimum of 1.2 m of frost cover must be provided.

Resistance to lateral forces / sliding resistance between the concrete footings and subsoils should be calculated in accordance with Section 6-8.4.3 of the OHBDC assuming a coefficient of friction of 0.45 between the concrete and the weathered shale bedrock to calculate the resistance of the wall footing against sliding.

The global factor of safety of a properly constructed cast-in-place concrete cantilever wall will be greater than 1.3 for the proposed wall height up to 4.6 m.

The geotechnical resistances provided are given under the assumption that the loads will be applied perpendicular to the surface of the footings. The inclination of the load should be taken into account in accordance with Section 6-8.4.2 of the OHBDC when the load is not applied perpendicular to the surface of the footing.

## 5.6 Excavations and Temporary Cut Slopes

Excavations for footing construction will extend through clayey silt to silty clay fill and hard clayey silt residual soil deposits. Cobbles and boulders could be encountered in the fill and residual soil at this site as inferred from grinding during drilling. Temporary open cut slopes should be maintained no steeper than 1 horizontal to 1 vertical (1H:1V). Where space restrictions dictate, the excavation could also be carried out within a fully braced excavation. Roadway protection for QEW for pier footing construction in the centre median and during removal of the existing structure will be required.

Groundwater seepage inflow into the excavations through the fill and residual soil deposit may occur but is expected to be minor, except during periods of sustained precipitation. Greater flows should be expected through the fractured shale bedrock where excavations extend below the surface of the bedrock. Pumping from well-filtered sumps located at the base of the excavation should

provide adequate groundwater control during foundation excavations. The considerations with respect to protection of the founding soils, however, as given in Section 5.2.1.4 must be recognized. Sumps should be maintained outside the actual footing limits. Surface water run-off should be directed away from the excavations at all times. The appropriate NSSP should be included in the contract documents.

Where space is restricted and / or roadway protection is required for footing / wall construction or removal of the existing structure, a temporary support system should be installed to support the sides of the excavation and permit the use of vertical cuts. The temporary support system could consist of soldier piles and lagging where the piles would be socketted into pre-augered holes extended into the shale bedrock below the excavation base. Some cobbles and boulders should be expected during augering for the soldier pile installation. Support to the soldier pile and lagging wall system could be in the form of struts and walers in the case of footing excavations or rakers and anchors in the case of retaining wall excavations.

The design of braced soldier pile and lagging walls should be based on a rectangular earth pressure distribution using the design parameters given below. Where the support to the wall is provided by anchors or rakers, the wall design should be based on a triangular earth pressure distribution using the design parameters given below. The raker / anchor support must be designed to accommodate the loads applied from pressures and surcharge pressures from area, line or point loads as well as the impact of sloping ground behind the system.

Unfactored triangular earth pressure distribution ( $p$  in  $\text{kN/m}^2$ ; increasing with depth), can be calculated as follows:

$$p = K_a \gamma H$$

where

$H$  = the height of the excavation at any point in metres

$K_a$  = 0.3 for level ground behind excavation

$\gamma$  = soil unit weight =  $21 \text{ kN/m}^3$

Unfactored rectangular earth pressure distribution ( $p$  in  $\text{kN/m}^2$ ; constant with depth), can be calculated as follows:



$$p = K \gamma H$$

where

H = the height of the excavation

K = 0.25 for level ground behind excavation

$\gamma$  = soil unit weight = 21 kN/m<sup>3</sup>

Passive toe restraint to the soldier piles may be determined using a triangular pressure distribution acting over an equivalent width equal to three times the pile socket diameter. The coefficient of passive lateral earth pressure,  $K_p$ , for the socket within the hard residual soil or weathered bedrock may be taken as 8.7. The residual soil / weathered bedrock unit weight should be taken as 21 kN/m<sup>3</sup>. A groundwater level at about Elevation 105.5 m can be assumed at the proposed bridge foundation units.

Where roadway protection is required, grouted rock anchors are feasible and may be designed based on the following ultimate bond stresses as between grout and rock:

300 kPa – over the upper 3.0 m of bedrock

600 kPa – below the upper 3.0 m of bedrock

A factor of safety of at least 1.5 should be applied to the ultimate rock anchor capacity calculated from the above adhesion values. The maximum permissible stress in the anchor tendon or bar under the design load should not exceed 0.625 of the guaranteed ultimate tensile strength of the tendon or bar.

A performance test should be carried out on at least one anchor to confirm the design and the Contractor's installation method. The performance test should be carried out to 2.0 times the design working load. In addition, each anchor should be proof tested to 1.5 times its working load. The tensile stress in the anchor bar during test loading should not exceed 0.8 of the guaranteed ultimate tensile strength of the bar. Anchor installation and testing should be carried out under the full-time inspection of a geotechnical engineer. Anchor installation and preloading should be complete before the excavation proceeds below the anchor elevation.

All excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Ontario Occupational Health & Safety Act. The native soils at this site would be classified as Type I soil.

## 5.7 Backfilling

It is understood that the existing structure carrying Third Line underneath the QEW will have to be partially removed to well below the level of the QEW to eliminate any hard points below the future QEW pavement. The asphalt should be stripped from the existing Third Line within the backfilling limits and all subgrade soils proof-rolled to aid backfill placement. Backfilling of the structure may be carried out using clean earth fill meeting the specifications of OPSS 212 or Select Subgrade Material meeting the specifications of OPSS 1010, depending on material availability. All backfill should be placed in regular lifts with loose thickness not exceeding 300 mm, and be compacted to at least 95 percent of the material's Standard Proctor maximum dry density. The final lift prior to placement of the granular subbase or base course should be compacted to 100 percent of the Standard Proctor maximum dry density. Inspection and field density testing should be carried out by qualified geotechnical personnel during all fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved. Any permanent soil slopes should be maintained not steeper than 2 horizontal to 1 vertical (2H:1V).

**GOLDER ASSOCIATES LTD.**



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SEMP/ASP/FJH/clg

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## 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

	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

#### (b) Cohesive Soils

#### 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 <sub>p</sub>	plastic limit
w <sub>l</sub>	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 <sub>R</sub>	relative density (specific gravity, G <sub>s</sub> )
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)
γ	unit weight

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



## LIST OF SYMBOLS

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

### I. GENERAL

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

#### (a) Index Properties (con't.)

$w$	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)

#### (c) 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

#### (d) Consolidation (one-dimensional)

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (overconsolidated range)
$C_s$	swelling index
$C_\alpha$	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	Overconsolidation ratio = $\sigma'_p / \sigma'_{vo}$

#### (e) 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 = (Compressive strength)/2

# LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

## WEATHERING STATE

**Fresh:** no visible sign of weathering.

**Faintly weathered:** weathering limited to the surface of major discontinuities.

**Slightly weathered:** penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

**Moderately weathered:** weathering extends throughout the rock mass but the rock material is not friable.

**Highly weathered:** weathering extends throughout rock mass and the rock material is partly friable.

**Completely weathered:** rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

## BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	> 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	< 6 mm

## JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	> 3 m
Wide	1 - 3 m
Moderately close	0.3 - 1 m
Close	50 - 300 mm
Very close	< 50 mm

## GRAIN SIZE

Term	Size*
Very Coarse Grained	> 60 mm
Coarse Grained	2 - 60 mm
Medium Grained	60 microns - 2 mm
Fine Grained	2 - 60 microns
Very Fine Grained	< 2 microns

Note: \*Grains > 60 microns diameter are visible to the naked eye.

## CORE CONDITION

### Total Core Recovery

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

### Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

### Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid sticks.

## DISCONTINUITY DATA

### Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

### Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

### Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

### Abbreviations

B - Bedding	P - Polished
FO - Foliation/Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane/Zone	R - Ridged/Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
MF - Mechanical Fracture	C - Curved
- Parallel To	
⊥ - Perpendicular To	



PROJECT 001-1158		RECORD OF BOREHOLE No 1B		1 OF 1		METRIC					
W.P. 180-00-00		LOCATION N 4809382, E 286521		ORIGINATED BY GM							
DIST 4 HWY QEW		BOREHOLE TYPE 114mm Solid Stem Augers		COMPILED BY SEP							
DATUM Geodetic		DATE Feb. 12/01		CHECKED BY ASP							
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100			
108.9	GROUND SURFACE										
0.0	Clayey Silt to Silty Clay, trace sand (Fill) Hard Red brown		1	SS	30						
107.4	Clayey Silt, trace sand and gravel (Residual Soil) Hard Red brown		2	SS	68						
1.5			3	SS	75						
105.8	Grinding at 2.7m depth										
3.1	Moderately to highly weathered, red brown with occasional grey seams, calcareous SHALE BEDROCK (Queenston Formation).  Bedrock cored from 3.1m to 7.7m.  For bedrock coring details see Record of Drillhole 1B.										
101.2	END OF BOREHOLE										
7.7	Note: 1. Open borehole dry upon completion of overburden drilling. 2. Water level in piezometer at 3.6m depth (Elev. 105.3m) on March 26, 2001 and at 4.0m depth (Elev. 104.9m) on April 30, 2001.										

