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**REPORT ON**

**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN  
REHABILITATION OR REPLACEMENT OF THE  
ARGYLE STREET SOUTH BRIDGE OVER THE GRAND RIVER  
HIGHWAY 6, CALEDONIA, SITE 9-2  
GWP 3805-01-00, AGREEMENT NUMBER 3005-A-000270**

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## TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
<b>PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT</b>	
1.0 INTRODUCTION .....	1
2.0 SITE DESCRIPTION .....	2
3.0 INVESTIGATION PROCEDURES .....	3
4.0 SITE GEOLOGY AND STRATIGRAPHY .....	5
4.1 Surficial Geology .....	5
4.2 Bedrock Geology .....	5
4.3 Site Stratigraphy .....	5
4.3.1 Pavement and Concrete .....	6
4.3.2 Fill and Topsoil .....	6
4.3.3 Sand and Gravel .....	7
4.3.4 Clayey Silt .....	7
4.3.5 Silt .....	7
4.3.6 Sand .....	7
4.3.7 Sandy Silt .....	7
4.3.8 Bedrock .....	8
4.4 Groundwater Conditions .....	9
<b>PART B - PRELIMINARY FOUNDATION DESIGN</b>	
5.0 ENGINEERING RECOMMENDATIONS .....	11
5.1 General .....	11
5.2 Existing Bridge Foundations .....	11
5.3 New Bridge Foundations .....	12
5.3.1 Spread Footing Foundations .....	12
5.3.2 Deep Foundations .....	14
5.3.3 Summary of Foundation Alternatives .....	15
5.3.4 Retained Soil System (RSS) Walls .....	16
5.3.5 Lateral Earth Pressures .....	16
5.3.6 Embankments .....	18
5.3.7 Excavations and Temporary Cut Slopes .....	18
LIST OF ABBREVIATIONS	
LIST OF SYMBOLS	
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY	
RECORDS OF BOREHOLES	
FIGURE 1 - Site Location Map	
DRAWING 1 - Borehole Locations and Soil Strata	
FIGURE 2 - Regional Physiography Plan, Caledonia	
FIGURE 3 - Regional Bedrock Geology, Caledonia	
APPENDIX A - Laboratory Test Data (Figures A-1 to A-3 and Analytical Testing)	
APPENDIX B - PHOTOGRAPHS	

**PART A**

**PRELIMINARY FOUNDATION INVESTIGATION REPORT  
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## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (Morrison Hershfield) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a preliminary foundation investigation at the site of the proposed rehabilitation or replacement of the Argyle Street South Bridge on the former Highway 6 over the Grand River in Caledonia, Ontario (Site 9-2). The location of the bridge is shown on the Key Plan, Figure 1.

It is understood that the presently preferred alternatives are the rehabilitation of the existing bridge and foundations and the construction of a new five span bridge closely following the existing alignment. The purpose of the foundation investigation is to determine the subsurface soil, rock and groundwater conditions at the bridge site by drilling boreholes and carrying out in-situ tests and laboratory tests on selected samples. The terms of reference for the work are outlined in Golder's Total Project Management (TPM) proposal P21-3125, dated September 5, 2002. The field investigation work plan was revised as stated in Golder's letters dated September 5 and October 7, 2003. The work was carried out in accordance with our Quality Control of TPM Services Plan, Purchase Order No. 3005-A-000270, dated October 25, 2002.

Morrison Hershfield provided Golder with drawings for the existing bridge. Existing MTO foundation investigation reports available for the area of the site through Geocres were reviewed together with the April 1927 design drawings for the existing bridge. Bedrock is exposed in the riverbed at the existing bridge and the borehole data for the area of the site, including the results of previous investigations available for the dam and Canadian National Railway (CNR) bridge located approximately 600 metres upstream of the site, the recent Imperial Oil pipeline crossing of the Grand River approximately 1.6 kilometres upstream of the site and the recently constructed forcemain immediately downstream of the site indicate that at least the upper 4 to 5 metres of the rock is highly weathered and fractured with gypsum seams and some cavities attributed to gypsum solutioning. Rock Quality Designations (RQD's) in this zone range from 0 to 20 per cent and are typically zero. In addition, existing borehole data indicate that approximately 3.5 metres of fill has been placed in the existing bridge approaches.



## **2.0 SITE DESCRIPTION**

The existing bridge, constructed circa 1927, is a two lane, nine span structure carrying the north-south directions of Argyle Street pedestrian and road traffic over the Grand River. Each span of the existing structure is about 22 metres long, for a total length of approximately 198 metres. Site photographs are provided in Appendix B.

The existing deck surface is at about elevation 190.75 metres. The river water level was at about elevation 185.5 metres during the field investigation.

### 3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out in two phases employing two different drill rigs supplied and operated by Lantech Drilling Services Inc. in order to minimize the inconvenience to the traveling public and to enhance safety. The first phase of the investigation was carried out between October 1 and 5, 2003 with an all terrain vehicle mounted mobile B-57 drill rig. At that time, four boreholes were drilled, two adjacent to the bridge abutments and two at the approaches. Boreholes 1 and 2 at the bridge abutments were drilled and sampled to depths of 17.1 and 17.4 metres, respectively. The borehole locations are shown in plan on Drawing 1. The approach holes (boreholes 3 and 4) were drilled to depths of 6.9 metres.

The second phase of the investigation was carried out between October 27 and November 1, 2003 during which time four boreholes were drilled from the bridge at various pier locations. The pier boreholes, numbered 5 to 8, were drilled to depths varying from 14.3 to 17.3 metres below the existing bridge deck. The pier boreholes were drilled with a CME-45 drill rig mounted on skids. Boreholes 5 and 6 were drilled from the west sidewalk while boreholes 7 and 8 were drilled from the east sidewalk. Boreholes 6 and 8 were drilled through the existing pier footings. The skid mounted rig was moved to the various locations by both a winch and lifting with a boom truck.

The abutment and approach boreholes were advanced with 152 millimetres diameter solid stem augers. The abutment and pier holes were advanced into the bedrock with NW size casing and NQ size rock core. The bedrock surface and condition were proven in the two abutment boreholes by rock coring in NQ size. In the overburden in boreholes 1 through 4, Standard Penetration Testing (SPT) was carried out at regular intervals of depth with 50 millimetre outside diameter split spoon samplers. It should be noted that three SPT tests were carried out in the rock in borehole 2. The cored length of bedrock at each borehole location is tabulated below.

Borehole Number	Component of Structure	Borehole Location (Station, Offset)	Collar Elevation (m)	Overburden or Concrete/ Rock Interface		Cored Length (m)
				Elevation (m)	Depth (m)	
1	South Abutment	9+894.3, 10.1m Right	189.69	183.65	6.04	11.06
2	North Abutment	10+103.3, 9.1m Left	190.23	184.59	5.64	11.76
3	North Approach	10+116.9, 6.0m Left	190.07	-	-	-
4	South Approach	9+880.7, 6.2m Right	190.86	-	-	-
5	Proposed Pier	10+020.1, 5.3m Left	191.42	184.59	6.83	8.87
6	Existing Pier	9+942.7, 4.8m Left	191.27	184.44	6.83	9.52
7	Proposed Pier	9+976.6, 6.2m Right	191.44	184.89	6.55	7.71
8	Existing Pier	10+054.0, 5.3m Right	191.23	183.85	7.38	11.14

Boreholes 3 and 4 were approach boreholes and, thus, were not cored.

Groundwater conditions were observed in the open boreholes prior to rotary drilling with water. Deep and shallow piezometers were installed in boreholes 1 and 2 to permit monitoring of the groundwater levels at the abutment locations. Water levels in the installations were obtained on October 3 and 31, 2003 and groundwater was collected from borehole 2 for analytical testing on October 31, 2003. The analytical results are provided in Appendix A. The installations were abandoned following the October 31, 2003 readings and water sampling. All of the boreholes were backfilled and abandoned in compliance with MTO and Ontario Regulation 128 recommended procedures. The pier footings were backfilled with premixed concrete and the sidewalks were patched with quick set high strength concrete.

The field work was supervised on a full-time basis by members of our engineering staff who located the boreholes in the field, directed the drilling, sampling and in-situ testing operations, and logged the boreholes. The soil and rock samples were identified in the field, placed in labeled containers and transported to our laboratory in London, Ontario for further examination. Index and classification tests consisting of grain size analyses and water content determinations were carried out on selected samples. The results of the field and laboratory testing are given on the Record of Borehole sheets and in Appendix A. Compressive strength testing was carried out on four NQ size samples of the pier footing concrete. The results of the testing are shown on the Record of Borehole sheets. The rock cores were logged in detail by a geologist who is familiar with the geology of the area. In addition, the total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured and are shown on the Record of Borehole sheets. Selected photographs of the rock core are provided in Appendix B.



## **4.0 SITE GEOLOGY AND STRATIGRAPHY**

### **4.1 Surficial Geology**

The surficial deposits are comprised of the Wentworth Till sheet, a sandy silt to clayey silt till deposit with irregular interbeds of silty to sandy deposits. This till sheet was transported in a southwestward direction across the Caledonia area by glaciers that emanated from the Lake Ontario basin. This direction of glacial movement is indicated by the numerous elongate northeast to southwest orientated drumlin ridges comprised of till that dot the area as shown on Figure 2. The advance of the glacial ice associated with the deposition of the till also scoured the bedrock surface, greatly influencing the present bedrock surface topography that underlies the area.

Much of the area within the Grand River Valley was inundated by post glacial ponds and deposited a blanket of glaciolacustrine clayey silt and silty clay over much of the low areas. These deposits comprise the Haldimand Clay Plains that are characteristic of the Grand River Valley. The clay sequence may also contain local interbedded areas of silt and sand. Locally, the drumlin ridges tend to protrude through the clay.

The main drainage courses which pass through the region, such as the Grand River, contain recent alluvial deposits of clays, silts and sands associated with the stream channels and adjacent flood plains.

### **4.2 Bedrock Geology**

The site is underlain by Silurian-age dolomite, shaley dolomite and shale of the Salina Formation. The Salina Formation hosts the gypsum deposits of the Grand River Valley. The Salina Formation is underlain by the Guelph Formation. The strata are near flat lying with a gentle southward dip of approximately 0.5 per cent.

The Salina Formation consists of six members (Members A, B, C, E, F and G). The D Member (halite salt strata of the Salina Formation) was not deposited in this area. The regional bedrock geology is shown on Figure 3.

### **4.3 Site Stratigraphy**

The detailed subsurface soil, rock, surface water and groundwater conditions encountered at the borehole locations, 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 and in Appendix A. The stratigraphic boundaries shown on the borehole sheets and Drawing 1 are inferred from non-continuous sampling and, therefore, may represent transitions between soil

types rather than exact planes of geological change. Subsurface conditions will vary between and beyond the borehole locations.

In summary, the subsoils at the abutments and approaches generally consist of variable thicknesses of pavements, fill and topsoil materials to between elevation 186 and 189 metres. These deposits are underlain by generally thin deposits of sand and gravel, sandy silt, silt, clayey silt and sand over the bedrock. At the pier locations, the bedrock is exposed below about 0.6 meters of water and/or thin sandy silt deposits. The bedrock surface was encountered at elevations between 183.7 and 184.9 metres at the borehole locations.

Locations and elevations of the borings, together with the interpreted stratigraphical profiles, are shown on the attached Drawing 1. A detailed description of the subsurface conditions encountered in the boreholes for this investigation is provided on the Record of Borehole sheets and is summarized in the following sections.

#### **4.3.1 Pavement and Concrete**

Boreholes 3 and 4 encountered about 150 and 200 millimetres of asphalt at the north and south approaches, respectively.

Boreholes 5 to 8 were advanced through the existing 150 to 200 millimetre thick concrete sidewalks. Boreholes 6 and 8 were cored through the concrete footings of the existing bridge piers. The footings were 790 and 1210 millimeters thick at the locations of boreholes 6 and 8, respectively. Laboratory testing on the concrete cores indicated compressive strengths of between 23 and 50 megapascals, with an average of about 36 megapascals.

#### **4.3.2 Fill and Topsoil**

At the north approach, the asphalt was underlain by about 1.1 metres of granular base materials over 1.4 metres of firm clayey silt fill and 0.3 metres of topsoil. At the south approach, the asphalt was underlain by about 0.7 meters of loose to compact sandy silt. At boreholes 1 and 2, advanced adjacent to the south and north abutments, layers of compact silty sand and sandy silt fill and stiff to hard clayey silt fill were encountered to depths of about 3.5 to 4.1 metres below ground surface. Also, 0.8 metres of silty sand fill with concrete, wood, gravel, cobbles and boulders was encountered over the concrete pier foundation in borehole 8.

Standard penetration testing in the fill/topsoil materials indicated N values between 5 and 36 blows per 0.3 metres penetration. The fill materials had water contents of about 5 to 37 per cent, with an average of about 15 per cent. Figure A-1 in Appendix A shows a gradation curve for the sandy silt fill materials recovered from borehole 4.



#### **4.3.3 Sand and Gravel**

A 1.5 metre thick layer of dense sand and gravel was encountered at elevation 186.1 metres beneath the fill materials in borehole 2. The sand and gravel deposit had a single N value of 37 blows per 0.3 metres penetration and a water content of about 9 per cent.

#### **4.3.4 Clayey Silt**

A 0.6 metre thick layer of stiff clayey silt was encountered at elevation 187.2 metres beneath the topsoil in borehole 3. The clayey silt deposit had a single N value of 9 blows per 0.3 metres and a water content of about 32 per cent. A single Atterberg limits determination carried out on the sample of clayey silt indicated plastic and liquid limits of 22 and 42 per cent, respectively, with a plasticity index of 20 per cent.

