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**FOUNDATION INVESTIGATION AND DESIGN REPORT  
WELLINGTON ROAD STRUCTURE REPLACEMENT  
HIGHWAY 401 FROM 1.0 KILOMETRES WEST OF HIGHWAY 402  
TO 1.0 KILOMETRES EAST OF WELLINGTON ROAD  
GWP 476-89-00, AGREEMENT NO. 3005-A-000399  
MINISTRY OF TRANSPORTATION - SOUTHWESTERN REGION**

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LIST OF ABBREVIATIONS

LIST OF SYMBOLS

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## **PART A – FOUNDATION INVESTIGATION REPORT**

**WELLINGTON ROAD STRUCTURE REPLACEMENT  
HIGHWAY 401 FROM 1.0 KILOMETRES WEST OF  
HIGHWAY 402 TO 1.0 KILOMETRES EAST OF WELLINGTON ROAD  
GWP 476-89-00, AGREEMENT NO. 3005-A-000399  
MINISTRY OF TRANSPORTATION – SOUTHWESTERN REGION**

## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder Associates) has been retained by Delcan Corporation (Delcan) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations as part of the detail design work for GWP 476-89-00. The project involves the detail design of the widening and improvements of Highway 401 including the Wellington Road interchange in London, Ontario.

This report addresses the replacement of the Wellington Road underpass structure and the provision of new ramps.

The purpose of the foundation investigation is to determine the subsurface conditions at the locations of the proposed works by drilling boreholes and carrying out in situ testing and laboratory testing on selected samples. The terms of reference for the scope of work are outlined in the MTO's Request for Proposal and in Golder Associates' proposal P41-3017-1 dated July 14, 2004. The work was carried out in accordance with our Quality Control Plan for Foundation Engineering dated September 21, 2004.

The centreline and stations of the alignment were surveyed by others prior to commencing the foundation investigation program. Delcan provided Golder Associates with preliminary drawings for this project in digital format.

## **2.0 SITE DESCRIPTION**

GWP 476-89-00 comprises the design of interchange improvements at Highway 401 and Wellington Road in London, Ontario. The location of the project is shown on the Key Plan, Figure 1.

Highway 401 is one of the most important transportation facilities in Ontario and connects major urban centres in southern Ontario with Quebec and the United States of America. In this section, Highway 401 is a Class I, controlled access, divided rural freeway. From the west project limit to Wellington Road, Highway 401 is comprised of four main lanes. From Wellington Road to the east project limit, Highway 401 is comprised of five main lanes. From Highway 402 to Wellington Road, Highway 401 is a four-lane cross section (7.50 metres per direction). From Wellington Road easterly, Highway 401 is a six-lane cross section (11.00 metres per direction) except between Station 23+519 and 23+940 where 2 eastbound lanes are present. The median is 6.6 to 7.8 metres wide and the right-of-way (ROW) is 91 metres wide.

Wellington Road within the project limits is a four lane cross section consisting of four 3.5 metre wide lanes (two in each direction) with associated speed change lanes and tapers. The median is 2.0 metres wide.

The existing Wellington Road Underpass structure (Site 19-369) is a reinforced concrete rigid frame tee-beam structure. The current deck (top of asphalt) elevation is about 269 metres and the Highway 401 pavement surface is at about elevation 262 metres.

The adjacent topography is generally flat to slightly rolling with a ground surface elevation of about 260 metres. Land use in the area is typically commercial.

### **2.1 Site Geology**

This project lies within the physiographic region of southwestern Ontario known as the Mount Elgin Ridges<sup>1</sup>. The soils generally consist of moraines of clay or silty clay with vales of alluvium consisting of gravel, sand and silt.

Based on the Ontario Department of Mines Preliminary Map P.606 entitled "Pleistocene Geology of the St. Thomas Area (East Half), Southern Ontario", the site lies between the Ingersoll and Westminster moraines. The predominant soils at the site consist of glacial tills deposited by the Erie Lobe of the St. Thomas moraine during the Late Wisconsin period of glaciation. From

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<sup>1</sup> L.J. Chapman and D.F. Putnam: The Physiography of Southern Ontario, Third Edition. Ontario Geological Survey, Special Volume 2, 1984.

Dingman Drive easterly to the east project limit, the soils consist of the Port Stanley silty clay and clayey silt, which is locally overlain by thin patches of lacustrine silts. At Dingman Creek, deposits of modern alluvium consisting of gravel, sand and silt are present. From Dingman Creek to Westminster Drive, surficial lacustrine or pond deposits of sand and silty sand predominate and are intersected by localized valley trains. West of Westminster Drive, the Port Stanley till is present and is intersected at the west project limit by the Catfish Creek silty sand till.

The underlying bedrock is reported to be limestone of the Dundee Formation of the Hamilton Group of Middle Devonian age. The bedrock surface is estimated to be some 55 metres below ground surface or at about elevation 205 metres.

### 3.0 INVESTIGATION PROCEDURES

The field work for this portion of the investigation was carried out between December 6, 2004 and February 3, 2005, during which time twenty three boreholes were drilled adjacent to the proposed structure and along the alignments of the proposed Wellington Road and interchange ramp embankment fills.

The locations of the boreholes are shown on the Borehole Location Plan, Drawing 1. The table below summarizes the borehole locations, ground surface elevations at the borehole locations and borehole depths.

<u>BOREHOLE</u>	<u>LOCATION (m)</u>		<u>GROUND SURFACE</u> <u>ELEVATION</u>	<u>BOREHOLE DEPTH</u>
	<u>Northing</u>	<u>Easting</u>	(m)	(m)
WELLINGTON ROAD STRUCTURE BOREHOLES				
1	4,754,393	409,959	261.23	14.05
2	4,754,418	409,932	261.77	20.27
3	4,754,429	409,907	261.70	20.27
4	4,754,466	409,932	262.00	21.79
5	4,754,501	409,874	260.68	14.17
6	4,754,484	409,916	260.53	17.22
7	4,754,422	409,958	261.00	17.98
8	4,754,438	409,947	260.85	17.98
9	4,754,506	409,901	260.45	17.22
10	4,754,455	409,898	261.33	20.27
APPROACH AND RAMP EMBANKMENT BOREHOLES				
11	4,754,556	409,863	259.76	9.60
12	4,754,558	409,826	260.31	8.08
13	4,754,625	409,908	259.91	5.03
14	4,754,583	409,795	262.27	6.55
15	4,754,358	409,968	261.71	9.60
16	4,754,314	409,997	261.80	6.55
17	4,754,264	410,033	261.91	5.03
18	4,754,624	409,847	262.18	5.03
19	4,754,228	409,921	262.45	5.03
20	4,754,244	409,960	263.79	6.55



<u>BOREHOLE</u>	<u>LOCATION (m)</u>		<u>GROUND SURFACE</u> <u>ELEVATION</u>	<u>BOREHOLE DEPTH</u>
	<u>Northing</u>	<u>Easting</u>	(m)	(m)
21	4,754,394	409,915	268.51	14.17
22	4,754,443	409,878	268.49	14.17
23	4,754,296	409,970	265.90	14.17

The investigation was carried out using a truck mounted CME 55 power auger and an all-terrain vehicle mounted CME 750 power auger supplied and operated by specialist drilling contractors. In the boreholes, samples of the overburden were obtained at suitable intervals of depth using 50 millimetre outside diameter split spoon sampling equipment in accordance with the standard penetration test (SPT) procedures. The boreholes were terminated between 5.0 and 21.8 metres below the existing ground surface. Groundwater conditions in the boreholes were observed throughout the drilling operations and piezometers were installed in boreholes 6 and 8. The boreholes were backfilled in accordance with current MTO procedures and Ontario Regulation 128/03.

The field work was supervised on a full-time basis by experienced 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 samples were identified in the field, placed in labeled containers and transported to our London laboratory for further examination and testing. Index and classification tests consisting of water content determinations, grain size distribution analyses and Atterberg limits determinations were carried out on selected samples. The results of the testing are shown on the Record of Borehole sheets and in Appendix A.

The as-drilled borehole locations and ground surface elevations at the borehole locations were determined by members of our staff relative to geodetic datum. The locations of the boreholes are shown on the Record of Borehole sheets and on Drawings 1, 2, 3, 4 and 5, attached.

Golder Associates carried out the preliminary foundation investigation and design for this structure. The results of the investigation and our preliminary foundation engineering recommendations were provided in Golder Associates Report No. 001-3225-1 entitled "Preliminary Foundation Investigation and Design, Proposed Wellington Road Underpass, Highway 401, Site 19-369, GWP 476-89-00" dated August 1, 2002. The results of the preliminary foundation investigation were reviewed during the preparation of this report and Records of Boreholes 1 and 2 (denoted P1 and P2 in this report) are provided in Appendix B. The table below summarizes the borehole locations, ground surface elevations at the borehole locations and borehole depths for the boreholes from the preliminary design.

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<u>BOREHOLE</u>	<u>LOCATION (m)</u>		<u>GROUND SURFACE</u> <u>ELEVATION</u>	<u>BOREHOLE DEPTH</u>
	<u>Northing</u>	<u>Easting</u>	(m)	(m)

## WELLINGTON ROAD STRUCTURE BOREHOLES – PRELIMINARY DESIGN

P1	4,754,411	409,937	261.50	20.27
P2	4,754,472	409,892	261.00	19.51

In addition, MTO's Foundation Investigation Report, Geocres No. 40I14-122 entitled "Wellington Road Underpass, WP 476-89-05, Site 19-369, Highway 401, District 2, London", dated January 18, 1994 was reviewed during the preparation of this report and the relevant Records of Boreholes are also included in Appendix B.

## **4.0 SUBSURFACE CONDITIONS**

### **4.1 Site Stratigraphy**

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the in situ testing and the laboratory testing carried out on selected samples, are given on the attached Record of Borehole sheets following the text of this report and in Appendix A. The Records of Boreholes from previous investigations are included in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous samples and observations of drilling resistance and, therefore, may represent transitions between soil types rather than exact planes of geological change. Further, the subsurface conditions will vary between and beyond the borehole locations.

In summary, the boreholes drilled at the site encountered surficial topsoil and/or fill underlain by strata of clayey silt. Layers of sands, sandy silt, silty sand and silts were also encountered.

The locations and elevations of the boreholes, together with the interpreted stratigraphic profiles, are shown on the attached Drawings 1, 2, 3, 4 and 5. A detailed description of the subsurface conditions encountered in the boreholes is provided on the Record of Borehole sheets and is summarized in the following sections.

### **4.2 Wellington Road Underpass Structure**

Boreholes 1 through 10, inclusive, and P1 and P2 were advanced at the replacement structure location.

#### **4.2.1 Topsoil**

Topsoil was encountered at ground surface in boreholes 1, 2, 6, 7, 8, 9, 10, P1 and P2. The topsoil was 0.2 to 0.7 metres thick at the borehole locations with an average thickness of about 0.4 metres.

In addition, buried topsoil was encountered beneath the fill in boreholes 1 and P1 at elevation 260.3 and 260.4 metres, respectively. The buried topsoil was 0.3 to 0.5 metres thick at the borehole locations and had N values as determined in the standard penetration test of 10 to 44 blows per 0.3 metres with water contents of 22 to 24 per cent.

#### **4.2.2 Concrete**

A 0.3 metre thick layer of concrete was encountered beneath the surficial topsoil in borehole 10.

### **4.2.3 Pavement Structure**

Boreholes 3 and 4 were advanced through the Highway 401 median shoulder pavement structure. The pavements consisted of 0.10 metres of asphalt and 0.13 to 0.15 metres of granular base.

### **4.2.4 Fill**

Fill materials were encountered beneath the surficial topsoil in boreholes 1, 2, 7, P1 and P2, beneath the pavement structure in boreholes 3 and 4, beneath the concrete in borehole 10 and at ground surface in borehole 5. The fill materials consisted of silty sand and gravel to clayey silt with varying amounts of topsoil. The fill materials were 0.1 to 2.7 metres thick at the borehole locations with an average thickness of about 1.2 metres. The fill materials had N values of 7 to 44 blows per 0.3 metres and in situ water contents of 15 to 34 per cent with an average water content of 21 per cent.

A grain size distribution curve for a sample of the fill materials obtained from the standard penetration testing is provided on Figure A-1.

### **4.2.5 Clayey Silt**

Stiff to hard clayey silt was encountered beneath the topsoil in boreholes 1, 6, 8, 9 and P1 between elevation 259.9 metres and 260.6 metres, beneath the fill in boreholes 2, 3, 4, 5, 7, 10 and P2 between elevation 258.8 metres and 260.5 metres, beneath the sand and gravel in boreholes 5 and 9 at elevation 256.3 and 253.0 metres, respectively, and at depth beneath the sands in boreholes 1, 2, 4, 8 and 10 between elevation 242.9 metres and 255.8 metres, beneath the silt in boreholes 3, 4, 5, 6, 7, 9, 10 and P1 between elevation 241.8 metres and 253.2 metres, and beneath the silty sand in boreholes 7, P1 and P2 between elevation 242.8 metres and 243.3 metres. Where fully penetrated, the clayey silt layers were 0.5 to 13.3 metres thick with an average thickness of about 6.3 metres. The clayey silt had N values of 9 to 100 blows per 0.3 metres with natural water contents of 12 to 29 per cent. The average natural water content of the clayey silt was about 17 per cent. The clayey silt had corresponding average plastic and liquid limits of 14 and 26 per cent, respectively, based on fifteen Atterberg limits determinations. The Atterberg limits data are provided on the Plasticity Chart, Figure A-7, and indicate an inorganic clayey silt of low plasticity.

Grain size distribution curves for samples of the clayey silt recovered from the standard penetration testing are provided on Figures A-2 and A-3.

#### **4.2.6 Sand and Gravel**

A 0.8 metre thick layer of dense sand and gravel was encountered beneath the clayey silt in borehole 5 at elevation 257 metres. The sand and gravel had an N value of 31 blows per 0.3 metres and a natural water content of 11 per cent.

#### **4.2.7 Sands**

Layers of loose to very dense sands were encountered beneath the clayey silt in boreholes 1, 8, 9 and 10 between elevation 253.3 and 256.2 metres, beneath the clayey silt in boreholes 5 and P1 at elevation 246.8 and 247.2 metres, respectively, beneath the silty sand in boreholes 2, 8 and P2 between elevation 244.0 and 245.9 metres, beneath the sandy silt in borehole 7 at elevation 245.0 metres and beneath the silt in borehole 4 at elevation 247.4 metres. Borehole 5 was terminated in the sands after exploring them for 0.3 metres. Where fully penetrated, the sand layers were 0.3 to 3.4 metres thick. The sands had N values of 5 to greater than 100 blows per 0.3 metres and natural water contents of 17 to 26 per cent with an average water content of 22 per cent.

A grain size distribution curve for a sample of the sand recovered from the standard penetration testing is provided on Figure A-4.

#### **4.2.8 Silts**

Layers of loose to very dense silts were encountered beneath the clayey silt in boreholes 1, 2, 4, 5, 6, 7, 8, 9 and P1 between elevations 242.3 and 254.7 metres, beneath the silty sand in boreholes 9 and 10 at elevations 244.3 and 243.7 metres, respectively, beneath the sandy silt in boreholes 3 and 6 at elevation 244.5 and 244.2 metres, respectively, and beneath the sand in borehole 8 at elevation 243.5 metres. Borehole 8 was terminated in the silts after exploring them for 0.6 metres. Where fully penetrated, the silt layers were 0.4 to 3.5 metres thick. The silts had N values of 9 to greater than 100 blows per 0.3 metres and natural water contents of 13 to 25 per cent with an average water content of 20 per cent.

A grain size distribution curve for a sample of the silt recovered from the standard penetration testing is provided on Figure A-5.

#### **4.2.9 Silty Sand and Sandy Silt**

Dense to very dense silty sand and/or sandy silt was encountered beneath clayey silt in boreholes 3, 10 and P2 between elevations 246.2 and 247.1 metres, beneath the sands in boreholes 7, P1 and P2 between elevations 243.8 and 246.1 metres and beneath the silts in boreholes 1, 2, 6, 7, 8 and 9 between elevations 245.8 and 248.4 metres. Borehole 1 was terminated in a layer of sandy silt

after exploring it for 1.3 metres. Where fully penetrated, the sandy silt and silty sand layers were 0.5 to 3.0 metres thick. The sandy silt and silty sand had N values of 49 to greater than 100 blows per 0.3 metres and natural water contents of 13 to 20 per cent.

Grain size distribution curves for samples of the sandy silt and silty sand recovered from the standard penetration testing are provided on Figure A-6.

### 4.3 Interchange Embankment Fills

Boreholes 11 to 23, inclusive were advanced in the areas of both the new and existing approach ramp embankments.

#### 4.3.1 Topsoil

Topsoil was encountered at ground surface in boreholes 11 to 17. The topsoil was 0.2 to 0.4 metres thick at the borehole locations.

Buried topsoil was encountered beneath the fill in borehole 14 at elevation 259.0 metres, within the fill in borehole 15 at elevation 260.0 metres, beneath the fill in borehole 18 at elevation 260.4 metres and beneath the fill in borehole 22 at elevation 260.57 metres. The buried topsoil was 0.3 to 0.6 metres thick at the borehole locations. The buried topsoil had N values of 8 to 20 blows per 0.3 metres and water contents of 31 to 34 per cent.

#### 4.3.2 Pavement Structure

The existing W-N ramp shoulder structure was encountered at ground surface in borehole 18 and consisted of 0.34 metres of granular base and 0.39 metres of granular subbase.

The Wellington Road and existing N-E ramp pavement structures were encountered at ground surface in boreholes 19 to 23. A summary of the pavement component thicknesses are summarized below:

<u>BOREHOLE</u>	<u>PAVEMENT COMPONENT THICKNESS (m)</u>		
	<u>ASPHALT</u>	<u>CONCRETE</u>	<u>GRANULAR BASE</u>
19	0.15	-	0.31
20	0.15	-	0.31
21	0.10	0.10	0.41
22	0.10	0.10	0.41
23	0.20	-	0.30

### **4.3.3 Fill**

Fill materials were encountered beneath the surficial topsoil in boreholes 12 to 17, inclusive, and beneath the pavement structure in boreholes 18 to 23, inclusive. The fill materials were encountered between elevation 259.7 and 267.9 metres. The fill materials generally consisted of clayey silt with varying amounts of topsoil or silty sand and gravel. Cobble sized particles were encountered in the sand and gravel fill materials. In addition, a 0.25 metre thick layer of concrete was encountered within the fill in borehole 17 at elevation 261.2 metres. The fill materials were from 0.4 to 9.5 metres thick at the borehole locations with an average thickness of about 3.3 metres. The fill materials had N values of 6 to greater than 100 blows per 0.3 metres and in situ water contents of 3 to 33 per cent with an average water content of 14 per cent.

Grain size distribution curves for samples of the fill materials recovered from the standard penetration testing are provided on Figure A-8.

### **4.3.4 Clayey Silt**

Stiff to hard clayey silt was encountered beneath the surficial topsoil in borehole 11 at elevation 259.4 metres, beneath the fill in boreholes 12, 13, 15, 16, 17, 19, 20, 21 and 23, between elevation 257.8 metres and 261.1 metres, beneath the buried topsoil in boreholes 14 and 22 at elevation 258.6 metres and 256.9 metres, respectively, beneath the sand layers in borehole 12 at elevation 256.2 metres and 253.6 metres, and beneath the sandy silt and silty sand in boreholes 14 and 18 at elevation 255.9 metres and 259.3 metres, respectively. Boreholes 11, 13, 14, 15, 16, 17, 18, 19, 20, 21 and 23 were terminated in clayey silt after exploring it for 0.2 to 9.2 metres. Where fully penetrated in boreholes 12, 14 and 22, the clayey silt was 0.8 to 4.6 metres thick with an average thickness of about 2.3 metres. The clayey silt had N values of 9 to 78 blows per 0.3 metres with natural water contents of 12 to 25 per cent. The average water content of the clayey silt was about 17 per cent. The clayey silt had corresponding average plastic and liquid limits of 15 and 27 per cent, respectively, based on fourteen Atterberg limits determinations. The Atterberg limits data are provided on the Plasticity Chart, Figure A-13 and indicate an inorganic clayey silt of low plasticity.

Grain size distribution curves for samples of the clayey silt recovered from the standard penetration testing are provided on Figures A-9 and A-10.

### **4.3.5 Sands**

Layers of compact to very dense sands were encountered beneath and interlayered with the clayey silt in borehole 12 at elevations 252.8, 254.8 and 257.1 metres. Borehole 12 was terminated in the lower sand layer after exploring it for 0.6 metres. The sand layers were 0.9 to 1.2 metres

thick, where fully penetrated. The sands had N values of 12 to 52 blows per 0.3 metres and natural water contents of 14 to 26 per cent with an average water content of 21 per cent. A grain size distribution curve for a sample of the sand is shown on Figure A-11.

#### 4.3.6 Silty Sand and Sandy Silt

Layers of compact silty sand and sandy silt were encountered beneath the clayey silt in borehole 14 at elevation 256.3 metres and beneath the buried topsoil in borehole 18 at elevation 260.1 metres. These layers were 0.4 to 0.8 metres thick and had N values of 11 to 24 blows per 0.3 metres with natural water contents of 16 to 20 per cent.

A grain size distribution curve for a sample of the sandy silt recovered from the standard penetration testing is provided on Figure A-12.

#### 4.3.7 Silt

Beneath the clayey silt, borehole 22 encountered and was terminated in a layer of dense silt. The silt was encountered at elevation 255.4 metres and was explored for 1.1 metres prior to terminating the borehole. The silt had an N value of 44 blows per 0.3 metres and a natural water content of 20 per cent.

### 4.4 Groundwater Conditions

Groundwater conditions were observed during and on completion of drilling and sampling and piezometers were installed in boreholes 6 and 8 prior to backfilling. Details of the groundwater conditions encountered and subsequently measured in the installations are provided on the Record of Borehole sheets and are summarized below.

BOREHOLE	GROUND SURFACE ELEVATION	ENCOUNTERED GROUNDWATER LEVEL		INSTALLATION	MEASURED GROUNDWATER LEVEL					
		Depth	Elevation		September 29, 2001		December 1&3, 2004		December 16, 2004	
					Depth	Elevation	Depth	Elevation	Depth	Elevation
	(m)	(m)	(m)		(m)	(m)	(m)	(m)	(m)	(m)
1	261.23	7.92	253.31							
		12.40	248.83							
2	261.77	12.65	249.12							
3	261.70	2.29	259.41							
4	262.00	2.29	259.71							
5	260.68	3.66	257.02							
		13.87	246.81							
6	260.53	11.89	248.64	Shallow			0.61	259.92		
				Deep			1.83	258.70		
7	261.00	10.52	250.48							



BOREHOLE	GROUND SURFACE ELEVATION	ENCOUNTERED GROUNDWATER LEVEL		INSTALLATION	MEASURED GROUNDWATER LEVEL					
		Depth	Elevation		September 29, 2001		December 1&3, 2004		December 16, 2004	
					Depth	Elevation	Depth	Elevation	Depth	Elevation
	(m)	(m)	(m)		(m)	(m)	(m)	(m)	(m)	(m)
8	260.85	13.11	247.74	Shallow					3.86	256.99
		5.18	255.67	Deep					2.01	258.84
9	260.45	6.86	253.59							
10	261.33	5.33	256.00							
11	259.76		dry							
12	260.31	3.20	257.11							
		5.49	254.82							
		7.47	252.84							
13	259.91		dry							
14	262.27		dry							
15	261.71		dry							
16	261.80		dry							
17	261.91		dry							
18	262.18		dry							
19	262.45		dry							
20	263.79		dry							
21	268.51		dry							
22	268.49	13.72	254.77							
23	265.90		dry							
P1	261.50	14.17	247.33	Shallow	4.14	257.36	2.84	258.66		
				Deep	3.34	258.16	0.48	261.02		
P2	261.00	13.72	247.28	Shallow	1.68	259.32	0.86	260.14		
				Deep	2.84	258.16	2.34	258.66		

Groundwater was encountered at depths of 2.3 to 13.9 metres below ground surface or between elevation 246.8 and 259.7 metres. Boreholes 11, 13 through 18, 19 through 21 and 23 remained dry during drilling.

