

**Golder Associates Ltd.**

500 Nottinghill Road  
London, Ontario, Canada N6K 3P1  
Telephone: (519) 471-9600  
Fax: (519) 471-4707



**REPORT ON**

**PRELIMINARY FOUNDATION INVESTIGATION  
PROPOSED WONDERLAND ROAD UNDERPASS  
HIGHWAY 401, GWP 476-89-00  
AGREEMENT NUMBER 3005-A-000117**

Submitted to:

Cole, Sherman & Associates  
75 Commerce Valley Drive East  
Thornhill, Ontario  
L3T 7N9

**DISTRIBUTION:**

- 6 Copies - Cole, Sherman & Associates
- 2 Copies - Golder Associates Ltd.

February 11, 2002

001-3225

Geocres No. 40114-132



**Golder Associates Ltd.**

500 Nottingham Road  
London, Ontario, Canada N6K 3P1  
Telephone: (519) 471-9600  
Fax: (519) 471-4707



February 11, 2002

001-3225

Cole, Sherman & Associates  
75 Commerce Valley Drive East  
Thornhill, Ontario  
L3T 7N9

Attention: Mr. T. Sorochinsky, P. Eng.

**RE: PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN  
PROPOSED WONDERLAND ROAD UNDERPASS  
GWP 476-89-00  
HIGHWAY 401**

Dear Sirs:

Please find enclosed five (5) copies of each of the Preliminary Foundation Investigation and the Preliminary Foundation Investigation and Design reports for the proposed Wonderland Road underpass together with two digital copies of the reports on compact disks. The number of printed reports and digital copies is as per the subconsultant agreement for this project.

We have received the January 28, 2002 memorandum containing comments made by the Ministry of Transportation, Ontario (MTO) Foundations Section with respect to the draft report prepared for the proposed structure. We have discussed these comments with Mr. F.J. Heffernan, P. Eng. MTO's designated contact, and have incorporated the comments into the report as appropriate, and as discussed below.

**Comment 1:** The Pavements and Foundations Section has assigned Geocres Number 40I14-132 for this report. The Geocres number should be shown on the title page of the Final Foundation Report.

**Response:** Geocres Number 40I14-132 will be on the finalized Preliminary Foundation Report.

**Comment 2:** Assumptions made for the estimate of settlement due to the proposed approach embankment grade raise should be given, as well as the footing width, for which the geotechnical resistance at SLS was recommended.



**Response:** Assumptions used for estimating settlement will be provided. A footing width of 5 metres was assumed.

**Comment 3:** Recommendations were given for piles to be driven to elevation 220 metres. It should be realized that no subsurface information is available below elevation 230 metres at the north abutment. The design should be revised to account for the above.

**Response:** One of the options for the preliminary design recommends driving the piles to below elevation 220 metres based on the conditions at the south abutment borehole and the consistency between the two boreholes. With this expected consistency, the pile design may remain unchanged for preliminary design.

**Comment 4:** The note referring to Standard SS103-11 on the General Arrangement Drawing is not required for the preliminary design stage of the project. The value of the ultimate capacity to be used with SS103-11 should be revised.

**Response:** The unfactored ultimate capacity should be 2700 kilonewtons; the note will be removed.

**Comment 5:** The magnitude of downdrag loading should be provided in the foundation report instead of leaving the computation to the structural engineer.

**Response:** We will provide the downdrag loading.

**Comment 6:** Section referring to the horizontal subgrade reaction requires clarification/revision. The formula given in the report applies to the horizontal soil reaction for cohesionless soil, which is not a case for this site.

**Response:** The formula for horizontal subgrade reaction will be revised to address the cohesive soils at the site.

**Comment 7:** MTO logo is shown on the Record of Borehole sheets, which may indicate that the logs were prepared by MTO. It is suggested that the logo of the Consultant be added to the Record of Borehole sheets. Groundwater conditions should be indicated on the Record of Borehole sheets.

**Response:** MTO's logo will be replaced by Golder Associates' logo on the Record of Borehole sheets and a note indicating that the boreholes remained dry will be added.

We trust that this letter and our finalized reports adequately address the comments made by the MTO Foundations Section. Please do not hesitate to contact our office if you have any questions or require further information.

Yours truly,

**GOLDER ASSOCIATES LTD.**

Philip R. Bedell, P. Eng.

cc: Mr. D. Regan, P. Eng.  
MTO Southwestern Region

Ms. A. Piascik, P. Eng.  
MTO Foundations Section

Mr. F.J. Heffernan, P. Eng.  
Designated MTO Contact

## TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
<b>PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT</b>	
1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	2
3.0 INVESTIGATION PROCEDURES.....	3
4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY.....	4
4.1 Site Geology .....	4
4.2 Site Stratigraphy .....	4
4.2.1 Topsoil .....	4
4.2.2 Clayey Silt.....	5
4.2.3 Sand .....	5
4.3 Groundwater Conditions.....	6
LIST OF ABBREVIATIONS	
LIST OF SYMBOLS	
RECORDS OF BOREHOLES	
FIGURE 1 - Site Location Map	
DRAWING 1 - Wonderland Road Underpass, Borehole Locations and Soil Strata	
APPENDIX A - Laboratory Test Data (Figures A-1 to A-3)	

## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by Cole, Sherman & Associates (CSA) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out preliminary foundation investigations at the sites of the proposed Highway 401 underpasses for Wonderland Road and Wellington Road in London, Ontario. This report addresses the Wonderland Road structure.

The purpose of the foundation investigation is to determine the subsurface conditions at the site of the proposed new bridge by drilling boreholes and carrying out in-situ tests and laboratory tests on selected samples. The terms of reference for the scope of work are outlined in Golder's Total Project Management (TPM) proposal P01-3064, dated August 2000. The work was carried out in accordance with our Quality Control of TPM Services Plan, Agreement No. 3005-A-000117, also dated August 2000.

CSA provided Golder with a preliminary drawing for the proposed Highway 401 underpass. The centreline and stations of the proposed alignments were surveyed by others prior to commencing the foundation field investigation program. The General Arrangement plan showing the proposed abutment layout of the structure was provided to us in digital format on November 2, 2001.

## **2.0 SITE DESCRIPTION**

The project area covered by this report extends along Wonderland Road at the crossing with Highway 401 at approximately the southwestern boundary of the City of London, Ontario (see Figure 1). Wonderland Road runs north-south and the highway runs approximately northeast-southwest at the proposed bridge location.