#### **4.3.5 Silt**

Beneath the sandy silt in borehole 1 and the fill in borehole 4, silt layers 0.3 to 1.6 metres thick were encountered at elevation 185.3 metres and 186.7 metres, respectively, above the bedrock. The silt layer in borehole 1 had standard penetration test N values of 37 blows per 0.3 metres penetration and 70 blows per 150 millimetres penetration. The water contents were about 11 and 17 per cent.

#### **4.3.6 Sand**

Beneath the clayey silt, borehole 3 encountered a 0.9 metre thick sand deposit at about elevation 186 metres over the layers of sandy silt material. The sand deposit had a standard penetration test N value of 22 blows per 0.3 metres penetration, based on a single standard penetration test. The water content of the sand sample collected was about 18 per cent.

#### **4.3.7 Sandy Silt**

Beneath the fill in borehole 1 at elevation 185.3 metres, in boreholes 3 and 4 at elevations 185.7 and 186.4 metres, respectively, deposits of compact to dense sandy silt were encountered. Where fully penetrated in borehole 1, the sandy silt layer was about 0.9 metres thick. Boreholes 3 and 4 were terminated at a depth of 6.9 metres in dense sandy silt layers after exploring those layers for some 2.4 metres. Also, a 0.3 meter thick deposit of sandy silt was encountered over the bedrock in the river bed at borehole 5. The sandy silt layers had standard penetration test N values of 22 to 49 blows per 0.3 metres penetration and water contents between about 8 and 22 per cent. Figure A-2 in Appendix A shows a gradation curve for the sandy silt materials recovered from borehole 1.



#### 4.3.8 Bedrock

A Golder geologist who is familiar with the geology of the Caledonia area, logged the rock cores from boreholes 1, 2, 5, 6, 7 and 8. These boreholes were drilled as part of the preliminary foundation investigation program to characterize the founding conditions for the existing and proposed bridge abutments and piers. The rock was continuously cored with a swivel type double tube NQ size wire line core barrel, except in borehole 2 where several standard penetration test samples were obtained in the rock. The core was carefully removed from the barrel following each run and care was taken to identify machine breaks, which are not counted in the SCR and RQD values. Detailed descriptions of the bedrock are provided on the Record of Borehole sheets and the bedrock stratigraphy is shown on Drawing 1. The following is a brief summary of the rock conditions.

The rock cores consisted of beds of gypsum, shale and dolostone as detailed on the Record of Borehole sheets. Recovery in the upper weathered portions of the boreholes was very low, which is typical of the area, and attributed to gypsum-karst dissolution, typically characterized by voids and/or vuggy intervals. Poor recovery is not attributed to the drilling techniques.

The measured TCR values ranged from 0 to 100 per cent with an average of about 40 per cent. SCR in the weathered/karstic upper bedrock zone ranged from 0 to 65 per cent with an average of about 15 per cent. It should be noted that 10 of the 29 core runs completed in the upper portion of the rock had an SCR of 0 per cent and the RQD was very low, with only 4 runs having RQD's greater than zero. No sudden loss of drill pressure or other evidence of large voids in the rock were noted during drilling.

In order to estimate the extent of the highly weathered/karstic upper bedrock zone, depths from inferred top of bedrock to rock with solid core recovery greater than 80 per cent at each borehole are tabulated below:

<i><b>Borehole Number</b></i>	<i><b>Location</b></i>	<i><b>Bedrock Surface Elevation (m)</b></i>	<i><b>Approximate Elevation of &gt;80% Core Recovery (m)</b></i>	<i><b>Inferred Depth of Highly Weathered/ Karstic Upper Bedrock (m)</b></i>
1	South Abutment	183.65	180.0	3.7
2	North Abutment	183.59	177.3	6.3
5	Proposed Pier	184.59	179.5	5.1
6	Existing Pier	184.44	180.5	3.9
7	Proposed Pier	184.89	178.8	6.1
8	Existing Pier	183.85	178.7	5.2

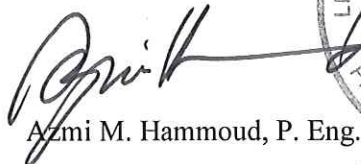
#### **4.4 Groundwater Conditions**

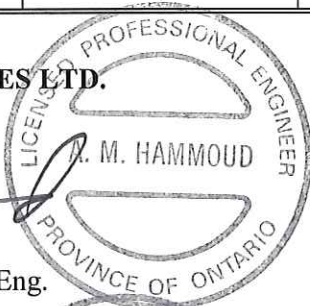
Water levels were noted in the boreholes during and upon completion of the drilling operations. These levels are shown on the attached Record of Borehole sheets. Piezometers were sealed in boreholes 1 and 2 to permit the monitoring of the groundwater levels in the overburden soils and in the bedrock at the abutments. Details of the piezometer installations and water level measurements are shown on the attached Record of Borehole sheets and a summary of the water levels measured on October 3 and 31, 2003 is provided in the table at the end of this section. The installations were abandoned in compliance with Ontario Regulation 128 recommended procedures following the October 31, 2003 readings and groundwater sampling. The results of the analytical testing carried out on the groundwater sample obtained from borehole 2 are detailed in Appendix A. The analytical testing indicated a pH value of 7.58 and a sulphate concentration of 1330 milligrams per litre.

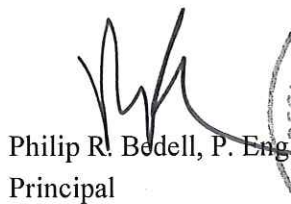
The Grand River water level was noted during drilling boreholes 5 to 7 at elevation 185.5 to 185.6 metres between October 27 and 31, 2003. The encountered water depths are summarized in the following table. It should be noted that the groundwater level and the river levels are subject to seasonal fluctuations.

Borehole Number and Installation	Ground/Sidewalk Surface Elevation (m)	Encountered Groundwater/ River Water Surface Elevation (m)	River Water Depth (m)	Measured Water Level Elevations	
				October 3, 2003 (m)	October 31, 2003 (m)
1, shallow	189.69	-	-	185.88	185.24
1, deep		-	-	186.34	186.22
2, shallow	190.23	-	-	186.85	185.41
2, deep		-	-	185.48	185.51
3	190.07	184.28	-	-	-
4	190.86	185.07	-	-	-
5	191.42	185.51	0.58	-	-
6	191.27	185.55	0.32	-	-
7	191.44	185.45	0.52	-	-
8	191.23	-	-	-	-

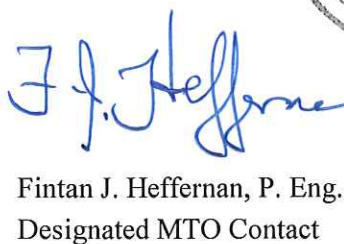
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**PART B**

**PRELIMINARY FOUNDATION DESIGN REPORT  
REHABILITATION OR REPLACEMENT OF THE  
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## **5.0 ENGINEERING RECOMMENDATIONS**

### **5.1 General**

This section of the report provides our recommendations on the foundation aspects of the preliminary design of the proposed rehabilitation or replacement of the Argyle Street South Bridge over the Grand River 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 methods and scheduling.

It is understood that the existing bridge foundations will be rehabilitated and/or the bridge will be replaced with a new structure and that the new approaches will tie in with the existing pavements. It is understood that the new bridge will be a five span structure built in two phases, the first phase will be just upstream of the existing bridge and the second will be at about the existing bridge location. Argyle Street (formerly Highway 6) will remain at the current grade and the new bridge structure centreline will be just west of the existing bridge.

### **5.2 Existing Bridge Foundations**

Based on the design drawings available for the existing bridge and our observations during the field investigation, the existing structure is founded on spread footings bearing on the rock surface. The concrete/rock interface was encountered at elevations 184.4 and 183.9 metres in boreholes 6 and 8, respectively. Laboratory testing of the concrete cores indicated compressive strengths of between 23 and 50 megapascals, with an average of about 36 megapascals.

The subsurface conditions encountered in the boreholes put down during the investigation indicated that the subsoils at the abutments and approaches generally consisted of variable thicknesses of fill and topsoil materials to between elevation 186 and 189 metres. These materials are underlain by generally thin deposits of sand and gravel, sandy silt, silt, clayey silt and sand over the bedrock. At the pier locations, the bedrock is exposed below about 0.6 meters of water and/or thin sandy silt deposits. The bedrock surface was encountered at elevations between 183.7 and 184.9 metres at the borehole locations. The boreholes indicated that the upper 4 to 7 metres of rock is highly weathered and extremely fissured or fractured. The project team members had identified the potential for problems with solution cavities in the rock mass at the area at the site. In order to better define the bedrock conditions, the boreholes were advanced deeper than the standard 3 metres into rock after consultation with MTO Foundations. No such problematic features were encountered in the eight boreholes drilled at the site.

Based on the results of boreholes 6 and 8 drilled at the site, the existing bridge piers 2 and 7 are supported on 36 megapascal concrete footings founded at very shallow depths on a 4 metre thickness of the poor quality rock having RQD's of 0 to 19 per cent. Remedial treatment of the rock would therefore be required in conjunction with a rehabilitation of the existing bridge to ensure satisfactory foundation performance in the future life of the bridge. Such a treatment could consist of grouting the poor quality rock to stabilize/improve the founding stratum. The extent of the grouting could be established during investigation for final design. Based on the results of the analytical testing carried out on the groundwater sample obtained from borehole 2, the grout and/or concrete will have a moderate exposure to sulphate attack and the use of Type 20 cement would be required.

Grouting would be carried out from the river, initially using a grout curtain to contain the mass beneath each footing and then injection of the mass below the footing. It should be noted that grouting in the river will have environmental issues that will result in higher than normal costs, constraints on construction timing, and the like.

### 5.3 New Bridge Foundations

Based on the information provided, due to property limitations, the existing approach alignments will need to be maintained by building the first half of the new bridge just offset from the existing structure while keeping Highway 6 traffic on the existing bridge. The second half of the new bridge will be built at about the existing bridge location after switching traffic to the new structure and demolishing the old bridge.

Consideration was given to founding the new bridge on the rock using spread footings and drilled cast-in-place concrete shafts (caissons).

#### 5.3.1 Spread Footing Foundations

Spread footings may be used to support the new bridge abutments, piers and any associated cantilever wing wall and/or retaining walls. For this alternative, the footing excavations should extend to sound rock at the approximate elevations tabulated below.

<i>Location</i>	<i>Borehole Number</i>	<i>Bedrock Surface Elevation (m)</i>	<i>Recommended Founding Elevation (m)</i>
South Abutment	1	183.65	180.0
North Abutment	2	183.59	177.0
Proposed Pier	5	184.59	179.3
Existing Pier	6	184.44	180.0
Proposed Pier	7	184.89	178.5
Existing Pier	8	183.85	179.5



The excavated rock should be replaced with mass concrete placed in the wet using a tremie operation into a steel shell/form. The footings would then be founded on the mass concrete. The mass concrete should extend at least 0.5 metres beyond the footing footprint. As indicated above, the concrete will have a moderate exposure to sulphate attack from the groundwater and the use of Type 20 cement is required. Considerable rock excavation is involved with this alternative. A second alternative is to found the spread footing near the surface of the bedrock, keying in at least 0.5 metres and carrying out remedial measures, such as grouting, to improve the rock integrity.

### Geotechnical Resistance

For preliminary design, spread footings placed on the properly prepared sound bedrock surface at depth or on mass concrete poured on the bedrock (alternative 1), a factored geotechnical resistance at Ultimate Limit States (ULS) of 2,000 kilopascals (kPa) may be assumed at the above noted elevations. This value is for vertical concentric loads only. Effects of load inclination and eccentricity need to be taken into account as appropriate in accordance with Section 6.7.4 of the Canadian Highway Bridge Design Code (CHBDC) using the curve for "cohesive soil or rock". Based on rock core recovered from boreholes including the presence of gypsum layers, a Serviceability Limit States (SLS) bearing resistance of 1800 kPa may be assumed. Based on the preliminary pier loads provided, a footing width of about 2 metres would be required.

The factored geotechnical resistance value given above assumes that controlled excavation, hoe ramming and/or cutting for footing construction is used and that the bedrock at and below the founding level has not been fractured by the excavation procedures and that no adverse jointing is present below the footings. All excavation should be carried out in the rock without dewatering. The contract documents should contain the MTO Special Provision 902S01 – Excavation and Backfilling – which contains reference to the use of a Quality Verification Engineer.

For the shallow alternative, where the spread footings are keyed at least 0.5 metres into the bedrock surface, a factored geotechnical resistance at ULS of 700 kilopascals and a SLS bearing resistance of 500 kilopascals may be assumed for the design of spread footings. Based on the preliminary pier loadings provided, a footing width of about 6.5 metres would be required.

All footing excavations should be inspected in the wet prior to placing mass concrete to ensure that the base has been adequately cleaned and that the bedrock conditions exposed at the founding level are consistent with the design assumptions. All loose or shattered rock within the footprint of the footings should be removed from the base of the excavation and replaced with concrete.

### Resistance to Lateral Forces

Resistance to lateral forces/sliding resistance between the concrete footings and mass concrete should be calculated in accordance with Section 6.7.5 of the CHBDC assuming an unfactored angle of friction of 35 degrees. If necessary, sliding resistance can be supplemented by doweling

into the mass concrete. The dowels should be a minimum of one metre long within the mass concrete (embedded length in the mass concrete) and the structural strength of the dowel and the compressive strength of the concrete should not be exceeded.

### Frost Protection

For spread footings placed on bedrock or mass concrete, frost protection cover is not required.

### **5.3.2 Deep Foundations**

Alternatively, consideration may be given to constructing the replacement structure on caissons extending to below the elevations noted above, especially at the abutments where deep excavations and mass concrete may be problematic. It is assumed that the abutment pile caps would be “perched” within the approach embankment fill, such that the pile cap base would be provided with at least 1.2 metres of soil cover. Also, a temporary liner will be required to support the overburden soils at the abutment caisson drill holes during drilling, installation and concrete placement. In addition, a sacrificial steel casing will be required in the zone from the top of rock to the founding elevation noted in Section 5.3.1.