The installations in boreholes 6, 8, P1 and P2 were completed within the sands, silts and silty sands beneath the clayey silt and clayey silt with shallow piezometers installed above the deeper installations. The groundwater levels measured in the deep piezometers were 0.5 to 2.3 metres below ground surface or between elevation 258.2 and 258.8 metres. The groundwater levels measured in the shallow piezometers were 0.6 to 4.1 metres below ground surface or between elevations 257.0 and 260.1 metres.

The groundwater levels are expected to fluctuate seasonally and are expected to be higher during periods of sustained precipitation or during spring melt conditions.

## **5.0 MISCELLANEOUS**

The investigation was carried out using equipment supplied and operated by Lantech Drilling Services Inc. and Aardvark Drilling Inc., both of which are Ontario Ministry of Environment licensed well contractors. The field operations were supervised by Mr. Michael Arthur and Mr. Robert Cotnam under the direction of Mr. David J. Mitchell. The laboratory testing was carried out at Golder Associates' London laboratory under the direction of Mr. Chris M. Sewell. The laboratory is an accredited participant in the MTO Soil and Aggregate Proficiency Program and is certified by the Canadian Council of Independent Laboratories for testing Types C and D aggregates. This report was prepared by Mr. Michael E. Beadle, P. Eng. under the direction of the Project Manager, Mr. Philip R. Bedell, P. Eng. This report was reviewed by Mr. Fintan J. Heffernan, P. Eng., the Designated MTO Contact and Quality Control Auditor for this assignment.

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## **PART B – FOUNDATION DESIGN REPORT**

**WELLINGTON ROAD STRUCTURE REPLACEMENT  
HIGHWAY 401 FROM 1.0 KILOMETRES WEST OF  
HIGHWAY 402 TO 1.0 KILOMETRES EAST OF WELLINGTON ROAD  
GWP 476-89-00, AGREEMENT NO. 3005-A-000399  
MINISTRY OF TRANSPORTATION – SOUTHWESTERN REGION**

## **6.0 ENGINEERING RECOMMENDATIONS**

### **6.1 General**

This section of the report provides our recommendations on the foundation aspects of the design of the proposed replacement of the Wellington Road structure over Highway 401 and the related new 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 methods and scheduling.

It is understood that the existing reinforced concrete, rigid frame structure will be demolished and a new four span CPCI concrete girder bridge will be constructed immediately east of the existing bridge. The elevation of the Highway 401 pavement surface under the centre of the existing structure is at elevation 262 metres and the proposed new pavement surface at the centre of the replacement structure is elevation 270.45 metres.

New embankments up to 8.5 metres in height will be required for the realigned Wellington Road and new interchange ramps.

### **6.2 Replacement Bridge Foundations**

The subsoils encountered in the boreholes put down during the investigation typically consist of surficial topsoil and/or fill underlain by clayey silt. Layers of sands, silty sand, sandy silts and silts were also encountered. The groundwater level was measured between about elevations 257 and 260 metres.

Based on the understanding that the proposed structure is to be built using integral abutments with piers on spread footings and the subsurface information noted above, consideration may be given to supporting the new abutments on steel piles driven into the dense to very dense silts and sandy silts at about elevation 246 metres. The piles would be driven through the new and/or existing embankment fill and clayey silt.

The piers could be supported either on shallow spread footing foundations or on deep piled foundations.

### **6.2.1 Deep Foundations**

It is understood that consideration is being given to designing the replacement structure with integral abutments. Driven HP 310 x 110 steel H-piles to about elevation 246 metres are considered suitable for the abutment support. Similarly, H-piles driven to about elevation 246 metres could also be used to support the central piers. In the case of integral abutments, augering and placement of a corrugated steel pipe (CSP) liner around the upper 3 metres of the pile is required.

#### Geotechnical Axial Resistance – Driven Steel H-Piles

For design, the factored axial geotechnical resistance at Ultimate Limit States (ULS) for HP 310 x 110 piles driven into the dense to very dense silts and sandy silts at about elevation 246 metres may be taken as 1,200 kilonewtons (kN) per pile. The geotechnical resistance at SLS will depend on pile configuration; however, a value of 900 kN per pile may be assumed.

Care will be required during pile driving to ensure that the piles are not overdriven into the lower clayey silt deposit. Based on the boreholes, the piles at the north and south abutments should be driven to elevation 246 metres. However, in accordance with Special Provision 903S01, provision should be made to re-tap the piles to confirm the set after adjacent piles have been driven.

The pile driving note to be added to the drawing is:

"Piles to be driven in accordance with Standard SS 103-11 using an ultimate capacity of 3,000 kN per pile but must be driven below elevation 247 metres and not below elevation 244 metres without approval of the Engineer."

Should the piers be founded on deep foundations, HP 310 x 110 steel H piles driven to elevation 246 metres may be designed using the above values. Alternatively, 300 millimetre diameter tube piles driven closed-ended into the very dense sands and silty sands may be utilized. The tube piles may be designed with a factored axial geotechnical resistance at ULS of 1,300 kN and the geotechnical resistance at SLS may be taken as 1,000 kN.

#### Downdrag Load (Negative Skin Friction)

The new approach embankments will cause consolidation settlement of the underlying thick clayey silt deposits as a result of increased vertical grades. The consolidation settlement is time-dependent and will not completely occur during the construction period. Post-construction settlement of the clayey silt deposits will take place and settlement of the clayey materials relative to the piles will result in the development of negative skin friction acting on the piles. Therefore,

negative skin friction or downdrag loads will need to be taken into account during design of the piles supporting the abutments.

The magnitude of the downdrag load acting on a pile is a function of the adhesion (skin friction) that develops between the pile and the clay, and the surface area of the pile within the clay deposit. The unit negative skin friction acting on a unit area along a single pile can be calculated using the following equation:

$$f_{ns} = \beta \sigma'_v$$

where  $f_{ns}$  = unit negative skin friction  
 $\beta$  = shaft resistance factor = 0.25  
 $\sigma'_v$  = Effective vertical (overburden) pressure

For this site  $\sigma'_v$  Can be calculated (approximately) for design purposes as  $\sigma'_v = \gamma' z$

where  $\gamma'$  = buoyant unit weight of soil (assume 9 kN/m<sup>3</sup>)  
 $z$  = depth below final road surface (m)

The total downdrag load is a function of the surface area of the pile within the cohesive soil. The load calculated in this manner is a nominal (unfactored) load. The structural engineer needs to multiply this load by a load factor of 1.25, as defined in the CHBDC, and include it as part of the load effects acting on the pile as described in the CHBDC. Based on the results of the investigation, the unfactored downdrag load acting on the piles may be taken as 250 kilonewtons per pile.

### Resistance to Lateral Loads

The lateral loading could be resisted fully or partially by the use of battered piles. In the case of integral abutments, 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 ranges in subgrade reaction coefficient where:

$$k_s = \begin{aligned} &\text{coefficient of horizontal subgrade reaction (MPa/m)} \\ &= n_h (z/d) \quad \text{for cohesionless soils} \\ &= \frac{k_{si}}{5d} \quad \text{for cohesive soils} \end{aligned}$$

$d$  = pile width or diameter (m)

$n_h, k_{si}$  = constant of horizontal subgrade reaction (MPa/m)

$z$  = depth below ground surface grade (m)

Dense to very dense sand and gravel (embankment fill)	$n_h = 7$ to 14
Stiff to hard clayey silt (above elevation 247 metres)	$k_{si} = 15$ to 35
Dense to very dense silts and sandy silts (below elevation 247 metres)	$n_h = 10$ to 15

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 horizontal subgrade reaction in the direction of loading by a reduction factor  $R$  as follows:

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

#### Frost Protection

The pile caps should be provided with a minimum of 1.2 metres of soil cover for frost protection.

### **6.2.2 Shallow Foundations**

Based on the results of the investigation, the new bridge piers may be founded on spread footings bearing on the very stiff to hard clayey silt at between elevation 258.5 metres and 260.0 metres. It should be noted that perched water in the fill materials was noted in some of the boreholes. Pumping from properly constructed and filtered sumps in the base of the excavation may be required to control seepage.

#### Geotechnical Resistance

For the configuration of the bridge as shown on the General Arrangement drawing, and based on the results of this investigation, the founding level for spread footings on the very stiff to hard clayey silt would be at or below:

South Pier - elevation 260.0 metres  
 Central Pier - elevation 258.5 metres  
 North Pier - elevation 259.0 metres

The geotechnical resistances for 3 metre wide spread footings are given in the table below.

<b><i>Founding Option</i></b>	<b><i>Factored Geotechnical Resistance</i></b>	<b><i>Geotechnical Resistance</i></b>
	<b><i>ULS</i></b>	<b><i>SLS</i></b>
Spread footings on very stiff to hard clayey silt	450 kPa	300 kPa

This founding levels for the pier footing are as much as 3.5 metres below ground or pavement surface.

The above geotechnical resistances assume, however, that appropriate construction procedures are adopted during footing construction to ensure that the founding soils are not softened/disturbed prior to concrete placement.

In addition, the abutments could also be founded on shallow spread footings perched in the embankments on a compacted Granular A pad. Abutment footings constructed in this manner may be designed using a factored geotechnical resistance at ULS of 900 kilopascals (kPa) and a geotechnical resistance at SLS of 350 kPa. The Granular A pad should extend into the very stiff clayey silt.

#### Resistance to Lateral Forces

Resistance to lateral forces/sliding between the concrete spread footings and the subsoil should be calculated in accordance with Section 6-8.4.3 of the Canadian Highway Bridge Design Code (CHBDC). Assuming that the founding soils are not loosened/disturbed during excavation and footing construction, the following angle of friction between the concrete and the founding soils and corresponding unfactored coefficient of friction,  $\tan \delta$ , may be used:

Footings on clayey silt	angle of friction	29°
	$\tan \delta$	0.55

#### Frost Protection

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

#### Construction Considerations

The founding soils are sensitive to disturbance and loosening due to water seepage and/or ponding. Placement of a working slab will be required at the base of excavation for the footing area. Exposure without protection of the working slab may result in loosening of the founding



soils. The cleaned excavation base should be inspected by qualified geotechnical personnel prior to placing the working slab. It is recommended that the footing excavation be carried out such that the final 0.5 metres of excavation is completed with the geotechnical personnel on site and the working slab be placed immediately after footing inspection.

### 6.3 Retained Soil Systems

It is understood that mechanically-reinforced soil retaining wall systems (Retained Soil System or RSS wall) may be used at the abutments. RSS walls typically consist of granular fill placed and compacted in layers and reinforced with metal or fabric strips or grids. A facing material, typically pre-cast concrete panels mechanically fastened to the reinforcing strips or grids, is used to form the face of the reinforced soil structure and to prevent the loss of fill material. These reinforced earth fills will be in the order of 8 metres high. The areas of proposed filling should be prepared by removing all topsoil and deleterious materials and proofrolling the exposed subgrade to delineate soft spots and the like.

The use of RSS walls is considered appropriate for retaining walls or wing walls founded on the very stiff to hard clayey silt. The RSS walls should be founded at about elevation 259 metres on the very stiff to hard clayey silt. The excavations for the wall facing should be backfilled with compacted Granular A to underside of footing elevation. Assuming that the RSS wall acts as a unit and utilizes the full width of the reinforced soil mass, which is generally taken as 0.7 times the height of the wall, the following factored geotechnical resistances at ULS may be used for design of RSS walls founded on a properly prepared sand and gravel subgrade:

<i>Wall Height</i>	<i>Assumed Wall Width</i>	<i>Assumed Footing Width</i>	<i>Factored Geotechnical Resistance at ULS</i>
8 metres	5.5 metres	1 metre	300 kPa at north abutment 200 kPa at south abutment

The geotechnical resistance at SLS, for 25 millimetres of settlement, may be taken as 200 kPa at the north abutment and 135 kPa at the south abutment.

The resistance to lateral forces/sliding resistance between the compacted granular fill (assumed to be Granular A) and the subgrade soils should be calculated in accordance with Section 6.7.5 of the CHBDC. The unfactored coefficient of friction,  $\tan \delta$ , may be taken as 0.6 between the compacted Granular A at the concrete footing. In accordance with the CHBDC, a factor of 0.8 is to be applied in calculating the factored horizontal resistance.

The internal stability of the mechanically-reinforced soil walls should be checked by the RSS supplier/designer. The Factor of Safety related to global stability under static loading for properly designed and constructed RSS walls at this site is greater than 1.3.

The design and construction of the RSS walls should be carried out in accordance with the manufacturer's design recommendations.

#### 6.4 Lateral Earth Pressures

The lateral pressures acting on the 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 but with less than 5 per cent passing the 200 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 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 1.4 metres behind the back of the stem (Case i from Commentary on CHBDC Figure C6.9.1(l)) 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(l)).
- 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</u> (Type III)
Soil unit weight:	22 kN/m <sup>3</sup>	21 kN/m <sup>3</sup>

	<u>GRANULAR A</u>	<u>GRANULAR B (Type III)</u>
Coefficients of lateral earth pressure:		
Active, $K_a$	0.27	0.31
At rest, $K_o$	0.43	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.

## 6.5 Embankments

It is understood that the embankment fills will be raised to as much as 8.5 metres in height in conjunction with the construction of the proposed replacement bridge. The fill materials are to consist of well compacted on site borrow materials. 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 available for embankments constructed with the native materials founded on the very stiff to hard clayey silt subgrade soils at the site.

The topsoil fill 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 under the direction of qualified geotechnical personnel.

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 and compacted in regular lifts with loose thickness not exceeding 300 millimetres. Where existing embankments are widened, the new fill should be benched into the existing fill in accordance with OPSD 208.010. Also, any embankments in excess of 8 metres in height should be provided with a 2 metre wide bench at mid-height.

### 6.5.1 Settlement

Settlement analyses were carried out for the approach embankments based on the borehole data obtained during the investigation. The following parameters were used in analysis:

<u>SOIL UNIT</u>	<u>RECOMPRESSION INDEX, <math>C_r</math></u>	<u>INITIAL VOID RATIO, <math>e_0</math></u>
Clayey Silt	0.015	0.55

The embankment fill loads were modelled as an infinitely long embankment having the cross-sectional dimensions of the proposed fills.

#### Wellington Road

Based on the results of the analyses, it is estimated that some 100 millimetres of total settlement of the completed embankments will occur under the maximum fill height. Further, it is estimated that 50 per cent of this settlement will occur in the first year and that 90 per cent of this settlement will occur after about five years. It is recommended that the embankment construction and widening be carried out as soon as possible in advance of bridge construction to allow some of this settlement to take place.

#### Interchange Ramps

Based on the information provided, the E-N/S and S-W ramps will tie into the Wellington Road embankments. At their highest, these embankments will be some 6 to 7 metres high. Total settlements of 60 to 70 millimetres may be expected for these embankments.

## 6.6 Excavations and Temporary Cut Slopes

Excavations for footing construction at the pier locations will extend primarily through fill materials and clayey silt. The base of the spread footing excavations would be below the groundwater level as measured in the standpipes and piezometers. The groundwater level is expected to fluctuate and the depth of excavation below the groundwater will depend on the time of year of construction. Temporary open cut slopes within the fill materials should be maintained no steeper than 1 horizontal to 1 vertical.

Water seepage into the excavations at the pier locations should be expected and will be heavier during periods of sustained precipitation. Groundwater was encountered at elevation 259.4 to 259.7 metres in December 2004.

The consideration with respect to protection of the founding soils, however, as given in Section 6.2.2 under the heading Construction Considerations must be recognized. Sumps should be maintained outside of the actual footing limits. Surface water runoff should be directed away from the excavations at all times. The appropriate Non Standard Special Provision (NSSP) should be included in the contract documents.

Where space is restricted and will not permit open cuts, a temporary roadway protection 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 H-piles would be driven to a suitable depth and horizontal lagging installed as the excavation proceeds or driven steel sheet piling. Support to the system could be in the form of struts and walers in the case of footing excavations or rakers and anchors in the case of roadway protection.

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.

The temporary excavation support system should be designed and constructed in accordance with MTO's Special Provision 539S01. The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in SP 539S01.

The support systems may be designed using the following parameters:

<u>SOIL TYPE</u>	<u>COEFFICIENT OF EARTH PRESSURE</u>			<u>INTERNAL ANGLE OF FRICTION</u> (degrees)	<u>UNIT WEIGHT</u> (mg/m <sup>3</sup> )
	<u>Active, <math>K_a</math></u>	<u>At Rest, <math>K_0</math></u>	<u>Passive, <math>K_p</math></u>		
Clayey Fill	0.41	0.58	2.5	25	2.0
Granular Fill	0.38	0.55	2.7	27	2.1
Clayey Silt	0.33	0.50	3.0	30	2.0

The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficients should be adjusted accordingly.

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 fill materials at this site would be classified as Type 3 soils as would any cohesionless materials below the groundwater level. The native clayey materials, properly dewatered cohesionless materials, and glacial tills would be classified as Type 2 soils.

## **7.0 MISCELLANEOUS**

This report was prepared by Mr. Michael E. Beadle, P.Eng. under the direction of the Project Manager, Mr. Philip R. Bedell, P. Eng. This report was reviewed by Mr. Fintan J. Heffernan, P.Eng., the Designated MTO Contact and Quality Control Auditor for this assignment.

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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.) split spoon sampler for a distance of 300 mm (12 in.)

#### Consistency

	<u>kPa</u>	<u>psf</u>
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
$w_p$	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
$SO_4$	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

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

## LIST OF SYMBOLS

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

### I. General

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

### II. STRESS AND STRAIN

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

### III. SOIL PROPERTIES

#### (a) Index Properties

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

#### (a) Index Properties (continued)

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

#### (b) Hydraulic Properties

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

#### (c) Consolidation (one-dimensional)

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

#### (d) Shear Strength

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

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



**RECORD OF BOREHOLE No 1**

1 OF 1

**METRIC**

PROJECT 041-130229-2

G.W.P. 476-89-00

LOCATION N 4752187.5 ; E 482705.8

ORIGINATED BY MA

DIST HWY HWY 401

BOREHOLE TYPE POWER AUGER (HOLLOW STEM)

COMPILED BY BG

DATUM GEODETIC

DATE November 28, 2004

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL					
261.23	GROUND SURFACE						20	40	60	80	100	10	20	30	
0.00	TOPSOIL, silty Brown														
260.53															
0.70	FILL, silty sand and gravel		1	SS	10										
0.91	Compact Brown														
259.86	TOPSOIL, clayey														
1.37	Stiff Brown and black		2	SS	11										
	CLAYEY SILT, trace sand, trace gravel														
	Stiff to hard Brown becoming grey at about elev. 257.6m		3	SS	18										
			4	SS	30										0 11 54 35
			5	SS	23										
256.51															
4.72	CLAYEY SILT, trace sand, trace gravel with sand partings		6	SS	19										
256.05	Very stiff Grey														
5.18	CLAYEY SILT, trace sand, trace gravel		7	SS	21										
	Very stiff Grey		8	SS	15										
			9	SS	22										
253.31			10	SS	31										
7.92	SAND, trace silt														
252.70	Dense Grey														
8.53	CLAYEY SILT, trace sand with silt layers		11	SS	20										1 4 55 40
	Stiff to very stiff Grey														
			12	SS	20										
248.82															
12.41	SILT		13	SS	12										
248.43	Compact Grey														
12.80	SANDY SILT														
	Very dense Grey														
247.18			14	SS	105/ 175mm										
14.05	END OF BOREHOLE Groundwater enc. in borehole at elev. 253.31m and elev. 248.83m during drilling Nov. 10/04														

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

**RECORD OF BOREHOLE No 2**

1 OF 2

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752278.5 ; E 482637.4 ORIGINATED BY MA  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE November 28, 2004 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE						
261.77	GROUND SURFACE													
0.00 261.43	TOPSOIL, clayey Brown													
0.34	FILL, clayey silt, trace sand , trace gravel, trace topsoil Very stiff Brown		1	SS	24		261					○		
260.25														
1.52	CLAYEY SILT, trace sand, trace gravel Very stiff to hard Brown becoming grey at about elev. 258.4m		2	SS	24		260					○		
			3	SS	28		259					○		
			4	SS	60		258					○		
			5	SS	28		257					○		
			6	SS	27		256					○		
			7	SS	34		255					○		
			8	SS	18		254					○		
255.06 6.71	CLAYEY SILT, trace sand with silty sand layers Very stiff Grey													
			9	SS	20		253							
			10	SS	17		252							
			11	SS	20		251							
			12	SS	17		250					○		
250.11 11.66	SILT, trace sand to some clay Compact Grey													
			13	SS	16		249					○		
			14	SS	14		248					○		
247.14 14.63							247							

Continued Next Page

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

PROJECT		041-130229-2		RECORD OF BOREHOLE No 2		2 OF 2		METRIC	
G.W.P.		476-89-00		LOCATION		N 4752278.5 ;E 482637.4		ORIGINATED BY	
DIST		HWY HWY 401		BOREHOLE TYPE		POWER AUGER (HOLLOW STEM)		COMPILED BY	
DATUM		GEODETIC		DATE		November 28, 2004		CHECKED BY	

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 (%)		
								<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE</div></div>										<div><div>102030</div><div>○</div></div>		
	SANDY SILT Very dense Gey		15	SS	81		246							○			0 34 60 6			
245.50																				
16.27	SILTY SAND, Very dense Grey		16	SS	133/ 200mm		245							○						
244.00																				
17.77	SAND with silty sand layers Very dense Grey		17	SS	101		244									○				
242.87							243													
18.90	CLAYEY SILT, trace sand, trace gravel Hard Grey		18	SS	51		242							○						
241.50 20.27	END OF BOREHOLE  Groundwater encountered in borehole at elev. 249.12m during drilling Dec. 1&2, 2004																			

**RECORD OF BOREHOLE No 3**

1 OF 2

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752219.6 ; E 482657.0 ORIGINATED BY RC  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE November 28, 2004 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>P</sub>	W	W <sub>L</sub>		
261.70	GROUND SURFACE					▽	20 40 60 80 100	○ UNCONFINED   + FIELD VANE	WATER CONTENT (%)			kN/m <sup>3</sup>	GR   SA   SI   CL	
0.10	ASPHALT						20 40 60 80 100	● QUICK TRIAXIAL   × LAB VANE						
0.23	FILL, Granular base													
	FILL, silty sand and gravel, Loose to Compact Brown		1	SS	7									
			2	SS	11									
			3	SS	24									
258.80														
2.90	CLAYEY SILT, trace sand, trace gravel Very stiff Brown		4	SS	25									
258.04														
3.66	CLAYEY SILT, trace sand Stiff to very stiff Brown becoming grey at about 8.69m depth		5	SS	22									
			6	SS	25									
			7	SS	25									
			8	SS	18									
			9	SS	21									
			10	SS	16									
			11	SS	14									
			12	SS	12									
			</											

Continued Next Page

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

<b>PROJECT</b> 041-130229-2		<b>RECORD OF BOREHOLE No 3</b>		2 OF 2	<b>METRIC</b>
<b>G.W.P.</b> 476-89-00		<b>LOCATION</b> N 4752219.6 ; E 482657.0		<b>ORIGINATED BY</b> RC	
<b>DIST</b> _____ <b>HWY</b> HWY 401		<b>BOREHOLE TYPE</b> POWER AUGER (HOLLOW STEM)		<b>COMPILED BY</b> BG	
<b>DATUM</b> GEODETIC		<b>DATE</b> November 28, 2004		<b>CHECKED BY</b> _____	