The proposed bridge deck is at elevation 275.5 metres and the top of pavement elevation at Highway 401 is at about elevation 267.5 metres.

### **3.0 INVESTIGATION PROCEDURES**

The field work for this investigation was carried out between August 21 and 29, 2001. At that time two boreholes were put down at the site of the proposed bridge abutments. The boreholes were drilled and sampled to depths of 38.0 to 50.3 metres. The borehole locations are shown in plan on Drawing 1.

The investigation was carried out using a track vehicle mounted CME-55 drill rig supplied and operated by Lantech Drilling Services Inc. The boreholes were advanced using a combination of 208 millimetre outside diameter continuous flight hollow stem augers, 124 millimetre outside diameter solid stem augers and rotary mud drilling techniques. In the boreholes, samples of the overburden were obtained at regular intervals of depth using 50 millimetre outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedures. Groundwater conditions in the open boreholes were observed throughout the drilling operations. Both of the boreholes were backfilled using Ministry of Transportation, Ontario (MTO) recommended procedures.

The field work was supervised on a full-time basis by members of our engineering staff who located the boreholes in the field, directed the drilling, sampling and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labeled containers and transported to our laboratory in London, Ontario for further examination. Index and classification tests consisting of grain size analyses, Atterberg limits tests, consolidation testing and water content determinations were carried out on selected samples. The results of the field and laboratory testing are given on the Record of Borehole sheets and in Appendix A.

The as-drilled borehole locations and elevations were surveyed by Callon Dietz Inc. The elevations at the borehole locations are understood to be referenced to geodetic datum.



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

### **4.1 Site Geology**

The area of the site is located in the western limit of the physiographic region known as the Westminster Moraine. Geological information indicates that the general soil conditions for the area of the site consist of the Port Stanley silty clay till and clayey silt till with localized lacustrine deposits. Clayey silts predominate at the site.

The bedrock in the area of the site is considered to consist of limestone belonging to the Delaware Formation which belongs to the Hamilton Group of Middle Devonian Age. The bedrock surface is estimated to be at about elevation 170 metres, some 97 metres below ground surface.

### **4.2 Site Stratigraphy**

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

In summary, the subsoils at the site generally consist of variable thicknesses of topsoil underlain by 2.8 to 4.3 metres of very stiff to hard clayey silt crust which was underlain by an extensive deposit of firm to hard clayey silt materials below about elevation 263 metres.

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

#### **4.2.1 Topsoil**

Silty topsoil layers were encountered in both of the boreholes at ground surface. The topsoil layers were 0.1 to 0.8 metres thick.

#### **4.2.2 Clayey Silt**

Beneath the topsoil, both boreholes encountered and were terminated in an extensive deposit of clayey silt materials. The clayey silt deposit had a 2.8 to 4.3 metres thick very stiff to hard crust that extended to elevation 262.4 to 263.0 metres. Beneath the crust, the boreholes were advanced into clayey silt materials to elevations of 215.7 and 229.5 metres, or depths of 38.0 and 50.3 metres.

The clayey silt crust had standard penetration test N values of 15 to 37 blows per 0.3 metres penetration, with an average of about 27 blows per 0.3 metres penetration. The remainder of the clayey silt deposit had standard penetration test N values ranging between the weight of the sampling hammer and 30 blows per 0.3 metres penetration above elevation 234 metres, with an average of about 15 blows per 0.3 metres penetration indicating a firm to very stiff consistency. Below elevation 234 metres, the N values were between 24 and 56 blows per 0.3 metres penetration, with an average of about 41 blows per 0.3 metres penetration, indicating a generally very stiff to hard condition. Also, a single N value of 116 blows per 0.3 metres penetration was measured at the bottom of borehole 1 at about elevation 216 metres. In situ shear strength testing attempted in borehole 2 indicated shear strengths of 144 kilopascals (kPa) or greater. A remoulded shear strength gave a sensitivity value of 2.2.

Figure A-1 in Appendix A shows gradation curves for 8 samples recovered from the clayey silt deposit. The deposit consists mainly of silt and clay size material with trace to some sand and trace fine gravel. The water contents of the clayey silt samples collected from the boreholes were between about 11 and 24 per cent, with an average of about 18 per cent. The average plastic and liquid limits for the clayey silt, based on eleven samples tested, are 16 and 27 per cent, respectively, with an average plasticity index of 11 per cent. The results are plotted on the plasticity chart, Figure A-2, and show the deposit to be a clayey silt of low plasticity.

The results of consolidation testing carried out on sample 8 from borehole 2 are provided on Figure A-3 in Appendix A. The results indicate that the clayey silt is preconsolidated about 100 kPa beyond the existing overburden pressure.

#### **4.2.3 Sand**

Within the clayey silt deposit in borehole 2, a 0.3 metre thick pocket of compact sand was encountered at about elevation 234 metres. The sand had a standard penetration test N value of 33 blows per 0.3 metres penetration.

### **4.3 Groundwater Conditions**

Water levels were noted in the open boreholes during and upon completion of the drilling operations. Both boreholes remained dry during drilling as indicated on the Record of Borehole sheets. However, based on water content and colour changes at the base of the clayey silt crust a long-term groundwater level at about elevation 262 to 263 metres is inferred.

#### **GOLDER ASSOCIATES LTD.**

Azmi M. Hammoud, P. Eng.

Philip R. Bedell, P. Eng.  
Principal

Fintan J. Heffernan, P. Eng.  
Designated MTO Contact

AMH/PRB/FJH/cb  
\\ldn\_main\data\active\3200\001-3200\001-3225 cs - gwp 476 - 401 wonderland\reports\final report\0211-rpt (part a)-found inv & design (wonderland).doc

## LIST OF ABBREVIATIONS

The abbreviations commonly employed on each "Record of Borehole", on the figures and in the text of the report, are as follows:

### I. SAMPLE TYPES

<i>AS</i>	auger sample
<i>CS</i>	chunk sample
<i>DO</i>	drive open
<i>DS</i>	Denison type sample
<i>FS</i>	foil sample
<i>RC</i>	rock core
<i>ST</i>	slotted tube
<i>TO</i>	thin-walled, open
<i>TP</i>	thin-walled, piston
<i>WS</i>	wash sample
<i>SS</i>	split spoon

### II. PENETRATION RESISTANCES

#### Dynamic Penetration Resistance:

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 0.3 m (12 in.).