### Geotechnical Axial Resistance

The load carrying capacity for drilled shafts depends on the total length of the caissons, the length of the rock socket and the diameter of the caissons. For preliminary design, 1.2 metre diameter caissons founded at least 0.3 metres below the surface of the sound bedrock, the elevations of which are noted in Section 5.3.1, could be designed for a factored geotechnical resistance at ULS of 2500 kPa. If the caissons are socketed 1.5 metres into sound rock, the ULS bearing resistance may be increased to 3000 kPa. The SLS bearing resistances in both cases are 2200 kPa.

MTO's Special Provision SP902S01 should be included in the Contract Documents requiring inspection and approval of the foundation areas by the Quality Verification Engineer prior to drilled shaft installation and concreting to ensure that all loose and/or fractured rock has been removed from the foundation areas.

### Resistance to Lateral Loads

The resistance to lateral loading will have to be derived from the soil or rock in front of the caissons. The resistance to lateral loading in front of the caisson may be calculated using subgrade reaction theory where the coefficient of horizontal subgrade reaction,  $n_h$ , is based on the following equation for granular soils:



$$k_h = \frac{n_h z}{B}$$

where

$n_h$  is the constant of horizontal subgrade reaction, as given below;  
z is the depth (m); and  
B is the pile diameter (m).

The following ranges for the value of  $n_h$  may be assumed in the structural analysis. The range in values reflects the variability in the subsurface conditions as well as the two extremes of design.

Soil Unit	$n_h$
Embankment fill and surficial soils (assumed to be compacted granular fill)	5 MPa/m

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

Caisson Pile Spacing in Direction of Loading d = Caisson Diameter	Reduction Factor
8d	1.0
6d	0.7
4d	0.4
3d	0.25

### Frost Protection

The cast-in-place concrete pile caps should be provided with a minimum of 1.2 metres of soil cover for frost protection.

### **5.3.3 Summary of Foundation Alternatives**

Due to space limitations, and as indicated in Section 5.3.2 above, the abutments for the replacement bridge will likely need to be constructed on caisson foundations. Geotechnical design alternatives were provided for founding the bridge piers on spread footings constructed on mass concrete extending to the sound rock, spread footings keyed at least 0.5 metres into the rock surface or on caissons extending to 0.3 to 1.5 metres into the sound rock. An overview of the advantages, disadvantages, costs and risks of these alternatives is provided below.



#### SPREAD FOOTINGS ON MASS CONCRETE

- Advantage: Excavation extends to sound rock.  
Disadvantages: Rock excavations will be 4 to 6 metres deep and difficult.  
Excavation and concreting in the wet.  
Cost/Risk: High costs but low risk since the depth of excavation is defined.

#### SPREAD FOOTINGS KEYED INTO ROCK SURFACE

- Advantage: Only shallow rock excavations are required.  
Disadvantages: Lower bearing capacities and remedial measures are not well defined.  
Excavation and concreting in the wet.  
Cost/Risk: Costs may escalate depending on the amount of grouting required.

#### CAISSONS

- Advantage: Construction will be similar to the abutments.  
Disadvantages: Caissons will be deep and installation in the upper fractured zone will be difficult.  
Excavation and concreting in the wet.  
Cost/Risk: Cost can be defined prior to construction.

Based on foundation engineering considerations, the preferred foundation alternative would consist of a combination of spread footings on mass concrete for the piers and caissons for the abutments or for piers where the new piers are in close proximity to the existing piers, thus precluding deep open cut excavation.

### **5.3.4 Retained Soil System (RSS) Walls**

A mechanically-reinforced soil retaining wall system (retained soil system or 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. Use of an RSS wall is considered appropriate for the proposed wing walls and/or retaining walls associated with the new structure. Design recommendations will be provided during the detail design stage if RSS walls are to be used for this project.

### **5.3.5 Lateral Earth Pressures**

The lateral pressures acting on the new bridge abutments and associated 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 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 abutments, in accordance with the CHBDC:

- 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 0.075 millimetre sieve should be used as backfill behind the abutments and walls. This fill should be compacted in loose lifts not greater than 200 millimetres in thickness to 95 per cent of the material's standard Proctor maximum dry density in accordance with OPSS 501. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Other aspects of the abutment granular backfill requirements with respect to subdrains and frost taper should be in accordance with Ontario Provincial Standard Drawing (OPSD) 3501.00 and 3504.00.
- A compaction surcharge equal to 12 kPa should be included in the lateral earth pressures for the structural design of the abutment wall, in accordance with CHBDC Figure 6.9.3. Compaction equipment should be used in accordance with OPSS 501.06.
- The granular fill may be placed either in a zone with a width equal to at least 1.2 metres behind the back of the stem (Case i from Commentary on CHBDC Figure C6.9.1(I)) or within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical extending up and back from the rear face of the footing (Case ii from Commentary on CHBDC Figure C6.9.1(I)).
- For Case i, the pressures are based on the proposed embankment fill materials and the following parameters (unfactored) may be assumed:

Soil unit weight:		21 kN/m <sup>3</sup>
Coefficients of lateral earth pressure:	Active, $K_a$	0.33
	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:

	<u>GRANULAR A</u>	<u>GRANULAR B TYPE II</u>
Soil unit weight:	22 kN/m <sup>3</sup>	21 kN/m <sup>3</sup>
Coefficients of lateral earth pressure:		
	Active, $K_a$	0.31
	At rest, $K_o$	0.47

- If the wall support and superstructure allow 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.

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 subdrains and frost taper should be in accordance with OPSD 3501.00.

### **5.3.6 Embankments**

It is assumed that only minor grade changes may be required for the proposed new bridge. Embankment side slopes formed no steeper than 2 horizontal to 1 vertical are considered suitable for this site. A Factor of Safety against deep seated failure of greater than 1.3 is obtained for embankments constructed with the native sandy silt till materials.

The topsoil and organic materials should be removed from within the area of the embankment and the exposed subgrade soils should be proofrolled prior to fill placement.

Construction of the embankment above the prepared subgrade may be carried out using clean earth fill (in accordance with OPSS 212) or select subgrade material (in accordance with OPSS 1010) depending on material availability. All embankment fill should be placed in regular lifts with loose thickness not exceeding 300 millimetres and be compacted to at least 95 per cent of the material's standard Proctor maximum dry density.

### **5.3.7 Excavations and Temporary Cut Slopes**

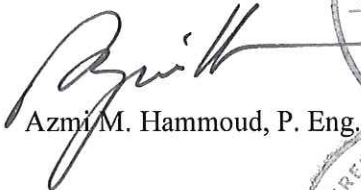
Excavations for the construction of new abutment pile caps will extend through the existing fill and topsoil materials as well as the surficial soil deposits. At the proposed new bridge location, for the option for spread footings bearing at depth, the excavation for spread footing construction will be much deeper and will extend into the bedrock. Temporary open cut slopes should be maintained no steeper than 1 horizontal to 1 vertical in the overburden and at a nominal slope of 4 vertical to 1 horizontal in the bedrock.

Surficial water seepage into the excavations should be expected and will be heavier during periods of sustained precipitation. Pumping from well filtered sumps located at the base of the excavations may be required to provide groundwater control in shallow excavations. It is anticipated that all rock excavations will be carried out in the wet.

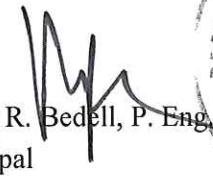


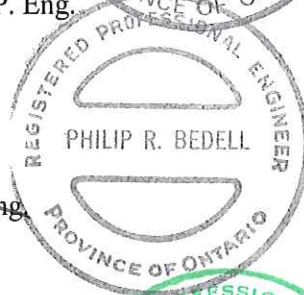
All excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Ontario Occupational Health and Safety Act and Regulations For Construction Projects. The existing fill materials and the granular deposits at the abutment locations would be classified as Type 3 soils.

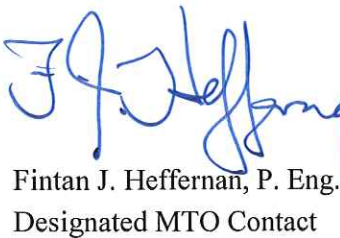
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AMH/PRB/FJH/cr  
n:\active\2002\3200\021-3233 - mh - bridge - caledonia\reports\final report\0430- (revised) (parts a&b) prelim inv & design report.doc

## 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

	$c_u, s_u$	
	<b>kPa</b>	<b>psf</b>
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  $\times$  acceleration due to gravity)



# 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

<u>Description</u>	<u>Bedding Plane Spacing-</u>
Very thickly bedded	>2 m
Thickly bedded	0.6 m to 2m
Medium bedded	0.2 m to 0.6m
Thinly bedded	60 m 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

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

## GRAIN SIZE

<u>Term</u>	<u>Size*</u>
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 (TCR)

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

### 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
M F - Mechanical Fracture	C - Curved
- Parallel To	
⊥ - Perpendicular To	

PROJECT 021-3233

**RECORD OF BOREHOLE No 1**

1 OF 2

**METRIC**

G.W.P. 3805-01-00

LOCATION N 4770263.3; E 267921.1

ORIGINATED BY DJM

DIST HWY 6

BOREHOLE TYPE POWER AUGER, SOLID STEM & Nw CASING

COMPILED BY WDF

DATUM GEODETIC

DATE October 1, 2003 - October 2, 2003

CHECKED BY DJM

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
189.69	GROUND SURFACE						20	40	60	80	100					
0.00	(FILL), Silty sand and gravel, with asphalt and topsoil															
189.23	Dark brown															
0.46	(FILL), sandy silt some gravel, trace asphalt		1	SS	20											
	Compact		2	SS	25											
	Brown		3	SS	20											
186.95																
2.74	(FILL), sandy silt, trace gravel, roots and brick		4	SS	16											
186.18	Compact															
3.51	Brown															
	SANDY SILT, trace clay, some gravel		5	SS	23											
185.27	Compact															
4.42	Brown															
	SILT, some sand, some rock fragments,		6	SS 70/150mm												
	Dense to very dense		7	SS	37											
	Grey and brown															
183.65			8	SS 30/60mm												
6.04	Light grey to dark grey DOLOMITIC SHALE, moderate to low recovery as cylindrical core and angular, broken fragments. Surfaces are slightly weathered with brown stains.		9	CORE	NQ		67	40	0							
			10	CORE	NQ		23	10	0							
			11	CORE	NQ		58	35	13							
181.09																
8.60	Grey, fresh, medium strong non-dolomitic/calcareous SHALE		12	CORE	NQ		59	0	0							
8.84	White, fresh, medium-strong GYPSUM, with shaley laminae															
180.52	Grey, fresh, medium strong non-dolomitic/calcareous SHALE		13	CORE	NQ		93	53	45							
9.17																
179.08																
10.61	Light brown, fresh, medium strong, laminated gypsiferous DOLOSTONE. Gypsum occurs as nodules and laminae.		14	CORE	NQ		100	63	53							
			15	CORE	NQ		77	42	32							
176.28																
13.41	White, fresh, medium strong GYPSUM with dolomitic shale laminae.		16	CORE	NQ		72	38	34							
175.52																
14.17	Light brown, fresh, medium strong laminated, vuggy gypsiferous DOLOSTONE. Gypsum occurs as nodules and laminae.		17	CORE	NQ		95	90	72							

ON\_MTO 021-3233MTO.GPJ ON\_MOT.GDT 4/1/04 DATA INPUT:

Continued Next Page

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity

O 3% STRAIN AT FAILURE



PROJECT <u>021-3233</u>		<b>RECORD OF BOREHOLE No 1</b>		2 OF 2	<b>METRIC</b>
G.W.P. <u>3805-01-00</u>	LOCATION <u>N 4770263.3 ; E 267921.1</u>	ORIGINATED BY <u>DJM</u>			
DIST <u>HWY 6</u>	BOREHOLE TYPE <u>POWER AUGER, SOLID STEM &amp; Nw CASING</u>	COMPILED BY <u>WDF</u>			
DATUM <u>GEODETIC</u>	DATE <u>October 1, 2003 - October 2, 2003</u>	CHECKED BY <u>DJM</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE 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					WATER CONTENT (%)				
								○ UNCONFINED		+ FIELD VANE			● QUICK TRIAXIAL		× LAB VANE		
								20	40	60	80	100	10	20	30		
174.11	Grey SHALE grading to light brown grey DOLOMITIC SHALE. Fresh, medium strong. Vuggy GYPSUM, weak, slightly weathered. Grey, medium strong, thinly laminated DOLOMITIC SHALE with gypsum laminae and nodules		17	CORE	NQ		95	90	72								
15.94			18	CORE	NQ		100	90	63								
172.59			19	CORE	NQ		75	50	33								
17.10	END OF BOREHOLE																
Water level in Deep installation at elev. 186.34m OCT. 3, 2003. Water level in Shallow installation at elev. 185.88m OCT. 3, 2003.																	
Water level in Deep installation at elev. 186.22m OCT. 31, 2003. Blockage in Shallow installation at elev. 185.24m OCT. 31, 2003.																	
Abandoned Oct. 31, 2003.																	