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 (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>						
246.16																					
15.54	SANDY SILT Very dense Grey		14	SS	124																
244.45			15	SS	50/ 50mm																
244.45	SILT, some sand, trace clay Very dense Grey																				
17.25																					
			16	SS	100/ 150mm																
242.50																					
19.20	CLAYEY SILT, some sand, trace gravel Very stiff Grey																				
241.43			17	SS	27																
20.27	END OF BOREHOLE																				
	Groundwater encountered in borehole at elev.259.41m during drilling Nov. 28, 2004																				

**RECORD OF BOREHOLE No 4**

1 OF 2

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752260.9 ; E 482688.0 ORIGINATED BY RC  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE November 29, 2004 CHECKED BY

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							w <sub>p</sub> w   w <sub>L</sub>		
						● QUICK TRIAXIAL   × LAB VANE	20   40   60   80   100				10   20   30						
262.00	GROUND SURFACE																
0.10	ASPHALT																
0.25	FILL, Granular base																
	FILL, sand and gravel, trace to some silt																
	Compact to dense																
	Brown		1	SS	44		261										
			2	SS	14		260										
259.71																	
2.29	CLAYEY SILT, trace sand, trace gravel		3	SS	15		259										
	Stiff to very stiff		4	SS	26												
	Brown becoming grey at about 3.66m depth		5	SS	25		258										
			6	SS	19		257										
			7	SS	13		256										
			8	SS	18		255										
254.68																	
7.32	SILT, trace to some sand		9	SS	23		254										
	Compact Grey																
253.16							253										
8.84	CLAYEY SILT, trace sand		10	SS	15		252										
	Stiff to very stiff Grey																
			11	SS	29		251										
							250										
249.50			12	SS	28		249										
12.50	SILT, trace sand																
	Compact to very dense Grey																
			13	SS	>100		248										
247.37																	
14.63																	

Continued Next Page

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

PROJECT <u>041-130229-2</u>		<b>RECORD OF BOREHOLE No 4</b>		2 OF 2		<b>METRIC</b>	
G.W.P. <u>476-89-00</u>		LOCATION <u>N 4752260.9 ; E 482688.0</u>		ORIGINATED BY <u>RC</u>			
DIST <u>          </u> HWY <u>HWY 401</u>		BOREHOLE TYPE <u>POWER AUGER (HOLLOW STEM)</u>		COMPILED BY <u>BG</u>			
DATUM <u>GEODETIC</u>		DATE <u>November 29, 2004</u>		CHECKED BY <u>          </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL LIMIT   MOISTURE   LIQUID CONTENT   LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>					
			14	SS	30															
			15	SS	117															
244.02																				
17.98																				
	CLAYEY SILT, trace sand, trace gravel Very stiff to hard Grey		16	SS	21															
			17	SS	28															
240.21			18	SS	36															
21.79	END OF BOREHOLE																			
	Groundwater encountered in borehole at elev. 259.71m during drilling Nov. 29, 2004																			

**RECORD OF BOREHOLE No 5**

1 OF 1

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752292.8 ; E 482625.2 ORIGINATED BY MA  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE December 2, 2004 CHECKED BY

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									
260.68	GROUND SURFACE						20	40	60	80	100								
0.00	FILL, clayey silt trace to some, trace gravel, trace topsoil Compact Brown																		
			1	SS	14														
			2	SS	12														
258.55																			
2.13	CLAYEY SILT, trace sand, trace gravel Very stiff Brown		3	SS	29														
			4	SS	25														
257.02																			
3.66	SAND AND GRAVEL, some silt Dense Brown		5	SS	31														
256.26																			
4.42	CLAYEY SILT, trace sand Stiff Grey		6	SS	11														
			7	SS	11														
254.74																			
5.94	CLAYEY SILT, trace sand, with silt layers Stiff to very stiff Grey		8	SS	13														
			9	SS	16														
			10	SS	25														
			11	SS	28														
250.48																			
10.20	SILT, trace sand Compact to dense Grey		12	SS	24														
			13	SS	38														
247.57																			
13.11	CLAYEY SILT, trace sand, with silt layers Very stiff Grey																		
246.81																			
13.87	SAND Compact Grey		14	SS	18														
246.81																			
14.17	END OF BOREHOLE WL enc. in BH at elev. 257.02m and elev. 246.81m during drilling Dec. 3, 2004																		

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



# RECORD OF BOREHOLE No 6

1 OF 2

**METRIC**




PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752274.8 ; E 482667.2 ORIGINATED BY MA  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE December 2, 2004 CHECKED BY

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							
260.68	GROUND SURFACE															
0.00	TOPSOIL, clayey Brown															
260.41	CLAYEY SILT, trace sand, trace gravel															
0.27	Stiff to hard Brown becoming grey at about 257.5m depth		1	SS	9											
			2	SS	42											
			3	SS	55											
			4	SS	14											
256.87	CLAYEY SILT, trace sand, with silt and fine sand layers		5	SS	17											
3.81	Very stiff to hard Grey		6	SS	33											
			7	SS	24											
			8	SS	27											
			9	SS	20											
			10	SS	15											
			11	SS	23											
			12	SS	16											
247.42	SILT, trace sand															
13.26	Very dense Grey		13	SS	142/ 200mm											
245.90																
14.78																

Continued Next Page

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

PROJECT <u>041-130229-2</u>		<b>RECORD OF BOREHOLE No 6</b>		2 OF 2		<b>METRIC</b>	
G.W.P. <u>476-89-00</u>		LOCATION <u>N 4752274.8 ; E 482667.2</u>		ORIGINATED BY <u>MA</u>			
DIST <u>          </u> HWY <u>HWY 401</u>		BOREHOLE TYPE <u>POWER AUGER (HOLLOW STEM)</u>		COMPILED BY <u>BG</u>			
DATUM <u>GEODETIC</u>		DATE <u>December 2, 2004</u>		CHECKED BY <u>          </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)											
								<div><div></div><div></div><div></div><div></div><div></div></div>					<div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div></div>									
								20	40	60	80	100	20	40	60	80	100	10	20	30	GR	SA	SI	CL
	SANDY SILT Very dense Grey		14	SS	110/ 125mm		245																	
244.37								244																
16.31	SILT ,trace sand Dense Grey																							
243.61			15	SS	36																			
17.07																								
17.22	CLAYEY SILT, trace sand, trace gravel Hard Grey <b>END OF BOREHOLE</b>  Groundwater encountered in borehole at elev. 248.64m during drilling Dec. 3, 2004 Groundwater measured in shallow standpipe. at elev. 259.92m and in deep piezo. at elev. 258.70m on Dec. 3, 2004																							

**RECORD OF BOREHOLE No 7**

1 OF 2

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752212.8 ; E 482709.2 ORIGINATED BY MA  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE December 15, 2004 - December 16, 2004 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
261.00	GROUND SURFACE							20 40 60 80 100						
0.00	TOPSOIL, silty Brown							○ UNCONFINED   + FIELD VANE						
260.70								● QUICK TRIAXIAL   × LAB VANE						
0.30	FILL, clayey silt, trace sand, trace gravel, trace topsoil Compact Brown		1	SS	14		260							
259.63														
1.37	CLAYEY SILT, trace sand, trace gravel Very stiff to hard Brown becoming grey at about elev. 258.1m		2	SS	30		259							
			3	SS	48		258							
			4	SS	24		257							
			5	SS	22		256							
			6	SS	52		255							
255.82														
5.18	CLAYEY SILT, trace sand with silt layers Stiff to very stiff Grey		7	SS	25		254							
			8	SS	18		253							
			9	SS	26		252							
			10	SS	20		251							
250.48														
10.52	SILT, some sand, trace clay Compact Grey		12	SS	28		250							
250.03														
10.97	CLAYEY SILT, some sand Very stiff Grey						249							
249.11														
11.89	SILT, trace sand Loose Grey		13	SS	9		248							
247.74														
13.26	SANDY SILT, trace clay, with silty fine sand layers Very dense Grey		14	SS	101/ 150mm		247							

Continued Next Page

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

ONL\_MTO 04-1130-229-2.GPJ ON\_MOT.GDT 2/22/06

PROJECT <u>041-130229-2</u>		<b>RECORD OF BOREHOLE No 7</b>		2 OF 2	<b>METRIC</b>
G.W.P. <u>476-89-00</u>		LOCATION <u>N 4752212.8 ; E 482709.2</u>		ORIGINATED BY <u>MA</u>	
DIST <u>          </u> HWY <u>HWY 401</u>		BOREHOLE TYPE <u>POWER AUGER (HOLLOW STEM)</u>		COMPILED BY <u>BG</u>	
DATUM <u>GEODETIC</u>		DATE <u>December 15, 2004 - December 16, 2004</u>		CHECKED BY <u>          </u>	

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 (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE					w <sub>p</sub> w      w <sub>L</sub>							
							20	40	60	80	100									
245.46			15	SS	109/ 150mm								○							
15.54	SAND, trace silt Very dense Grey																			
243.99			16	SS	110/ 100mm								○							
17.01	SILTY SAND, Very dense Grey																			
243.32																				
17.68	CLAYEY SILT, with sandy silt layers		17	SS	63								○							
243.02	Hard Grey												○							
17.98	END OF BOREHOLE																			
	Groundwater encountered in borehole at elev. 250.48m during drilling Dec. 15&16, 2004																			

# RECORD OF BOREHOLE No 8

1 OF 2

**METRIC**

PROJECT 041-130229-2

G.W.P. 476-89-00

LOCATION N 4752229.8 ; E 482698.2

ORIGINATED BY MA

DIST HWY HWY 401

BOREHOLE TYPE POWER AUGER (HOLLOW STEM)

COMPILED BY BG

DATUM GEODETIC

DATE December 15, 2004

CHECKED BY

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 (%)				
260.85	GROUND SURFACE							20	40	60	80	100										
0.00	TOPSOIL. silty Brown																					
260.55	CLAYEY SILT, trace sand, trace gravel Very stiff to Hard Brown becoming grey at about elev. 257.95m																					
0.30			1	SS	43		260							○								
			2	SS	50		259							○								
			3	SS	52		258							○								
			4	SS	26		257							○								
			5	SS	22		256							○								
			6	SS	33		255							○								
255.67																						
5.18	SAND, trace silt Compact to dense, Grey		7	SS	25		254								○							
			8	SS	31		253								○		0 89 7 4					
254.14																						
6.71	CLAYEY SILT, with silt and fine sand layers Very stiff to hard Grey		9	SS	25		252															
			10	SS	34		251															
			11	SS	17		250							○			0 2 66 32					
249.72			12	SS	26		249															
11.13	SILT, some sand, trace clay Compact to very dense Grey																					
			13	SS	16		248								○							
			14	SS	108/ 150mm		247								○							
246.22																						
14.63	SILTY SAND, Very dense Grey						246															

Continued Next Page

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

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

**RECORD OF BOREHOLE No 9**

1 OF 2

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752296.8 ; E 482652.2 ORIGINATED BY RC  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE January 19, 2005 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>P</sub>	W	W <sub>L</sub>	WATER CONTENT (%)				
								20 40 60 80 100									
260.45	GROUND SURFACE																
0.00	TOPSOIL, silty Black																
0.23	CLAYEY SILT, trace sand, trace gravel Very stiff to Hard Brown becoming grey at about elev. 256.7m		1	SS	23		260										
			2	SS	54		259										
			3	SS	55		258										
			4	SS	36		257										
			5	SS	22		256										
			6	SS	45		255										
			7	SS	28		254										
			8	SS	33		253										
253.74							252										
6.71	SAND AND GRAVEL Loose Grey		9	SS	5		251										
252.98							250										
7.47	CLAYEY SILT, trace sand, trace gravel Very stiff Grey		10	SS	16		249										
							248										
			11	SS	38		247										
							246										
			12	SS	20		245										
249.32							244										
11.13	CLAYEY SILT, trace sand with silt layers Very stiff to hard						243										
248.87							242										
11.58	Grey SILT, some clay Compact Grey		13	SS	25		241										
							240										
247.04							239										
13.41	SILTY SAND Very dense Grey		14	SS	100/ 100mm		238										
							237										
245.82							236										
14.63							235										

Continued Next Page

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

<b>PROJECT</b> 041-130229-2		<b>RECORD OF BOREHOLE No 9</b>		2 OF 2	<b>METRIC</b>
<b>G.W.P.</b> 476-89-00		<b>LOCATION</b> N 4752296.8 ; E 482652.2		<b>ORIGINATED BY</b> RC	
<b>DIST</b> _____ <b>HWY</b> HWY 401		<b>BOREHOLE TYPE</b> POWER AUGER (HOLLOW STEM)		<b>COMPILED BY</b> BG	
<b>DATUM</b> GEODETIC		<b>DATE</b> January 19, 2005		<b>CHECKED BY</b> _____	

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 (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)				GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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								20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			

ON\_MTO 04-1130-229-2.GPJ ON\_MOT.GDT 2/22/06



**RECORD OF BOREHOLE No 10**

1 OF 2

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752245.8 ; E 482649.2 ORIGINATED BY RC  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE January 21, 2005 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						W <sub>P</sub> W                      W <sub>L</sub>			GR	SA	SI	CL
								20	40	60	80	100		WATER CONTENT (%)						
						○ UNCONFINED                      + FIELD VANE														
						● QUICK TRIAXIAL                      × LAB VANE														
261.33	GROUND SURFACE					▽	261													
0.00	TOPSOIL. silty Black						260													
260.87							259													
0.46	CONCRETE						258													
260.57							257													
0.85	FILL, clayey silt, some sand, trace gravel, trace topsoil Very stiff Brown		1	SS	23		256													
	CLAYEY SILT, trace sand, trace gravel Very stiff to Hard Brown becoming grey at about elev. 256.8m		2	SS	43		255													
			3	SS	20		254													
			4	SS	35		253													
			5	SS	25		252													
			6	SS	20		251													
256.15							250													
5.18	SAND, trace silt Compact						249													
255.84	Grey		7	SS	16		248													
5.49	CLAYEY SILT, trace sand, trace gravel Stiff to very stiff Grey		8	SS	20	247														
			9	SS	28															
			10	SS	48															
			11	SS	13															
251.12																				
10.21	CLAYEY SILT, with fine sand layers Stiff Grey		12	SS	14															
			13	SS	14															
248.22																				
13.11	CLAYEY SILT, trace sand with silt layers Stiff Grey		14	SS	9															
246.70																				
14.63																				

Continued Next Page

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

**RECORD OF BOREHOLE No 10**

2 OF 2

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752245.8 ; E 482649.2 ORIGINATED BY RC  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE January 21, 2005 CHECKED BY

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									WATER CONTENT (%)			GR	SA	SI	CL
												○ UNCONFINED					+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE				
								20	40	60	80	100											

**RECORD OF BOREHOLE No 11**

1 OF 1

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752437.0 ; E 482615.2 ORIGINATED BY MA  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE December 6, 2004 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
								WATER CONTENT (%)										
259.76	GROUND SURFACE						20	40	60	80	100	10	20	30				
0.00	TOPSOIL, silty, Brown																	
259.39																		
0.37	CLAYEY SILT, trace sand, trace gravel Stiff to very stiff Brown becoming grey at about elev. 2.90m		1	SS	12	259							○					
			2	SS	23	258							○	-○-				
			3	SS	19	257							○		0 8 59 33			
			4	SS	18	256							○					
			5	SS	16	255												
			6	SS	18	254												
254.58													○					
5.18	CLAYEY SILT, trace sand with silt layers Stiff to hard Grey		7	SS	78	253												
			8	SS	23	252								-○-				
			9	SS	66	251												
			10	SS	27								○					
250.16			11	SS	10													
9.60	END OF BOREHOLE																	
	Borehole dry during drilling Dec. 6, 2004																	

**RECORD OF BOREHOLE No 12**

1 OF 1

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752349.0 ; E 482578.2 ORIGINATED BY MA  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE December 8, 2004 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED		+ FIELD VANE						
								● QUICK TRIAXIAL		× LAB VANE						
						20	40	60	80	100						
260.31	GROUND SURFACE															
0.00	TOPSOIL, silty, Brown															
0.15	(FILL), clayey silt, trace topsoil, trace sand, gravel															
259.79	Brown															
0.52	CLAYEY SILT, trace sand, trace gravel Very stiff Brown becoming grey at about 3.0m depth		1	SS	18								○			
			2	SS	24								○			
			3	SS	26								○		2 8 58 32	
257.11			4	SS	52								○			
3.20	SAND, trace silt Compact to very dense Grey													○		
256.20			5	SS	12									○		
4.11	CLAYEY SILT, trace sand Stiff to very stiff Grey													○		
254.82			6	SS	18									○		
5.49	SAND, trace silt Compact Grey		7	SS	16									○		
			8	SS	29									○	0 80 14 6	
253.60			9	SS	9									○		
6.71	CLAYEY SILT, trace sand Stiff Grey													○		
252.84														○		
7.47	SAND, trace silt Compact Grey		10	SS	14									○		
252.23																
8.08	END OF BOREHOLE															
	Groundwater encountered in borehole at elev. 252.84m, 254.82m, and at 257.11m during drilling Dec. 8, 2004															

**RECORD OF BOREHOLE No 13**

1 OF 1

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752027.2 ; E 482682.9 ORIGINATED BY MA  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE December 8, 2004 CHECKED BY

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												
259.91	GROUND SURFACE						20	40	60	80	100									
0.00	TOPSOIL, silty, Brown																			
0.23	FILL, sandy silt Compact Brown																			
259.00																				
0.91	FILL, clayey silt, trace sand, trace gravel with sandy silt pockets Stiff to very stiff Brown		1	SS	14									○						
														○						
257.78			2	SS	15									○						
2.13	CLAYEY SILT, trace sand, trace gravel Stiff to very stiff Brown becoming grey at 3.66m depth		3	SS	16									○						
			4	SS	24															
			5	SS	15									○						
255.49																				
4.42	CLAYEY SILT, trace sand Stiff Grey													○						
254.88			6	SS	13									○						
5.03	END OF BOREHOLE																			
	Borehole dry during drilling Dec. 8, 2004																			

**RECORD OF BOREHOLE No 14**

1 OF 1

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752377.2 ; E 482549.0 ORIGINATED BY MA  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE December 9, 2004 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED	+ FIELD VANE							
								● QUICK TRIAXIAL	× LAB VANE							
262.27	GROUND SURFACE						20	40	60	80	100					
0.00	TOPSOIL, silty, Brown															
0.20	(FILL), clayey silt, some sand, trace gravel, some topsoil Stiff Brown & black		1	SS	11											
260.90	(FILL), clayey silt, trace sand, trace gravel Stiff to very stiff Grey		2	SS	17											
1.37			3	SS	12											
259.02			4	SS	8											
3.25	TOPSOIL, clayey Stiff Grey															
258.61	CLAYEY SILT, trace sand, trace gravel Hard Brown becoming grey at about elev. 5.03m		5	SS	49											
3.66			6	SS	30											
256.33	SILTY SAND Compact Grey		7	SS	24											
5.94																
255.94	CLAYEY SILT, trace sand Very stiff Grey															
6.33	END OF BOREHOLE															
6.55	Borehole dry during drilling Dec. 9, 2004															

**RECORD OF BOREHOLE No 15**

1 OF 1

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752152.7 ; E 482723.5 ORIGINATED BY MA  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE December 13, 2004 CHECKED BY



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									
261.71	GROUND SURFACE																			
0.00	TOPSOIL, silty, Brown																			
0.18	(FILL), clayey silt, trace sand Very stiff Brown		1	SS	26								○							
260.34																				
1.37	(FILL), clayey silt, some sand, trace gravel, trace topsoil		2	SS	8									○						
260.03	Stiff Brown														○					
1.68	TOPSOIL, silty																			
259.58	Loose Black		3	SS	11										○					
2.13	(FILL), clayey silt, trace to some sand, trace gravel, trace organics																			
258.81	Stiff Brown		4	SS	20									○						
2.90	CLAYEY SILT, trace sand, trace gravel Very stiff Brown becoming grey at about 4.57m depth		5	SS	26									├───┤		0 10 60 30				
			6	SS	23									○						
			7	SS	24									○						
			8	SS	21										○					
255.00																				
6.71	CLAYEY SILT, trace sand Very stiff Grey		9	SS	20									○						
			10	SS	15									├───┤		0 3 71 26				
253.18																				
8.53	CLAYEY SILT, trace sand, with silt layers Stiff Grey																			
252.11			11	SS	10									○						
9.60	END OF BOREHOLE																			
	Borehole dry during drilling Dec. 13, 2004																			

**RECORD OF BOREHOLE No 16**

1 OF 1

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752112.9 ; E 482754.1 ORIGINATED BY MA  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE December 13, 2004 CHECKED BY

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												
261.80	GROUND SURFACE						20	40	60	80	100	10	20	30						
0.00	TOPSOIL, silty, Brown																			
0.15	(FILL), clayey silt, trace to some sand, trace gravel, trace topsoil Stiff to very stiff Brown & grey		1	SS	18															
			2	SS	10															
259.67																				
2.13	CLAYEY SILT, trace sand, trace gravel Very stiff to hard Brown becoming grey at about 4.27m depth		3	SS	26															
			4	SS	19															
			5	SS	64															
			6	SS	32															
			7	SS	27															
			8	SS	19															
255.25																				
6.55	END OF BOREHOLE  Borehole dry during drilling Dec. 13, 2004																			



**RECORD OF BOREHOLE No 17**

1 OF 1

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752053.8 ; E 482792.5 ORIGINATED BY MA  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE December 13, 2004 CHECKED BY

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														
261.91	GROUND SURFACE							20	40	60	80	100										
0.00	TOPSOIL, silty, Brown																					
0.21	(FILL), clayey silt, trace sand, trace gravel																					
261.24																						
0.67	Brown																					
0.91	CONCRETE Grey		1	SS	13		261															
260.48	(FILL), clayey silt, trace sand, trace gravel																					
1.43	Stiff Brown		2	SS	16		260															
	CLAYEY SILT, trace sand, trace gravel																					
	Very stiff to hard Brown becoming grey at about 4.42m depth		3	SS	29		259															
			4	SS	39																	
			5	SS	33		258															
			6	SS	29		257															
256.88	<b>END OF BOREHOLE</b>																					
5.03	Borehole dry during drilling Dec. 13, 2004																					

**RECORD OF BOREHOLE No 18**

1 OF 1

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752009.4 ; E 482718.3 ORIGINATED BY MA  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE December 9, 2004 CHECKED BY

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												
262.18	ROAD SHOULDER						20	40	60	80	100									
0.00	(FILL), crushed sand and gravel, trace silt																			
261.84	Brown																			
0.34	(FILL), sand and gravel, trace silt																			
261.45	Brown																			
0.73	(FILL), clayey silt, trace sand, trace gravel, trace topsoil Very stiff Brown & grey		1	SS	22								○							
260.35			2	SS	20								○		○					
1.83	TOPSOIL, clayey																			
260.05	Very Stiff																			
2.13	Black SANDY SILT, some clay Compact Brown & grey		3	SS	11								○			0 7 70 23				
259.28																				
2.90	CLAYEY SILT, trace sand with fine sand layers Very stiff Brown		4	SS	19								○			1 6 61 32				
			5	SS	24								○							
257.76																				
4.42	CLAYEY SILT, trace sand, trace gravel Very stiff Brown		6	SS	26								○							
257.15																				
5.03	END OF BOREHOLE																			
	Borehole dry during drilling Dec. 9, 2004																			