ON MOT 001-1158.GPJ ON MOT GDT 25/201



PROJECT: 001-1158

## RECORD OF DRILLHOLE: 1B

SHEET 2 OF 2

LOCATION: N 4809382; E 286521

DRILLING DATE: Feb.13/01

DATUM: Geodetic

INCLINATION: -90°

AZIMUTH: ---

DRILL RIG: CME-55

DRILLING CONTRACTOR: Master Soil Investigation Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN NO.	PENETRATION RATE (mm/min)	COLLAR CORRECTION (mm)	FLUSH	FR FRACTURE CL CLEAVAGE SH SHEAR VN VEIN	F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED	SM SMOOTH R-ROUGH ST-STEPPED PL PLANAR	FL FLEXURED UE UNEVEN W WAVY C-CURVED	BC BROKEN CORE MB MECH. BREAK B-BEDDING	DIAMETER POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous page		105.80											
		Moderately to highly weathered, red brown with occasional grey seams, thin laminated, fine-grained, weak to very weak, calcareous SHALE (Queenston Formation).		3.10											
4					1										
5					2										
6															
7					3										
8		END OF BOREHOLE		101.20 7.70											
9															
10															
11															
12															
13															

DEPTH SCALE

1:50

Golder  
Associates

LOGGED: GM

CHECKED: ASP

DRILLHOLE 1158 ROCK GPJ GLDR CAN GOT 25/01 PS

PROJECT 001-1158		RECORD OF BOREHOLE No 2B		1 OF 1		METRIC					
W.P. 180-00-00		LOCATION N 4809401; E 286536		ORIGINATED BY GM							
DIST 4 HWY QEW		BOREHOLE TYPE 114mm Solid Stem Augers		COMPILED BY SEP							
DATUM Geodetic		DATE Feb. 12/01		CHECKED BY ASP							
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	WATER CONTENT (%)	UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE							
108.7	GROUND SURFACE										
0.0	Clayey Silt to Silty Clay, trace sand and fine gravel (Fill) Very stiff Red brown		1	SS	24						
107.2	Clayey Silt, trace sand and fine gravel, trace shale fragments (Residual Soil) Hard Red brown		2	SS	100/25						
1.5	Grinding from 2.4m to 3.0m depth		3	SS	100/15						
105.6	Highly to moderately weathered, red brown with occasional grey seams, calcareous SHALE BEDROCK (Queenston Formation).  Bedrock cored from 3.3m to 6.2m.  For bedrock coring details see Record or Drillhole 2B.		4	AG							
3.1											
102.5	END OF BOREHOLE										
6.2	Note: 1. Open borehole dry upon completion of overburden drilling.										

ON MOT 001-1158 GPJ ON MOT GDT 25/9/01

PROJECT: 001-1158

## RECORD OF DRILLHOLE: 2B

SHEET 2 OF 2

LOCATION: N 4809401; E 286536

DRILLING DATE: Feb.14/01

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55

DRILLING CONTRACTOR: Master Soil Investigation Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN NO.	PENETRATION RATE (mm/min)	FLUSH COLLOID SUSPENSION	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN	F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED	SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR	FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED	BC-BROKEN CORE MB-MECH. BREAK B-BEDDING	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous page		105.40										
		Highly to moderately weathered, red brown with occasional grey seams, thin laminated, fine-grained, weak, calcareous SHALE (Queenston Formation).		3.30										
4		Extremely weak from 3.3m to 3.4m.			1		90							
5					2		90							
6				102.50										
		END OF BOREHOLE		6.20										
7														
8														
9														
10														
11														
12														
13														

DEPTH SCALE

1:50



LOGGED: GM

CHECKED: ASP

DRILLHOLE 1158BROCK GPJ GLDR CAN.GDT 25/9/01 PS



PROJECT 001-1158		<b>RECORD OF BOREHOLE No 3B</b>		1 OF 1	<b>METRIC</b>
W.P. 180-00-00	LOCATION N 4809319, E 286576	ORIGINATED BY GM			
DIST 4 HWY GEW	BOREHOLE TYPE 114mm Solid Stem Augers	COMPILED BY SEP			
DATUM Geodetic	DATE Feb 14/01	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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40					
108.0	GROUND SURFACE													
0.0	Clayey Silt to Silty Clay (Fill)													
107.2														
106.9	Clayey Silt, trace sand and gravel (Residual Soil) Hard Red brown		1	SS	100									
1.1	Highly to moderately weathered, red brown with occasional grey seams, calcareous SHALE BEDROCK (Queenston Formation).		2	SS	100/15									
	Smooth grinding at 2.7m depth		3	SS	90/15									
	Bedrock cored from 3.3m to 6.3m.													
	For bedrock coring details see Record or Drillhole 3B.													
101.7	END OF BOREHOLE													
6.3	Note: 1. Open borehole dry upon completion of overburden drilling. 2. Water level in piezometer at 2.0m depth (Elev. 106.0m) on March 26, 2001 and at 2.5m depth (Elev. 105.5m) on April 30, 2001.													

PROJECT: 001-1158

## RECORD OF DRILLHOLE: 3B

SHEET 2 OF 2

LOCATION: N 4809319; E 286576

DRILLING DATE: Feb.15/01

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: B-57

DRILLING CONTRACTOR: Master Soil Investigation Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN NO.	PENETRATION RATE (mm/min)	FLUSH	FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN	F-Fault J-Joint P-POLISHED S-SLICKENSIDED PL-PLANAR	SM-SMOOTH R-ROUGH ST-STEPPED S-SLICKENSIDED PL-PLANAR	FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED	BC-BROKEN CORE MB-MECH. BREAK B-BEDDING	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous page		104.70										
		Highly to moderately weathered, red brown with occasional grey seams, thin laminated, fine-grained, weak, calcareous SHALE (Queenston Formation).		3.30										
4				1										
5		Residual soil zones, 50mm to 75mm thick at 4.9m and 6.2m depth.		2										
6														
		END OF BOREHOLE		101.70										
7				6.30										
8														
9														
10														
11														
12														
13														

DEPTH SCALE

1:50



LOGGED: GM

CHECKED: ASP

DRILLHOLE 1158 ROCK GPJ GLDR CAN GOT 25/01 PS

PROJECT 001-1158			RECORD OF BOREHOLE No 4B			1 OF 1			METRIC								
W.P. 180-00-00			LOCATION N 4809334; E 2865588			ORIGINATED BY GM											
DIST 4 HWY QEW			BOREHOLE TYPE 114mm Solid Stem Augers			COMPILED BY SEP											
DATUM Geodetic			DATE Feb 14/01			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	20 40 60 80 100	20 40 60 80 100	20 40 60	W <sub>p</sub> W W <sub>L</sub>	γ	GR SA SI CL				
108.1	GROUND SURFACE						108										
0.0	Clayey Silt to Silty Clay (Fill)																
107.3																	
0.8	Clayey Silt, trace sand and gravel (Residual Soil)		1	SS	50		107										
106.6	Hard Red brown																
1.5	Highly to moderately weathered, red brown with occasional grey seams, calcareous SHALE BEDROCK (Queenston Formation).						106										
	Faint hydrocarbon odour at 1.5m depth.																
	Grinding at 2.7m depth.						105										
	Bedrock cored from 3.0m to 6.0m.																
	For bedrock coring details see Record or Drillhole 4B.						104										
							103										
102.1	END OF BOREHOLE																
6.0	Note: 1. Open borehole dry upon completion of overburden drilling.																



PROJECT: 001-1158

## RECORD OF DRILLHOLE: 4B

SHEET 2 OF 2

LOCATION: N 4809334; E 286588

DRILLING DATE: Feb.15/01

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: B-57

DRILLING CONTRACTOR: Master Soil Investigation Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	PENETRATION RATE (mm/min)	FLIGHT % RECOVERY	FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN	F-FAULT J-JOINT P-POLISHED S-SLICKENISED	SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR	FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED	BC-BROKEN CORE MB-MECH. BREAK B-BEDDING	DIAMETRAL POINT LOG INCL. (MPN)	NOTES WATER LEVELS INSTRUMENTATION
3		Refer to Previous page		105.10									
4		Highly to moderately weathered, red brown with occasional grey seams, thin laminated, fine-grained, weak to very weak, calcareous SHALE (Queenston Formation).		3.00									
5		Residual soil zones from 3.2m to 3.4m and 4.6m to 4.8m.											
6		END OF BOREHOLE		102.10									
7				6.00									
8													
9													
10													
11													
12													
13													

DEPTH SCALE

1:50


 LOGGED: GM  
 CHECKED: ASP

DRILLHOLE 1158ROCK.GPJ GLDR CAN.GOT 25/01/01 PS

PROJECT 001-1158		RECORD OF BOREHOLE No QEW1		1 OF 1		METRIC											
W.P. 180-00-00		LOCATION N 4809362 E 286557		ORIGINATED BY GM													
DIST 4 HWY QEW		BOREHOLE TYPE 114mm Solid Stem Augers		COMPILED BY SEP													
DATUM Geodetic		DATE Mar 19/01		CHECKED BY ASP													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W <sub>n</sub> W <sub>L</sub>	WATER CONTENT (%)	20 40 60	γ	GR SA SI CL			
108.5	GROUND SURFACE																
0.0	Asphalt																
107.9	Crushed limestone sand and gravel (Fill)		1	SS	15		108										
0.6	Compact Clayey Silt to Silty Clay, trace to some sand, trace gravel and shale fragments (Fill)		2	SS	12												
107.0	Soft Grey brown Moist Clayey Silt, trace sand, trace shale fragments (Residual Soil)		3	SS	65		107										
1.5	Hard Red brown Moist Moderately to highly weathered, red brown with occasional grey seams, calcareous SHALE BEDROCK (Queenston Formation).		4	SS	119		106										
106.1	Bedrock cored from 3.0m to 6.8m. For bedrock coring details see Record or Drillhole QEW1.						105										
2.4							104										
							103										
							102										
101.7	END OF BOREHOLE																
6.8	Note: 1. Open borehole dry upon completion of overburden drilling.																