ON\_MTO 021-3233MTO.GPJ ON\_MOT.GDT 4/1/04 DATA INPUT:



# RECORD OF BOREHOLE No 2

1 OF 2

METRIC

PROJECT 021-3233  
G.W.P. 3805-01-00 LOCATION N 4770467.2 ; E 267971.4 ORIGINATED BY DJM  
DIST HWY 6 BOREHOLE TYPE POWER AUGER, HOLLOW STEM & Nw CASING COMPILED BY WDF  
DATUM GEODETIC DATE October 2, 2003 - October 3, 2003 CHECKED BY DJM

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								
							20	40	60	80	100					
190.23	PAVEMENT SURFACE															
0.15	PAVING STONE (FILL), sand, fine to medium (FILL), sandy silt, trace clay, some gravel, trace bricks Compact Brown		1	SS	21											
188.86	(FILL), clayey silt, trace sand, some gravel, cinder layers Stiff to hard Brown and black		2	SS	36											
1.37																
187.33	(FILL), sandy silt, trace clay, some gravel, cinders and topsoil Compact Brown		3	SS	12											
2.90																
186.12	SAND AND GRAVEL, trace silt Dense Brown		4	SS	15											
4.11																
184.59	NO RECOVERY Probably Dolostone, light brown		5	SS	37											
5.64																
183.68	Light brown, stained, very vuggy DOLOSTONE. Recovered as broken core and angular fragments.		6	CORE	NQ											
6.55																
182.61	Grey, medium strong, massive to thinly laminated DOLOMITIC SHALE. Weathered surfaces, low recovery.		7	SS	100/75mm											
7.62																
180.60	Highly weathered grey, medium strong, massive to thinly laminated DOLOMITIC SHALE. Weathered surfaces, low recovery.		8	CORE	NQ											
9.63																
178.31	Completely weathered grey DOLOMITIC SHALE with gypsum nodules recovered from split spoon samples.		9	SS	10/50mm											
11.92																
177.34	Interbedded white, strong, fresh, coliform GYPSUM and strong, fresh, light brown, laminated SHALEY DOLOSTONE with nodular gypsum.		10	CORE	NQ											
12.89																
175.75	Grey, fresh, medium strong DOLOMITIC SHALE		11	CORE	NQ											
14.48																
										</						

Continued Next Page

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

ON MTO 021-3233MTO.GPJ ON MOT.GDT 4/1/04 DATA INPUT:

PROJECT 021-3233 **RECORD OF BOREHOLE No 2** 2 OF 2 **METRIC**  
 G.W.P. 3805-01-00 LOCATION N 4770467.2 ; E 267971.4 ORIGINATED BY DJM  
 DIST HWY 6 BOREHOLE TYPE POWER AUGER, HOLLOW STEM & Nw CASING COMPILED BY WDF  
 DATUM GEODETIC DATE October 2, 2003 - October 3, 2003 CHECKED BY DJM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ  kN/m³	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 × LAB VANE					w <sub>p</sub>	w	w <sub>L</sub>			
								20	40	60	80	100	10	20	30			
175.08	White, slightly weathered, strong GYPSUM  Light brown-grey, laminated, vuggy, slightly weathered, strong DOLOSTONE with gypsum nodules.		17	CORE	NQ		175	87	95	48								
15.15 174.78							174	100	100	75								
15.45			18	CORE	NQ		173											
173.24	White, strong, slightly weathered, GYPSUM																	
16.99 172.83	END OF BOREHOLE  Water level in Deep installation at elev. 185.48m OCT. 3, 2003. Water level in Shallow installation at elev. 186.85m OCT. 3, 2003.  Water level in Deep installation at elev. 185.51m OCT. 31, 2003. Water level in Shallow installation at elev. 185.41m OCT. 31, 2003.  Abandoned Oct. 31, 2003.																	
17.40																		

ON\_MTO 021-3233MTO.GPJ ON\_MOT.GDT 4/1/04 DATA INPUT:

**RECORD OF BOREHOLE No 3**

1 OF 1

**METRIC**

PROJECT 021-3233  
G.W.P. 3805-01-00 LOCATION N 4770478.9 ; E 267978.8 ORIGINATED BY DJM  
DIST HWY 6 BOREHOLE TYPE POWER AUGER, SOLID STEM (UNCASED) COMPILED BY WDF  
DATUM GEODETIC DATE October 3, 2003 CHECKED BY DJM

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 × LAB VANE											
190.07	PAVEMENT SURFACE						20	40	60	80	100	10	20	30					
0.00	ASPHALT																		
0.15	(FILL), silty sand and crushed gravel Compact Grey																		
188.85			1	SS	26		189												
1.22	(FILL), clayey silt, trace sand, mottled Firm Brown and grey		2	SS	6		188												
187.48			3	SS	8														
2.59	TOPSOIL, clayey																		
187.17	Stiff Black						187												
2.90	CLAYEY SILT, trace sand		4	SS	9														
186.56	Stiff Brown																		
3.51	SAND, fine, some silt, trace gravel Compact Brown		5	SS	22		186												
185.65																			
4.42	SANDY SILT, some gravel Compact Brown		6	SS	22		185												
184.68																			
5.39	SANDY SILT, with angular gravel, cobbles Dense Brown						184												
183.21			7	SS	49														
6.86	END OF BOREHOLE																		
	Water level encountered at elev. 184.28m OCT. 3, 2003.																		

ON\_MTO 021-3233MTO.GPJ ON\_MOT.GDT 4/1/04 DATA INPUT:





ARGYLE STREET STRUCTURE

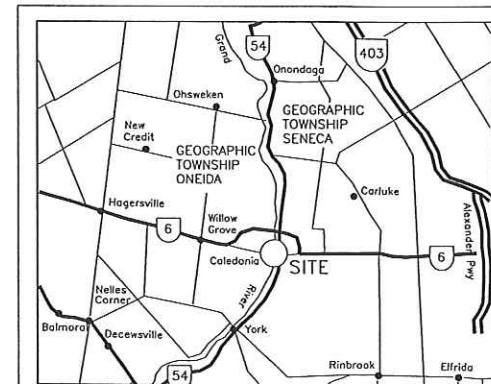
SHEET

BOREHOLE LOCATIONS & SOIL STRATA



Golder Associates Ltd.  
LONDON, ONTARIO, CANADA

REFERENCE  
DRAWING SUPPLIED BY MORRISON HERSHFIELD ENTITLED  
BRIDGE SITE PLAN  
BRIDGE CROSSING AT THE KING'S HIGHWAY 6 AND GRAND RIVER  
WP 3805-01-00 ETR 143-6  
PLAN DATE FEB / 03



KEY PLAN

LEGEND

- Borehole
- Seal
- Piezometer
- N Blows/0.3m (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL in piezometer OCT. 31, 2003.
- WL during drilling

No.	ELEVATION (metres)	CO-ORDINATES	
		NORTHING	EASTING
1	189.69	4 770 263.3	267 921.1
2	190.23	4 770 467.2	267 971.4
3	190.07	4 770 478.9	267 978.8
4	190.86	4 770 251.9	267 912.7
5	191.42	4 770 387.3	267 947.7
6	191.27	4 770 313.9	267 922.9
7	191.44	4 770 342.4	267 944.4
8	191.23	4 770 415.8	267 968.9

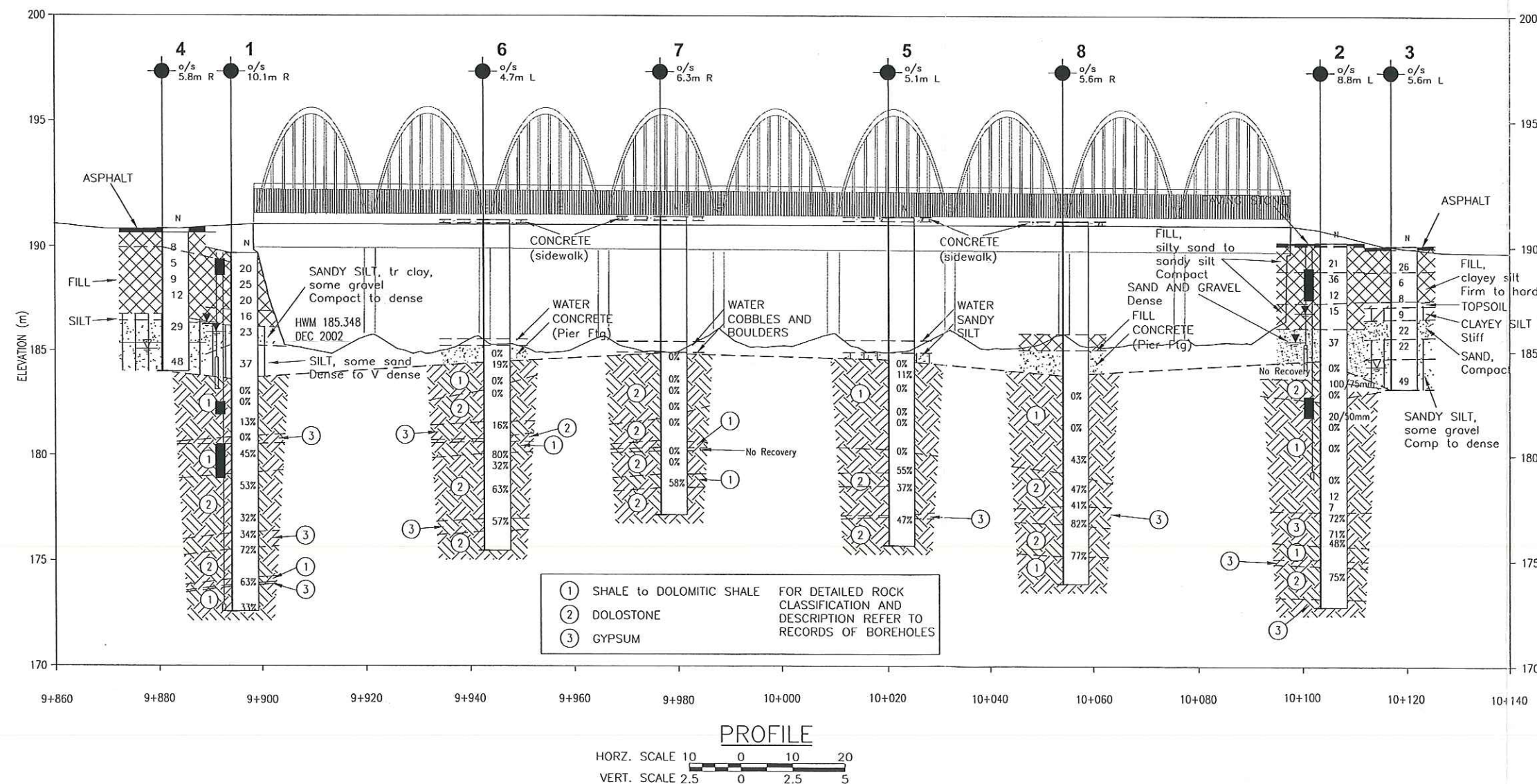
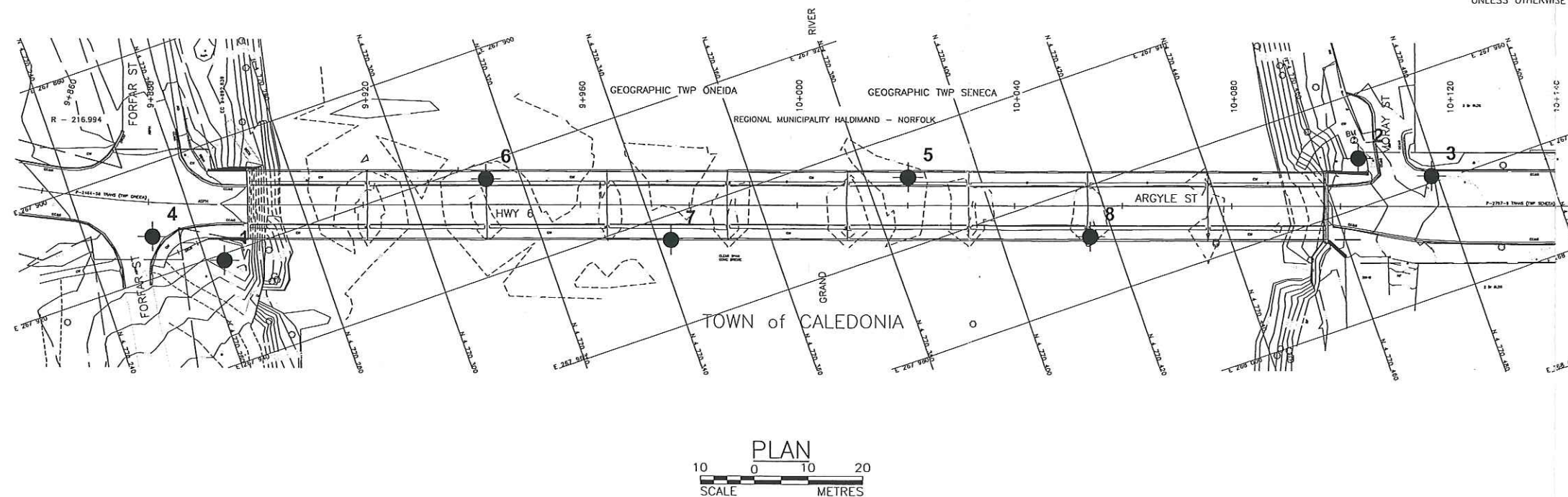
NOTES

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

1	APR 2004	WDF	ISSUED AS FINAL
NO.	DATE	BY	REVISION

Geocres No. 30M4-101

HWY. No.	6	PROJECT NO.:	021-3233
SUBM'D.	-	CHKD.	-
DRAWN:	WDF	CHKD.	AMH
		APPD.	
		DWG.	1



11" x 17" plot half scale

D size dwg 22" x 32"

1 = 1 metric

PLOT DATE: April 01, 2004  
FILENAME: C:\Project\3805-01-00\3805-01-00.DWG



**RECORD OF BOREHOLE No 4**

1 OF 1

**METRIC**

PROJECT 021-3233 G.W.P. 3805-01-00 LOCATION N 4770251.9 ; E 267912.7 ORIGINATED BY DJM  
DIST HWY 6 BOREHOLE TYPE POWER AUGER, SOLID STEM (UNCASED) COMPILED BY WDF  
DATUM GEODETIC DATE October 3, 2003 CHECKED BY DJM

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 (%)
190.86	PAVEMENT SURFACE							20	40	60	80	100		10	20	30		
0.00	ASPHALT																	
0.20	(FILL), silty sand and crushed gravel Dense Grey																	
189.95	(FILL), sandy silt, trace to some clay, trace gravel and brick Loose to compact Brown		1	SS	8		190											
0.91			2	SS	5		189											
			3	SS	9		188											
			4	SS	12		187											
186.75	SILT, some sand, trace organic material Dark grey SANDY SILT, trace clay, trace gravel Compact Brown		5	SS	29		186											
4.11																		
186.44																		
4.42	SANDY SILT, trace clay, some gravel, with cobbles Dense Brown and grey						185											
185.37																		
5.49			6	SS	48													
184.00	END OF BOREHOLE						184											
6.86	Water level encountered at elev. 185.07m OCT. 3, 2003.																	