**RECORD OF BOREHOLE No 19**

1 OF 1

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752016.4 ; E 482684.1 ORIGINATED BY RC  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE February 1, 2005 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
262.45	PAVEMENT SURFACE						20	40	60	80	100						
0.00	ASPHALT																
0.15	(FILL), silty sand and gravel																
261.99	Brown																
0.46	(FILL), silty sand and gravel with cobbles Compact to very dense Brown		1	SS	67								○				
			2	SS	42								○				
			3	SS	23								○				
259.55																	
2.90	CLAYEY SILT, trace sand, trace gravel Very stiff to hard Brown becoming grey at about 4.42m depth		4	SS	24								○	├───┤		3 13 56 28	
			5	SS	43								○				
			6	SS	27								○				
257.42	<b>END OF BOREHOLE</b>																
5.03	Borehole dry during drilling Feb. 1, 2005																

**RECORD OF BOREHOLE No 20**

1 OF 1

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752038.6 ; E 482724.0 ORIGINATED BY RC  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE February 1, 2005 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
								WATER CONTENT (%)										
263.79	PAVEMENT SURFACE						20	40	60	80	100							
0.00	ASPHALT																	
0.15	(FILL), sand and gravel																	
263.33	Brown																	
0.46	(FILL), silty sand and gravel, some cobbles Dense to very dense Brown		1	SS	37													
			2	SS	52													
			3	SS	100/ 150mm													
261.05																		
2.74	CLAYEY SILT, trace sand, trace gravel Very stiff Brown becoming grey at about 5.79m depth		4	SS	21													
			5	SS	16													
			6	SS	18													
			7	SS	27													
			8	SS	-													
257.24	END OF BOREHOLE																	
6.55	Borehole dry during drilling Feb. 1, 2005																	

**METRIC**

PROJECT 041-130229-2

G.W.P. 476-89-00

LOCATION N 4752187.8 :E 482666.2

ORIGINATED BY RC

DIST HWY HWY 401

BOREHOLE TYPE POWER AUGER (HOLLOW STEM)

COMPILED BY BG

DATUM GEODETIC

DATE February 2, 2005

CHECKED BY \_\_\_\_\_

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 (%)		
								20	40	60	80						100	10	20
268.51	PAVEMENT SURFACE																		
	ASPHALT																		
0.20	CONCRETE																		
267.90	(FILL), sand and gravel																		
0.61	Brown																		
	(FILL), silty sand and gravel		1	SS	40							○							
	Dense to very dense																		
	Brown		2	SS	47							○							
			3	SS	50/ 150mm														
265.77																			
2.74	(FILL), sand, some gravel		4	SS	38							○				25 58 17 0			
	Dense																		
	Brown		5	SS	39							○							
264.09																			
4.42	(FILL), sand and gravel, trace silt		6	SS	10							○							
263.79	Compact																		
4.72	Brown												○						
	(FILL), clayey silt, trace sand, trace																		
	gravel		7	SS	14								○						
	Stiff																		
	Brown & grey		8	SS	12								○						
261.80																			
6.71	(FILL), clayey silt, trace sand, trace		9	SS	14								○						
	gravel, some topsoil																		
	Stiff																		
	Brown		10	SS	12									○					
259.98																			
8.53	(FILL), silty sand		11	SS	37								○			0 12 61 27			
	Dense																		
	Brown																		
258.45																			
10.06	CLAYEY SILT, trace sand, trace		12	SS	40											0 6 64 30			
	gravel with sand layers																		
	Very stiff to hard																		
	Brown becoming grey at about																		
	11.58m depth																		
			13	SS	32														
			14	SS	27														
254.34																			
14.17	END OF BOREHOLE																		
	Borehole remained dry during drilling																		
	on Feb. 2, 2005																		

ON\_MTO 04-1130-229-2.GPJ ON\_MOT.GDT 2/22/06

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

**RECORD OF BOREHOLE No 22**

1 OF 1

**METRIC**

PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752233.8 ; E 482629.2 ORIGINATED BY RC  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE February 2, 2005 CHECKED BY

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									WATER CONTENT (%)			GR	SA
								20	40	60	80	100									
268.49	PAVEMENT SURFACE																				
	ASPHALT																				
0.20	CONCRETE																				
267.88	(FILL), sand and gravel																				
0.61	Brown																				
	(FILL), silty sand and gravel																				
	Compact to dense		1	SS	37																
	Brown																				
			2	SS	16																
			3	SS	16																
265.59																					
2.90	(FILL), sand and gravel, trace silt																				
	Loose		4	SS	6																
	Brown																				
			5	SS	6																
264.07																					
4.42	(FILL), clayey silt, trace sand, trace gravel																				
	Stiff		6	SS	14																
	Brown & grey																				
			7	SS	13																
			8	SS	11																
			9	SS	8																
260.57			10	SS	20																
7.92	TOPSOIL, clayey																				
	Very stiff																				
	Black																				
259.96																					
8.53	CLAYEY SILT, trace sand, trace gravel																				
	Very stiff to hard																				
	Brown		11	SS	28																
			12	SS	35																
256.91																					
11.58	CLAYEY SILT, trace sand																				
	Very stiff																				
	Grey		13	SS	21																
255.38																					
13.11	SILT, some clay with sand layers																				
	Dense																				
	Grey																				
			14	SS	44																
254.32																					
14.17	END OF BOREHOLE																				
	Groundwater encountered in borehole at elev. 254.77m Feb. 2, 2005																				

ON\_MTO 04-1130-229-2.GPJ ON\_MOT.GDT 2/22/06

**RECORD OF BOREHOLE No 23**

1 OF 1

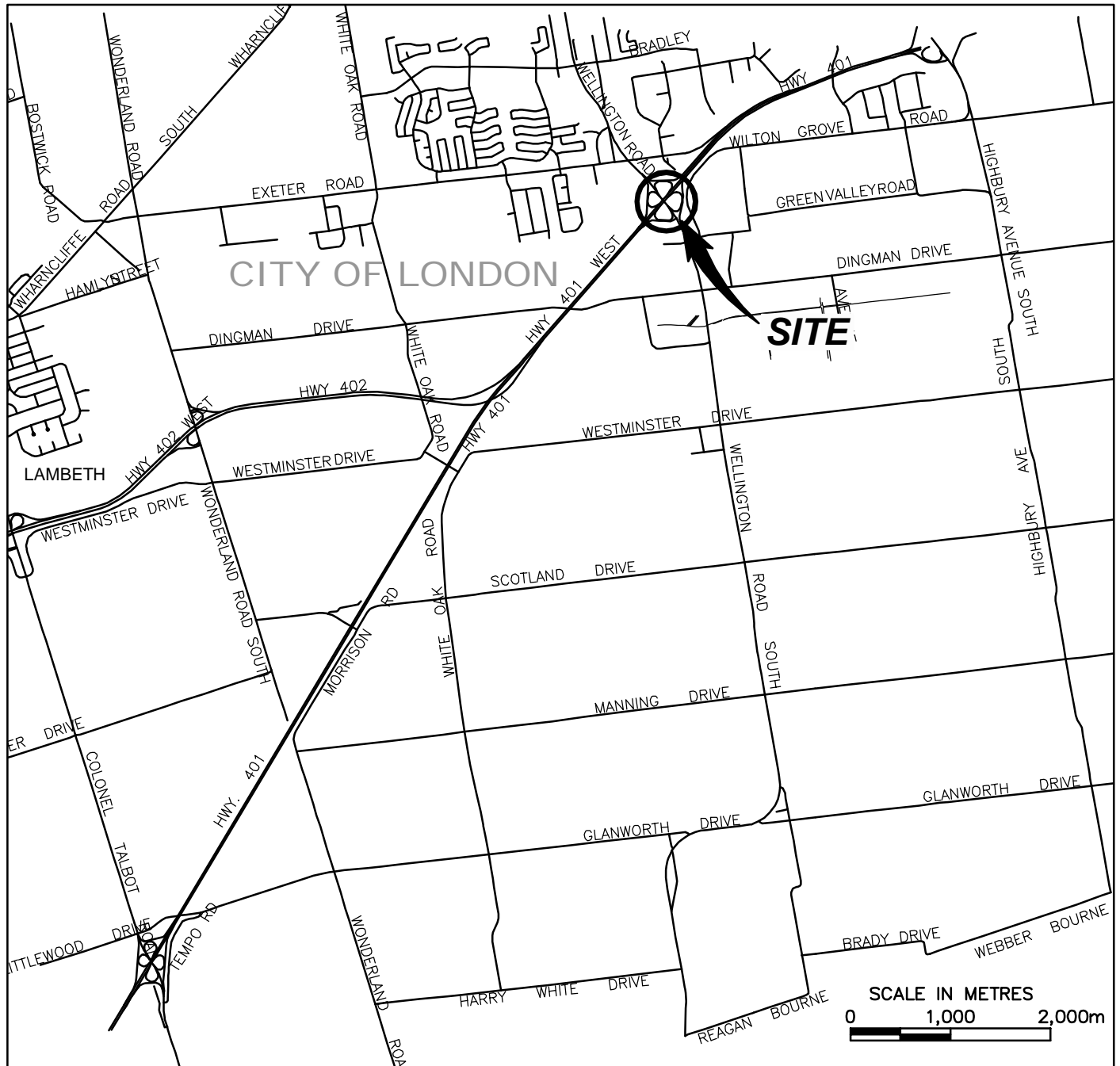
**METRIC**


PROJECT 041-130229-2  
G.W.P. 476-89-00 LOCATION N 4752088.4 ; E 482732.7 ORIGINATED BY RC  
DIST HWY HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE February 3, 2005 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)								
265.90	PAVEMENT SURFACE							20	40	60	80	100						GR	SA	SI	CL
0.00	ASPHALT																				
0.20	(FILL), sand and gravel																				
265.40	Brown																				
0.50	(FILL), silty sand and gravel																				
	Compact to very dense		1	SS	100/ 150mm		265									○					
	Brown		2	SS	23		264									○					
263.77	(FILL), clayey silt, trace sand, trace gravel																				
2.13	Very stiff		3	SS	26												○				
263.00	Grey						263														
2.90	(FILL), clayey silt, trace to some sand, trace gravel, trace to some topsoil		4	SS	29												○				
	Very stiff to hard		5	SS	42		262										○				
	Brown		6	SS	15		261											○			
			7	SS	34													○			
259.96	CLAYEY SILT, trace sand, trace gravel						260											○			
5.94	Very stiff to hard		8	SS	43													○			
	Brown becoming grey at about 8.53m depth		9	SS	37		259											○			
			10	SS	32		258												┌───┐		
							257											○			
			11	SS	25		256														
			12	SS	41		255											○			
254.32	CLAYEY SILT, trace sand with silt layers						254											○			
11.58	Very stiff		13	SS	26		253														
	Grey						252											○			
251.73	END OF BOREHOLE		14	SS	18																
14.17	Borehole dry during drilling Feb. 3, 2005																				

ON\_MTO 04-1130-229-2.GPJ ON\_MOT.GDT 2/22/06

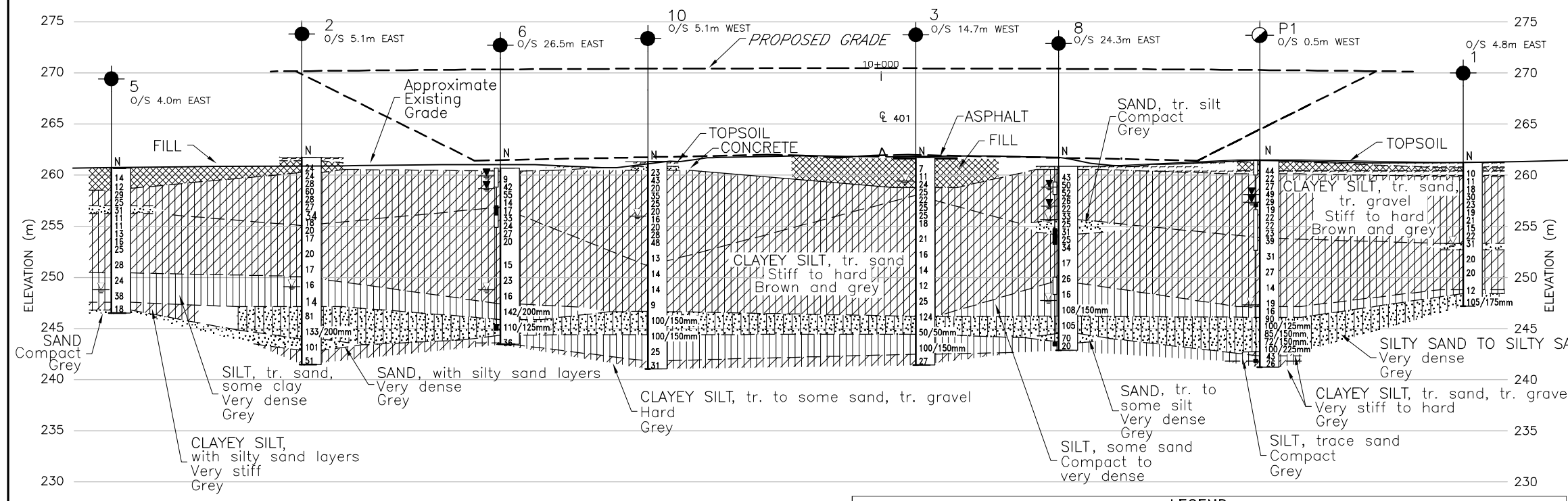
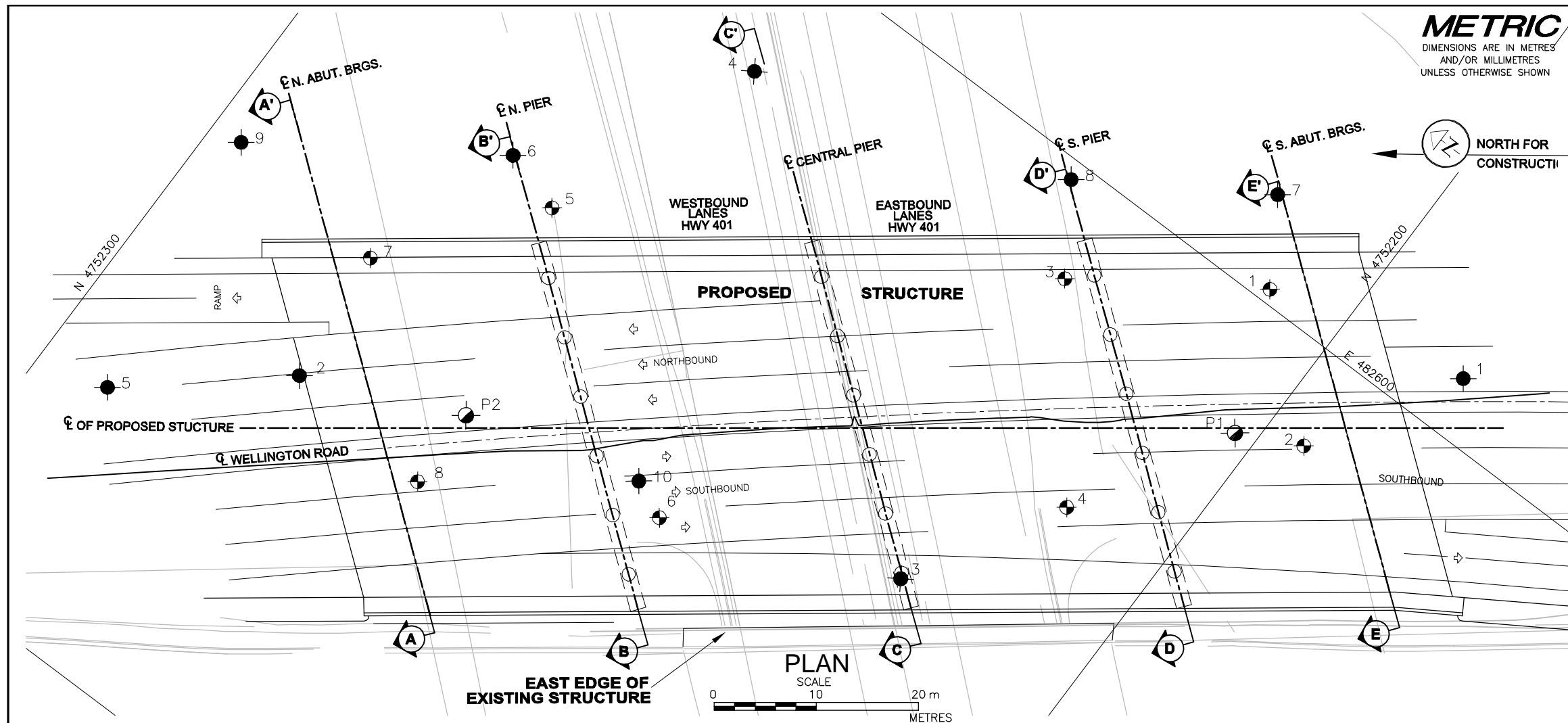
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



PROJECT WELLINGTON ROAD AT HIGHWAY 401 WP. 476-89-00			
TITLE  KEY PLAN			
 Golder Associates LONDON, ONTARIO	PROJECT No. 041-130-229-2-1		FILE No. 041130229-2-F001
	DESIGN		SCALE N.T.S. REV. 0
	CADD	WDF/DCH Feb. 16/06	FIGURE 1
	CHECK		
	REVIEW		



D size dwg 24" x 36" 11" x 17" plot half scale  
1 = 1 metric



PROFILE ALONG CL OF PROPOSED STRUCTURE

LEGEND	
	Borehole (Current Investigation)
	Borehole (Golder report #001-3225-1)
	Borehole and Cone (Previous Investigation GEOCREs No. 40114-122)
	N
	Seal
	Piezometer
	WL in piezometer
	WL during drilling
	Blows/0.3m (Std. Pen. Test, 475 j/blow)

**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

DIST 1  
CONT. No.  
WP No. 476-89-00

WELLINGTON ROAD  
STRUCTURE

BOREHOLE LOCATIONS & SOIL STRATA

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

**KEY PLAN**  
SCALE IN METRES  
0 50 100m

No.	ELEVATION (metres)	CO-ORDINATES (UTM NAD83, ZONE 17)	
		NORTHING	EASTING
CURRENT			
1	261.23	4 752 187.5	482 705.7
2	261.77	4 752 278.5	482 637.4
3	261.70	4 752 220.0	482 657.0
4	262.00	4 752 260.9	482 688.0
5	260.68	4 752 292.8	482 625.2
6	260.68	4 752 274.8	482 667.2
7	261.00	4 752 212.8	482 709.2
8	260.85	4 752 229.8	482 698.2
9	260.45	4 752 296.8	482 652.2
10	261.33	4 752 245.8	482 649.2
GOLDER 001-3225-1			
P1	261.50	4 752 202.1	482 688.1
P2	261.00	4 752 263.2	482 644.1
GEOCREs No. 40114-122			
1	261.00	4 752 207.8	482 701.3
2	261.70	4 752 196.0	482 691.1
3	260.70	4 752 224.5	482 690.1
4	261.80	4 752 210.9	482 672.3
5	260.50	4 752 268.7	482 665.4
6	262.00	4 752 242.0	482 647.5
7	260.80	4 752 279.9	482 650.8
8	262.20	4 475 263.0	482 636.1

**NOTES**

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

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

Borehole locations from previous investigations are approximate.