#### Standard Penetration Resistance, N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 0.3 m (12 in.).

<i>WH</i>	sampler advanced by static weight-weight, hammer
<i>PH</i>	sampler advanced by hydraulic force
<i>PM</i>	sampler advanced by manual force

### III. SOIL DESCRIPTION

#### (a) Cohesionless Soils

	"N" Blows/0.3 m or Blow/ft.
Relative Density	
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

#### (b) Cohesive Soils

	"Cu" = "Su"	
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 1000
Stiff	50 to 100	1000 to 2000
Very stiff	100 to 200	2000 to 4000
Hard	over 200	over 4000

### IV. SOIL TESTS

<i>C</i>	consolidation test
<i>H</i>	hydrometer analysis
<i>M</i>	sieve analysis
<i>MH</i>	combined analysis, sieve and hydrometer <sup>1</sup>
<i>Q</i>	undrained triaxial <sup>2</sup>
<i>R</i>	consolidated undrained triaxial <sup>2</sup>
<i>S</i>	drained triaxial
<i>U</i>	unconfined compression
<i>V</i>	field vane test
<i>Chem</i>	chemical analysis

#### NOTES:

1. Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.
2. Undrained triaxial tests in which pore pressures are measured are shown as Q or R.

## LIST OF SYMBOLS

### I. GENERAL

$\pi$	= 3.1416
e	= base of natural logarithms 2.7183
$\log_e$	a or $\ln$ a, natural logarithm of a
$\log_{10}$	a or $\log$ a, logarithm of a to base 10
$t$	time
$g$	acceleration due to gravity
$V$	volume
$W$	weight
$m$	mass
$M$	moment
$F$	factor of safety

### II. STRESS AND STRAIN

$u$	pore pressure
$\sigma$	normal stress
$\sigma'$	normal effective stress ( $\sigma$ is also used)
$\tau$	shear stress
$\varepsilon$	linear strain
$\varepsilon_{sy}$	shear strain
$\nu$	Poisson's ration ( $\mu$ is also used)
$E$	modulus of linear deformation (Young's modulus)
$G$	modulus of shear deformation
$K$	modulus of compressibility
$\eta$	coefficient of viscosity

### III. SOIL PROPERTIES

#### (a) Unit weight

$\gamma$	unit weight of soil (bulk density)
$\gamma_s$	unit weight of solid particles
$\gamma_w$	unit weight of water
$\gamma_d$	unit dry weight of soil (dry density)
$\gamma'$	unit weight of submerged soil
$G_s$	specific gravity of solid particles $G_s = \gamma_s/\gamma_w$
$e$	void ratio
$n$	porosity
$w$	water content
$S_r$	degree of saturation

#### (b) Consistency

$w_L$	liquid limit
$w_P$	plastic limit
$I_P$	plasticity index
$w_S$	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
$D_r$	relative density = $(e_{max} - e)/(e_{max} - e_{min})$

#### (c) Permeability

$h$	hydraulic head or potential
$q$	rate of discharge
$v$	velocity of flow
$i$	hydraulic gradient
$\kappa$	coefficient of permeability
$j$	seepage force per unit volume

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

$m_v$	coefficient of volume change = $-\Delta e/(1+e)\Delta\sigma'$
$C_c$	compression index = $-\Delta e/\Delta\log_{10}\sigma'$
$c_v$	coefficient of consolidation
$T_F$	time factor = $c_v t/d^2$ ( $d$ , drainage path)
$U$	degree of consolidation

#### (e) Shear strength

$\tau_f$	shear strength	$\left. \begin{array}{l} \text{in terms} \\ \text{of effective} \\ \text{stress} \end{array} \right\} \tau_f = c' + \sigma' \tan \phi$
$c'$	effective cohesion intercept	
$\phi'$	effective angle of shearing resistance, or friction	
$S_u$	apparent cohesion*	
$\phi_u$	apparent angle of shearing resistance, or friction	$\left. \begin{array}{l} \text{in terms of} \\ \text{total stress} \end{array} \right\} \tau_f = cu + \sigma \tan \phi_u$
$\mu$	coefficient of friction	
$S_t$	sensitivity	

\*For the case of a saturated cohesive soil,  $\phi_u = 0$  and the undrained shear strength  $\tau_f = S_u$  is taken as half the undrained compressive strength.

PROJECT 001-3225

# RECORD OF BOREHOLE No 1

1 OF 4

METRIC

G.W.P. 476-89-00

LOCATION

4749081.8 N, 406225.8 E ( WONDERLAND ROAD SITE)

ORIGINATED BY SM

DIST HWY 401

BOREHOLE TYPE

POWER AUGER (HOLLOW STEM) & ROTARY DRILLING WITH MUD

COMPILED BY DJM

DATUM GEODETIC

DATE

21.8.01 - 22.8.01

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100		
265.94	GROUND SURFACE												
0.00	TOPSOIL, silty Brown												
265.18													
0.76	CLAYEY SILT, trace sand, trace gravel Very stiff to hard Brown		1	SS	15	265							
			2	SS	17	264							
			3	SS	34	263							9 46 45
			4	SS	37	262							
262.43						261							
3.51	CLAYEY SILT, trace sand, trace gravel Firm to hard Grey		5	SS	13	260							
			6	SS	13	259							
			7	SS	11	258							
			8	SS	8	257							
						256							
			9	SS	16	255							6 49 45
			10	SS	20	254							
						253							
			11	SS	10	252							
			12	SS	11								

Continued Next Page

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

○ 3% STRAIN AT FAILURE

PROJECT 001-3225 RECORD OF BOREHOLE No 1 2 OF 4 METRIC  
G.W.P. 476-89-00 LOCATION 4749081.8 N, 406225.8 E ( WONDERLAND ROAD SITE) ORIGINATED BY SM  
DIST HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) & ROTARY DRILLING WITH MUD COMPILED BY DJM  
DATUM GEODETIC DATE 21.8.01 - 22.8.01 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
	CLAYEY SILT, trace sand, trace gravel Firm to hard Grey		13	SS	17		250							
			14	SS	13		249							
			15	SS	17		248							
			16	SS	20		247							
			17	TW	WH		246							
			18	SS	24		245							
			19	SS	18		244							
			20	SS	18		243							
			21	SS	15		242							
			22	SS	17		241							
							240							
							239							
							238							
							237							

ON\_MOT 0013225A.GPJ ON\_MOT.GDT 11/2/02 DATA INPUT:

Continued Next Page

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





PROJECT <u>001-3225</u>		<b>RECORD OF BOREHOLE No 1</b>		4 OF 4 <b>METRIC</b>	
G.W.P. <u>476-89-00</u>	LOCATION <u>4749081.8 N, 406225.8 E ( WONDERLAND ROAD SITE)</u>	ORIGINATED BY <u>SM</u>			
DIST <u>HWY 401</u>	BOREHOLE TYPE <u>POWER AUGER (HOLLOW STEM) &amp; ROTARY DRILLING WITH MUD</u>	COMPILED BY <u>DJM</u>			
DATUM <u>GEODETIC</u>	DATE <u>21.8.01 - 22.8.01</u>	CHECKED BY <u>AMH</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								20 40 60 80 100										

215.65 50.29	CLAYEY SILT, trace sand, trace gravel Firm to hard Grey		33	SS	55		220												2 17 48 33		
			34	SS	56																
			35	SS	116																
	End of Borehole  Borehole remained dry during drilling Aug. 21 and 22, 2001.																				

PROJECT 001-3225

# RECORD OF BOREHOLE No 2

1 OF 3

METRIC

G.W.P. 476-89-00

LOCATION

4749019.1 N, 406266.3 E ( WONDERLAND ROAD SITE)

ORIGINATED BY SM

DIST HWY 401

BOREHOLE TYPE

POWER AUGER (HOLLOW STEM) & ROTARY DRILLING WITH MUD

COMPILED BY DJM

DATUM GEODETTIC

DATE

29.8.01

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						
267.45	GROUND SURFACE						20 40 60 80 100		10 20 30						
0.09	TOPSOIL, silty Brown CLAYEY SILT, trace sand, trace gravel Very stiff to hard Brown		1	SS	29										
			2	SS	33										
			3	SS	36										
			4	SS	17										
			5	SS	22										
263.03	CLAYEY SILT, trace sand, trace gravel Firm to hard Grey		6	SS	20										
4.42			7	SS	17										
			8	TW	PH										
			9	SS	11										
			10	SS	10										
			11	TW	PH										
			12	SS	7										
			13	SS	15										
			14	SS	11										

Continued Next Page

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

O<sup>3%</sup> STRAIN AT FAILURE

# RECORD OF BOREHOLE No 2

2 OF 3

METRIC

PROJECT 001-3225  
G.W.P. 476-89-00 LOCATION 4749019.1 N, 406266.3 E ( WONDERLAND ROAD SITE) ORIGINATED BY SM  
DIST HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) & ROTARY DRILLING WITH MUD COMPILED BY DJM  
DATUM GEODETIC DATE 29.8.01 CHECKED BY AMH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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		
	CLAYEY SILT, trace sand, trace gravel Firm to hard Grey						252							
			15	SS	16		251							
							250							
			16	SS	15		249							
							248							
			17	SS	19		247							
							246							
			18	SS	16		245							
							244							
			19	SS	17		243							
							242							
			20	SS	30		241							
							240							
			21	SS	10		239							
							238							
			22	SS	17									
			23	SS	19									

Continued Next Page

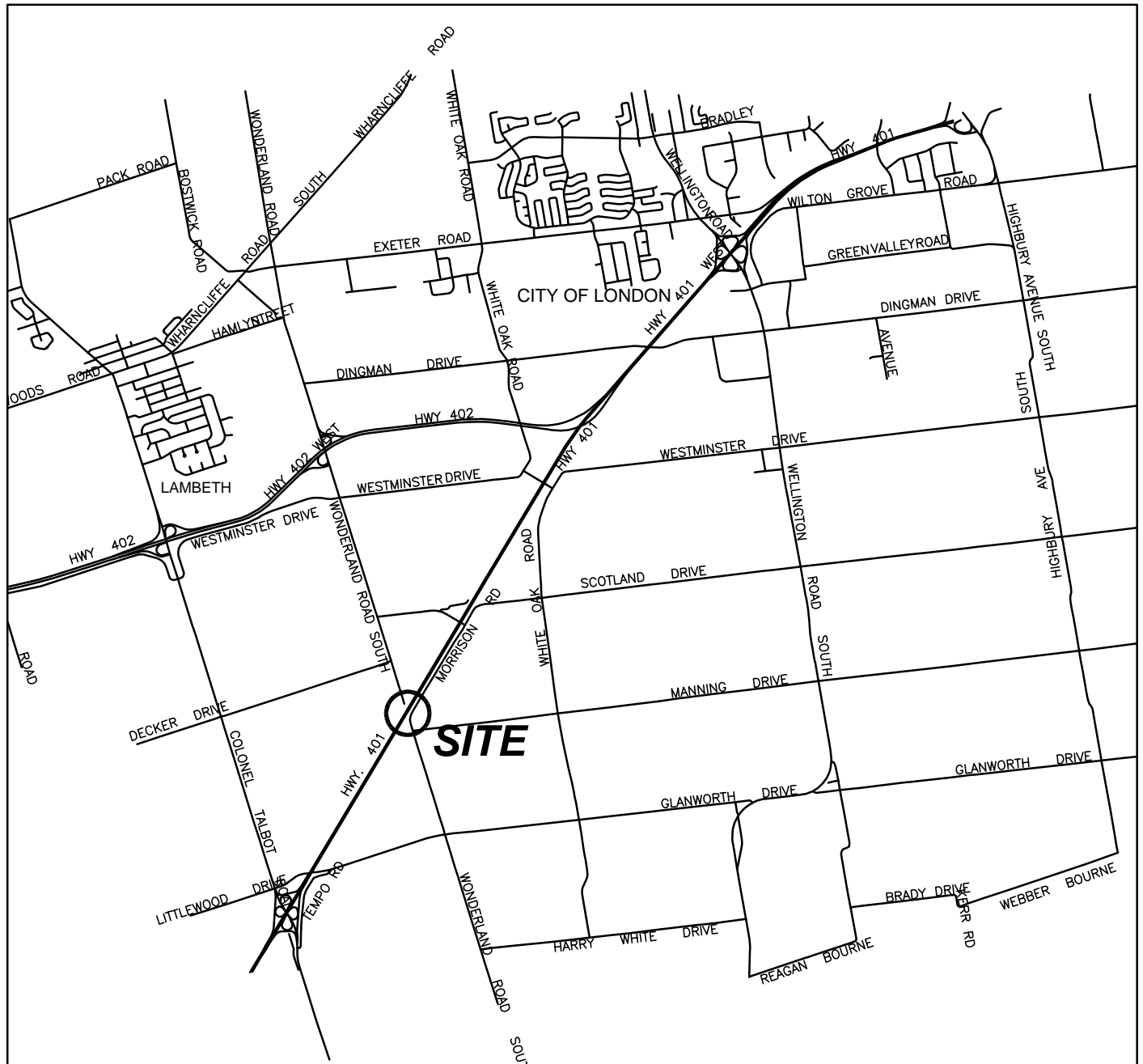
+<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE


ON\_MOT\_0013225A.GPJ ON\_MOT.GDT 11/2/02 DATA INPUT:

PROJECT <u>001-3225</u>		<b>RECORD OF BOREHOLE No 2</b>		3 OF 3		<b>METRIC</b>	
G.W.P. <u>476-89-00</u>		LOCATION <u>4749019.1 N, 406266.3 E ( WONDERLAND ROAD SITE)</u>		ORIGINATED BY <u>SM</u>			
DIST <u>          </u> HWY <u>401</u>		BOREHOLE TYPE <u>POWER AUGER (HOLLOW STEM) &amp; ROTARY DRILLING WITH MUD</u>		COMPILED BY <u>DJM</u>			
DATUM <u>GEODETIC</u>		DATE <u>29.8.01</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  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								<div>○ UNCONFINED      + FIELD VANE</div> <div>● QUICK TRIAXIAL      x LAB VANE</div>		<div>W<sub>p</sub></div> <div>W</div> <div>W<sub>L</sub></div>				
						20	40	60	80	100	10	20	30	
	CLAYEY SILT, trace sand, trace gravel Firm to hard Grey		24	SS	23							○		
						237								
			25	SS	16							○		
						236								
						235								
234.23			26	SS	33							○		
33.22 233.92 33.53	SAND, fine to medium, trace gravel Compact Grey CLAYEY SILT, trace sand, trace gravel Very stiff to hard Grey					234								
			27	SS	24							○		
						233								
						232								
			28	SS	35							○	—	7 56 37
						231								
						230								
229.50 37.95	End of Borehole  Borehole remained dry during drilling Aug. 29, 2001.		29	SS	31							○		

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



PROJECT		WONDERLAND ROAD STRUCTURE WP. 476-89-00 HWY. 401	
TITLE		SITE LOCATION MAP	
 <b>Golder Associates</b> LONDON, ONTARIO		PROJECT No.	001-3225
		DESIGN	WDF
		CADD	WDF
		CHECK	AMH
		REVIEW	
		FILE No.	00132250002
		SCALE	N.T.S.
		REV.	0
		<b>FIGURE 1</b>	



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

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



WONDERLAND ROAD STRUCTURE

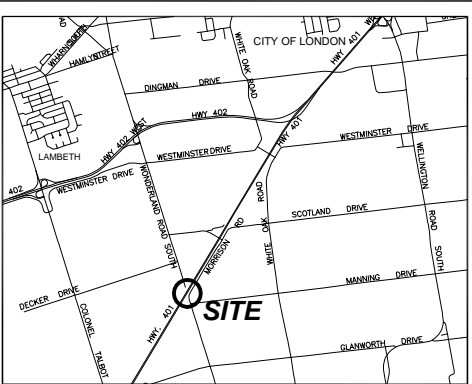
SHEET

BOREHOLE LOCATIONS & SOIL STRATA



Golder Associates Ltd.  
LONDON, ONTARIO, CANADA

REFERENCE  
DRAWING SUPPLIED BY MORRISON HERSFIELD ENTITLED  
HWY 401 WONDERLAND ROAD UNDERPASS, GENERAL ARRANGEMENT  
DATED NOV. 2001



KEY PLAN

LEGEND

- Borehole
- Seal
- Piezometer
- Blows/0.3m (Std. Pen. Test, 475 j/blow)
- WL in piezometer
- WL during drilling
- DRY Borehole during drilling