ON\_MTO 021-3233MTO.GPJ ON\_MOT.GDT 4/1/04 DATA INPUT:

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE

**RECORD OF BOREHOLE No 5**

1 OF 2

**METRIC**

PROJECT 021-3233 LOCATION N 4770387.3 ; E 267947.7 ORIGINATED BY DJM  
G.W.P. 3805-01-00 DIST HWY 6 BOREHOLE TYPE ROTARY DRILLING & Nw CASING COMPILED BY WDF  
DATUM GEODETIC DATE October 27, 2003 - October 28, 2003 CHECKED BY DJM

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	100					
191.42	SIDEWALK SURFACE																
0.00	CONCRETE																
0.20																	
							191										
							190										
							189										
							188										
							187										
							186										
185.51	Water Surface						185										
5.91	WATER						184										
184.93							183										
6.49	SANDY SILT, some gravel and shells						182										
184.59							181										
6.83	Brown and grey Grey, moderately strong, slightly to highly weathered DOLOMITIC SHALE		1	CORE	NQ		180	66	0	0							
			2	CORE	NQ		179	49	20	11							
			3	CORE	NQ		178	27	7	0							
			4	CORE	NQ		177	60	15	0							
			5	CORE	NQ		176	40	9	0							
180.29			6	CORE	NQ		175	39	8	0							
11.13	Light brown-grey, fresh, moderately strong, gypsiferous DOLOSTONE. Gypsum occurs as laminae and nodules		7	CORE	NQ		174	94	70	55							
			8	CORE	NQ		173	83	53	37							
177.16			9	CORE	NQ		172	89	70	47							
14.35	White, medium strong, fresh, nodular GYPSUM with dolomitic shaley partings. Light brown grey, fresh, moderately						171										

ON\_MTO 021-3233MTO.GPJ ON\_MOT.GDT 4/1/04 DATA INPUT:

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE





**RECORD OF BOREHOLE No 6**

1 OF 2

**METRIC**

PROJECT 021-3233  
G.W.P. 3805-01-00 LOCATION N 4770313.9 ; E 267922.9 ORIGINATED BY DJM  
DIST HWY 6 BOREHOLE TYPE ROTARY DRILLING & Nw CASING COMPILED BY WDF  
DATUM GEODETIC DATE October 28, 2003 - October 29, 2003 CHECKED BY DJM

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	× LAB VANE	20						40	60	80
191.27	SIDEWALK SURFACE																			
0.00	CONCRETE																			
0.15							191													
							190													
							189													
							188													
							187													
							186													
185.55	Water Surface						185													
5.72	WATER																			
185.23																				
6.04	CONCRETE		1	CORE	NQ			63	32	0										
184.44								68	28	19										
6.83	Grey, moderately strong, slightly weathered DOLOMITIC SHALE. Moderate to low recovery in the form of cylindrical core and angular fragments.		2	CORE	NQ															
			3	CORE	NQ			36	20	0										
183.10																				
8.17	Very low recovery of angular, vuggy DOLOSTONE fragments.		4	CORE	NQ			7	0	0										
181.58																				
9.69	White, medium strong, fresh nodular GYPSUM with dolomitic shaley partings.																			
			5	CORE	NQ															
180.78																				
10.49	Light brown-grey, fresh, medium strong, gypsiferous DOLOSTONE. Gypsum occurs as nodules.							T.C.R. (%)	78	31	16									
10.64	Grey, fresh, medium strong DOLOMITIC SHALE		6	CORE	NQ			S.C.R. (%)	100	80	80									
180.07	Light brown-grey, fresh, medium strong, gypsiferous, laminated DOLOSTONE.							R.Q.D. (%)												
11.20			7	CORE	NQ				83	68	32									
			8	CORE	NQ															
176.97																				
14.30	White and light brown, fresh, medium strong, nodular GYPSUM with some dolomitic shale bands.		9	CORE	NQ				97	83	63									
176.37																				
									95	80	57									

37.4 MPa

ON\_MTO 021-3233MTO.GPJ ON\_MOT.GDT 4/1/04 DATA INPUT:

Continued Next Page

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

PROJECT 021-3233

G.W.P. 3805-01-00

LOCATION N 4770313.9 ;E 267922.9

ORIGINATED BY DJM

DIST \_\_\_\_\_ HWY 6

BOREHOLE TYPE ROTARY DRILLING & NW CASING

COMPILED BY WDF

DATUM GEODETIC

DATE October 28, 2003 - October 29, 2003

CHECKED BY DJM

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 (%)									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					w <sub>p</sub> w w <sub>L</sub>									
							20 40 60 80 100						10 20 30									
14.90	Light brown-grey, fresh, medium strong, laminated, gypsiferous DOLOSTONE. Gypsum occurs as beds, bands and nodules.		9	CORE	NQ		176															
175.48								T.C.R. (%)	95	S.C.R. (%)	80	R.Q.D. (%)	57									
15.79								END OF BOREHOLE														

ON MTO 021-3233MTO.GPJ ON MOT,GDT 4/1/04 DATA INPUT:

+3, ×3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE



**RECORD OF BOREHOLE No 7**

1 OF 1

**METRIC**

PROJECT 021-3233  
G.W.P. 3805-01-00 LOCATION N 4770342.4 ; E 267944.4 ORIGINATED BY DJM  
DIST HWY 6 BOREHOLE TYPE ROTARY DRILLING & Nw CASING COMPILED BY WDF  
DATUM GEODETIC DATE October 30, 2003 - October 31, 2003 CHECKED BY DJM

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		
191.44	SIDEWALK SURFACE						20	40	60	80	100	10	20	30	kN/m <sup>3</sup>	GR SA SI CL				
0.00	CONCRETE																			
0.18																				

ON\_MTO 021-3233MTO.GPJ ON MOT.GDT 4/1/04 DATA INPUT:

PROJECT 021-3233

# RECORD OF BOREHOLE No 8

1 OF 2

METRIC

G.W.P. 3805-01-00

LOCATION N 4770415.8 ; E 267968.9

ORIGINATED BY DJM

DIST HWY 6

BOREHOLE TYPE ROTARY DRILLING & Nw CASING

COMPILED BY WDF

DATUM GEODETIC

DATE October 31, 2003 - November 1, 2003

CHECKED BY DJM

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 × LAB VANE												
191.23	SIDEWALK SURFACE						20	40	60	80	100	10	20	30	kN/m <sup>3</sup>	GR SA SI CL				
0.00	CONCRETE																			
0.18																				
185.84	Ground Surface																			
5.39	FILL, silty sand some gravel, concrete, wood, cobbles and boulders																			
185.06	Brown																			
6.17	CONCRETE		1	CORE	NQ		100	100	55							22.7 MPa				
183.85							90	85	80							50.3 MPa				
7.38	Light grey to dark grey, laminated DOLOMITIC SHALE. Moderate to low recovery as cylindrical core and angular broken core fragments. Surfaces are slightly weathered.		2	CORE	NQ		80	30	19							33.5 MPa				
			3	CORE	NQ		32	3	0											
			4	CORE	NQ		10	3	0											
179.19			5	CORE	NQ		57	43	43											
12.04	Light brown, fresh, medium strong, gypsiferous DOLOSTONE. Gypsum occurs as nodules and laminae.		6	CORE	NQ		80	47	47											
177.61			7	CORE	NQ		96	50	41											
13.62	White, fresh, medium strong, nodular to coliform GYPSUM and strong, fresh, light brown, laminated SHALEY DOLOSTONE with nodular gypsum.		8	CORE	NQ		95	88	82											
176.75																				
14.48	Light brown, fresh, medium strong, laminated, vuggy, gypsiferous DOLOSTONE. Gypsum occurs as																			

Continued Next Page

+ 3, x 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

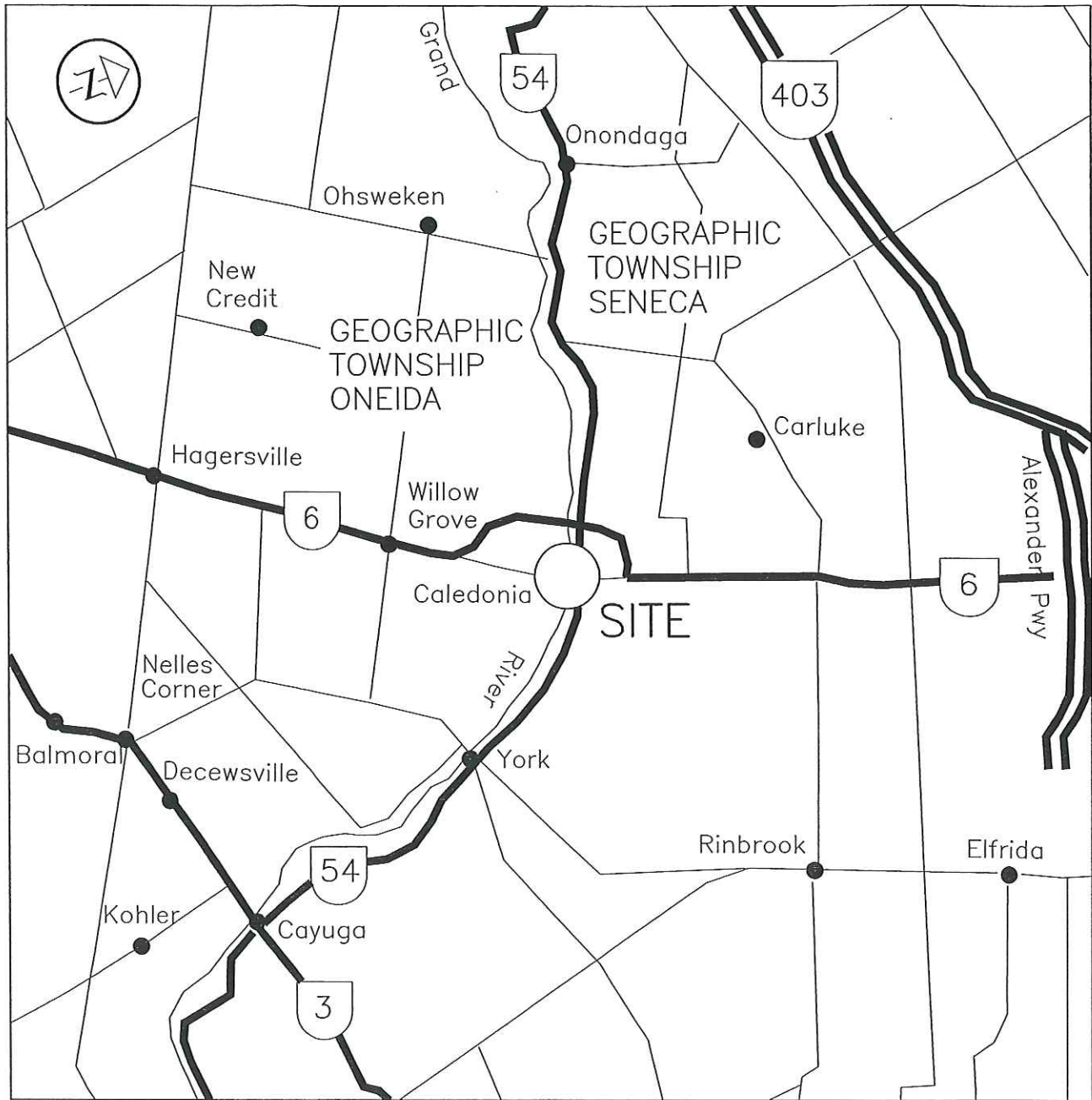
ON\_MTO 021-3233\MTG.GPJ ON\_MOT.GDT 5/3/04 DATA INPUT:

PROJECT <u>021-3233</u>		<b>RECORD OF BOREHOLE No 8</b>		2 OF 2	<b>METRIC</b>
G.W.P. <u>3805-01-00</u>	LOCATION <u>N 4770415.8 ; E 267968.9</u>	ORIGINATED BY <u>DJM</u>			
DIST <u>HWY 6</u>	BOREHOLE TYPE <u>ROTARY DRILLING &amp; Nw CASING</u>	COMPILED BY <u>WDF</u>			
DATUM <u>GEODETIC</u>	DATE <u>October 31, 2003 - November 1, 2003</u>	CHECKED BY <u>DJM</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 (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE					W <sub>p</sub>	W	W <sub>L</sub>		
						20	40	60	80	100	10	20	30				
	nodules and laminae.		8	CORE	NQ												
175.23 16.00	Grey SHALE grading to light grey DOLOMITIC SHALE. Fresh, medium strong, occasional vugs. Nodular gypsum 16.82m to 19.92m depth.		9	CORE	NQ												
173.92 17.31	END OF BOREHOLE																


ON\_MTO 021-3233MTO.GPJ ON\_MOT.GDT 5/3/04 DATA INPUT:

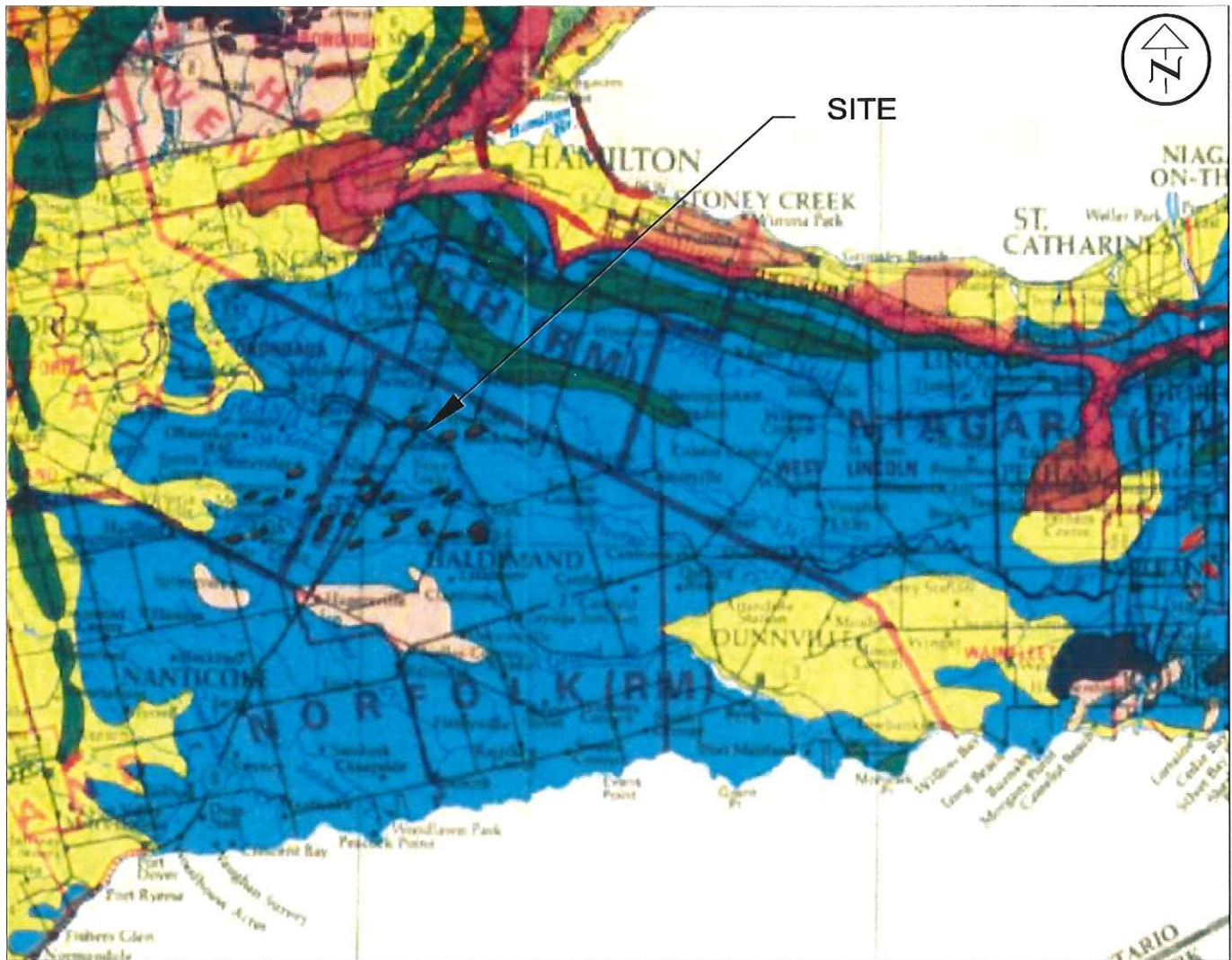




# NOTE

THIS DRAWING IS APPROXIMATE ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

PROJECT		ARGYLE STREET SOUTH BRIDGE OVER THE GRAND RIVER IN CALEDONIA GWP 3805-01-00			
TITLE		SITE LOCATION PLAN			
PROJECT No.		021-3233		FILE No. 0213233R001	
CADD		WDF	Dec 12/03	SCALE	N.T.S. REV. 0
CHECK		AMH	Dec 12/03	FIGURE 1	
 <b>Golder Associates</b> LONDON, ONTARIO					



### LEGEND

- |                                   |   |
|-----------------------------------|---|
| Till Moraine                      | Spillway  |
| Kame Moraine                      | Beaches and Shorecliffs                                   |
| Till Plain (drumlinized)          | Escarpment  |
| Drumlins                          | Limestone Plain   |
| Till Plain (undrumlinized)        | Shale Plain   |
| Bevelled Till Plain               | Peat and Muck   |
| Shallow Till and Rock Ridges      | International Boundary                                    |
| Bare Rock Ridges and Shallow Till | Interprovincial Boundary                                  |
| Clay Plain                        | County, District, Regional or District Municipal Boundary |
| Sand Plain                        | Township Boundary, surveyed                               |
| Esker                             | Township Boundary, unsurveyed                             |
|                                   | Multilane Highway   |
|                                   | King's Highway  |
|                                   | Secondary Highway   |

### NOTE

THIS DRAWING IS APPROXIMATE ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

PROJECT ARGYLE STREET SOUTH  
BRIDGE OVER THE GRAND RIVER IN CALEDONIA  
GWP 3805-01-00

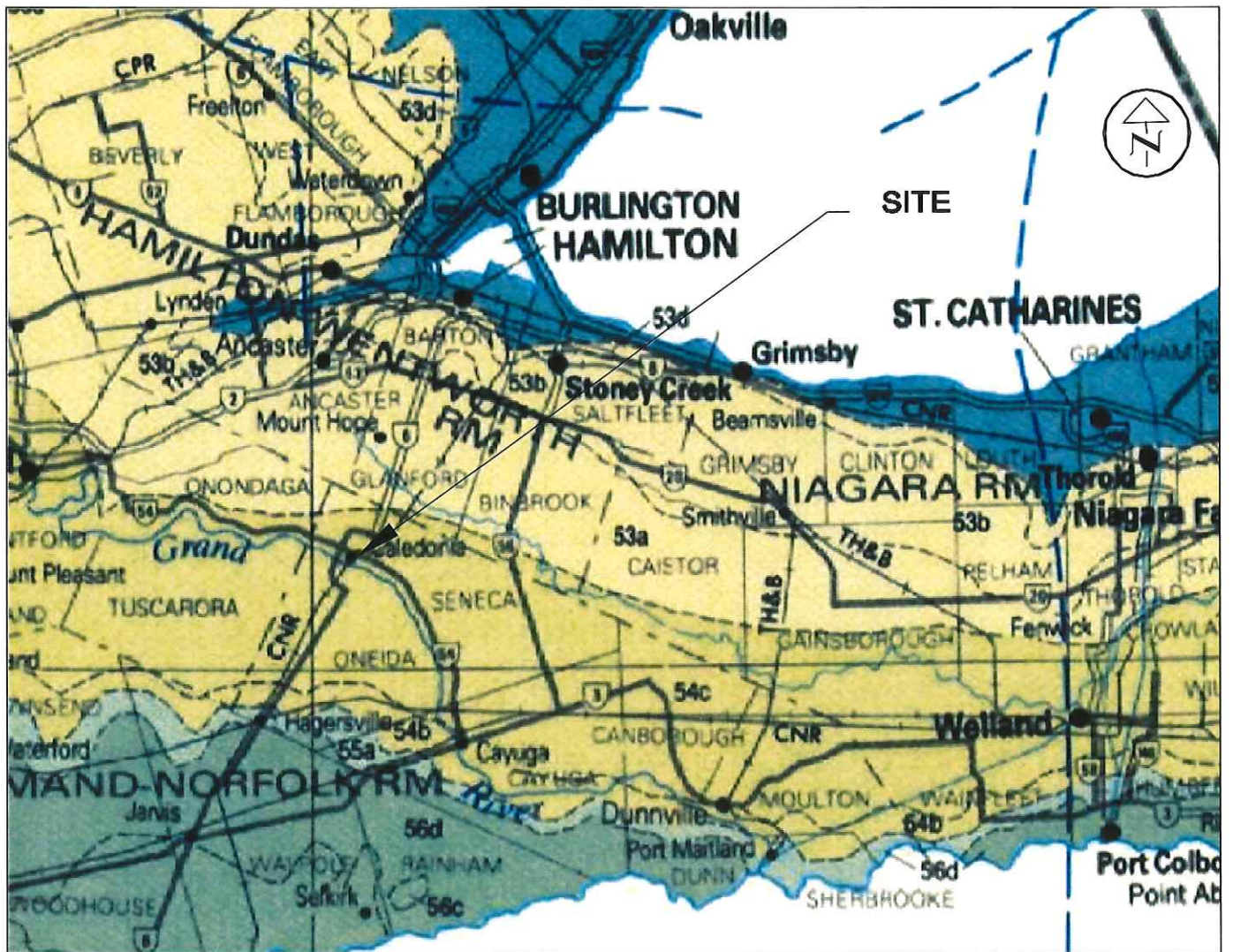
TITLE

### REGIONAL PHYSIOGRAPHY



PROJECT No. 021-3233			FILE No. 0213233R003	
CADD	WDF	Dec 16/03	SCALE	N.T.S. REV. 0
CHECK		Dec 16/03	FIGURE 2	





## LEGEND\*

### PHANEROZOIC<sup>b</sup>

#### PALEOZOIC

##### SILURIAN

##### UPPER SILURIAN

54

Limestone, dolostone, shale, sandstone, gypsum, salt

54a Bass Islands Fm

54b Bertie Fm.

54c Salina Fm.

54d Kenogami River Fm. (Upper Silurian to Lower Devonian)

##### MIDDLE AND LOWER SILURIAN

53

Sandstone, shale, dolostone, siltstone

53a Guelph Fm.

53b Lockport Fm.

53c Amabel Fm.

53d Clinton Gp.; Cataract Gp.

53e Thornloe Fm.; Earleton Fm.

53f Wabi Gp.

53g Attawapiskat Fm.

53h Ekwon River Fm.

53i Severn River Fm.

## NOTE

THIS DRAWING IS APPROXIMATE ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