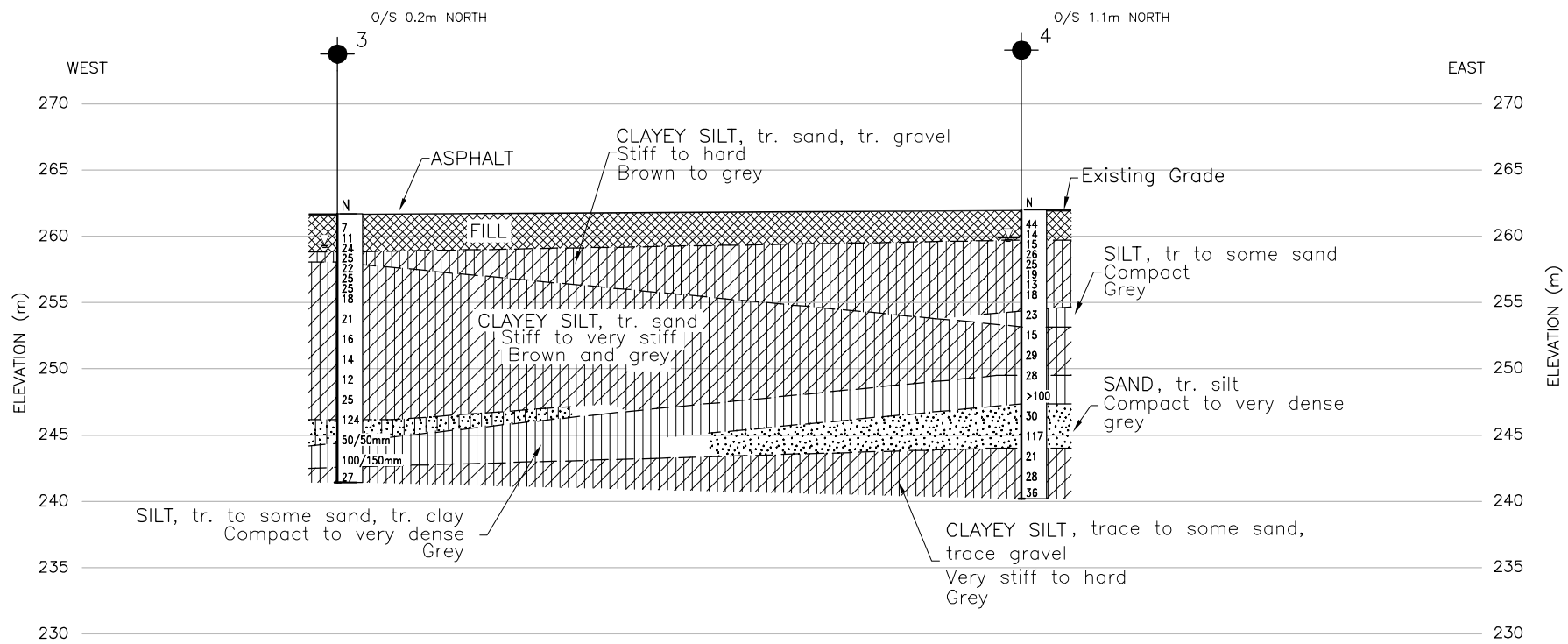
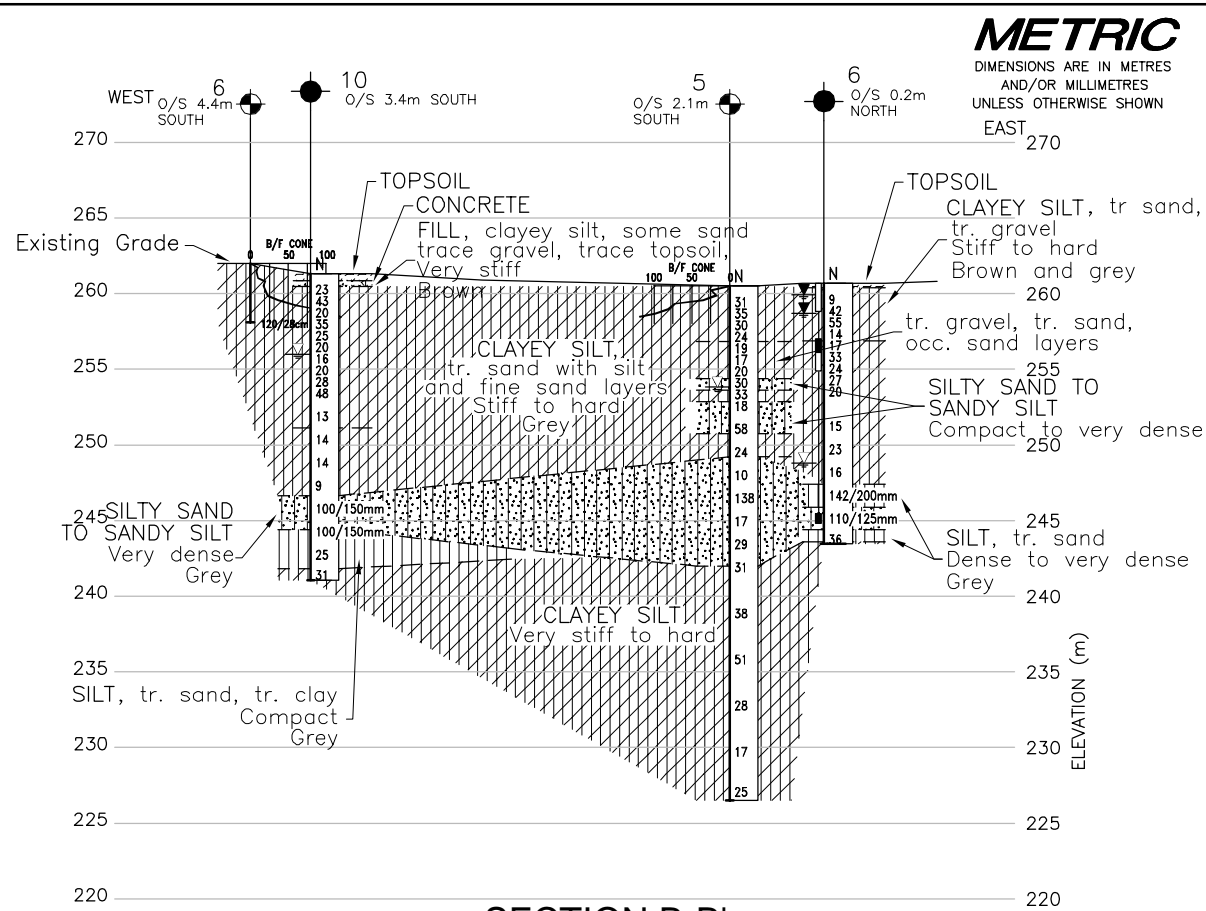
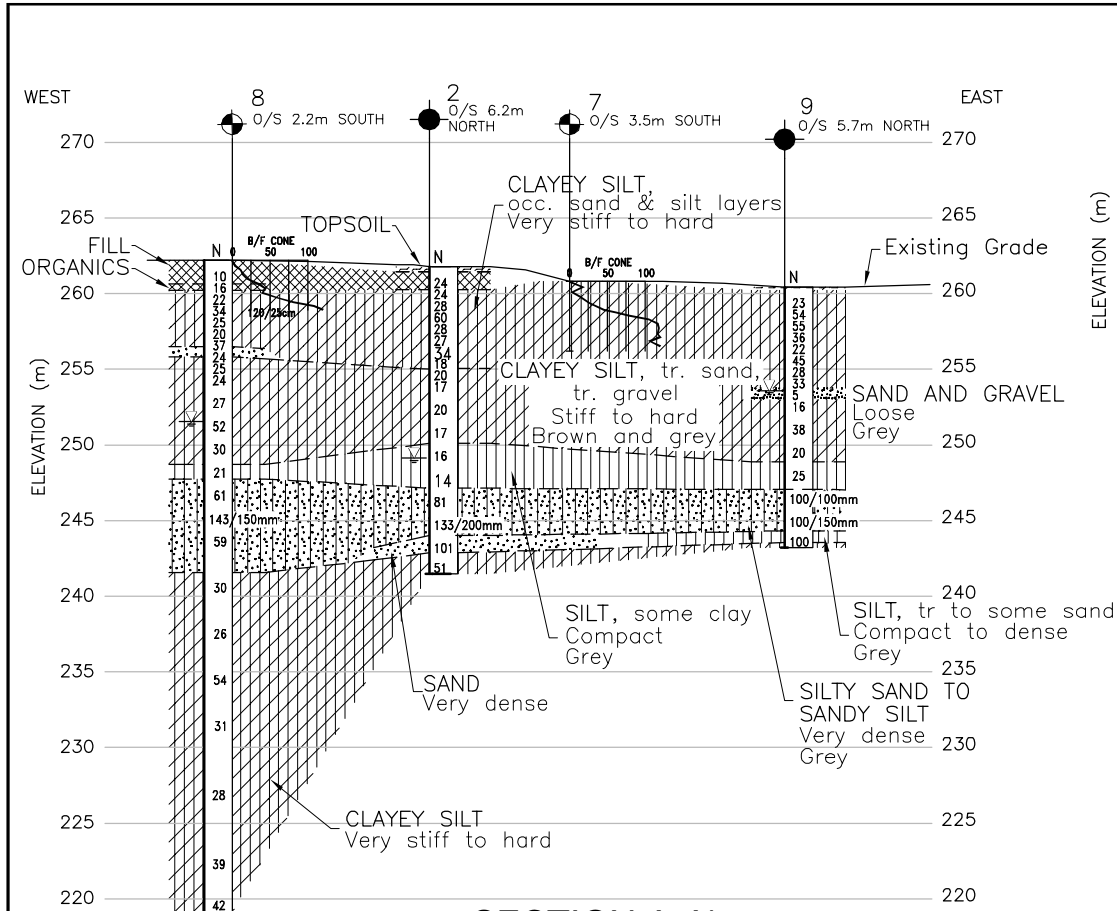
**REFERENCES**

Drawing Supplied by: Delcan entitled: Highway no. 401 geographic Township of Westminster County of Middlesex 19+761.880 to 25+400.000 scale 1:1000, Dated Feb. 2005 prepared for the Ministry of Transportation

Geocres No. 40114-133A

HWY. No. 401	PROJECT NO.: 04-1130-229-2-1
SUBM'D. -	CHKD: -
DRAWN: BG/DCH	CHKD. APPD.
	DWG. 1

D size dwg 24" x 36" 11" x 17" plot half scale  
1 = 1 metric



**METRIC**

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

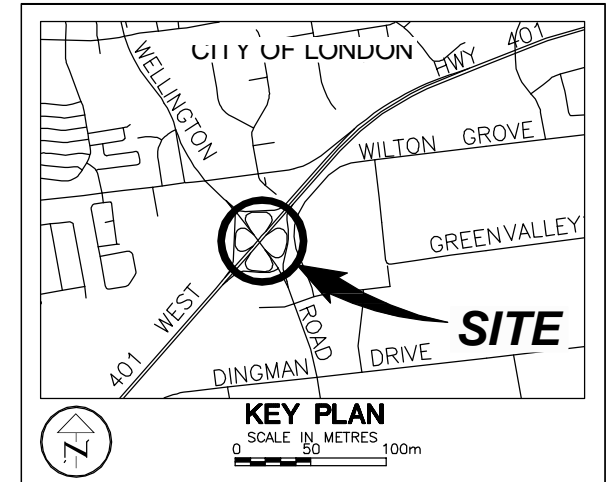
DIST 1 HWY. 401  
CONT. No.  
WP No. 476-89-00

WELLINGTON ROAD  
STRUCTURE  
SOIL STRATA

SHEET



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



LEGEND

- Borehole (Current Investigation)
- Borehole and Cone (Previous Investigation GEOCRES No. 40114-122)
- N Blows/0.3m (Std. Pen. Test, 475 j/blow)
- ≡ WL during drilling

No.	ELEVATION (metres)	CO-ORDINATES (UTM NAD83, ZONE 17)	
		NORTHING	EASTING
CURRENT			
2	261.77	4 752 278.5	482 637.4
3	261.70	4 752 220.0	482 657.0
4	262.00	4 752 260.9	482 688.0
6	260.68	4 752 274.8	482 667.2
9	260.45	4 752 296.8	482 652.2
10	261.33	4 752 245.8	482 649.2
GEOCRES No. 40114-122			
5	260.50	4 752 268.7	482 665.4
6	262.00	4 752 242.0	482 647.5
7	260.80	4 752 279.9	482 650.8
8	262.20	4 475 263.0	482 636.1

NOTES

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

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

Borehole locations from previous investigations are approximate.

REFERENCES

Drawing Supplied by: Delcan entitled: Highway no. 401 geographic Township of Westminster County of Middlesex 19+761.880 to 25+400.000 scale 1:1000, Dated Feb. 2005 prepared for the Ministry of Transportation

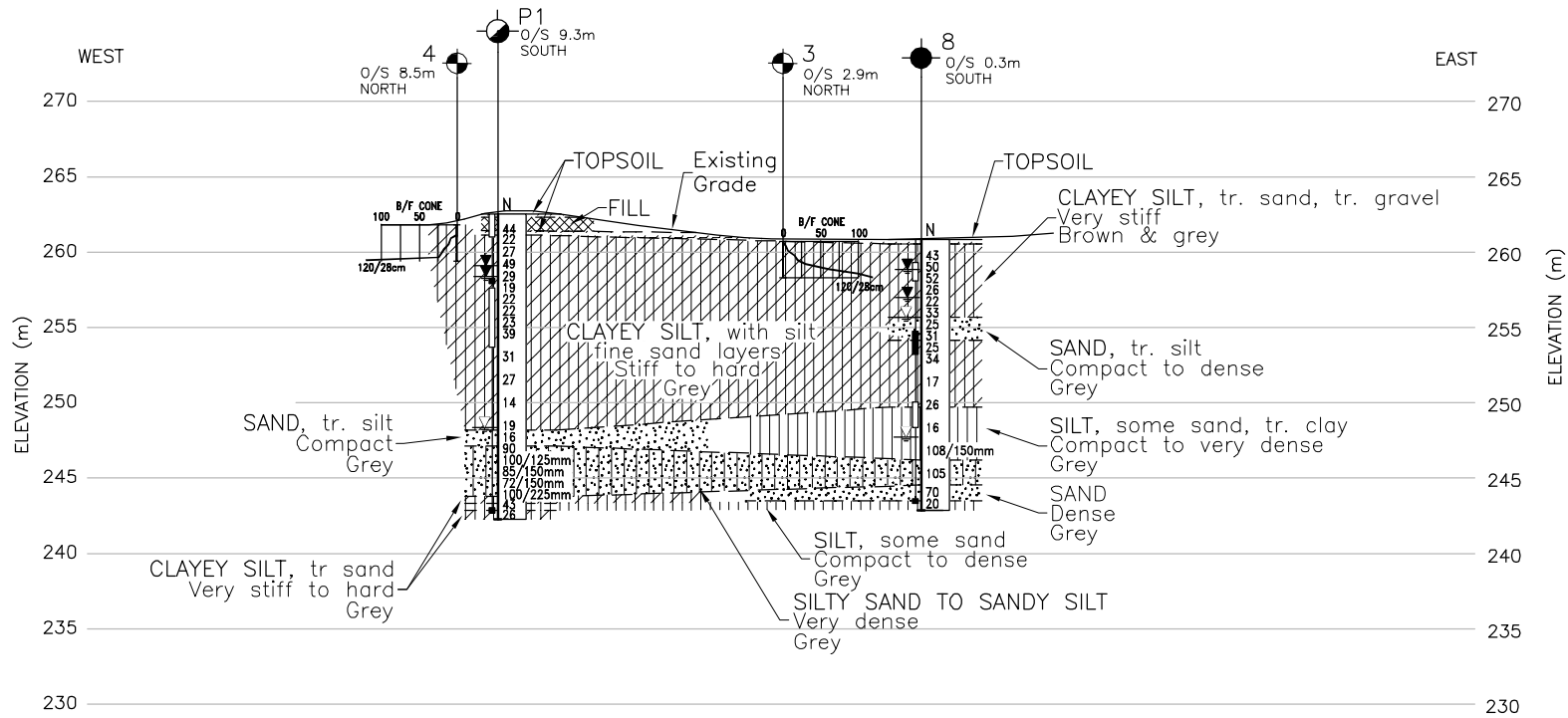
Geocres No. 40114-133A

HWY. No. 401	PROJECT NO.: 04-1130-229-2-1		
SUBM'D. -	CHKD: -	DATE: Feb. 14/06	
DRAWN: DCH	CHKD.	APPD.	DWG. 2

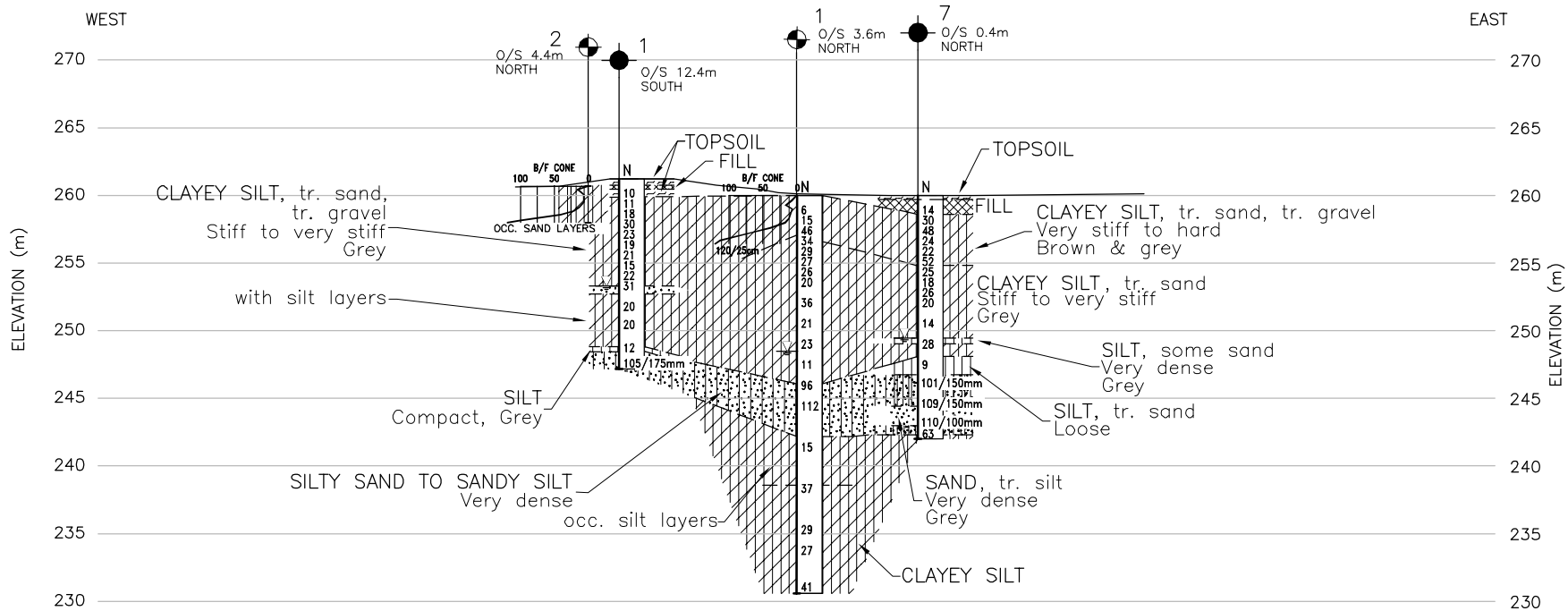
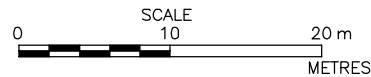
D size dwg 24" x 36" 11" x 17" plot half scale

1 = 1 metric

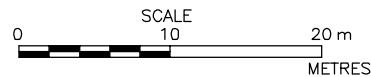
**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN



### SECTION D-D'



### SECTION E-E'



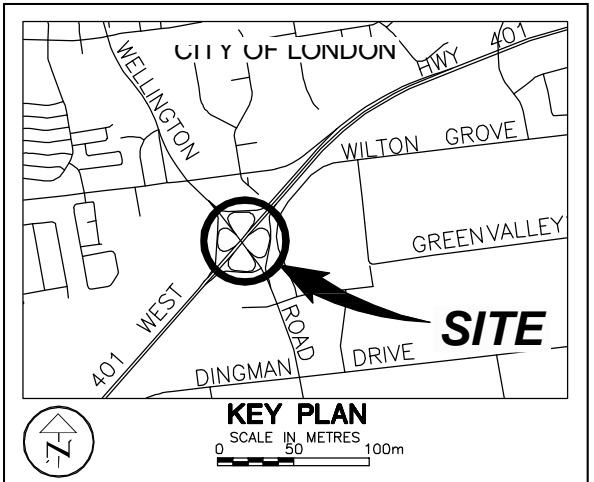
DIST 1 HWY. 401  
CONT. No.  
WP No. 476-89-00

WELLINGTON ROAD  
STRUCTURE  
SOIL STRATA

SHEET



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



### LEGEND

- Borehole (Current Investigation)
- Borehole (Golder report #001-3225-1)
- Borehole and Cone (Previous Investigation GEOCRES No. 40114-122)
- N Blows/0.3m (Std. Pen. Test, 475 j/blow)
- Seal
- Piezometer
- WL in piezometer
- WL during drilling

No.	ELEVATION (metres)	CO-ORDINATES (UTM NAD83, ZONE 17)	
		NORTHING	EASTING
CURRENT			
1	261.23	4 752 187.5	482 705.7
7	261.00	4 752 212.8	482 709.2
8	260.85	4 752 229.8	482 698.2
GOLDER 001-3225-1			
P1	261.50	4 752 202.1	482 688.1
GEOCRES No. 40114-122			
1	261.00	4 752 207.8	482 701.3
2	261.70	4 752 196.0	482 691.1
3	260.70	4 752 224.5	482 690.1
4	261.80	4 752 210.9	482 672.3

### NOTES

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

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Borehole locations from previous investigations are approximate.

### REFERENCES

Drawing Supplied by: Delcan entitled: Highway no. 401 geographic Township of Westminster County of Middlesex 19+761.880 to 25+400.000 scale 1:1000, Dated Feb. 2005 prepared for the Ministry of Transportation

Geocres No. 40114-133A

HWY. No. 401	PROJECT NO.: 04-1130-229-2-1		
SUBM'D. -	CHKD. -	DATE: Feb. 14/06	
DRAWN: DCH	CHKD.	APPD.	DWG. 3



D size dwg 24" x 36" 11" x 17" plot half scale  
1 = 1 metric

**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

DIST 1 HWY. 401  
CONT. No.  
WP No. 476-89-00

WELLINGTON ROAD  
RAMPS  
SOIL STRATA

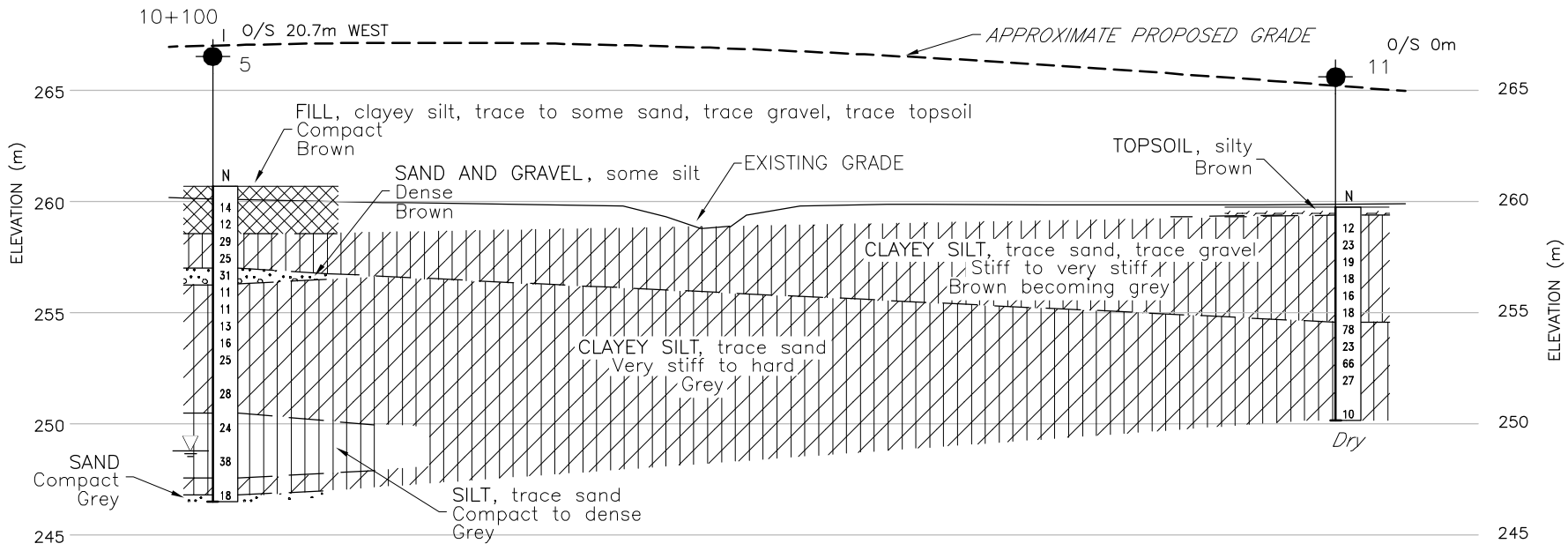
SHEET



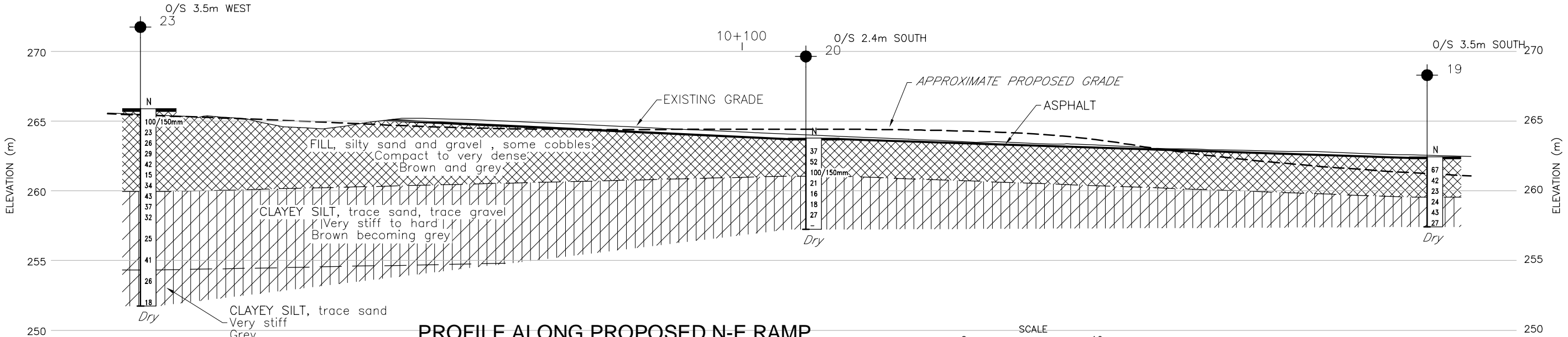
**Golder Associates Ltd.**  
LONDON, ONTARIO, CANADA

LEGEND

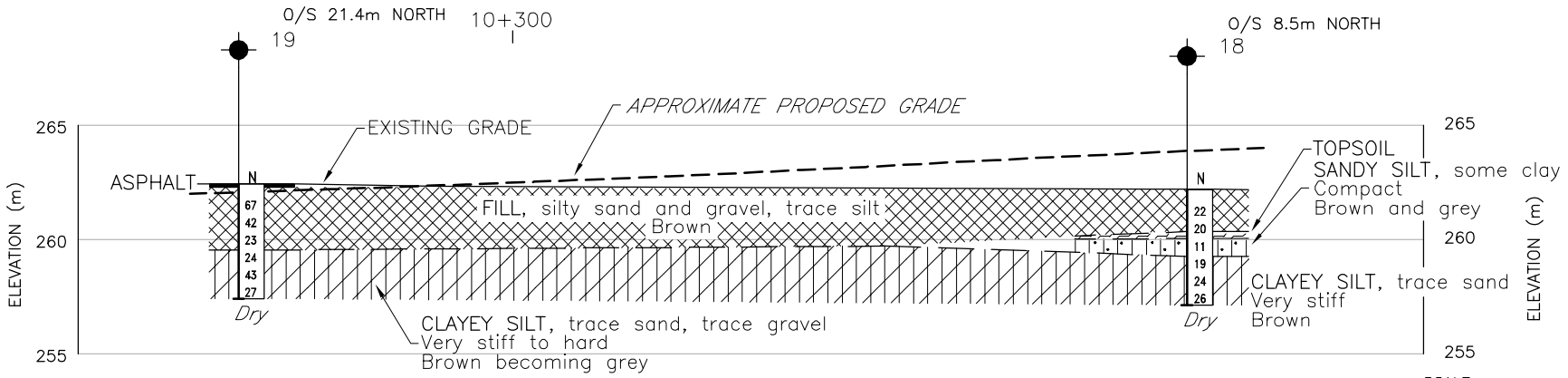
- Borehole (Current Investigation)
- Blows/0.3m (Std. Pen. Test, 475 j/blow)
- WL during drilling
- Borehole dry during drilling



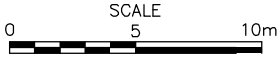
PROFILE ALONG PROPOSED S-W RAMP



PROFILE ALONG PROPOSED N-E RAMP



PROFILE ALONG PROPOSED W-N/S RAMP



No.	ELEVATION (metres)	CO-ORDINATES (UTM NAD83, ZONE 17)	
		NORTHING	EASTING
CURRENT			
5	260.68	4 752 292.8	482 625.2
11	259.76	4 752 237.0	482 615.2
18	262.18	4 752 009.4	482 718.3
19	262.45	4 752 016.4	482 684.1
20	263.79	4 752 038.6	482 724.0
23	265.90	4 752 088.4	482 732.7

NOTES

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

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

Borehole locations from previous investigations are approximate.