No.	ELEVATION (metres)	CO-ORDINATES	
		NORTH	EAST
1	265.94	4 749 081.8	406 225.8
2	267.45	4 749 019.1	406 266.3

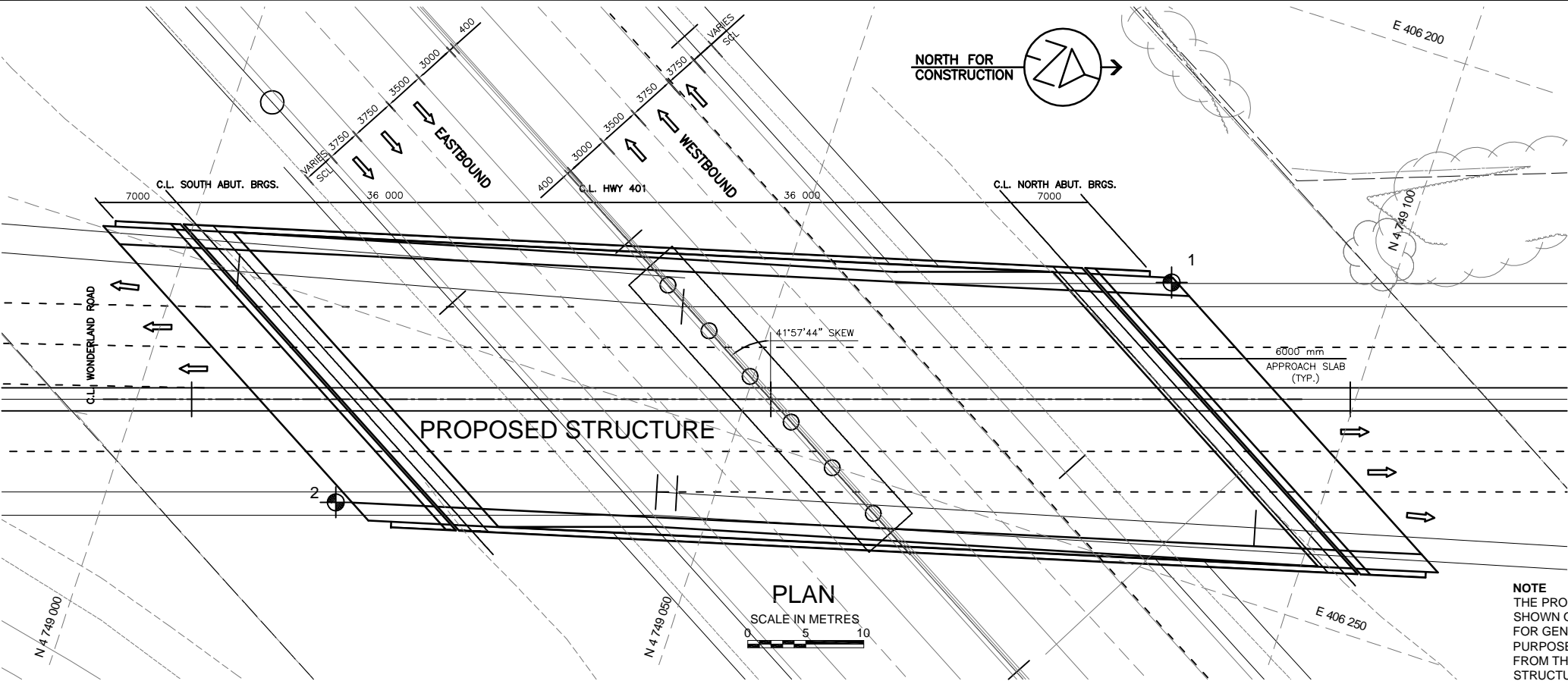
NOTES

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

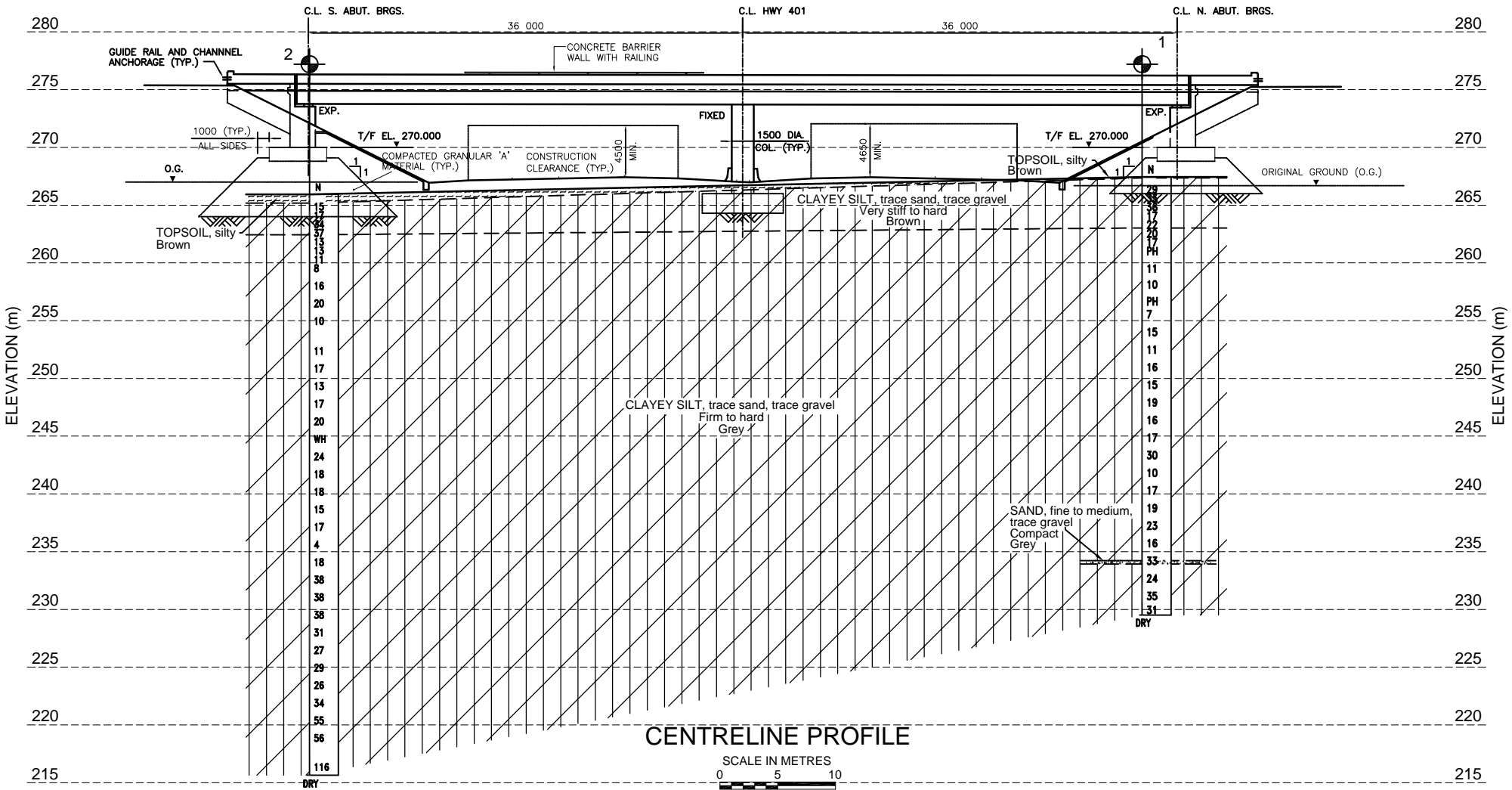
NO.	DATE	BY	REVISION

Geocres No. 40114-132

HWY. No.	401	PROJECT NO.:	001-3225
SUBM'D.	-	CHKD:	-
DRAWN:	WDF	CHKD:	AMH
DATE:	NOV. 2001	APPD.	
DWG.	1		



NOTE  
THE PROPOSED BRIDGE DETAILS  
SHOWN ON THIS DRAWING ARE  
FOR GENERAL REFERENCE  
PURPOSES ONLY AND MAY DIFFER  
FROM THOSE SHOWN ON THE  
STRUCTURAL DRAWINGS.