PROJECT

ARGYLE STREET SOUTH  
BRIDGE OVER THE GRAND RIVER IN CALEDONIA  
GWP 3805-01-00

TITLE

## REGIONAL BEDROCK GEOLOGY



PROJECT No. 021-3233			FILE No. 0213233R004	
CADD	WDF	Dec 16/03	SCALE	N.T.S. REV. 0
CHECK	AMH	Dec 16/03	FIGURE 3	

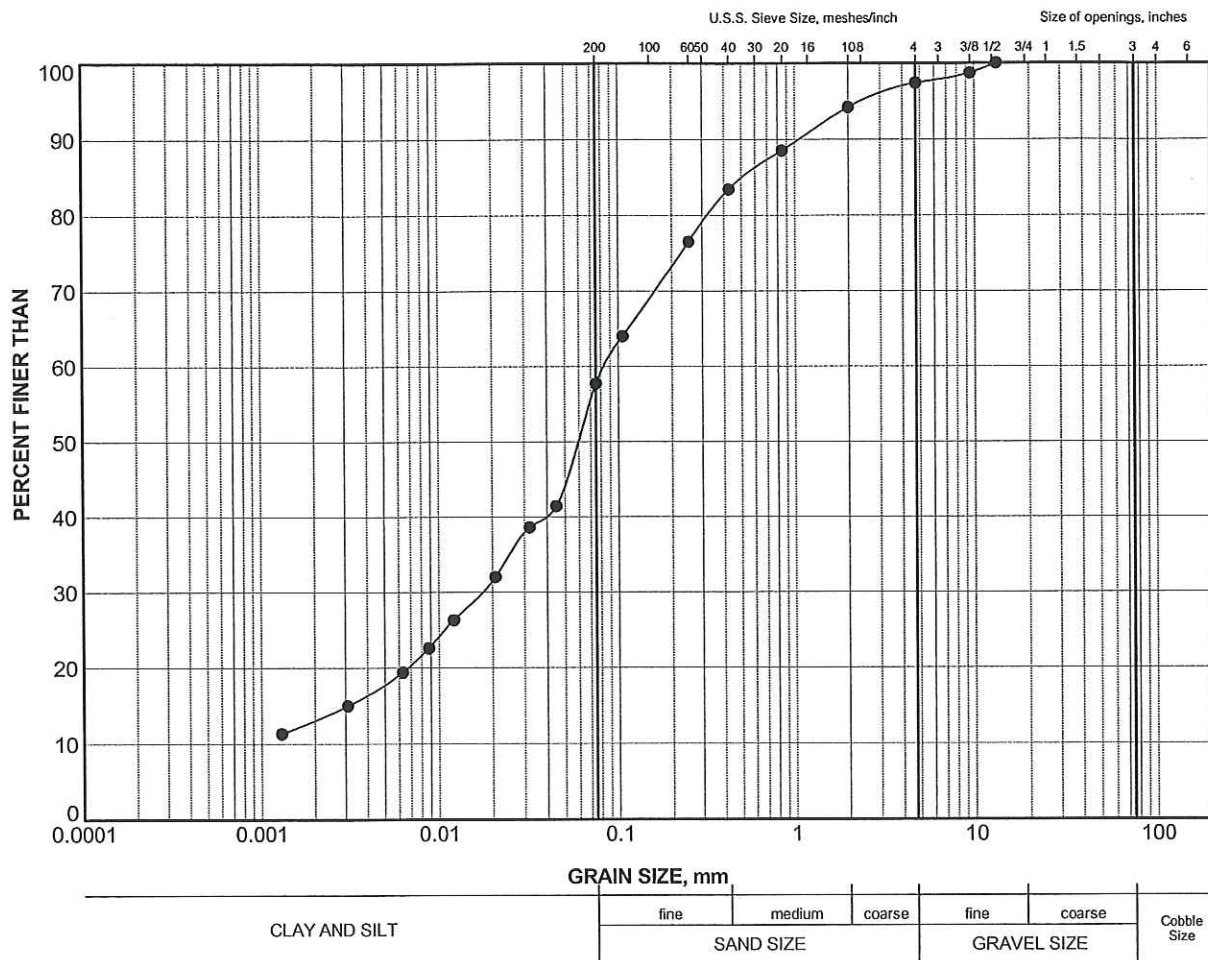


**APPENDIX A**


**LABORATORY TEST DATA**

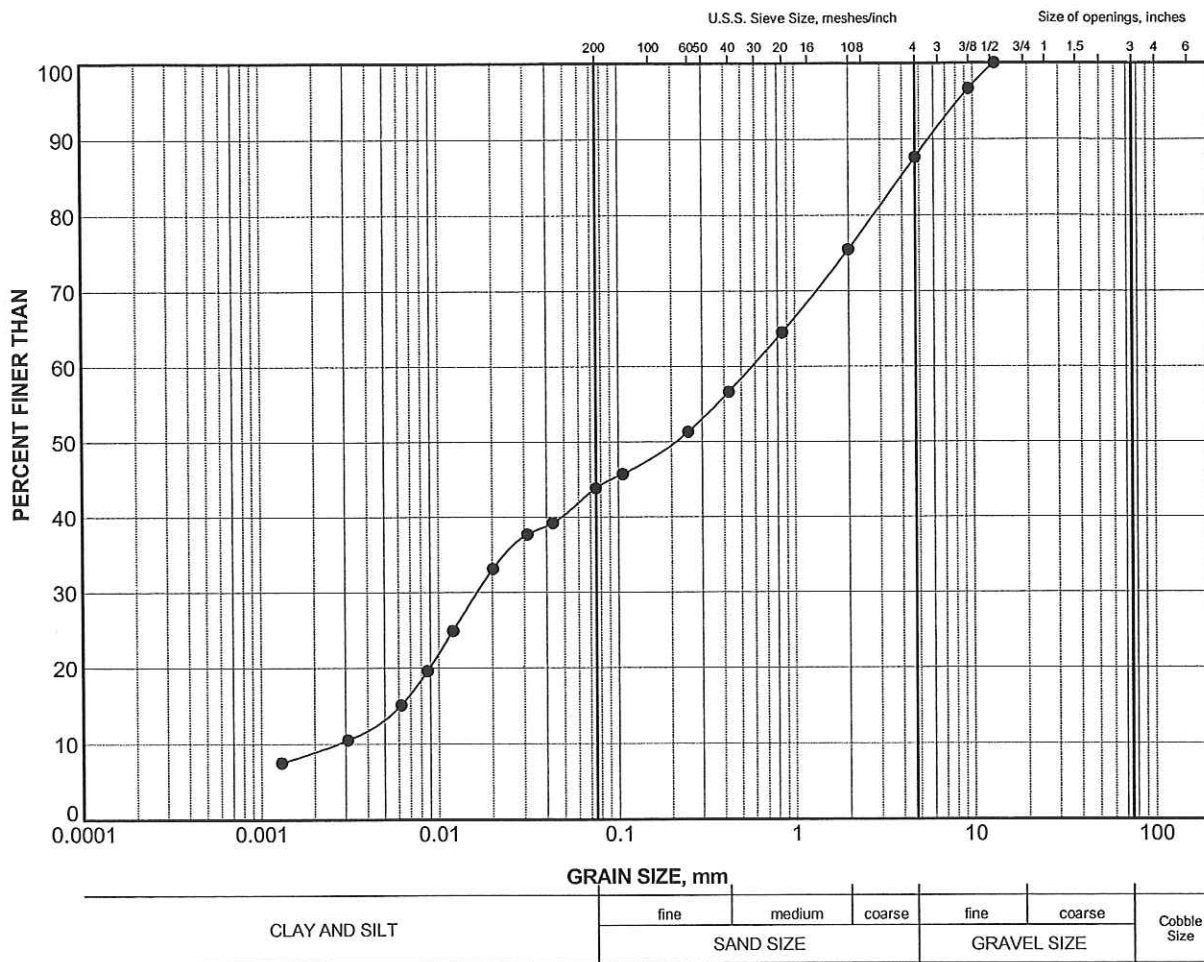
April 2004  
Revised May 2004

021-3233




LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	4	4	187.6

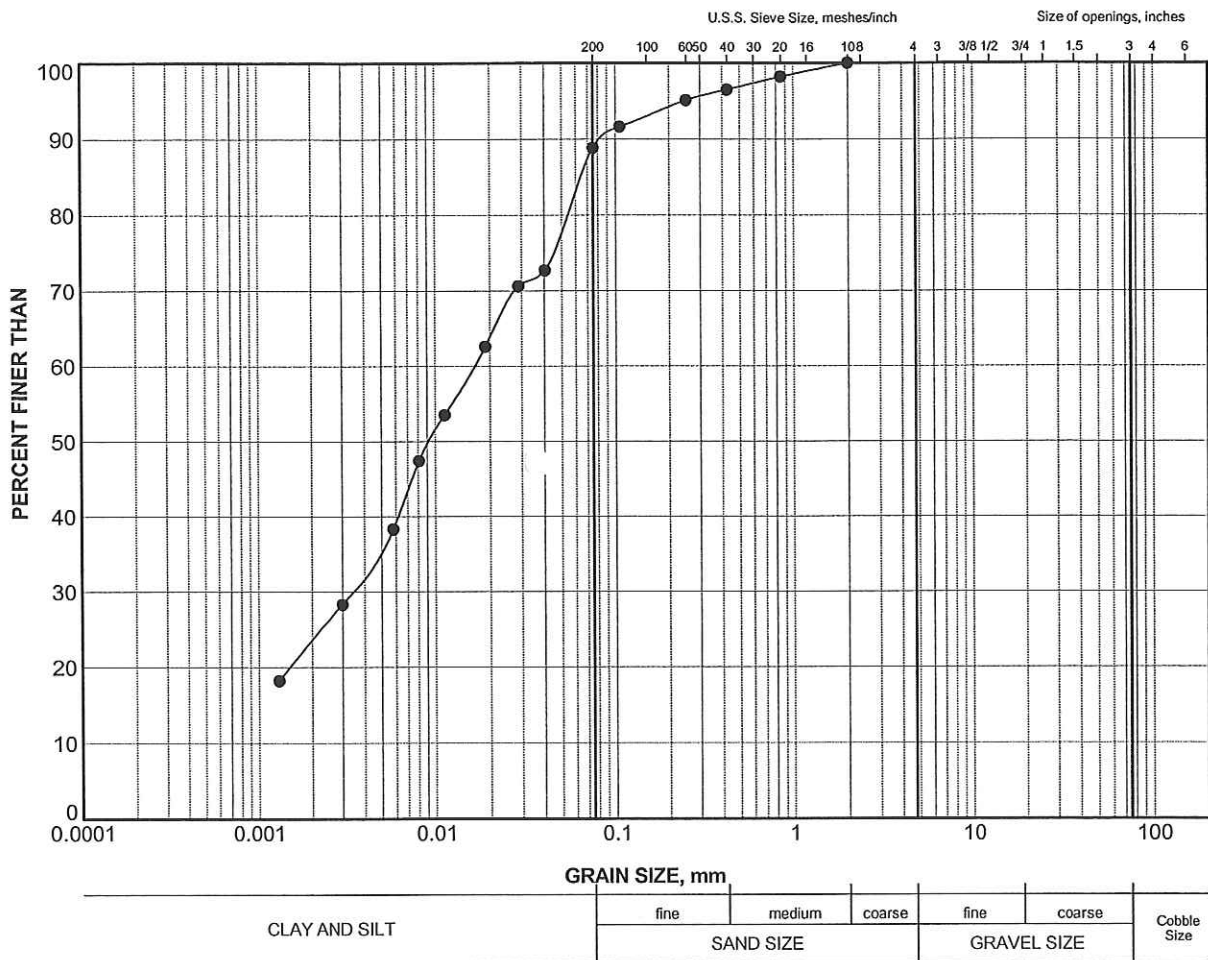
PROJECT		ARGYLE STREET SOUTH BRIDGE OVER THE GRAND RIVER IN CALEDONIA GWP 3805-01-00			
TITLE		GRAIN SIZE DISTRIBUTION FILL, sandy silt			
PROJECT No.		021-3233		FILE No. 021-3233MTO.GPJ	
DRAWN		WDF		12/12/03	
CHECK		AMH		12/12/03	
SCALE		N/A		REV.	
 <b>Golder Associates</b> LONDON, ONTARIO		<b>FIGURE A-1</b>			




LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	1	5	185.8

PROJECT		ARGYLE STREET SOUTH BRIDGE OVER THE GRAND RIVER IN CALEDONIA GWP 3805-01-00			
TITLE		GRAIN SIZE DISTRIBUTION SANDY SILT			
PROJECT No.		021-3233		FILE No. 021-3233MTO.GPJ	
DRAWN		WDF		12/12/03	
CHECK		AMH		12/12/03	
SCALE		N/A		REV.	
 <b>Golder Associates</b> LONDON, ONTARIO		<b>FIGURE A-2</b>			





LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	3	4	186.8

PROJECT				ARGYLE STREET SOUTH BRIDGE OVER THE GRAND RIVER IN CALEDONIA GWP 3805-01-00			
TITLE				GRAIN SIZE DISTRIBUTION CLAYEY SILT			
PROJECT No.		021-3233		FILE No.		021-3233MTO.GPJ	
DRAWN		WDF		SCALE		N/A	
CHECK		AMH		REV.			
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-3</b>			

## CERTIFICATE OF ANALYSIS

Attention: MR. STAN LOOMIS  
Client Name: Golder Associates Ltd. (London)  
Address: 500 Nottinghill Road  
London, ON  
N6K 3P1  
Telephone: 519-471-9600  
FAX: 519-471-4707

Laboratory Work Order: 109983

This Certificate of Analysis is for the following:

Sample Received on: 31-Oct-2003

Reported on: 4-Nov-2003

Client Reference:

Purchase Order:

Quotation No.:

The report contains the following sections:

- Section: 1. Case Narrative  
2. Analytical Results  
3. Methodology Summary  
4. Certificate of Quality Control  
5. Hold Time Report

Results for solids samples are corrected for moisture and reported as dry weight.

We are proud to be Accredited by: Standard Council of Canada (SCC) / CAEAL to ISO 17025 (#1799)  
New York State (#11730)

Water samples are discarded 4 weeks after the results have been reported. Solid samples are retained for 3 months.  
Storage for longer periods requires prior arrangement with the laboratory.

  
Reviewed and Authorized by

Darlene Hoogenes-Stastny  
Project Manager

NOTE: The enclosed results relate only to the sample or item as received by the laboratory.

This report may be reproduced in full. Reproduction of a partial report must have the written authorization of the laboratory.

CERTIFICATE OF ANALYSIS - SECTION 1

CASE NARRATIVE

Attention: MR. STAN LOOMIS  
Client Name: Golder Associates Ltd. (London)  
Address: 500 Nottingham Road  
London, ON  
N6K 3P1  
Telephone: 519-471-9600  
FAX: 519-471-4707

Laboratory Work Order: 109983

Sample(s) Received on: 31-Oct-2003

Reported on: 4-Nov-2003

Sample Shipment Receipt and Login:

Temperature on receipt was 12.6°C. The maximum allowable temperature is 10°C according to Canadian regulations or guidance documents. Samples submitted to the laboratory soon after sampling are exempt, provided that cooling has been initiated. Cooling is not required for certain situations such as: Waste for classification or specific matrices or tests such as PCB in oil.

There are no other notable comments.

Sample Analysis:

No exceptions were noted during analysis.

General Comments:

None.

PSC Analytical Services

921 Leathorne Street, London, Ontario, Canada N5Z 3M7 (519) 686-7558 1-800-268-7396 FAX: (519) 686-6374

Refer to the cover page for a list of report contents.



CERTIFICATE OF ANALYSIS - SECTION 2

ANALYTICAL RESULTS

Client: (1093) Golder Associates Ltd. (London), London

Reported: 4-Nov-2003

Page: 1 of 1

Attention: MR. STAN LOOMIS  
 Client Reference:  
 Work Order: 109983

Purchase Order:  
 Date Received: 31-Oct-2003  
 Sample Type: Liquid

Sample #	Test	Result	Units	EQL	Comment
----------	------	--------	-------	-----	---------

03-A036202 Sample Description: 021-3233 BH2

Date & Time Sampled: 31-Oct-2003

pH Value 7.58  
 Sulphate as SO4 1330

pH units 0.1  
 mg/L 2

EQL Estimated Quantitation Limit  
 Refer to the cover page for a list of report contents.

PSC Analytical Services

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CERTIFICATE OF ANALYSIS - SECTION 3

METHODOLOGY SUMMARY

Client: (1093) Golder Associates Ltd. (London), London

Reported: 4-Nov-2003

Page: 1 of 1

Attention: MR. STAN LOOMIS  
Client Reference:  
Work Order: 109983

Purchase Order:  
Date Received: 31-Oct-2003  
Sample Type: Liquid

Test	Methodology, Reference	Instrument	Analyst
pH Value	Electrometric Measurement EPA SW846 9040A	Orion pH/ISE Meter 710A	C. Lanaus
Sulphate as SO <sub>4</sub>	Automated Methyl Thymol Blue Colorimetry EPA SW846 9036	Technicon AA II - SO <sub>4</sub>	A. Ivanovic

Test procedures are based on the above references.