PROJECT: 001-1158

## RECORD OF DRILLHOLE: QEW1

SHEET 2 OF 2

LOCATION: N 4809362; E 286557

DRILLING DATE: Feb.19/01

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D-90

DRILLING CONTRACTOR: Master Soil Investigation Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH COLOR SPLIT	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN	F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED PL-PLANAR	SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR	FL-FLEXURED UE-UNEVEN W-WAY C-CURVED	BC-BROKEN CORE MB-MECH. BREAK B-BEDDING	HYDRAULIC CONDUCTIVITY K, cm/sec	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous page		105.50											
3		Moderately to highly weathered, red brown with occasional grey seams, thin laminated, fine-grained, very weak to weak, calcareous SHALE (Queenston Formation).		3.00											
4		Residual soil zones from 3.6m to 3.7m, 4.4m to 4.5m and 6.6m to 6.7m depth.													
5															
6															
7		END OF BOREHOLE		101.70 6.80											
8															
9															
10															
11															
12															
13															

DEPTH SCALE

1:50



LOGGED: GM

CHECKED: ASP

DRILLHOLE 1158 ROCK GPJ GLDR CAN.GOT.25/201.PS



PROJECT 001-1158		RECORD OF BOREHOLE No QE2		1 OF 1		METRIC											
W.P. 180-00-00		LOCATION N 4809347, E 286544		ORIGINATED BY GM													
DIST 4 HWY QEW		BOREHOLE TYPE 114mm Solid Stem Augers		COMPILED BY SEP													
DATUM Geodetic		DATE Mar 19/01		CHECKED BY ASP													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W <sub>n</sub> W <sub>L</sub>	WATER CONTENT (%)	γ	GR SA SI CL				
108.4	GROUND SURFACE																
0.0	Asphalt																
107.8	Crushed limestone sand and gravel road base (Fill)		1	SS	17		108										
0.6	Compact Clayey Silt to Silty Clay, trace sand and gravel (Fill)		2	SS	16												
106.9	Firm to stiff Black brown to red brown Moist		3	SS	102		107										
1.5	Red-brown SHALE bedrock (Queenston Formation)		4	SS	70/15		106										
105.3			5	SS	90/05												
3.1	END OF BOREHOLE																
	Note: Open borehole dry upon completion of drilling.																

ON MOT 001-1158 GPJ ON MOT GDT 25/9/01

PROJECT 001-1158		<b>RECORD OF BOREHOLE No 5</b>		1 OF 1	<b>METRIC</b>
W.P. 180-00-00		LOCATION N 4809316; E 286600		ORIGINATED BY GM	
DIST 4 HWY QEW		BOREHOLE TYPE 114mm Solid Stem Augers		COMPILED BY SEP	
DATUM Geodetic		DATE Feb 23/01		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	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED	+ FIELD VANE							● QUICK TRIAXIAL	x REMOULDED	
107.9	GROUND SURFACE																	
0.0	Clayey Silt, some sand, trace gravel, rootlets, trace shale fragments (Topsoil)		1	SS	10													
107.4	Stiff Black																	
0.5	Clayey Silt, trace sand and gravel (Residual Soil)		2	SS	100/25													
106.4	Hard Red brown																	
1.5	Moist Red-brown SHALE bedrock (Queenston Formation)		3	SS	100/15													
	Smooth grinding from 2.4m to 3.0m depth.		4	SS	50/03													
104.8	END OF BOREHOLE																	
3.1	Note: 1. Open borehole dry upon completion of drilling.																	

PROJECT 001-1158			RECORD OF BOREHOLE No 1			1 OF 1			METRIC			
W.P. 180-00-00			LOCATION N 4809395; E 286523			ORIGINATED BY GM						
DIST 4 HWY QEW			BOREHOLE TYPE 114mm Solid Stem Augers			COMPILED BY SEP						
DATUM Geodetic			DATE Feb 12/01			CHECKED BY ASP						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
108.9	GROUND SURFACE											
0.0	Clayey Silt to Silty Clay, trace sand and gravel and rootlets (Fill) Very stiff Red brown		1	SS	22		108					
107.4	Clayey Silt, trace sand (Residual Soil) Hard Red brown		2	SS	100/23		107					
	Grinding at 2.6m depth		3	SS	100/23							
105.9	Red-brown SHALE bedrock. (Queenston Formation) END OF BOREHOLE		4	SS	75/03		106					
3.1	Note: 1. Open borehole dry upon completion of drilling.											



PROJECT 001-1158		<b>RECORD OF BOREHOLE No 1D</b>		1 OF 1	<b>METRIC</b>
W.P. 180-00-00	LOCATION N 4809409, E 286512	ORIGINATED BY GM			
DIST 4 HWY GEW	BOREHOLE TYPE 114mm Solid Stem Augers	COMPILED BY SEP			
DATUM Geodetic	DATE Feb 27/01	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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40					
109.1	GROUND SURFACE													
0.0	Clayey Silt, trace sand, some grass (Topsoil)		1	SS	7									
108.6	Firm													
0.5	Black													
107.9	Clayey Silt to Silty Clay, trace sand and gravel (Fill)		2	SS	42									
1.2	Very stiff													
	Red brown													
	Moist													
	Red-brown SHALE bedrock (Queenston Formation)		3	SS	100									
			4	SS	100/23									
106.2														
2.9	END OF BOREHOLE													
	Note: 1. Open borehole dry upon completion of drilling.													

[illegible]

PROJECT: 001-1158

## RECORD OF DRILLHOLE: 1C

SHEET 2 OF 2

LOCATION: N 4809637; E 286316

DRILLING DATE: Feb.26/01

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: B-57

DRILLING CONTRACTOR: Master Soil Investigation Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	COLOR SPLIT FLUSH	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN	F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED	SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR	FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED	BC-BROKEN CORE MB-MECH. BREAK B-BEDDING	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous page		110.70										
		Moderately to highly weathered, red brown with occasional grey seams, thin laminated, fine-grained, weak to very weak, calcareous SHALE (Queenston Formation).		6.20										
7					1		BS							
					2		IS							
8					3		BS							
9														
		END OF BOREHOLE		107.70										
				9.20										
10														
11														
12														
13														
14														
15														
16														

DEPTH SCALE

1:50


 LOGGED: GM  
 CHECKED: ASP

DRILLHOLE 1158 ROCK GPJ GLDR CAN GOT 25/2/01 PS



## RECORD OF BOREHOLE No 2C

1 OF 1

METRIC

PROJECT 001-1158

W.P. 180-00-00

LOCATION N 4802599 E 286312

ORIGINATED BY GM

DIST 4 HWY QEW

BOREHOLE TYPE 114mm Solid Stem Augers

COMPILED BY SEP

DATUM Geodetic

DATE Feb 27/01

CHECKED BY ASP

[illegible]

PROJECT: 001-1158

## RECORD OF DRILLHOLE: 2C

SHEET 2 OF 2

LOCATION: N 4809599; E 286312

DRILLING DATE: Feb.27/01

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: B-57

DRILLING CONTRACTOR: Master Soil Investigation Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (mm/min)	FLUSH	RECOVERY	R.O.D.	FRACT. INDEX PER 0.3	DISCONTINUITY DATA	HYDRAULIC CONDUCTIVITY K, DYNAMIC	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
		Refer to Previous page		110.60										
		Moderately to highly weathered, red brown with occasional grey seams, thin laminated, fine-grained, weak, calcareous SHALE (Queenston Formation).		6.20										
7					1		80							
8					2		80							
9					3		80							
10		END OF BOREHOLE		106.70 10.10										
11														
12														
13														
14														
15														
16														

DEPTH SCALE

1:50

Golder  
Associates

LOGGED: GM

CHECKED: ASP

DRILLHOLE 1158ROCK.GPJ GLDR CAN.GDT 25/01/01 PS

PROJECT 001-1158		<b>RECORD OF BOREHOLE No 201</b>		1 OF 1	<b>METRIC</b>
W.P. 180-00-00	LOCATION N 4809210, E 286636	ORIGINATED BY PKS			
DIST 4 HWY GEW	BOREHOLE TYPE 114mm Solid Stem Augers	COMPILED BY SEP			
DATUM Geodetic	DATE Feb 21/01	CHECKED BY ASP			

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>		
105.9	GROUND SURFACE													
0.0	Clayey Silt to Silty Clay, some organics, trace shale fragments (Fill) Stiff to very stiff Red brown		1	SS	11									
	Rootlets from ground surface to 0.6m depth and at 2.3m depth.		2	SS	22									
			3	SS	16									
			4	SS	12									
102.8			5	SS	100/11									
3.1	Clayey Silt, some sand, trace gravel and shale fragments (Residual Soil) Hard Red brown													
102.1	Moist Red-brown SHALE bedrock. (Queenston Formation)		6	SS	100/11									
3.8														
101.2			7	SS	100/11									
4.7	END OF BOREHOLE													
	Note: 1. Open borehole dry upon completion of drilling.													



PROJECT 001-1158		<b>RECORD OF BOREHOLE No 202</b>		1 OF 1 <b>METRIC</b>	
W.P. 180-00-00		LOCATION N 4809180; E 286596		ORIGINATED BY PKS	
DIST 4 HWY QEW		BOREHOLE TYPE 114mm Solid Stem Augers		COMPILED BY SEP	
DATUM Geodetic		DATE Feb 21-22/01		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	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20	40							60	80	100
106.5	GROUND SURFACE																	
0.0	Topsoil																	
0.2	Clayey Silt to Silty clay, some sand, trace gravel, trace topsoil, shale fragments (Fill) Firm to stiff Red brown Moist		1	SS	6													
			2	SS	15													
			3	SS	9													
104.2																		
2.3	Clayey Silt to Silty Clay, some sand, trace gravel (Fill) Firm to very stiff Red brown Moist		4	SS	7													
			5	SS	17													
102.7																		
3.8	Red-brown SHALE bedrock (Queenston Formation)		6	SS	100/06													
101.5			7	SS	100													
5.0	END OF BOREHOLE																	
	Note: 1. Open borehole dry upon completion of drilling.																	