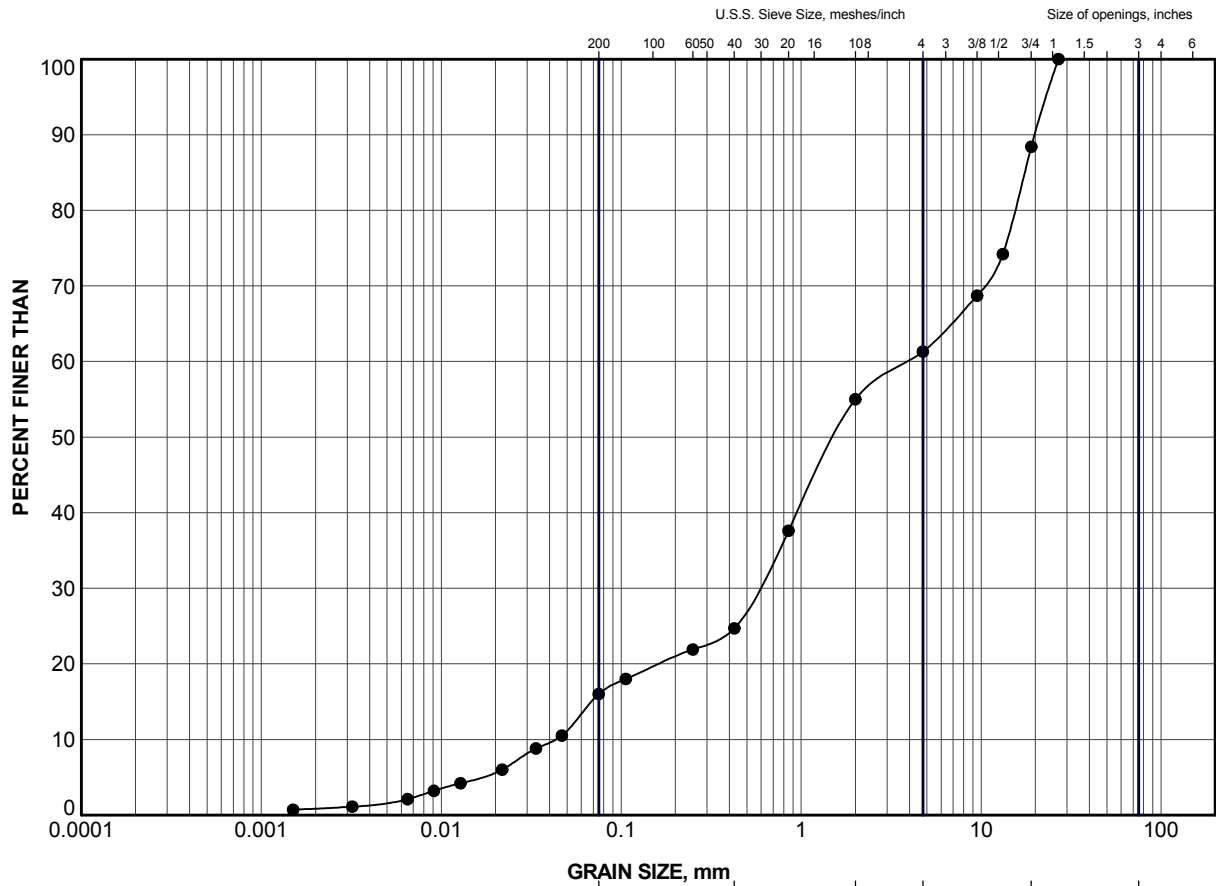
REFERENCES

Drawing Supplied by: Delcan entitled: Highway no. 401 geographic Township of Westminster County of Middlesex 19+761.880 to 25+400.000 scale 1:1000, Dated Feb. 2005 prepared for the Ministry of Transportation

Geocres No. 40114-133A


HWY. No. 401	PROJECT NO.:04-1130-229-2-1		
SUBM'D. -	CHKD. -	DATE: Feb. 14/06	
DRAWN: DCH	CHKD.	APPD.	DWG. 5

**APPENDIX A**  
**LABORATORY TEST DATA**

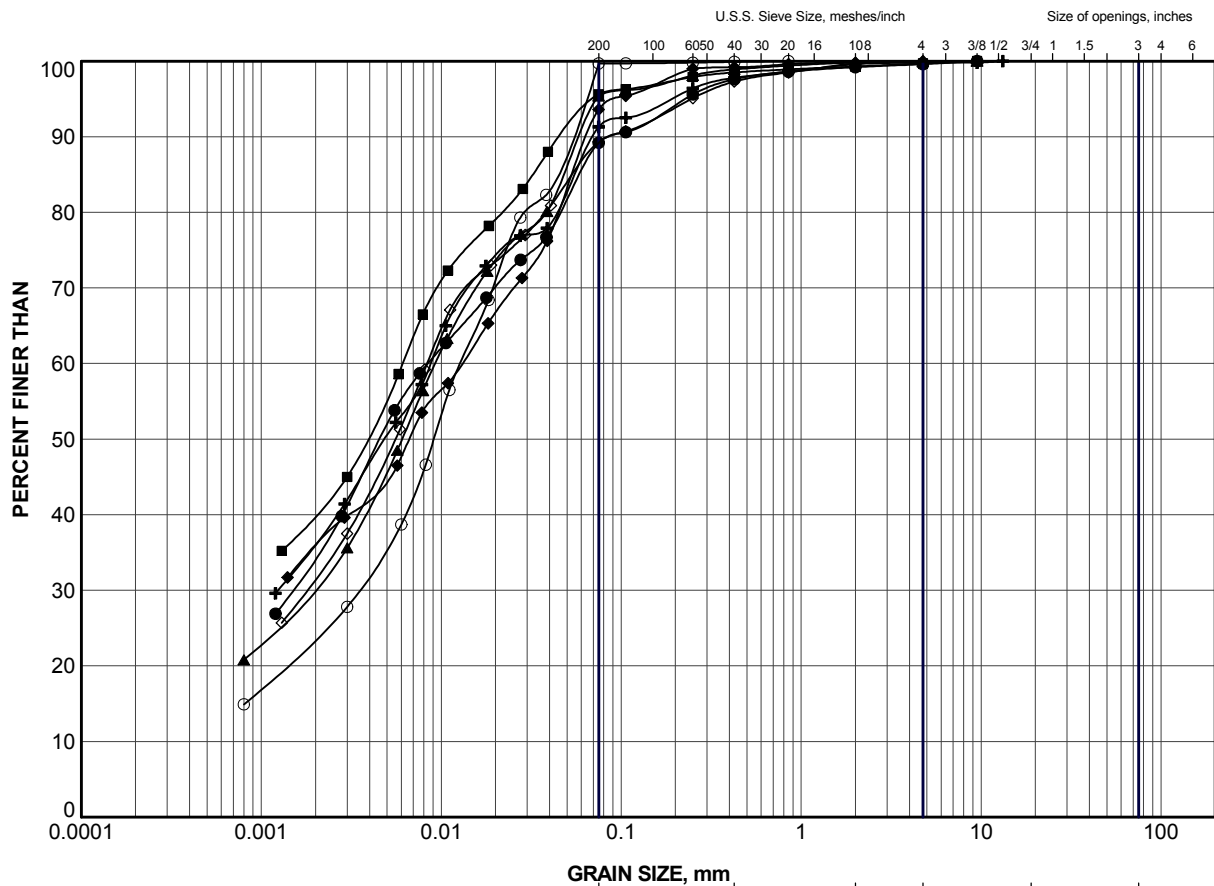


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	3	3	259.2

PROJECT				WELLINGTON ROAD AT HIGHWAY 401 GWP 476-89-00			
TITLE				GRAIN SIZE DISTRIBUTION (FILL) silty sand & gravel			
PROJECT No.		041-130229-2		FILE No.		04-1130-229-2.GPJ	
DRAWN		BG/DCH		Nov 14/05		SCALE N/A	
CHECK						REV.	
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-1</b>			

LDN\_MTO\_NEW\_GLDR\_LDNGDT



CLAY AND SILT	SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	1	4	257.9
■	1	11	251.9
▲	2	6	257.0
+	3	4	258.4
◆	3	12	250.8
◇	4	5	258.0
○	5	9	253.6

PROJECT

WELLINGTON ROAD AT HIGHWAY 401  
GWP 476-89-00

TITLE

## GRAIN SIZE DISTRIBUTION CLAYEY SILT

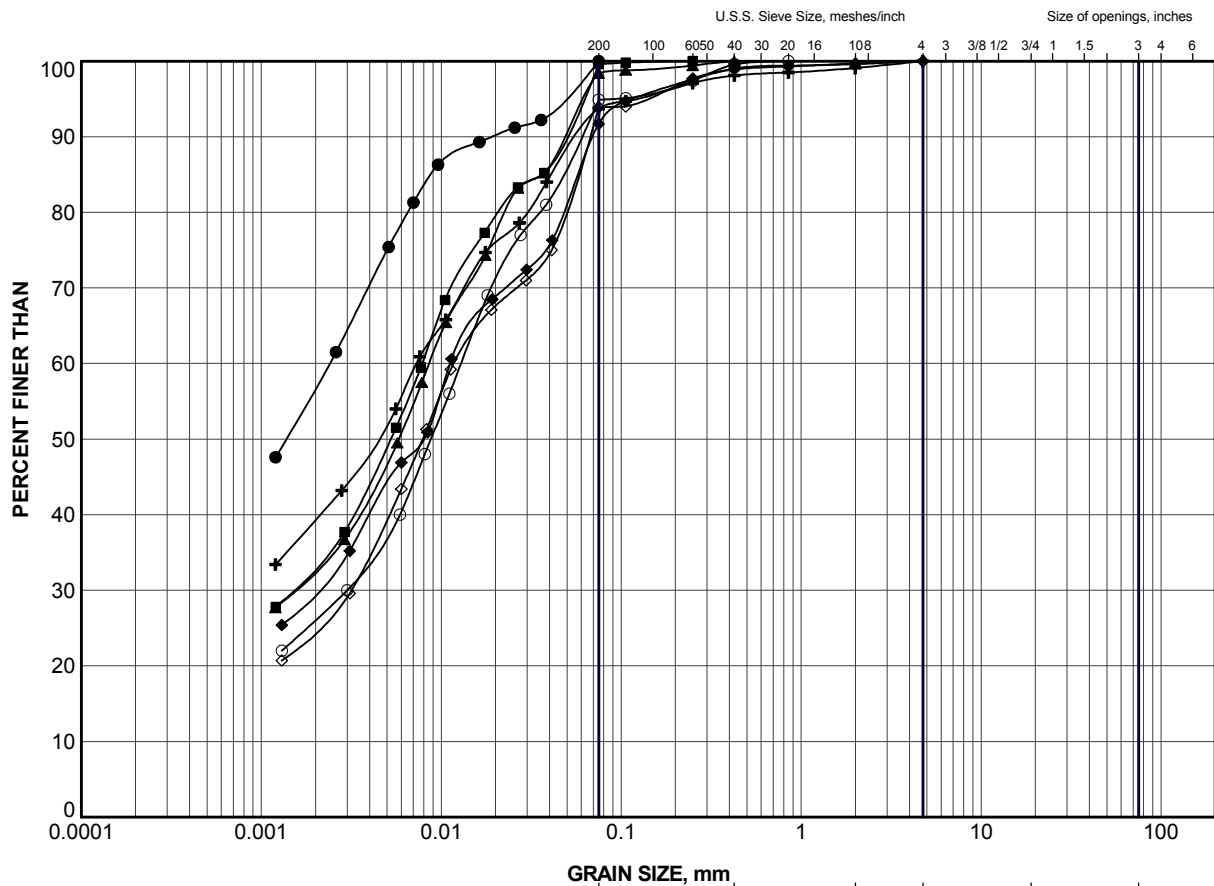


**Golder Associates**  
LONDON, ONTARIO

PROJECT No.	041-130229-2	FILE No.	04-1130-229-2.GPJ
DRAWN	DCH	Nov 18/05	SCALE N/A REV.
CHECK			

**FIGURE A-2**





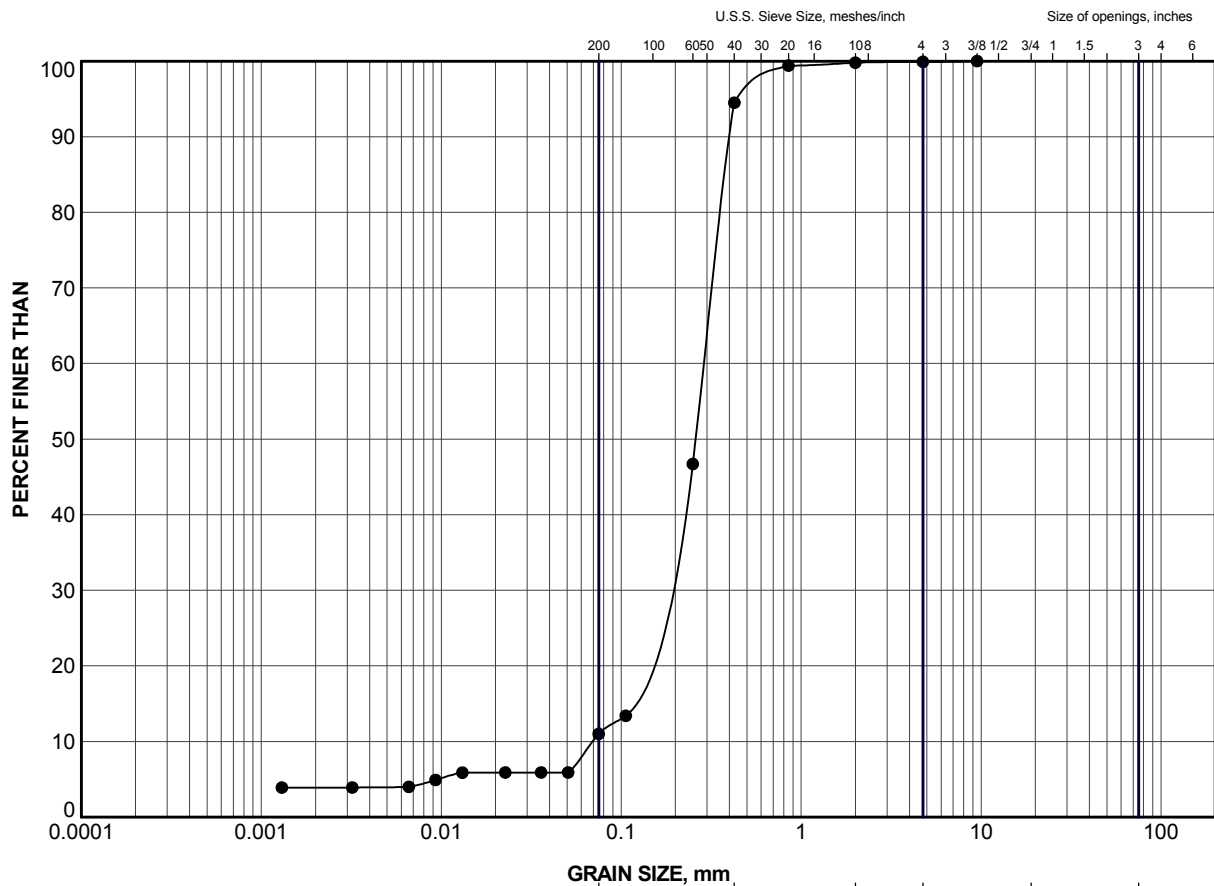
CLAY AND SILT	SAND SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	6	11	249.8
■	7	8	254.7
▲	8	11	251.5
+	9	7	254.2
◆	9	11	251.1
◇	10	5	257.3
○	10	13	248.9

PROJECT				WELLINGTON ROAD AT HIGHWAY 401 GWP 476-89-00			
TITLE				GRAIN SIZE DISTRIBUTION CLAYEY SILT			
PROJECT No.		041-130229-2		FILE No.		04-1130-229-2.GPJ	
DRAWN		DCH		Nov 18/05		SCALE N/A REV.	
CHECK						FIGURE A-3	



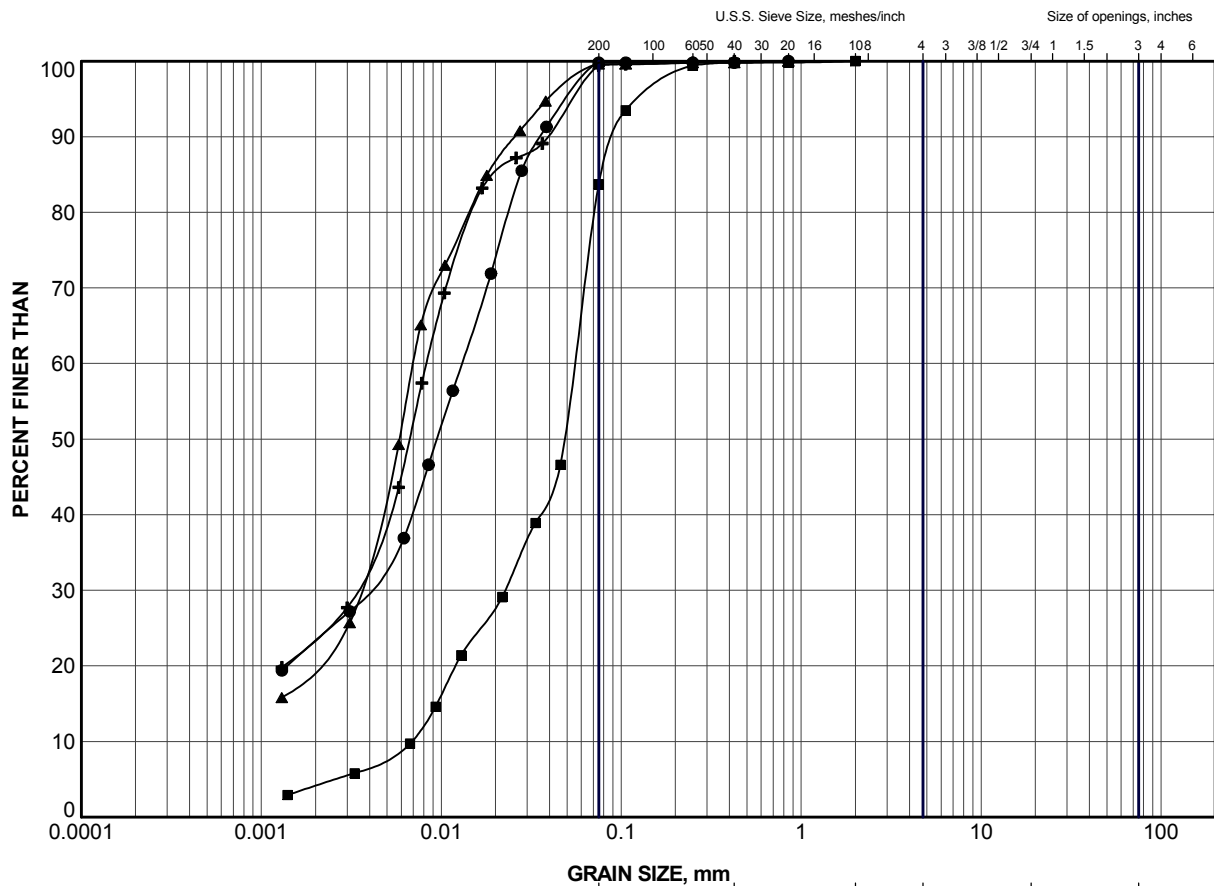


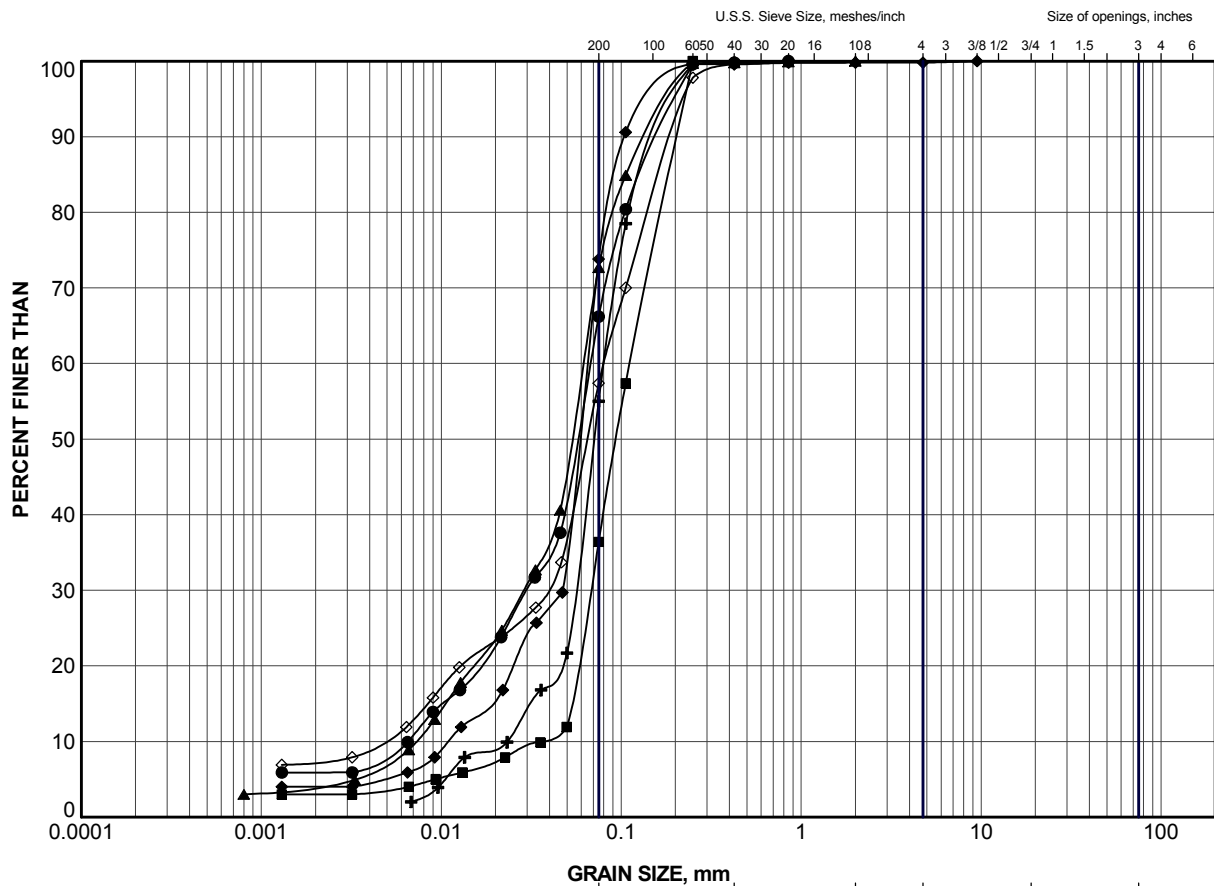
GRAVEL SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	8	8	254.6