EXPLANATION OF CODES:

EPA - US Environmental Protection Agency  
SM - Standard Methods for the Analysis of Waters and Wastewater

MOE - Ontario Ministry of the Environment  
P\_ - Philip Analytical Services Location

PSC Analytical Services

921 Leathorne Street, London, Ontario, Canada N5Z 3M7 (519) 686-7558 1-800-268-7396 FAX (519) 686-6374

Refer to the cover page for a list of report contents.

## CERTIFICATE OF ANALYSIS - SECTION 4

## CERTIFICATE OF QUALITY CONTROL

Client: Golder Associates Ltd. (London)  
Contact: MR. STAN LOOMIS

Date Reported: 4-Nov-2003  
Work Order: 109983

Matrix: Liquid

Client Reference:

			Process Blank			Process % Recovery			Matrix Spike			Duplicate					
Parameter	EQL	Units	Result	Upper Limit		Result	Lower Limit	Upper Limit		Result	Target	Lower Limit	Upper Limit	Duplicate ID	Original Result	Duplicate Result	QC Flag
pH Value	0.1	pH units				100.12	98.0	102.0						103-A036216	8.65	8.64	
pH Value	0.1	pH units				100.50	98.0	102.0						103-A036164	7.90	7.92	
pH Value	0.1	pH units				100.75	98.0	102.0						103-A036160	7.31	7.33	
pH Value	0.1	pH units				100.75	98.0	102.0						103-A035987	8.22	8.24	
Sulphate as SO4	2	mg/L	1.	2		95.65	85.0	115.0	103-F036043	65.	60.	48.	72.	103-F036043	24.	23.	

QC Flag(s) pertain to B-Process Blank, R-Process % Recovery, S-Matrix Spike and/or D-Duplicate  
When two values exist for the same Spike ID and parameter it indicates the performance of a Matrix Spike (MS) and Matrix Spike Duplicate (MSD).  
Refer to the cover page for a list of report contents.

NA Denotes Not Applicable

Page: 1 of 1

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CERTIFICATE OF ANALYSIS - SECTION 5

HOLD TIME REPORT

ONTARIO CONTAMINATED SITES

Client: (1093) Golder Associates Ltd. (London), London

Reported: 4-Nov-2003

Page: 1 of 1

Attention: MR. STAN LOOMIS  
 Client Reference:  
 Work Order: 109983

Purchase Order:  
 Date Received: 31-Oct-2003  
 Sample Type: Liquid

Analytical Tests	Date Analyzed	Hold Time (in days)	Actual Time (in days)	Exceeded	Comment
------------------	---------------	------------------------	--------------------------	----------	---------

The OMOEE Guidance Document on Contaminated Sites (May 1996) requires all soils for organic parameters be analyzed within 60 days. No criteria is specified for inorganic tests on soils. This reference may or may not be applicable to the samples reported.

03-A036202

Sample Type: Liquid

Date Sampled: 31-Oct-2003

pH Value	1-Nov-2003	14	1
Sulphate as SO4	4-Nov-2003	30	4

When the sampling date is not supplied, the hold time is calculated from the date received.  
 Refer to the cover page for a list of report contents.

PSC Analytical Services

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**APPENDIX B**  
**PHOTOGRAPHS**

April 2004  
Revised May 2004

021-3233

## PHOTOGRAPHS



Photo 1

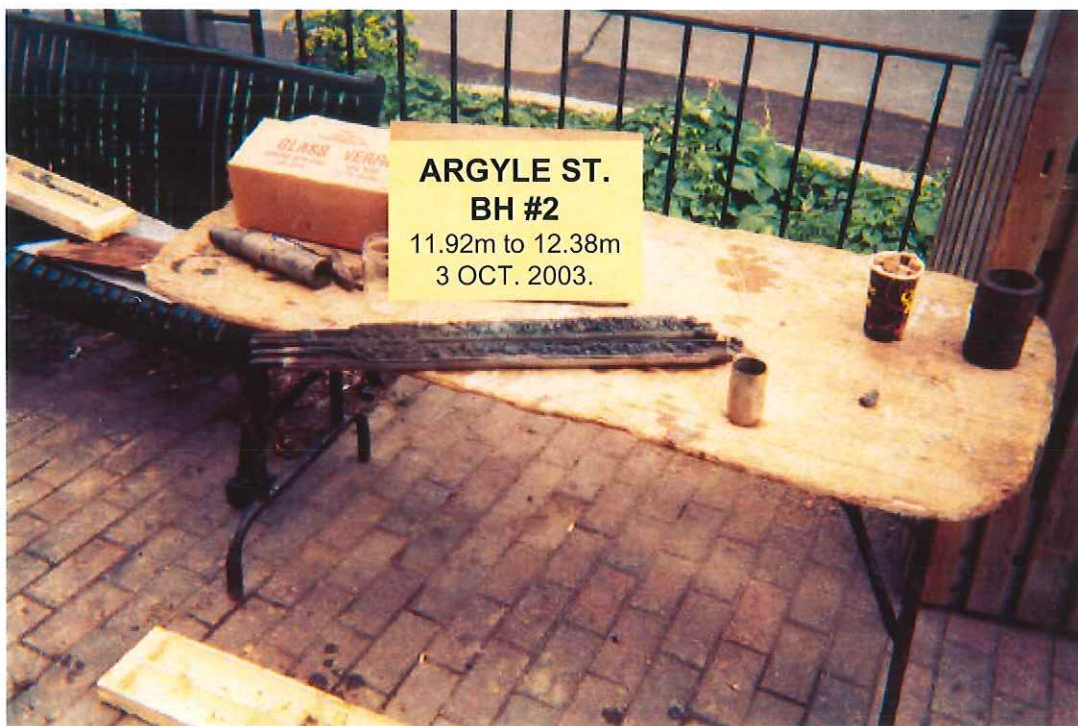


Photo 2      Borehole No. 2 – Split spoon in rock  
Elevation 178.31m to 177.85m.



## PHOTOGRAPHS

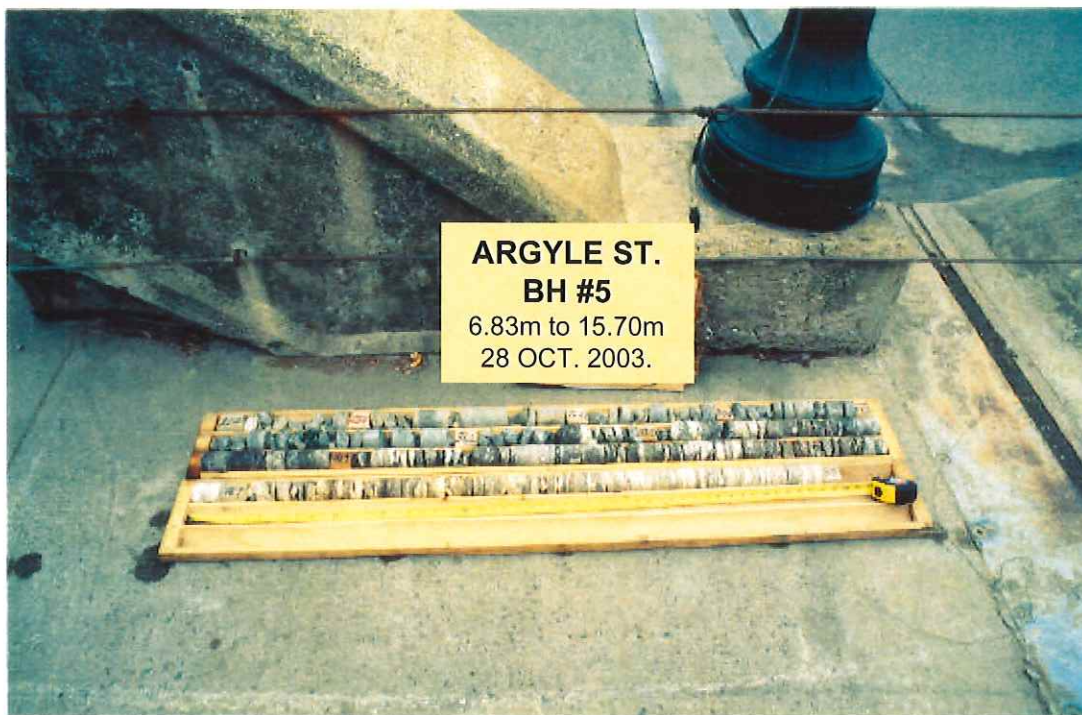


Photo 3      Borehole No. 5 – Rock core  
Elevation 184.59m to 175.72m.

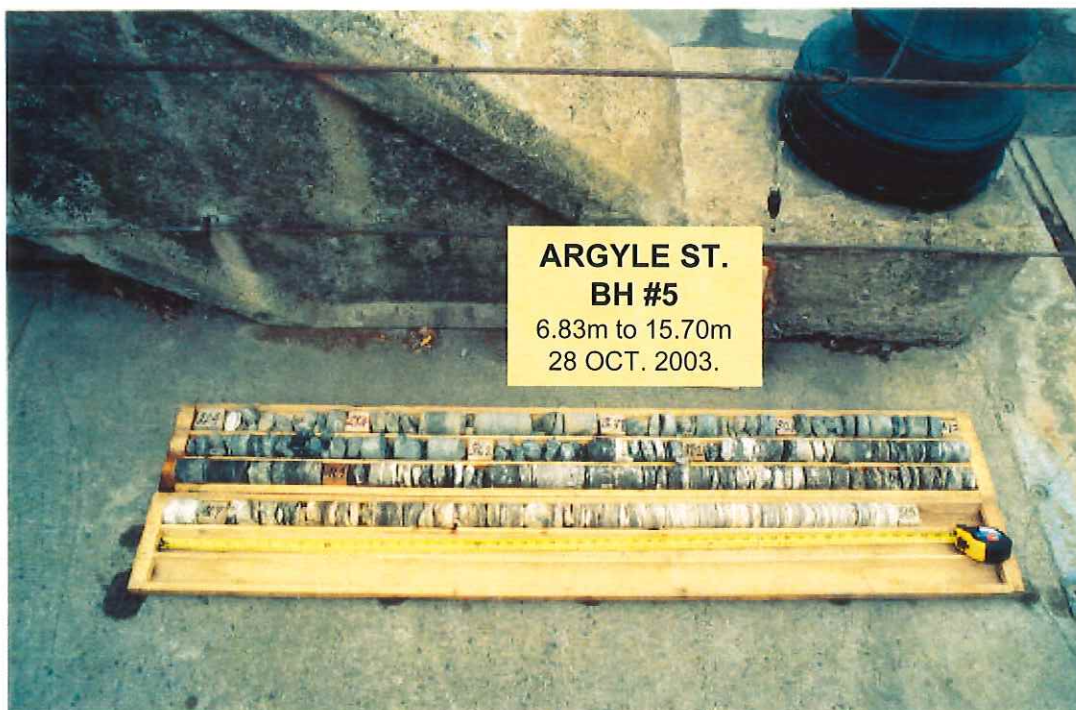


Photo 4      Borehole No. 5 – Rock core  
Elevation 184.59m to 175.72m.



# PHOTOGRAPHS



Photo 5 Borehole No. 8 – Rock core. Note concrete.  
Elevation 185.29m to 173.92m.

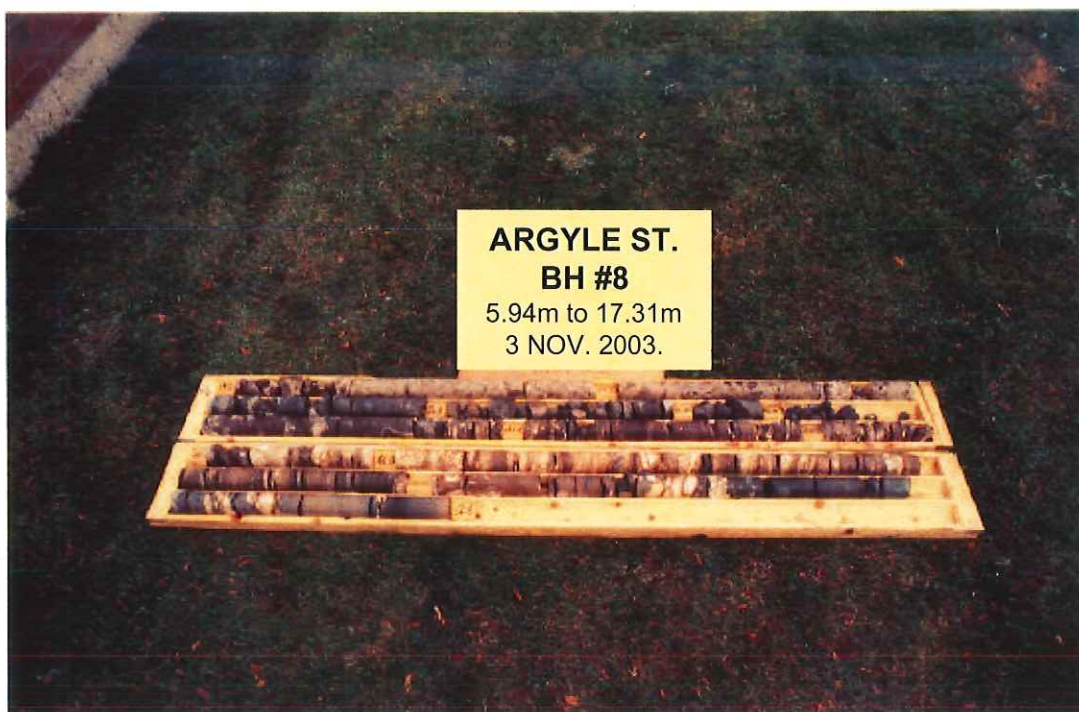


Photo 6 Borehole No. 8 – Rock core  
Elevation 185.29m to 173.92m.