ON MOT 001-1158 GPJ ON MOT G01 25/01

PROJECT 001-1158		RECORD OF BOREHOLE No 203		1 OF 1		METRIC											
W.P. 180-00-00		LOCATION N 4809168, E 286548		ORIGINATED BY PKS													
DIST 4 HWY GEW		BOREHOLE TYPE 114mm Solid Stem Augers		COMPILED BY SEP													
DATUM Geodetic		DATE Feb 22/01		CHECKED BY ASP													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	20 40 60	γ	GR SA SI CL			
107.2	GROUND SURFACE																
0.0	Topsoil																
0.2	Clayey Silt to Silty Clay, some sand, trace gravel and shale fragments (Fill)		1	SS	50		107										
	Stiff to hard		2	SS	38		106										
	Red brown		3	SS	12		105										
	Moist to dry		4	SS	92		104										
104.6	Clayey Silt with shale fragments (Residual Soil)																
2.6	Hard																
104.1	Red brown and grey																
3.1	Dry																
	Red-brown SHALE bedrock (Queenston Formation)																
102.6																	
4.0	END OF BOREHOLE																
	Note: 1. Open borehole dry upon completion of drilling.																

PROJECT 001-1158		<b>RECORD OF BOREHOLE No 300</b>		1 OF 1	<b>METRIC</b>
W.P. 180-00-00		LOCATION N 4809275, E 286609		ORIGINATED BY PKS	
DIST 4 HWY GEW		BOREHOLE TYPE 114mm Solid Stem Augers		COMPILED BY SEP	
DATUM Geodetic		DATE Feb 22/01		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 $\gamma$ 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						
							20 40 60 80 100	20 40 60 80 100						
107.0	GROUND SURFACE													
0.0	Clayey Silt, with rootlets (Topsoil) Soft Moist Black to brown		1	SS	10									
106.1														
0.9	Clayey Silt to Silty Clay, some sand, trace gravel and shale fragments, trace organics (Fill) Very stiff to hard Red brown		2	SS	29									
105.5														
1.5	Clayey Silt with shale fragments (Residual Soil) Moist		3	SS	101									
104.7														
2.3	Hard Red-brown Red-brown SHALE bedrock. (Queenston Formation)													
102.4														
4.6	END OF BOREHOLE  Note: 1. Open borehole dry upon completion of drilling.													



PROJECT <u>001-1158</u>		<b>RECORD OF BOREHOLE No 301</b>		1 OF 1	<b>METRIC</b>
W.P. <u>180-00-00</u>		LOCATION <u>N 4809228, E 286617</u>		ORIGINATED BY <u>GM</u>	
DIST <u>4</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>114mm Solid Stem Augers</u>		COMPILED BY <u>SEP</u>	
DATUM <u>Geodetic</u>		DATE <u>Mar 1/01</u>		CHECKED BY <u>ASP</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 $\gamma$ 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						
						20	40	60	80	100	20	40	60	
106.1	GROUND SURFACE													
0.0	Clayey Silt to Silty Clay, trace sand and gravel (Fill) Very stiff Red brown Moist		1	SS	28									
			2	SS	28									
103.8														
2.3	Red-brown SHALE bedrock. (Queenston Formation)		3	SS	100/12									
			4	SS	135/23									
102.4														
3.7	END OF BOREHOLE  Note: 1. Open borehole dry upon completion of drilling.													

PROJECT 001-1158		<b>RECORD OF BOREHOLE No 401</b>		1 OF 1	<b>METRIC</b>
W.P. 180-00-00	LOCATION N 4809297; E 286653	ORIGINATED BY PKS			
DIST 4 HWY QEW	BOREHOLE TYPE 114mm Solid Stem Augers	COMPILED BY SEP			
DATUM Geodetic	DATE Feb 22/01	CHECKED BY ASP			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	WATER CONTENT (%)	UNIT WEIGHT $\gamma$ KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40				
107.3	GROUND SURFACE												
0.0	Clayey Topsoil												
	Clayey Silt to Silty Clay, some sand, trace gravel and fragments, trace organics (Fill) Stiff to hard Red brown to grey Moist		1	SS	10								
			2	SS	37								
			3	SS	50								
105.0													
2.3	Clayey Silt, some to trace sand, trace gravel (Residual Soil) Hard Red		4	SS	100/15								
104.3													
3.1	Dry Red-brown SHALE bedrock. (Queenston Formation)  Grinding at 3.1m depth.		5	SS	100/15								
102.7													
4.6	END OF BOREHOLE												
	Note: 1. Open borehole dry upon completion of drilling.												

PROJECT 001-1158		RECORD OF BOREHOLE No 804		1 OF 1		METRIC											
W.P. 180-00-00		LOCATION N 4809436; E 286493		ORIGINATED BY GM													
DIST 4 HWY QEW		BOREHOLE TYPE 114mm Solid Stem Augers		COMPILED BY SEP													
DATUM Geodetic		DATE Feb 28/01		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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	γ	GR SA SI CL				
109.6	GROUND SURFACE		1	SS	25		109										
108.4	Clayey Silt to Silty Clay with to some sand and gravel (Fill) Very stiff to hard Red to brown to black Trace rootlets above 0.8m depth.		2	SS	36		108										
1.2	Red-brown SHALE bedrock. (Queenston Formation)		3	SS	100/23		107										
			4	SS	100/23		106										
			5	SS	100/13												
105.6			6	SS	100/15												
4.0	END OF BOREHOLE Note: 1. Open borehole dry upon completion of drilling.																

ON MOT 001-1158 GPJ ON MOT GDT 25/3/01



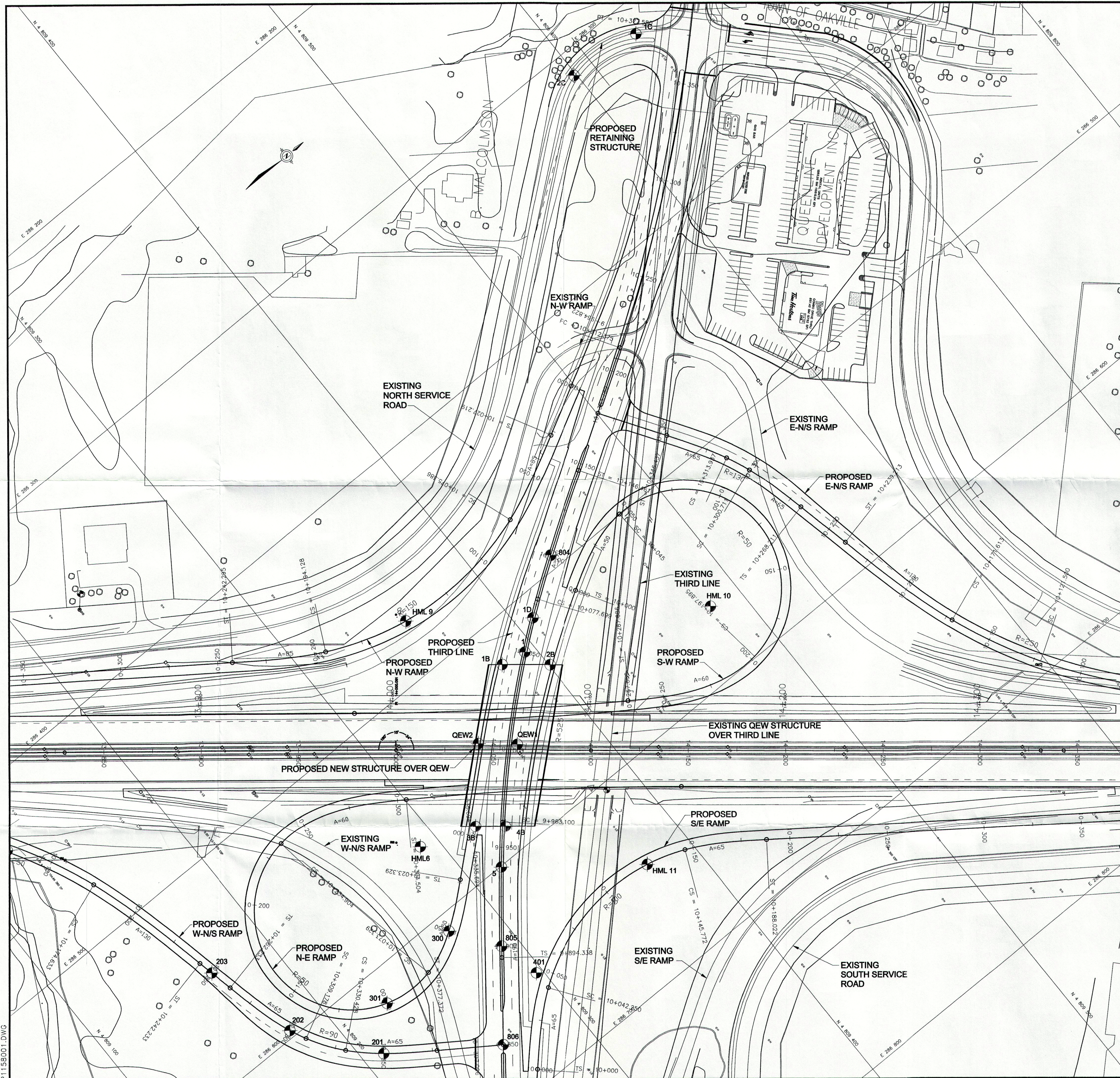
PROJECT 001-1158		<b>RECORD OF BOREHOLE No 805</b>		1 OF 1 <b>METRIC</b>	
W.P. 180-00-00		LOCATION N 4809291; E 286632		ORIGINATED BY GM	
DIST 4 HWY GEW		BOREHOLE TYPE 114mm Solid Stem Augers		COMPILED BY SEP	
DATUM Geodetic		DATE Feb. 15/01		CHECKED BY ASP	

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80
107.4	GROUND SURFACE															
0.0	Clayey Silt to Silty Clay, some sand and gravel, some rootlets (Topsoil)		1	SS	8											
106.8	Firm to stiff Black															
0.6	Clayey Silt, some sand and gravel, trace rootlets (Fill)		2	SS	7											
106.0	Firm Red brown															
1.4	Red-brown SHALE bedrock. (Queenston Formation)		3	SS	110											
	Grinding at 2.4m depth.															
105.0																
2.4	END OF BOREHOLE															
	Note: 1. Open borehole dry upon completion of drilling.															