PROJECT				WELLINGTON ROAD AT HIGHWAY 401 GWP 476-89-00			
TITLE				GRAIN SIZE DISTRIBUTION SAND			
PROJECT No.		041-130229-2		FILE No.		04-1130-229-2.GPJ	
DRAWN		BG/DCH		SCALE		N/A	
CHECK				REV.			
Golder Associates LONDON, ONTARIO		Nov 14/05		FIGURE A-4			




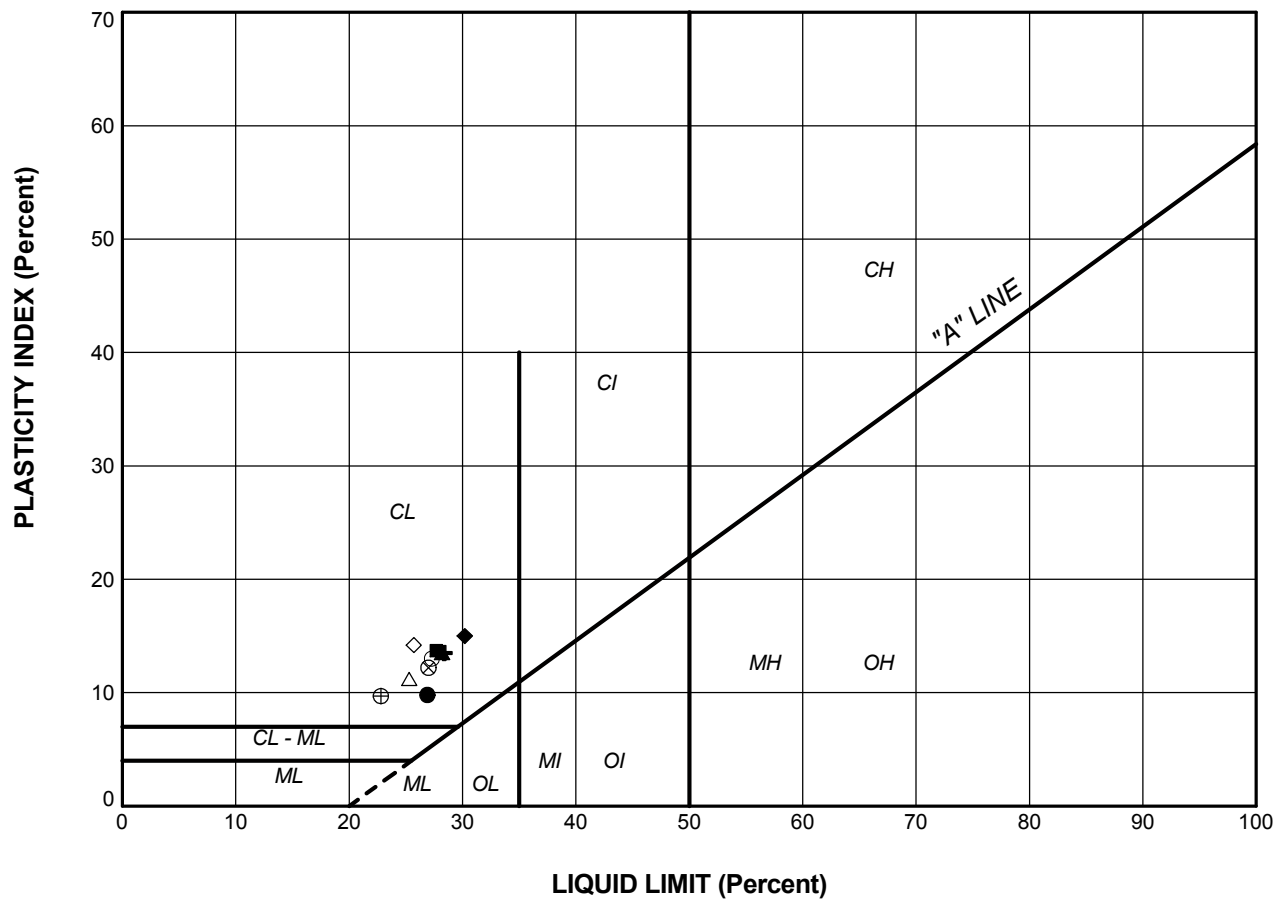


GRAVEL SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	2	15	246.3
■	3	15	245.2
▲	7	14	247.1
+	8	15	245.4
◆	9	15	245.5
◇	10	15	246.3

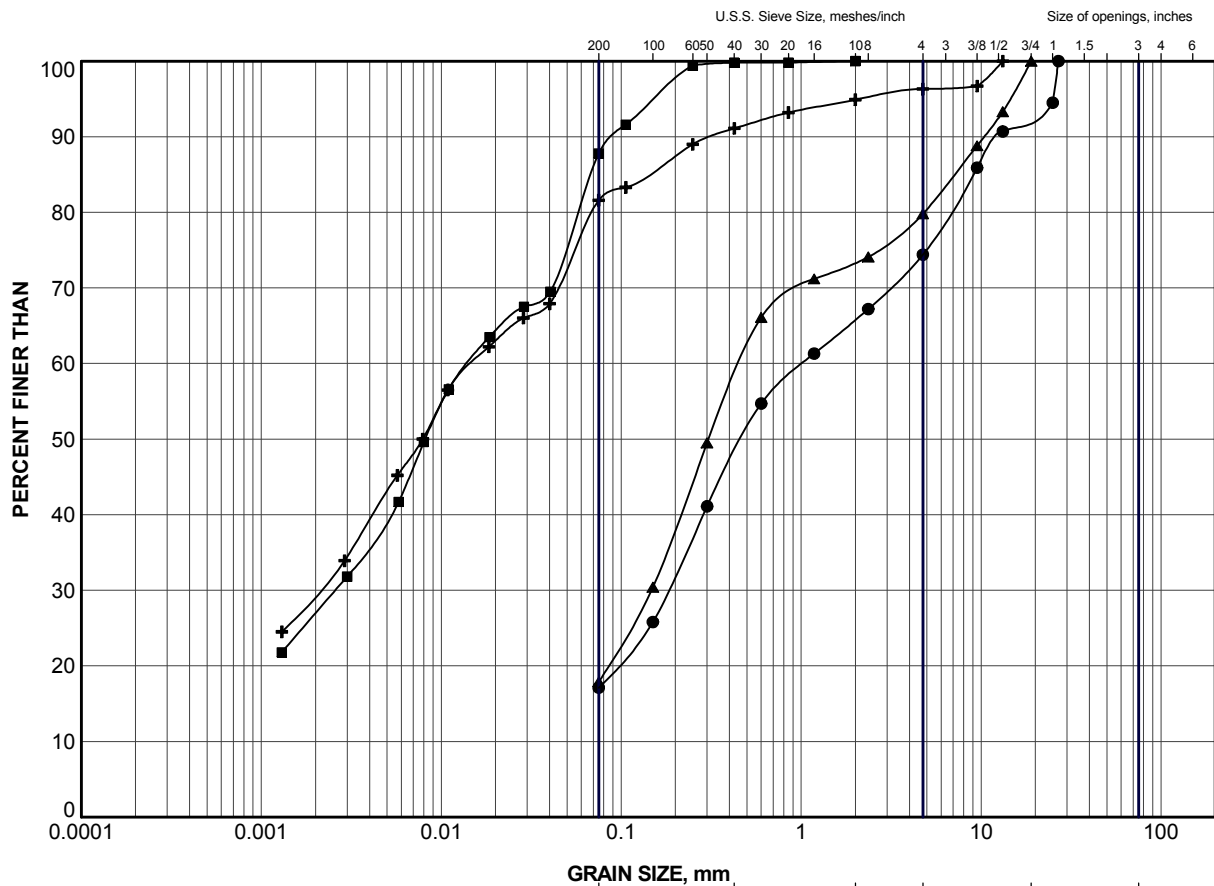
PROJECT				
WELLINGTON ROAD AT HIGHWAY 401 GWP 476-89-00				
TITLE				
GRAIN SIZE DISTRIBUTION SITY SAND & SILTY SAND				
PROJECT No. 041-130229-2		FILE No. 04-1130-229-2.GPJ		
DRAWN	DCH	Nov 18/05	SCALE	N/A
CHECK			REV.	
 <b>Golder Associates</b> LONDON, ONTARIO			<b>FIGURE A-6</b>	



### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	1	3	26.9	17.1	9.8
■	2	7	27.7	14.0	13.7
▲	3	5	28.2	14.7	13.5
+	5	8	28.4	14.9	13.5
◆	6	10	30.2	15.2	15.0
◇	7	7	25.7	11.5	14.2
○	8	12	27.3	14.3	13.0
△	9	5	25.3	14.1	11.2
⊗	10	5	27.0	14.8	12.2
⊕	10	12	22.8	13.1	9.7


PROJECT			
WELLINGTON ROAD AT HIGHWAY 401 GWP 476-89-00			
TITLE			
PLASTICITY CHART			
PROJECT No. 041-130229-2		FILE No. 04-1130-229-2.GPJ	
DRAWN	BG/DCH	Nov 14/05	SCALE N/A REV.
CHECK			
 <b>Golder Associates</b> LONDON, ONTARIO			<b>FIGURE A-7</b>

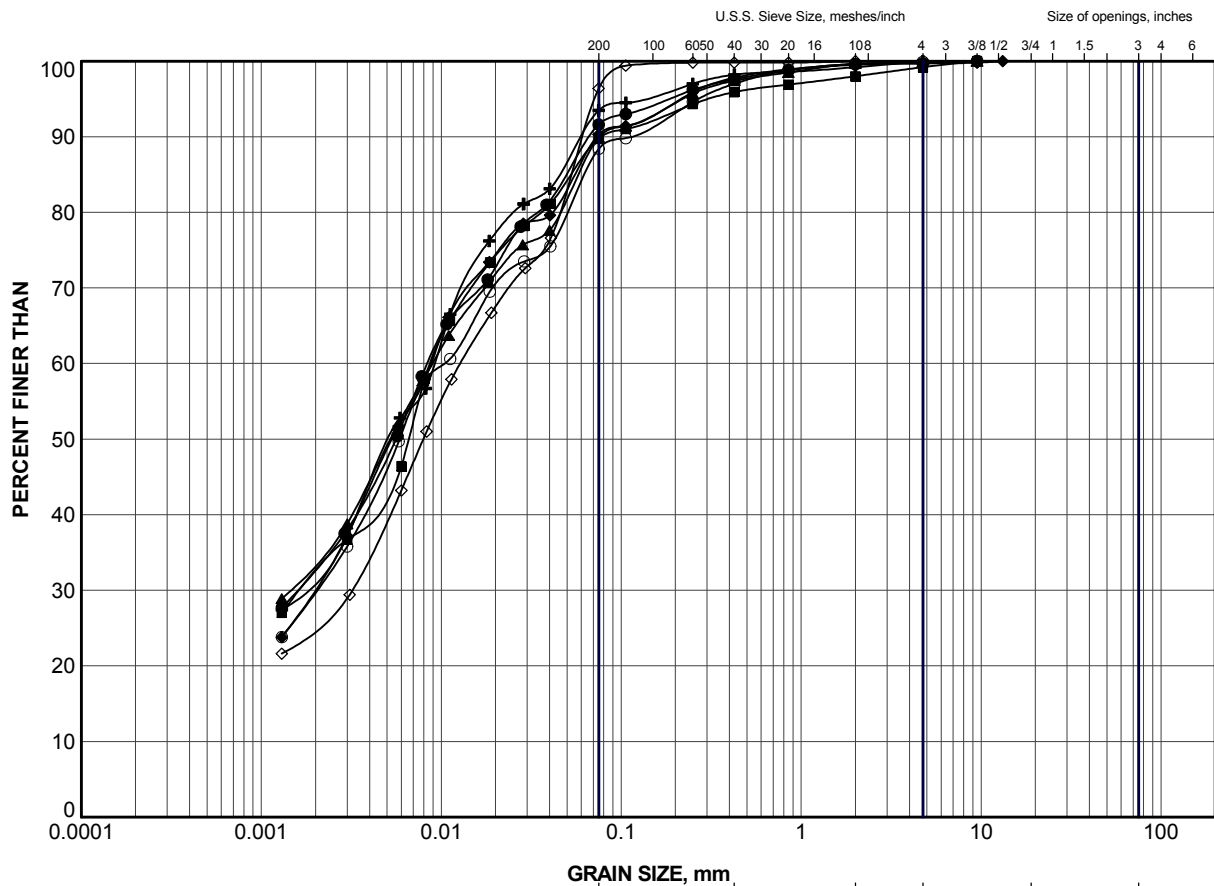


GRAVEL SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	21	4	265.2
■	21	11	259.1
▲	22	2	266.7
+	22	7	261.4

PROJECT				WELLINGTON ROAD AT HIGHWAY 401 GWP 476-89-00			
TITLE				GRAIN SIZE DISTRIBUTION FILL			
PROJECT No.		041-130229-2		FILE No.		04-1130-229-2.GPJ	
DRAWN		BG/DCH		SCALE		N/A	
CHECK		Nov 14/05		REV.			
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-8</b>			



CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	11	3	256.5
■	12	3	257.8
▲	13	5	255.9
+	14	5	257.5
◆	15	5	257.7
◇	15	10	253.9
○	16	3	259.3

PROJECT

WELLINGTON ROAD AT HIGHWAY 401  
GWP 476-89-00

TITLE

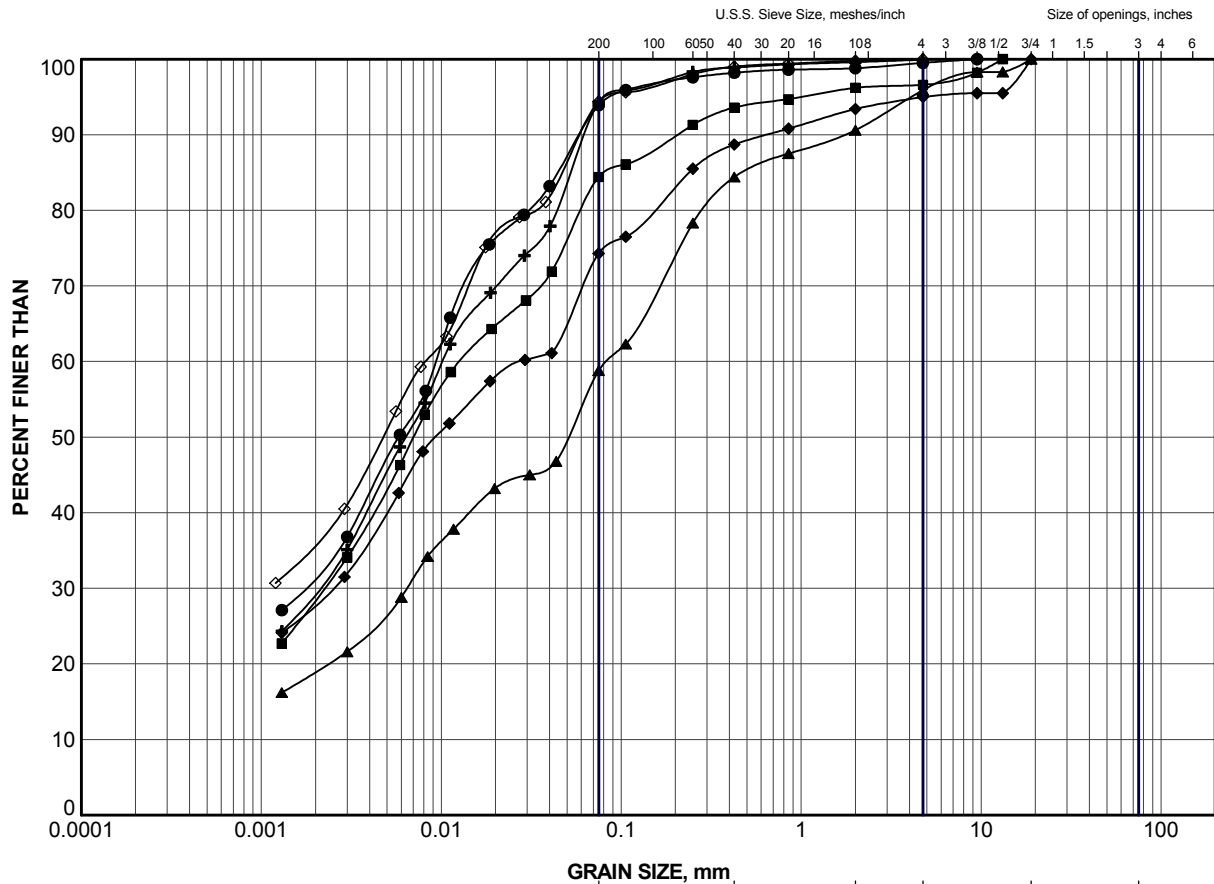
## GRAIN SIZE DISTRIBUTION CLAYEY SILT



**Golder Associates**  
LONDON, ONTARIO

PROJECT No.	041-130229-2	FILE No.	04-1130-229-2.GPJ
DRAWN	DCH	Nov 18/05	SCALE N/A REV.
CHECK			


**FIGURE A-9**



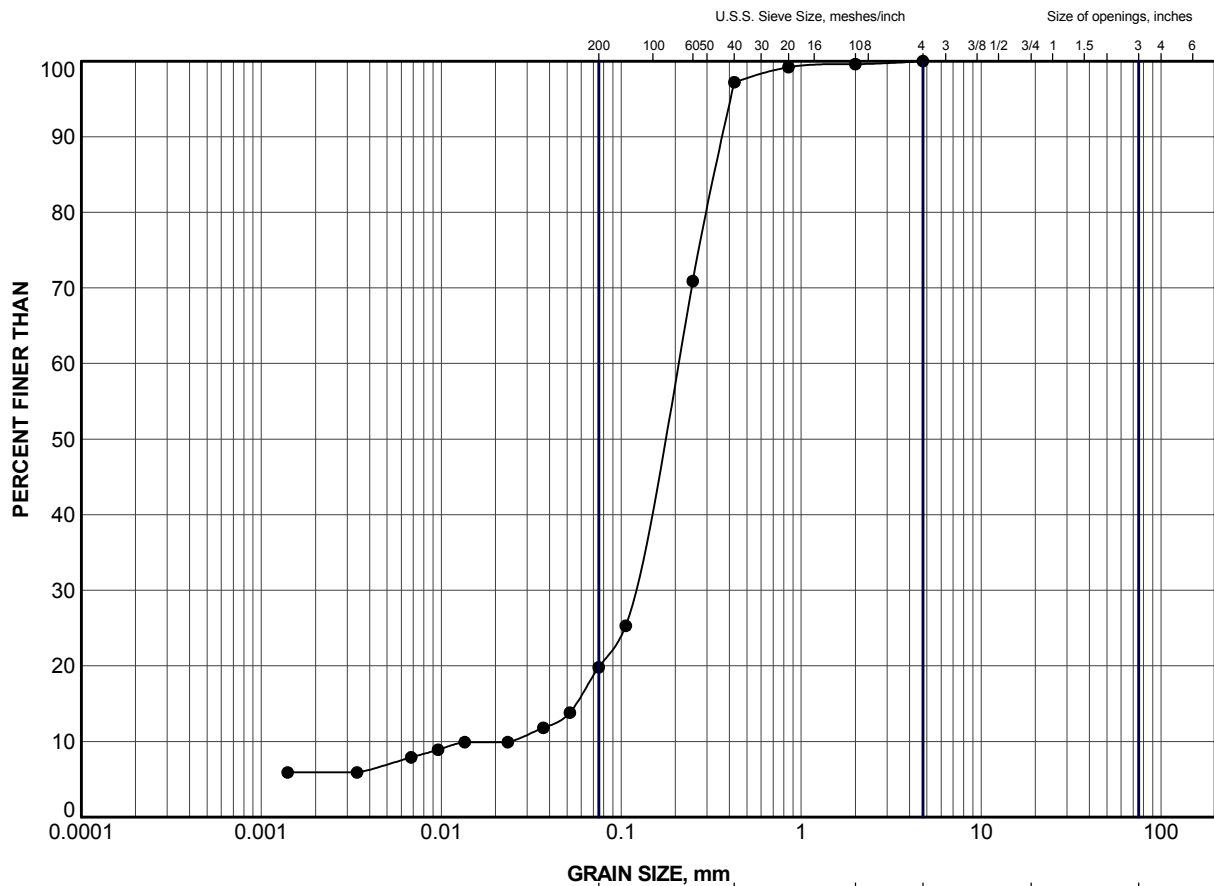
GRAVEL SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	18	4	258.9
■	19	4	259.2
▲	20	5	259.8
+	21	12	257.6
◆	22	11	259.1
◇	23	11	256.5

PROJECT				WELLINGTON ROAD AT HIGHWAY 401 GWP 476-89-00			
TITLE				GRAIN SIZE DISTRIBUTION CLAYEY SILT			
PROJECT No.		041-130229-2		FILE No.		04-1130-229-2.GPJ	
DRAWN		DCH		SCALE		N/A	
CHECK		Nov 18/05		REV.			
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-10</b>			




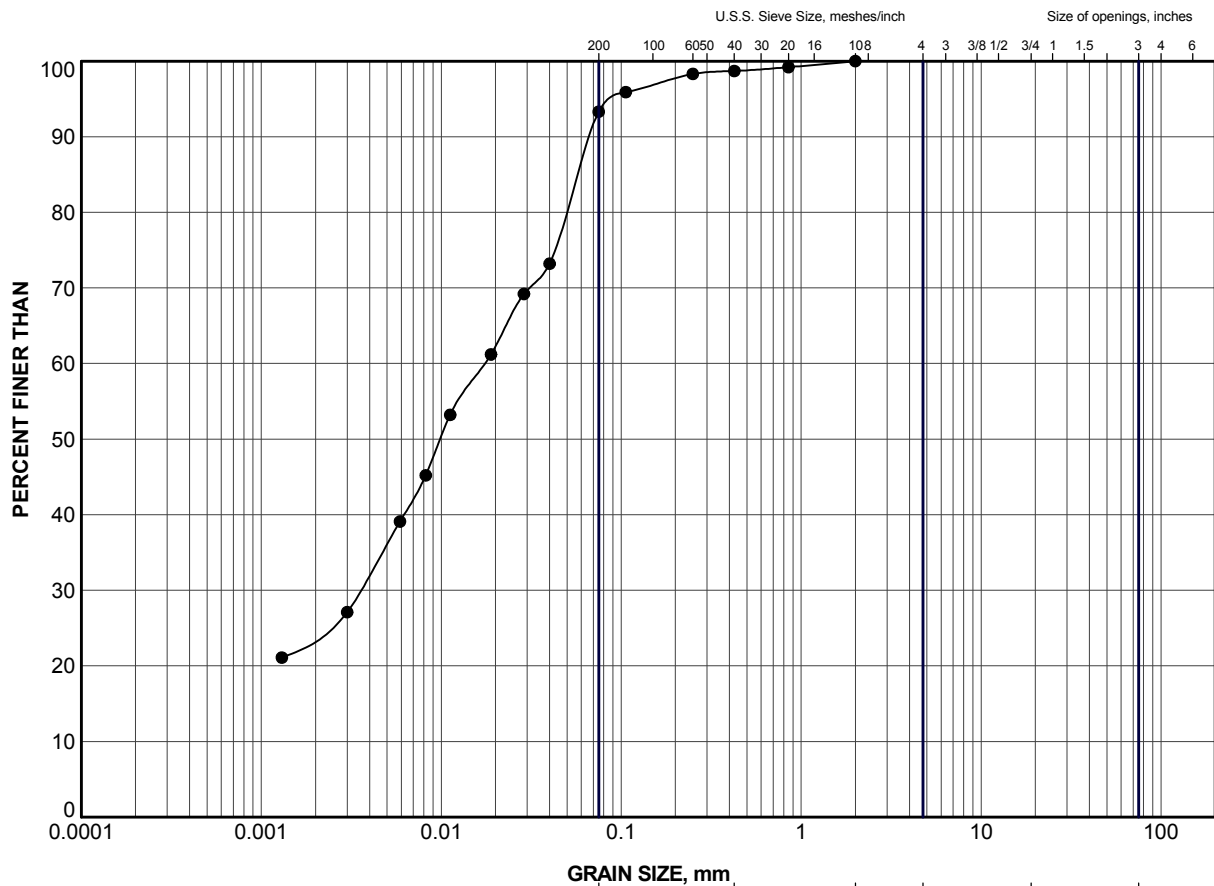


GRAVEL SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	12	8	254.0


PROJECT				
WELLINGTON ROAD AT HIGHWAY 401 GWP 476-89-00				
TITLE				
GRAIN SIZE DISTRIBUTION SAND				
PROJECT No. 041-130229-2		FILE No. 04-1130-229-2.GPJ		
DRAWN DCH		Nov 18/05		
CHECK				
 <b>Golder Associates</b> LONDON, ONTARIO		<b>FIGURE A-11</b>		