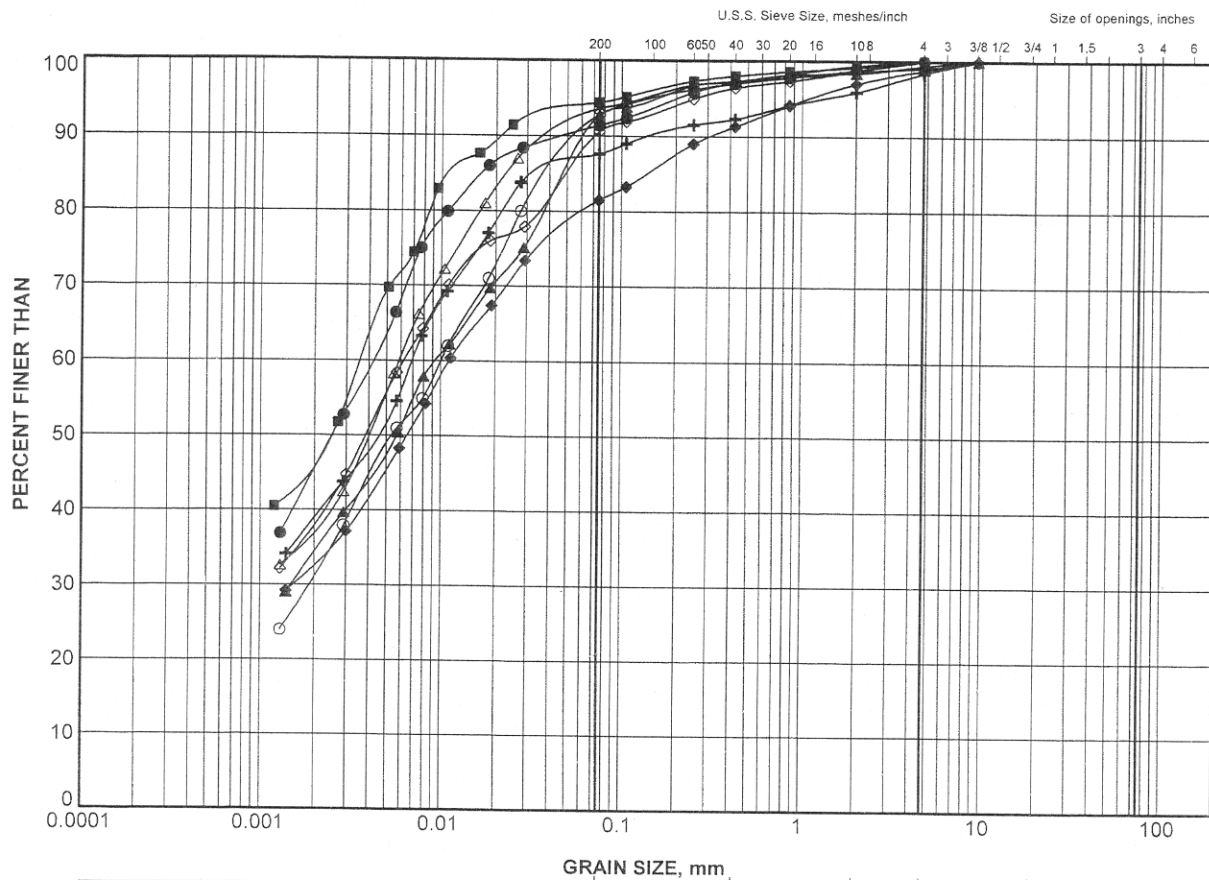


CENTRELINE PROFILE

SCALE IN METRES  
0 5 10

0013225D001.DWG

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



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	3	263.4
■	1	11	255.0
▲	1	20	240.3
+	1	27	229.6
◆	1	34	218.9
◇	2	8	261.1
○	2	18	246.5
△	2	28	231.3