ON MOT 001-1158 GPJ ON MOT GDT 25/9/01

PROJECT 001-1158			RECORD OF BOREHOLE No 806			1 OF 1			METRIC			
W.P. 180-00-00			LOCATION N 4809260, E 286671			ORIGINATED BY GM						
DIST 4 HWY GEW			BOREHOLE TYPE 114mm Solid Stem Augers			COMPILED BY SEP						
DATUM Geodetic			DATE Feb. 15/01			CHECKED BY ASP						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
104.4	GROUND SURFACE											
104.1	Clayey Silt to Silty Clay, some sand, trace gravel and rootlets (Topsoil)		1	SS	17		104					
0.3	Very stiff Brown											
103.6	Clayey Silt, trace sand and gravel (Residual Soil)		2	SS	100							
0.8	Hard Red brown											
	Red-brown SHALE bedrock. (Queenston Formation)						103					
102.3	Grinding at 2.1m depth.											
2.1	END OF BOREHOLE											
Note: 1. Open borehole dry upon completion of drilling.												



**METRIC**

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

DIST.	HWY. QEW
CONT No.	
WP No.	180-00-00

# QEW / THIRD LINE INTERCHANGE

SHEET



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



## KEY PLAN

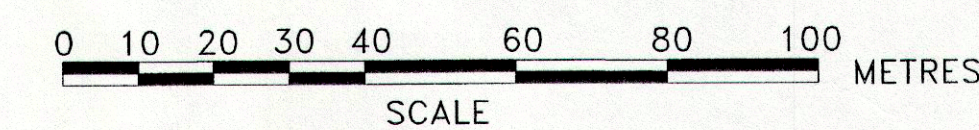
LEGEND



No.	ELEVATION	LOCATION	
		NORTHING	EASTING
1	108.9	4809395	286523
1B	108.9	4809382	286521
1C	116.9	4809637	286316
1D	109.1	4809409	286512
2B	108.7	4809401	286536
2C	116.8	4809599	286312
3B	108.0	4809319	286576
4B	108.1	4809334	286588
5	107.9	4809316	286600
201	105.9	4809210	286636
202	106.5	4809180	286596
203	107.2	4809168	286548
300	107.0	4809275	286609
301	106.1	4809228	286617
401	107.3	4809297	286653
804	109.6	4809436	286493
805	107.4	4809291	286632
806	107.4	4809260	286671
HML6	107.4	4809291	286566
HML 9	109.0	4809357	286472
HML 10	109.8	4809483	286565
HML 11	108.0	4809376	286647
QEW1	108.5	4809362	286557
QEW2	108.4	4809347	286544

## REFERENCE

Drawings provided in digital form from Morrison Hershfield File names  
"4173-03.DWG, ALIGN.DWG and QEWBASE.DWG"  
Drawing received MARCH, 2001

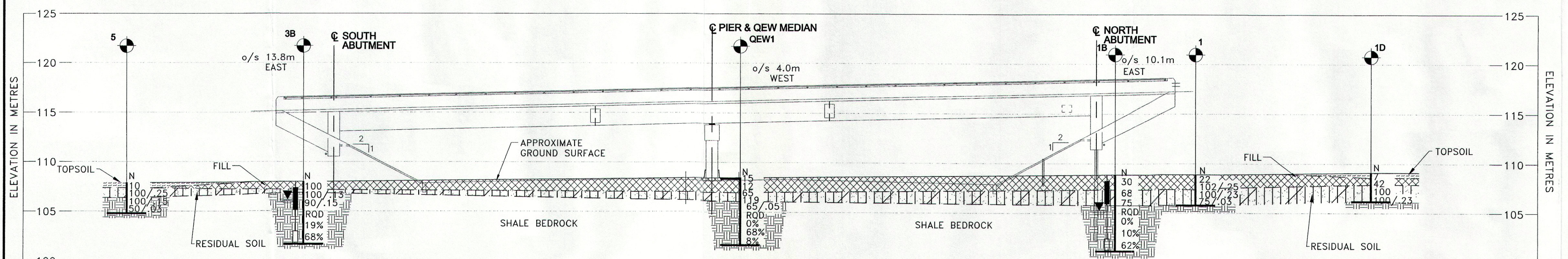
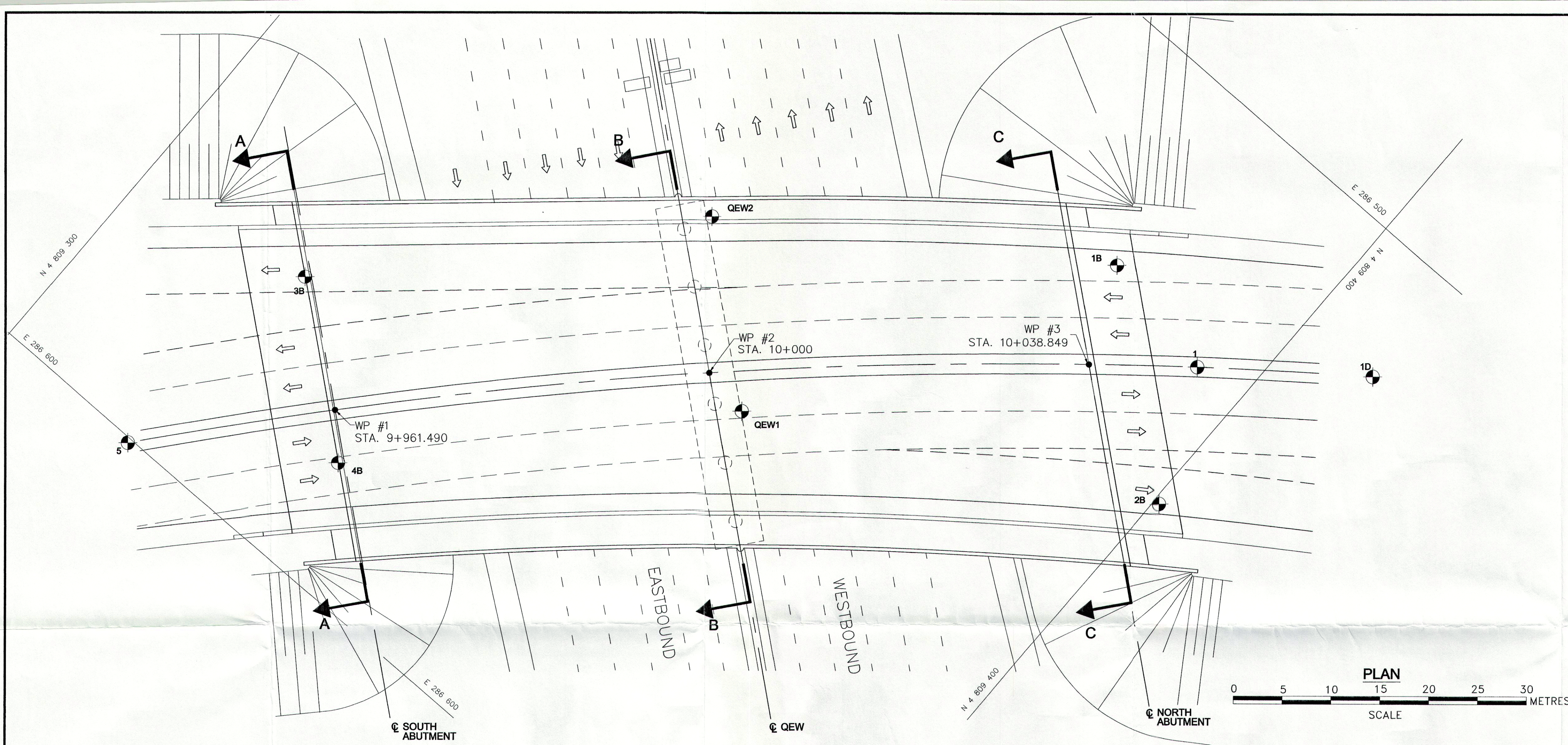