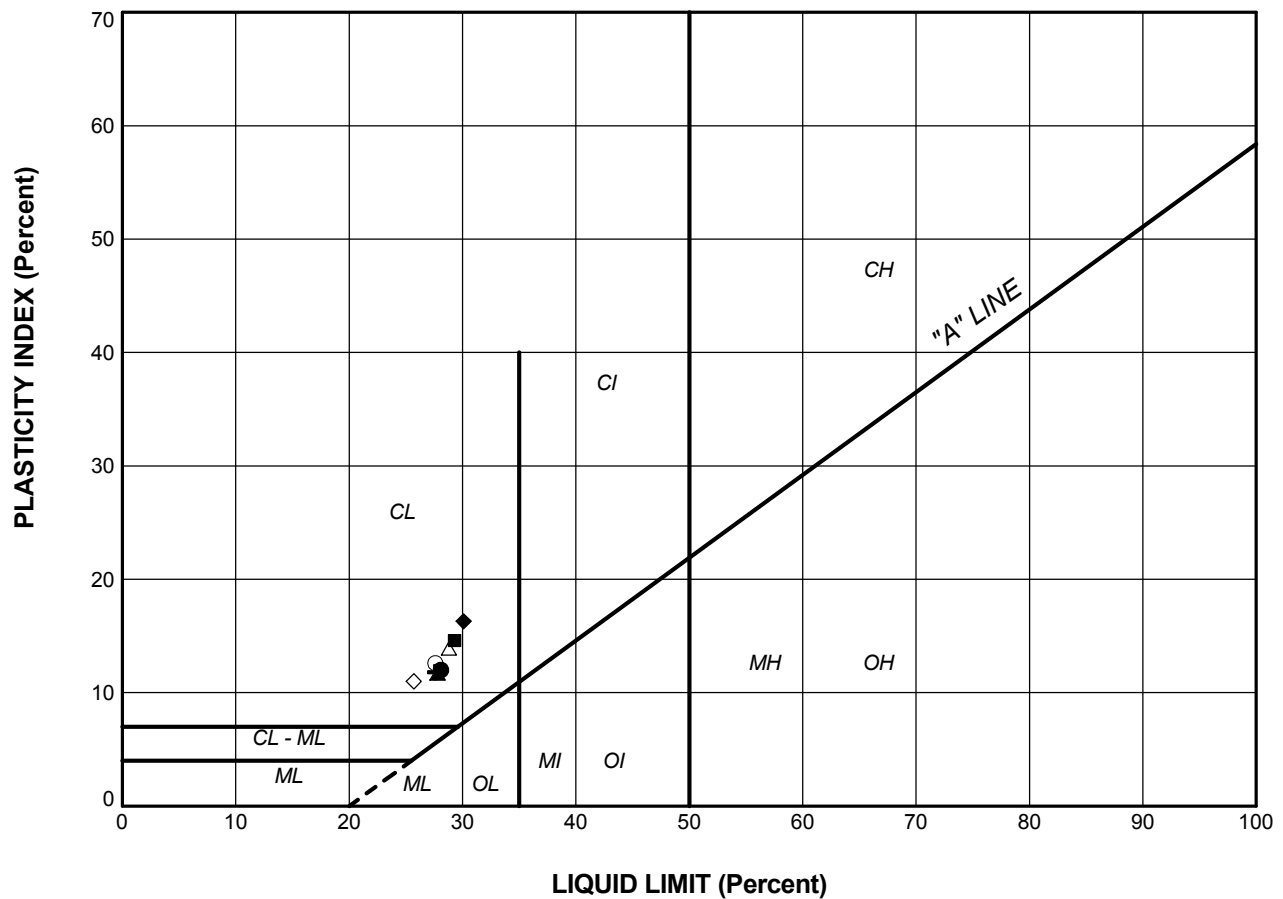


GRAVEL SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	18	3	259.7

PROJECT				WELLINGTON ROAD AT HIGHWAY 401 GWP 476-89-00			
TITLE				GRAIN SIZE DISTRIBUTION SANDY SILT			
PROJECT No.		041-130229-2		FILE No.		04-1130-229-2.GPJ	
DRAWN		BG/DCH		SCALE		N/A	
CHECK		Nov 18/05		REV.			
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-12</b>			




**SOIL TYPE**  
 C = Clay  
 M = Silt  
 O = Organic

**PLASTICITY**  
 L = Low  
 I = Intermediate  
 H = High

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	11	2	28.1	16.1	12.0
■	13	4	29.3	14.7	14.6
▲	15	5	27.8	16.1	11.7
+	16	4	27.6	15.8	11.8
◆	18	4	30.1	13.8	16.3
◇	20	4	25.7	14.7	11.0
○	22	12	27.6	15.0	12.6
△	23	10	28.8	14.9	13.9

PROJECT			
WELLINGTON ROAD AT HIGHWAY 401 GWP 476-89-00			
TITLE			
PLASTICITY CHART			
PROJECT No. 041-130229-2		FILE No. 04-1130-229-2.GPJ	
DRAWN	BG/DCH	Nov 14/05	SCALE N/A REV.
CHECK			
 <b>Golder Associates</b> LONDON, ONTARIO			<b>FIGURE A-13</b>

**APPENDIX B**

**RECORDS OF PREVIOUS BOREHOLES**

# RECORD OF BOREHOLE No 1

1 OF 2

**METRIC**

PROJECT 001-3225-1  
G.W.P. 476-89-00 LOCATION 4754411.2 N, 409936.9 E ( WELLINGTON ROAD SITE No. 19-369 ) ORIGINATED BY DJM  
DIST HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY DJM  
DATUM GEODETIC DATE August 28, 2001 CHECKED BY AMH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT		UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
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>	
261.50	GROUND SURFACE												
0.00	TOPSOIL, sandy												
0.20	Brown FILL, silty fine sand, with gravel Dense Brown												
260.43			1	SS	44								
1.07	TOPSOIL, silty												
260.13	Compact Black												
1.37	CLAYEY SILT, trace sand, trace gravel Very stiff to hard Brown to Grey at 5.2m depth		2	SS	22								
			3	SS	27								2 10 54 34
			4	SS	49								
			5	SS	29								
			6	SS	19								
			7	SS	22								4 62 34
			8	SS	22								
			9	SS	23								1 2 66 31
254.03													
7.47	CLAYEY SILT, with silt layers, trace sand Stiff to hard Grey		10	SS	39								
			11	SS	31								
			12	SS	27								
			13	SS	14								
			14	SS	19								2 65 33
247.17													
14.33	SAND, fine, trace silt Compact Grey		15	SS	16								

( Golder Report No. 001-3225-1 )

ONL\_MTO 00132255B.GPJ ON\_MOT.GDT 11/10/05

Continued Next Page

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

PROJECT <u>001-3225-1</u>		<b>RECORD OF BOREHOLE No 1</b>		2 OF 2	<b>METRIC</b>
G.W.P. <u>476-89-00</u>	LOCATION <u>4754411.2 N, 409936.9 E ( WELLINGTON ROAD SITE No. 19-369 )</u>	ORIGINATED BY <u>DJM</u>			
DIST <u>          </u> HWY <u>401</u>	BOREHOLE TYPE <u>POWER AUGER (HOLLOW STEM)</u>	COMPILED BY <u>DJM</u>			
DATUM <u>GEODETIC</u>	DATE <u>August 28, 2001</u>	CHECKED BY <u>AMH</u>			

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 (%)					
								20   40   60   80   100	20   40   60   80   100	10   20   30					
							○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × LAB VANE								
246.11															
15.39	SILTY FINE SAND Very dense Grey		16	SS	90		246								
			17	SS	100/ 125mm										
			18	SS	85/ 150mm		245								
			19	SS	72/ 150mm		244								
			20	SS	100/ 225mm		243								
242.75															
18.75	CLAYEY SILT, trace sand, trace gravel														
242.30	Hard Grey		21	SS	43		242								
241.84	SILT, trace sand														
19.66	Dense Grey														
241.23	CLAYEY SILT, trace sand		22	SS	26										
20.27	Very stiff Grey End of Borehole														
<div>( Golder Report No. 001-3225-1 )</div>															
NOTE: Water level encountered in Borehole at elev. 247.33 during drilling Aug. 28, 2001  Water level in Piezometer #1 (deep) at elev. 258.16 Sept. 29, 2001 Water level in Piezometer #2 (shallow) at elev. 257.36 Sept. 29, 2001															

# RECORD OF BOREHOLE No 2

1 OF 2

METRIC

PROJECT 001-3225-1  
G.W.P. 476-89-00 LOCATION 4754471.6 N, 409891.9 E ( WELLINGTON ROAD SITE No. 19-369 ) ORIGINATED BY DJM  
DIST HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY DJM  
DATUM GEODETIC DATE August 29, 2001 CHECKED BY AMH

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	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)		
261.00	GROUND SURFACE												
0.00	TOPSOIL, silty												
0.15	Brown												
260.39	FILL, sand trace silt, with gravel												
0.61	CLAYEY SILT, trace sand, trace gravel Very stiff to hard Brown to Grey at 3.7m depth		1	SS	58		260						
			2	SS	39		259						
			3	SS	23		258						
			4	SS	22		257						
			5	SS	19		256						
			6	SS	24		255						
			7	SS	20		254						
			8	SS	34		253						
			9	SS	27		252						
253.53	CLAYEY SILT, with silt layers, trace sand Very stiff grey Grey		10	SS	17		251						
7.47			11	TW	PH		250						
			12	SS	16		249						
			13	SS	23		248						
247.13	SILTY FINE SAND Dense to very dense Grey		14	SS	49		247						
13.87			15	SS	93/ 250mm								

( Golder Report No. 001-3225-1 )

1 8 59 32

Continued Next Page

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

**RECORD OF BOREHOLE No 2**

2 OF 2

**METRIC**

PROJECT 001-3225-1  
G.W.P. 476-89-00 LOCATION 4754471.6 N, 409891.9 E ( WELLINGTON ROAD SITE No. 19-369 ) ORIGINATED BY DJM  
DIST HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY DJM  
DATUM GEODETIC DATE August 29, 2001 CHECKED BY AMH

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 80 100	20 40 60 80 100	10 20 30								
245.81 15.09	SAND, fine, trace silt Very dense Grey		16	SS	75/ 150mm		245											
245.15																		
15.85	SILTY FINE SAND Very dense Grey		17	SS	58/ 150mm			244										
					18	SS	50/ 75mm											
243.11	CLAYEY SILT, with silt layers Very stiff to hard Grey		19	SS	50/ 75mm	243												
17.89																		
					20		SS	66										
241.49	End of Borehole		21	SS	27		242											
19.51																		
<div>NOTE: Water level encountered in Borehole at elev. 247.28 during drilling Aug. 29, 2001  Water level in Piezometer #1 (deep) at elev. 258.16 Sept. 29, 2001 Water level in Piezometer #2 (shallow) at elev. 259.32 Sept. 29, 2001</div> <div>( Golder Report No. 001-3225-1 )</div>																		

( Golder Report No. 001-3225-1 )



# RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 476 - 89 - 05 LOCATION Co-ords: N 4 754 197.7; E 409 942.7 ORIGINATED BY M V  
DIST 2 HWY 401 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V  
DATUM GEODETTIC DATE 93 01 25 TO 93 02 02 CHECKED BY P P

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 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			2C 40 60 80 100	100					
261.0	Ground Surface													
0.0	Trace of Sand and Trace of Gravel		1	SS	6		260							
	Occasional Sand Layers		2	SS	15		258							
			3	SS	46									
			4	SS	34									
			5	SS	29									
			6	SS	27									
			7	SS	26									
			8	SS	20									
	CLAYEY SILT, Hard to Very Stiff													
			9	SS	36									
			10	SS	21									
			11	SS	23									
			12	SS	11									
	Occasional Silt Layers													
247.1			13	SS	96									
13.9	SILTY SAND to SANDY SILT, Very Dense		14	SS	112									
243.2														
17.8	Occasional Silt Layers		15	SS	15									
			16	SS	37									
	CLAYEY SILT, Very Stiff to Hard		17	SS	29									
			18	SS	27									
231.6			19	SS	41									
29.4	End of Borehole													

(GEOCRES No. 40114-122)  
"Note; This Drawing has been Reduced and is in  
Imperial Units"



# RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 476 - 89 - 05 LOCATION Co-ords: N 4 754 185.7; E 408 933.0 ORIGINATED BY M V  
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST COMPILED BY M V  
DATUM GEODETIC DATE 93 02 11 CHECKED BY P P

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								
261.7	Toe of Embankment											
0.0	Probable CLAYEY SILT											
259.0												
2.7	End of Cone Test											

**( GEOCRETS No. 40114-122 )**

*" Note; This Drawing has been Reduced and is in Imperial Units "*

# RECORD OF BOREHOLE No 3

1 OF 1 METRIC

W.P. 476 - 89 - 05 LOCATION Co-ords: N 4 754 214.0; E 409 831.0 ORIGINATED BY M V  
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST COMPILED BY M V  
 DATUM GEODETIC DATE 93 02 11 CHECKED BY P P

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								
260.7	Ground Surface											
0.0	Probable CLAYEY SILT					260						
258.3												
2.4	End of Cone Test:						120/25cm					

**( GEOCRES No. 40114-122 )**

" Note; This Drawing has been Reduced and is in Imperial Units "



RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 476 - 89 - 05 LOCATION Co-ords: N 4 754 199.8; E 409 913.5 ORIGINATED BY M V  
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST COMPILED BY M V  
DATUM GEODETTIC DATE 93 02 11 CHECKED BY P P

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 7 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					
261.8	Hwy. 401 EBL Shoulder												
0.0	Asphalt Gravelly Sand (Fill)	X 2											
0.5	Probable												
259.4	CLAYEY SILT					260							
2.4	End of Cone Test												
<p>( GEOCREs No. 40114-122 )</p> <p>" Note; This Drawing has been Reduced and is in Imperial Units "</p>													

# RECORD OF BOREHOLE No 5

1 OF 2 METRIC

W.P. 476 - 89 - 05 LOCATION Co-ords: N 4 754 252.4; E 409 903.0 ORIGINATED BY M V  
DIST 2 HWY 401 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V  
DATUM GEODETTIC DATE 93 02 08 & 09 CHECKED BY P P

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			20 40 60 80 100	20 40 60 80 100					
260.5	Ground Surface													
0.0	Trace of Sand, Trace of Gravel, Occasional Sand Layers		1	SS	31		260							
			2	SS	35									
			3	SS	30		258							
			4	SS	24									
	CLAYEY SILT, Hard to Very Stiff		5	SS	19		256							
			6	SS	17									
254.4			7	SS	20									
6.1			8	SS	30		254							
	Clayey Silt		9	SS	33									
			10	SS	18		252							
			11	SS	58									0 88 (12)
	Clayey Silt		12	SS	24		250							
			13	SS	10		248							0 1 (99)
	SILTY SAND to SANDY SILT, Occasional Clayey Silt Layers, Compact to Very Dense		14	SS	138		246							0 32 (68)
			15	SS	17									
			16	SS	29		244							0 11 89
242.0			17	SS	31		242							
18.5							240							
			18	SS	38		238							
							236							
	CLAYEY SILT, Hard to Very Stiff		19	SS	51		234							
			20	SS	28		232							
230.0														
30.5														

Continued

+3, x5: Numbers refer to Sensitivity 20 15-5 (2) STRAIN AT FAILURE 10

Continued

(GEOCRETS No. 40114-122)  
"Note; This Drawing has been Reduced and is in Imperial Units"



# RECORD OF BOREHOLE No 5

2 OF 2

METRIC

W.P. 476 - 89 - 05 LOCATION Co-ords: N 4 754 252.4; E 409 903.0 ORIGINATED BY M V  
DIST 2 HWY 401 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V  
DATUM GEODETIC DATE 93 02 08 & 09 CHECKED BY P P

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80					
230.0	Continued															
30.5	CLAYEY SILT, Very Stiff		21	SS	17											
226.5			22	SS	25											
34.0	End of Borehole															

**( GEOCRES No. 40II4-122 )**

*" Note; This Drawing has been Reduced and is in Imperial Units "*

# RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 475 - 89 - 05 LOCATION Co-ords: N 4 754 230.9; E 409 888.7 ORIGINATED BY M V  
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST COMPILED BY M V  
DATUM GEODETTIC DATE 93 02 08 CHECKED BY P P

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								
262.0	Ground Surface												
0.0	Trace of Organics												
	Probable CLAYEY SILT												
258.1													
3.9	End of Cone Test												
<p>( GEOCRES No. 40114-122 )</p> <p>" Note; This Drawing has been Reduced and is in Imperial Units "</p>													



# RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 476 - 89 - 05 LOCATION Co-ords: N 4 754 268.4; E 409 890.7 ORIGINATED BY M V  
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST COMPILED BY M V  
 DATUM GEODETIC DATE 93 02 03 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W <sub>P</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub>	WATER CONTENT (%) 10 20 30	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							
260.8	Ground Surface											
0.0												
	Probable CLAYEY SILT											
256.2												
4.6	End of Cone Test											

(GEOCRES No. 40114-122)

" Note; This Drawing has been Reduced and is in Imperial Units "

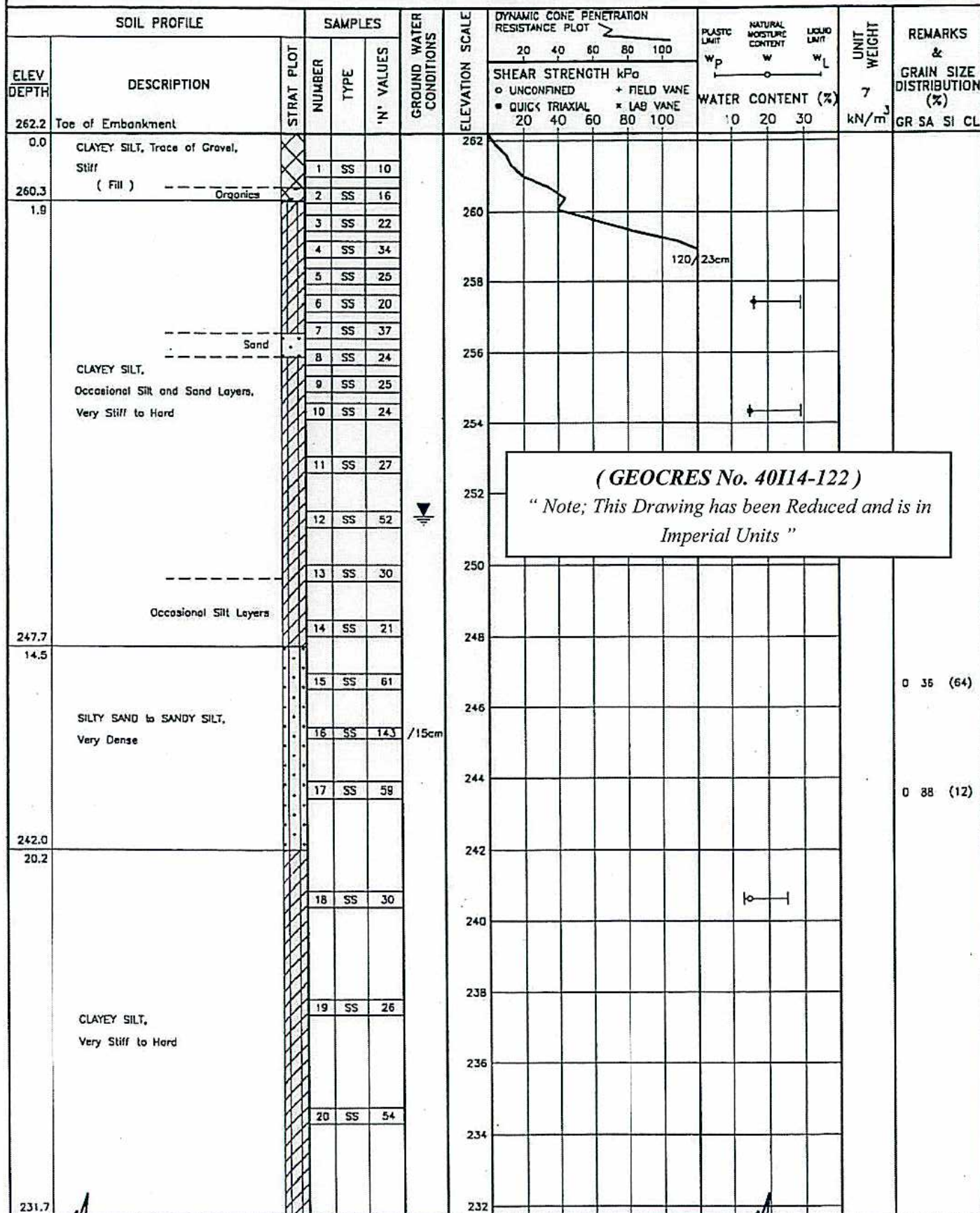


# RECORD OF BOREHOLE No 8

1 OF 2

METRIC

W.P. 476 - 89 - 05 LOCATION Co-ords: N 4 754 251.7; E 409 876.6 ORIGINATED BY M V  
DIST 2 HWY 401 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V  
DATUM GEODETTIC DATE 93 02 03 TO 93 02 05 CHECKED BY P P



Continued

Continued

+3, x5: Numbers refer to Sensitivity  
20 15 10 (2) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 8

2 OF 2 METRIC

W.P. 476 - 89 - 05 LOCATION Co-ords: N 4 754 251.7; E 409 876.6 ORIGINATED BY M V  
 DIST 2 HWY 401 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V  
 DATUM GEODETIC DATE 93 02 03 TO 93 02 05 CHECKED BY P P

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL 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	20	40	60	80	100	W <sub>P</sub>	W		
231.7	Continued    CLAYEY SILT, Very Stiff to Hard		21	SS	31											
230																
228																
226			22	SS	28											
224																
222			23	SS	39											
220																
219.1			24	SS	42											
43.1	End of Borehole															

**( GEOCRES No. 40I14-122 )**

" Note; This Drawing has been Reduced and is in  
Imperial Units "