PROJECT

PROPOSED WONDERLAND RD. BRIDGE  
HIGHWAY 401, GWP 476-89-00

TITLE

### GRAIN SIZE DISTRIBUTION CURVE CLAYEY SILT

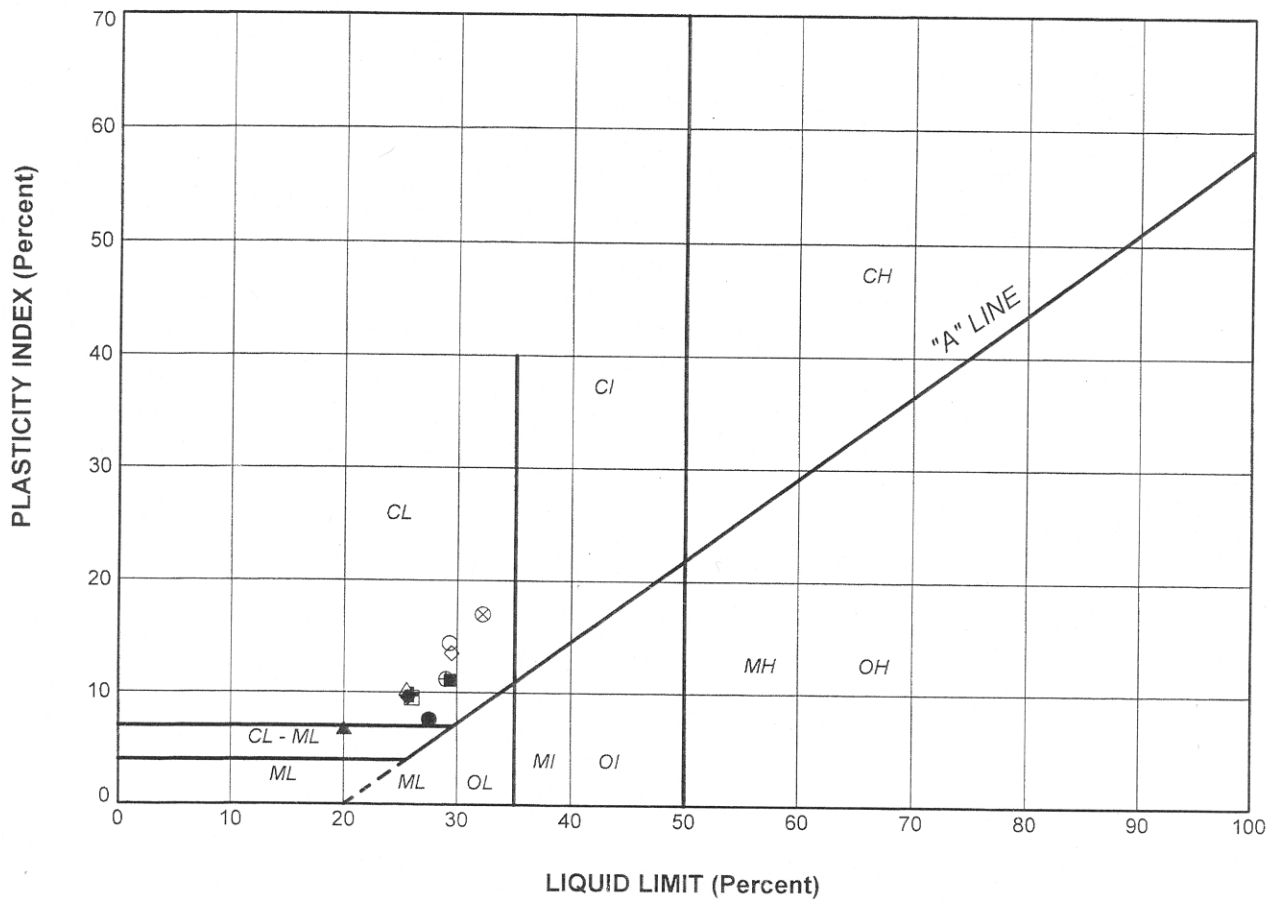


**Golder Associates**  
LONDON, ONTARIO

PROJECT No.	001-3225	FILE No.	0013225A.GPJ
DRAWN	WDF	12-11-01	SCALE N/A REV.
CHECK	<i>mm</i>	12-11-01	

**FIGURE A-1**





### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)	LL(%)	PL(%)	PI
●	1	3	263.7	27.5	19.9	7.6
■	1	7	260.6	29.4	18.3	11.1
▲	1	12	252.7	20.0	13.2	6.8
+	1	17	245.1	26.0	16.2	9.8
◆	1	20	240.5	25.6	16.0	9.6
◇	1	23	235.9	29.5	16.0	13.5
○	1	27	229.8	29.3	14.9	14.4
△	1	34	219.2	25.5	15.2	10.3
⊗	2	8	261.4	32.2	15.2	17.0
⊕	2	10	258.5	29.0	17.8	11.2
□	2	28	231.5	26.0	16.5	9.5

PROJECT

PROPOSED WONDERLAND RD. BRIDGE  
HIGHWAY 401, GWP 476-89-00

TITLE

### PLASTICITY CHART



**Golder Associates**  
LONDON, ONTARIO

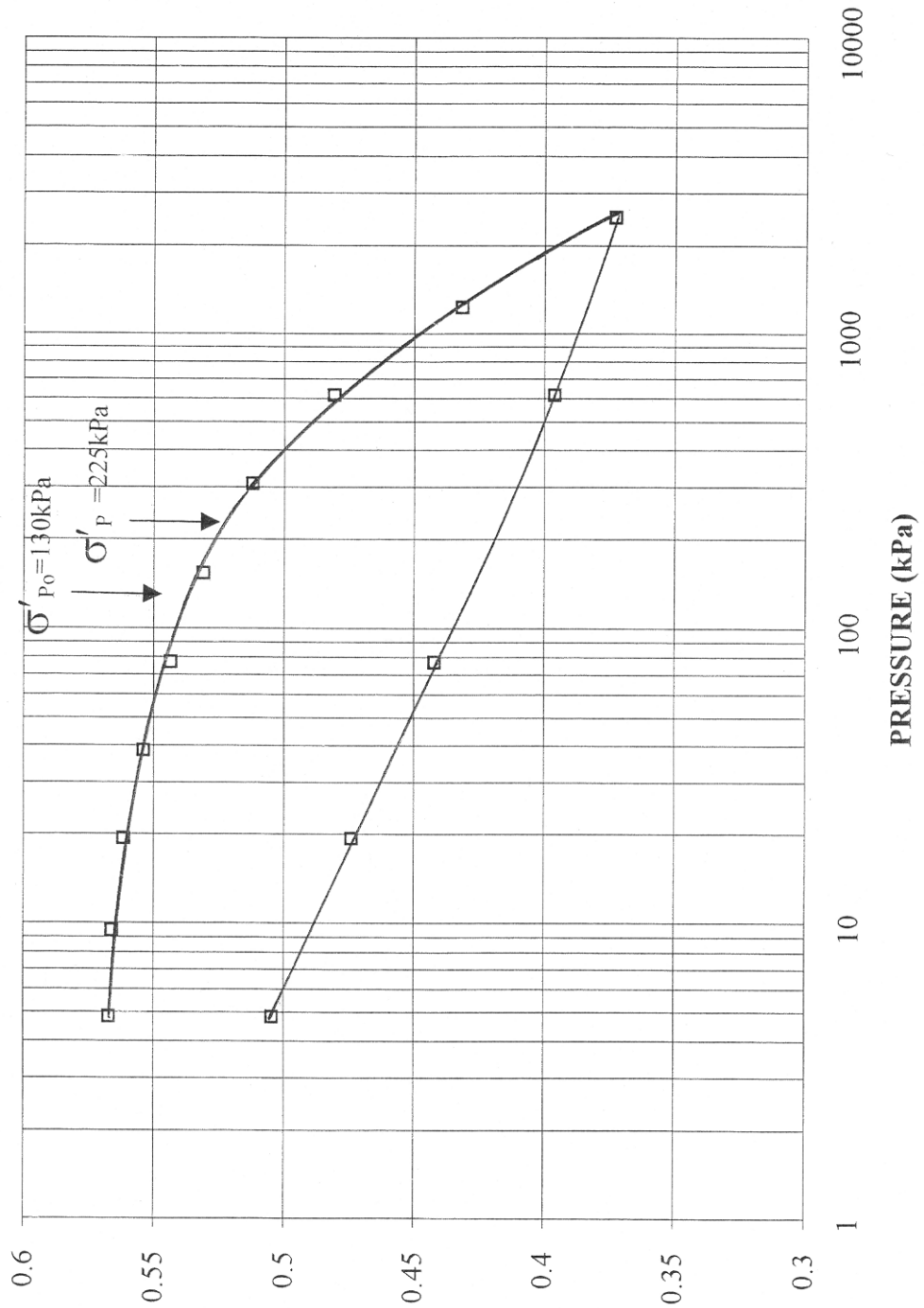
PROJECT No.	001-3225	FILE No.	0013225A.GPJ
DRAWN	WDF	12-11-01	SCALE N/A REV.
CHECK	ant	12-11-01	

**FIGURE A-2**

CONSOLIDATION TEST  
VOID RATIO VS. LOG PRESSURE

FIGURE A-3

CONSOLIDATION TEST  
VOID RATIO vs PRESSURE  
BH 2 SA 8  
Elev. 261



Project No. 001-3225

VOID RATIO