NO.	DATE	BY	REVISION

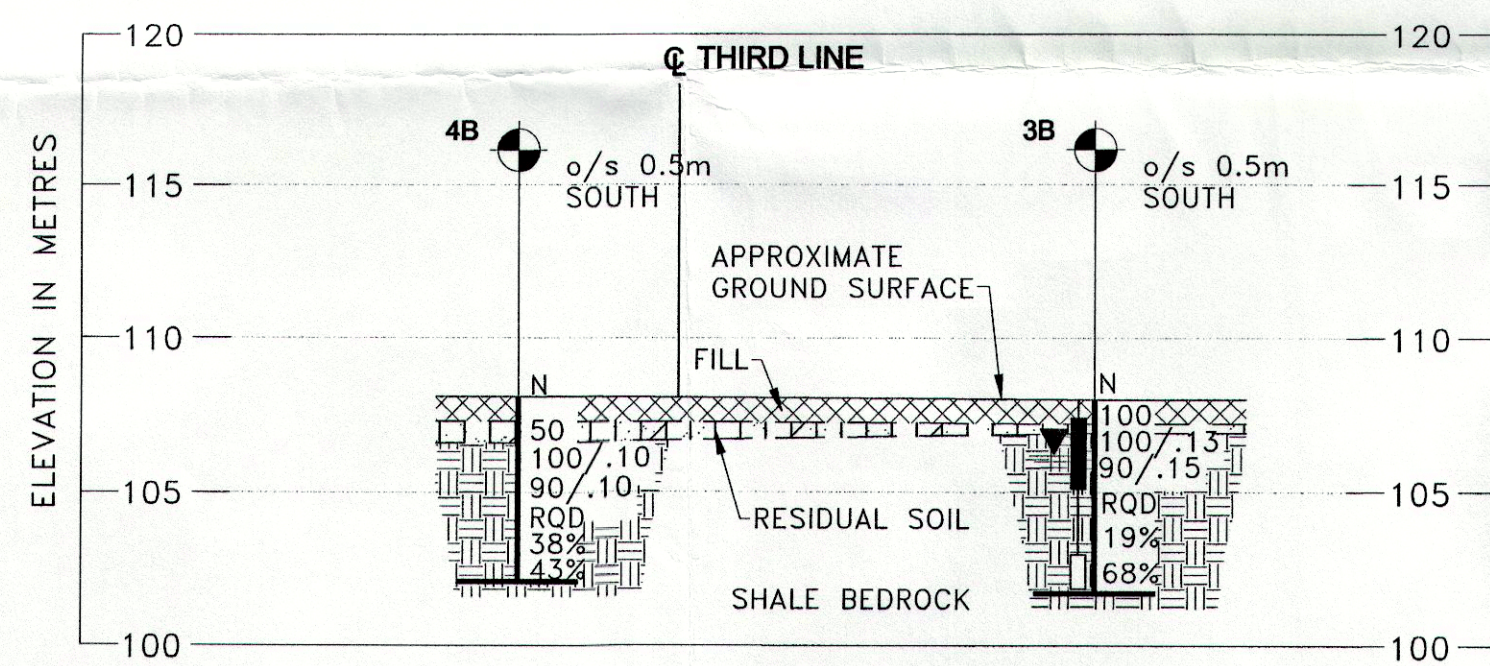
Geocres No.

HWY. QEW		PROJECT NO. 001-1158		DIST.	
SUBM'D. SEP		CHKD. ASP		DATE: SEPT. 2001	
DRAWN: JFC		CHKD. SEP		APPD.	
				DWG. 1	

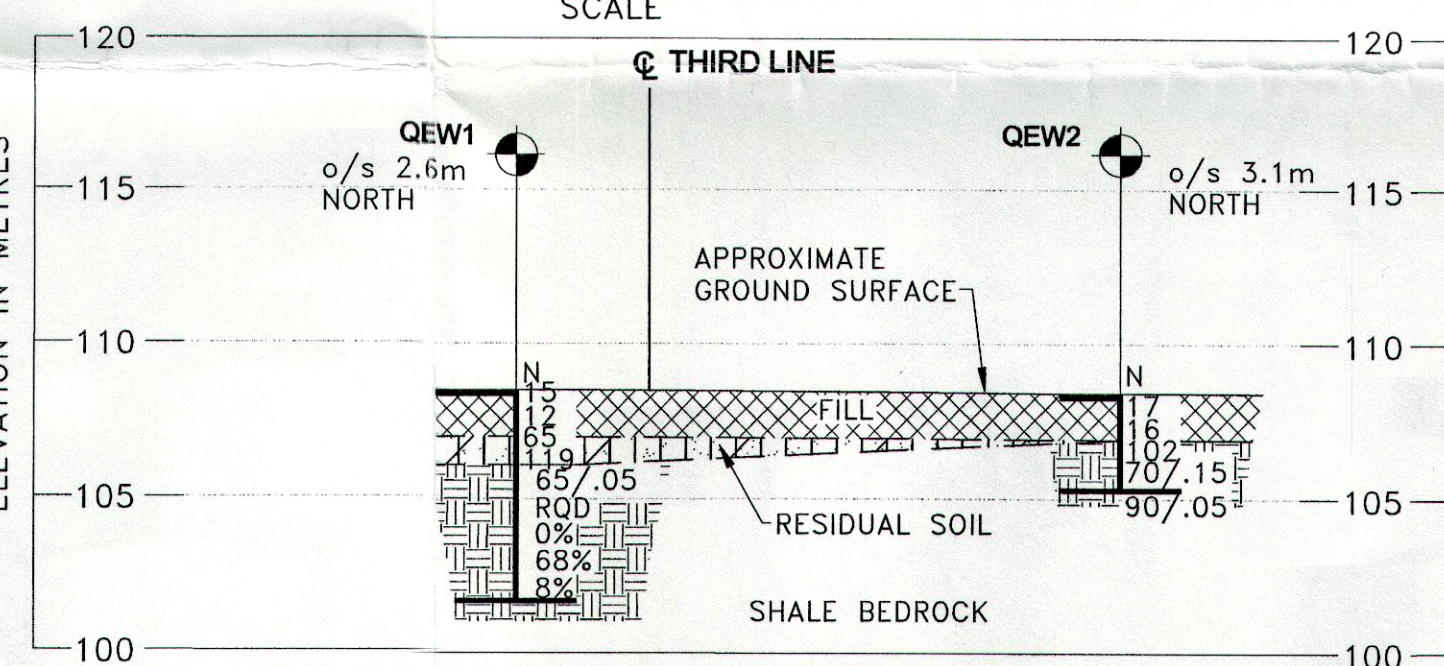




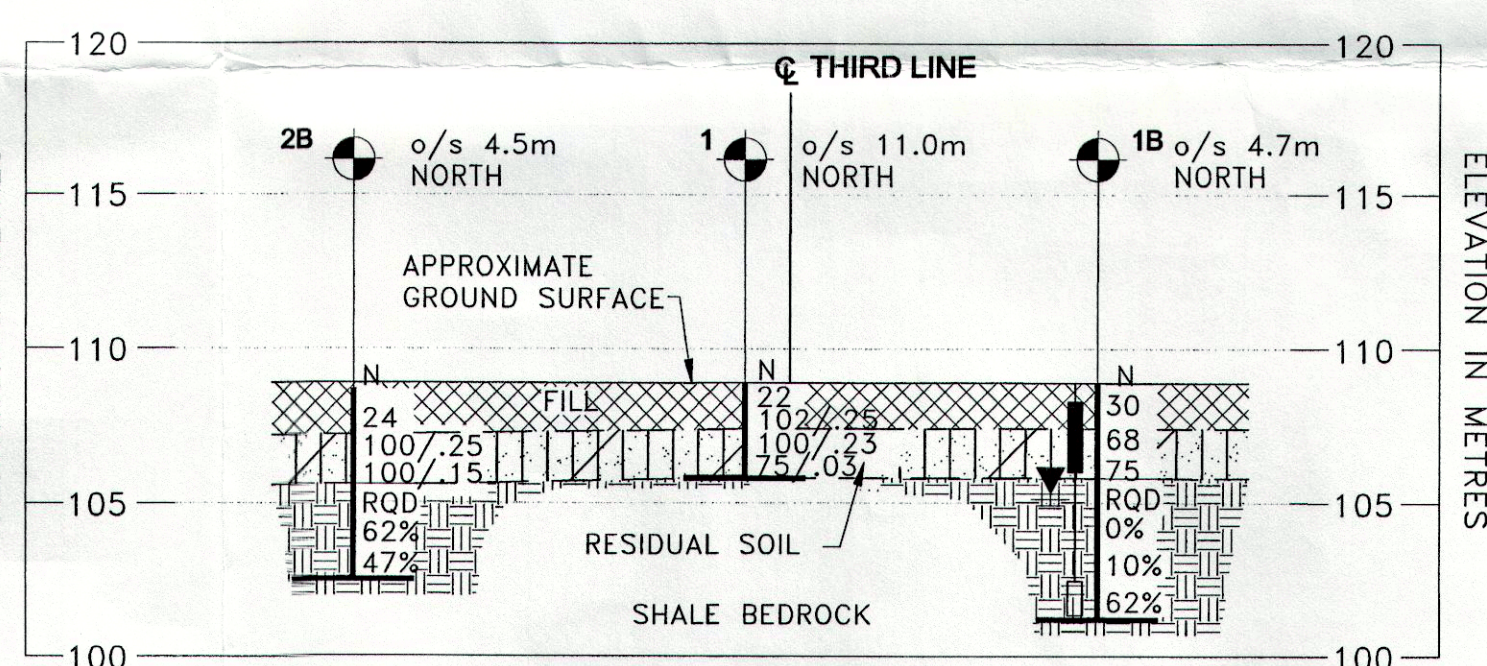
PROFILE ALONG CENTRELINE OF THIRD LINE



SECTION A-A

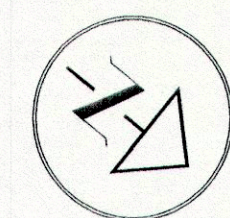


SECTION B-B



SECTION C-C

DIST. HWY. QEW  
CONT No.  
WP No. 180-00-00



THIRD LINE BRIDGE  
REPLACEMENT OVER QEW  
BOREHOLE LOCATIONS AND SOIL STRATA

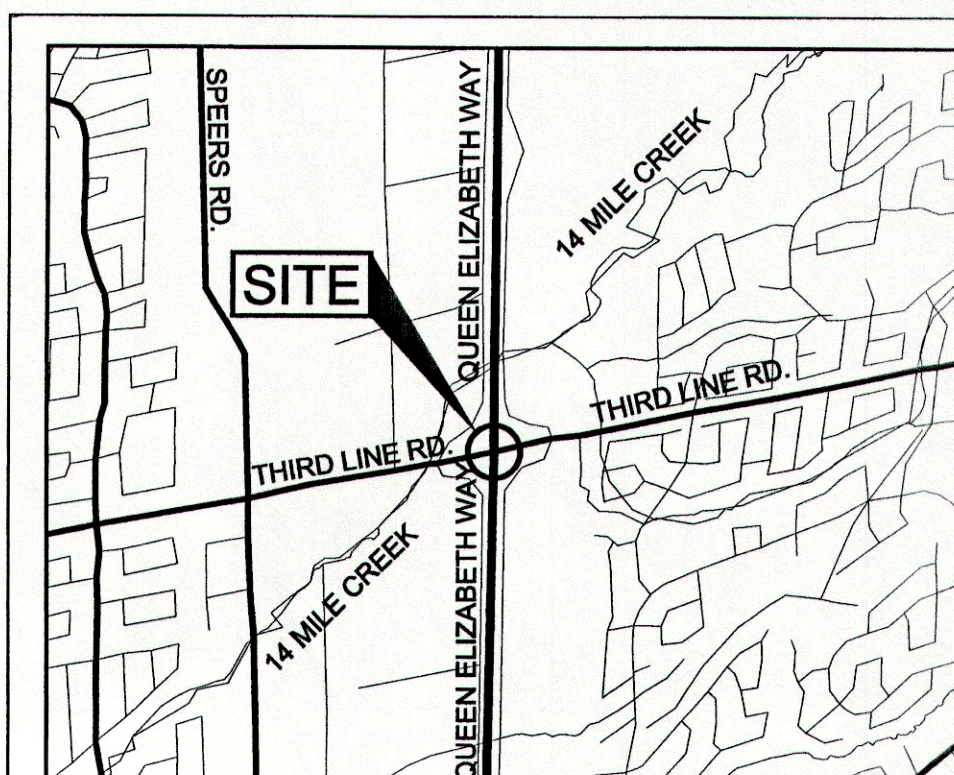
SHEET



Golder Associates Ltd.  
MISSISSAUGA, ONTARIO, CANADA

**METRIC**

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN



KEY PLAN

LEGEND

- Borehole
- Seal
- Piezometer
- N Standard Penetration Test value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL in piezometer on March 26, 2001

No.	ELEVATION	LOCATION	
		NORTHING	EASTING
1	108.9	4809395	286523
1B	108.9	4809382	286521
1D	109.1	4809409	286512
2B	108.7	4809401	286536
3B	108.0	4809319	286576
4B	108.1	4809334	286588
5	107.9	4809316	286600
QEW1	108.5	4809362	286557
QEW2	108.4	4809347	286544

NOTES

- The boundaries between soil strata have been established only at borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- The proposed bridge configuration shown on this drawing is shown only for general reference purposes and may differ from that shown on the Structural drawings.

REFERENCE

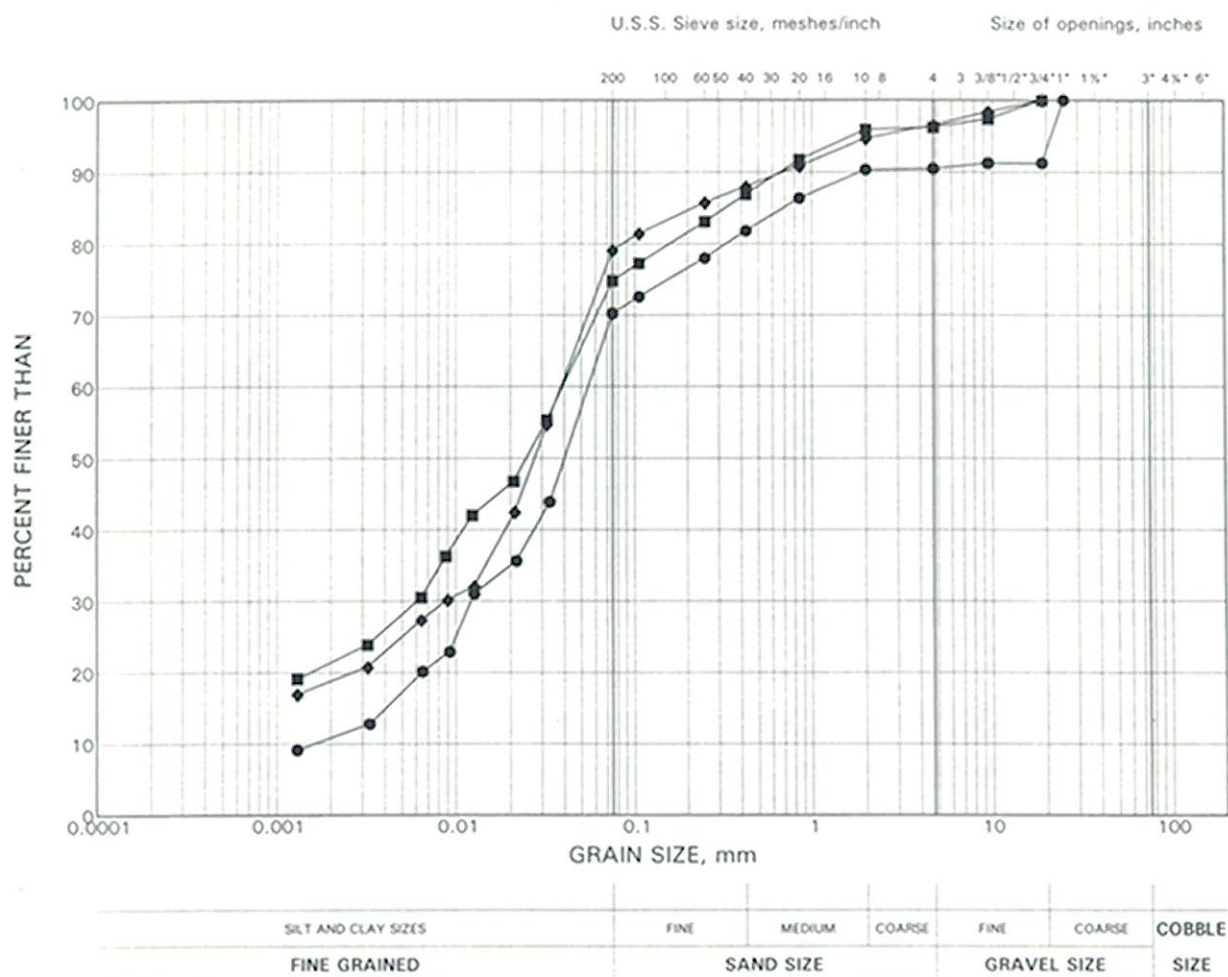
Drawing provided in digital form from Morrison Hershfield entitled "QEW STRUCTURE REHABILITATION GENERAL ARRANGEMENT."  
Drawing dated September, 2001

NO.	DATE	BY	REVISION
Geocres No.			
HWY. QEW	PROJECT NO. 001-1158-1	DIST.	
SUBM'D. SEP	CHKD. ASP	DATE: SEPT. 2001	SITE:
DRAWN: JFC	CHKD. SEP	APPD.	DWG. 2



# GRAIN SIZE DISTRIBUTION Clayey Silt (Fill)

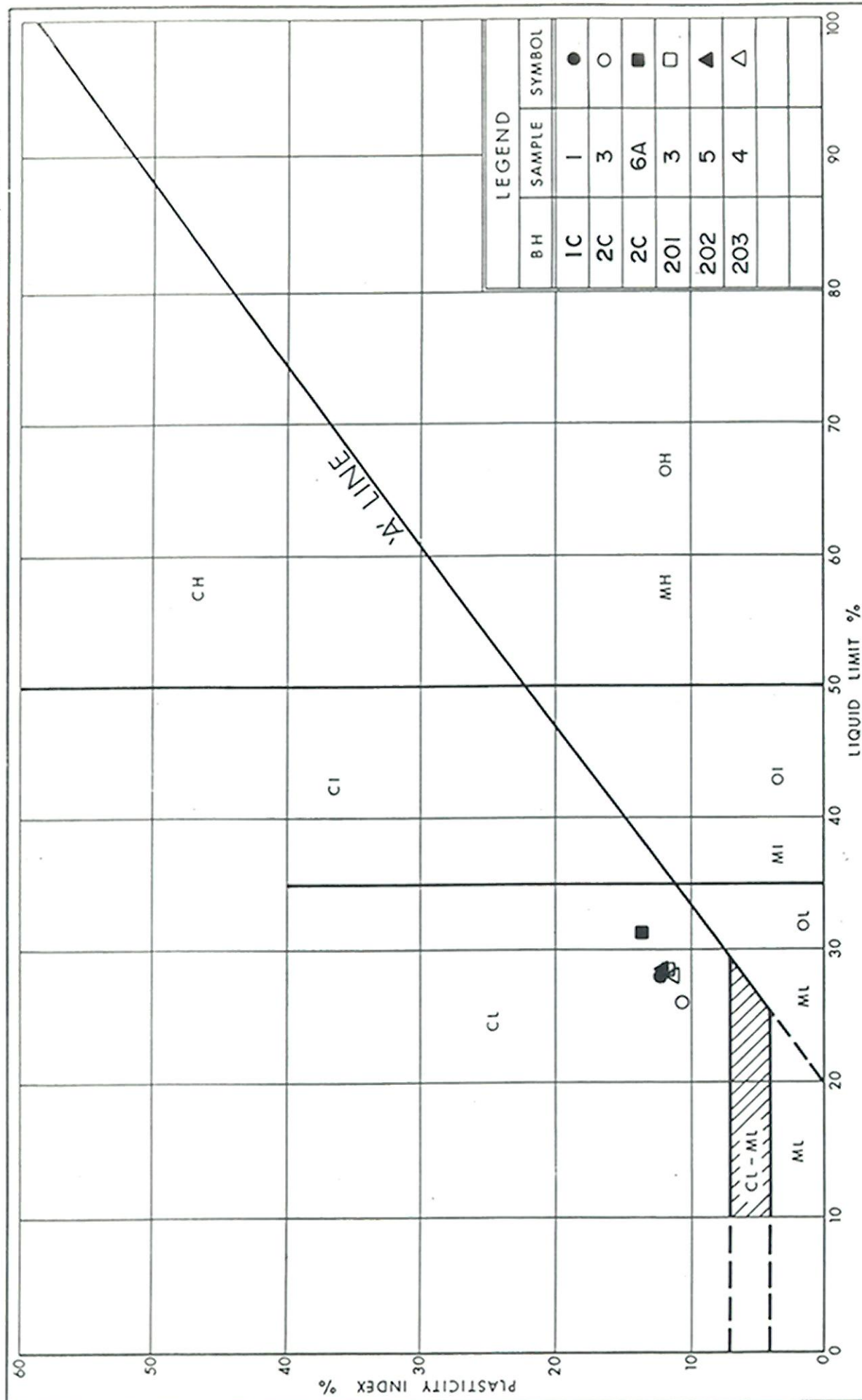
FIGURE 1



## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	2C	3	114.1
■	202	5	102.8
◆	203	4	104.9

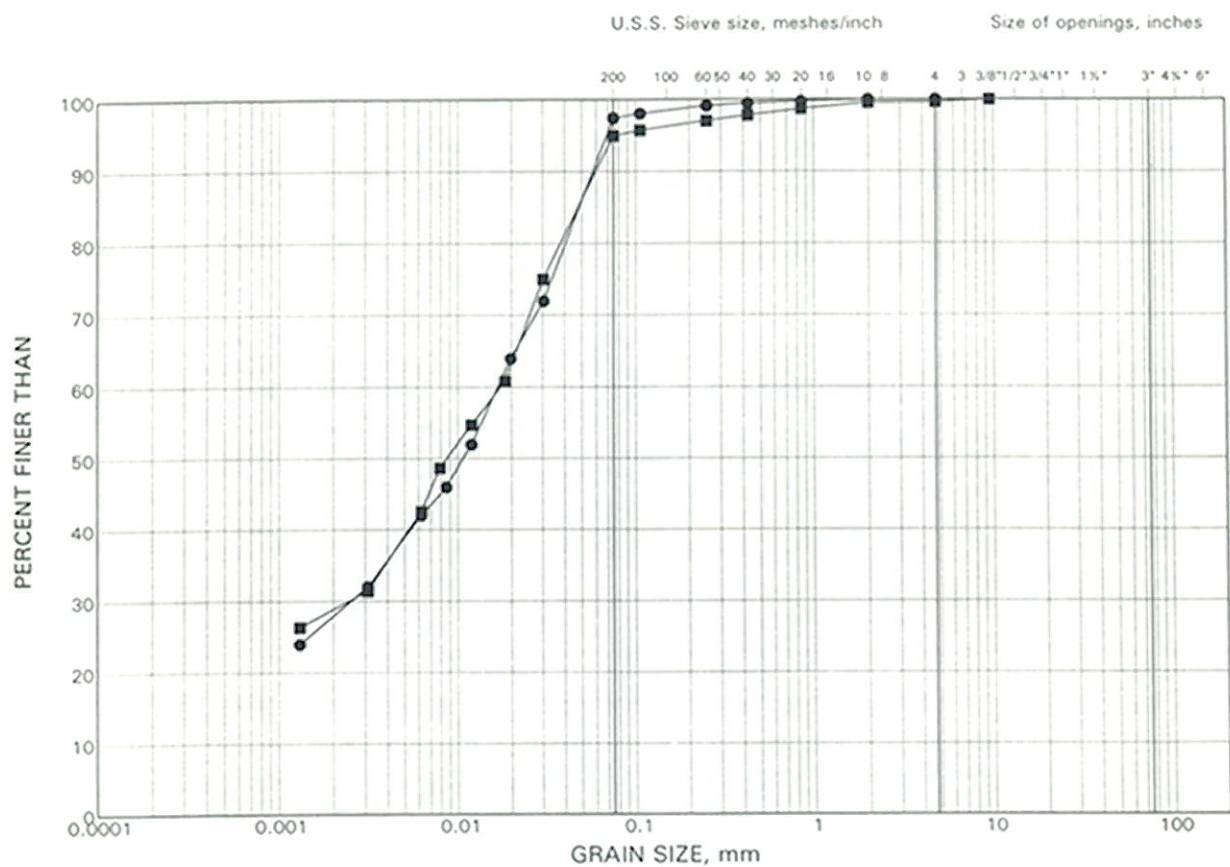
Oct 75, FF-S-21





# GRAIN SIZE DISTRIBUTION Clayey Silt (Residual Soil)

FIGURE 3



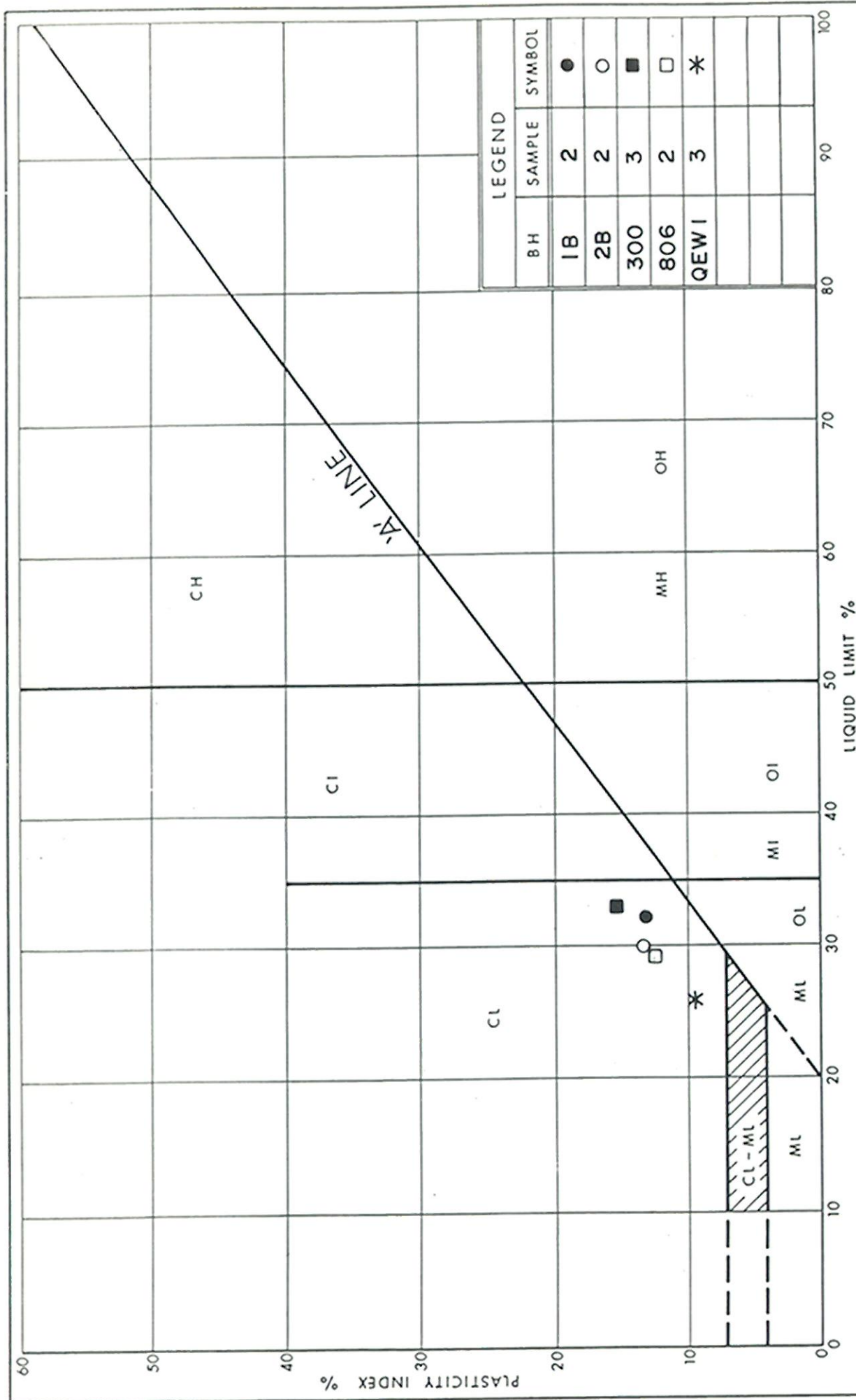
SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	2B	2	106.7
■	300	3	105.2



Oct 75, FF-S-21



PLASTICITY CHART  
CLAYEY SILT ( RESIDUAL SOIL )

FIG No 4

W P 180-00-00