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**FOUNDATION INVESTIGATION REPORT
BREAKAWAY AND OVERHEAD SIGNS
HIGHWAY 401
FROM 1.5 KILOMETRES WEST OF MANNING ROAD
EASTERLY TO 1.3 KILOMETRES EAST OF PUCE ROAD
GWP 62-00-00, AGREEMENT NO. 3005-A-000393
MINISTRY OF TRANSPORTATION - SOUTHWESTERN REGION**

Submitted to:

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LIST OF SYMBOLS

RECORDS OF BOREHOLES

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Dillon Consulting Limited (Dillon) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services as part of the detail design work for the section of Highway 401 described by GWP 62-00-00. This section of Highway 401 is some 9.9 kilometres in length and extends from 1.5 kilometres west of Manning Road in the Township of Sandwich South to 1.3 kilometres east of Puce Road in the Township of Maidstone, Ontario. The foundation component of the project includes:

- i) The grade raise and widening of the approach embankment/ramps at Manning Road;
- ii) Culvert extensions/replacements;
- iii) Overhead and breakaway signs;
- iv) Widening of the existing Puce River structure; and
- v) Widening of the existing Pike Creek structure.

This report addresses the proposed overhead and breakaway signs to be constructed for this project.

The purpose of this portion of the foundation investigation was to determine the subsurface conditions at the locations of the proposed breakaway and overhead signs 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 the MTO's request for proposal and in Golder Associates' proposal P31-3115, dated February 2, 2004. The work was carried out in accordance with our Quality Control Plan for Foundations Engineering dated March 29, 2004.

The proposed breakaway and overhead sign locations were surveyed by others prior to commencing the foundation investigation program. Dillon provided Golder Associates with preliminary drawings and the as-drilled borehole survey information for this project in digital format.

It should be noted that the chainage for Highway 401 changes from Sandwich South Township to Maidstone Township at Manning Road where Station 20+191.026 Sandwich South is equivalent to Station 10+000 Maidstone. Chainages west and east of Manning Road are suffixed SS and M respectively. The chainages at the project limits along Highway 401 are Station 18+675 Sandwich South at the west limit and 18+650 Maidstone at the east limit.

2.0 SITE DESCRIPTION

2.1 General

GWP 62-00-00 comprises the reconstruction and widening of some 9.9 kilometres of Highway 401 extending from 1.5 kilometres west of Manning Road easterly to 1.3 kilometres east of Puce Road. The work also includes the rehabilitation of Manning Road and Puce Road interchanges and the 6th and 9th Concession Roads within the project limits. The location of the project is shown on the Key Plan, Figure 1.

The subject section of Highway 401 is currently a four lane divided freeway with a depressed grass median. Interchanges are present at Manning Road and Puce Road. The interchanges each consist of four ramps, with two ramps in each of the southwest and northeast quadrants.

The topography of the area is generally flat. The primary land use in the area is agricultural.

2.2 Site Geology

The project lies within the Essex Clay Plain, a subregion of the physiographic region of southern Ontario known as the St. Clair Clay Plains, identified in "The Physiography of Southern Ontario" by Chapman and Putnam (1984). The clay plain is described as a till plain that has been smoothed by shallow deposits of lacustrine clay which settled in the depressions of the till. The prevailing soil type is reportedly the Brookston clay.

Based on the Ontario Department of Mines and Northern Affairs Preliminary Maps P.749 and P.750 entitled "Quaternary Geology of the Windsor-Essex Area" Western and Eastern Parts, respectively, the project area is reportedly located in predominantly clayey silt till. At the Manning Road interchange, a thin and discontinuous glaciolacustrine medium sand layer reportedly overlies the clayey silt till in the southeast, southwest and part of the northwest quadrants.

The underlying bedrock is reported to be limestone of the Dundee Formation of Middle Devonian age.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between July 27 and August 16, 2004, at which time twelve boreholes were drilled at the locations of the proposed overhead and breakaway signs. The locations of the boreholes are shown on the Borehole Location Plan, Drawings 1 through 4, inclusive.

The as-drilled borehole locations, ground surface elevations and borehole depths are as follows:

BOREHOLE	LOCATION (m)			GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
	Northing	Easting	Station		
Breakaway Signs					
BS-1	4678055.0	272793.7	19+000 SS	184.71	3.05
BS-2	4677912.8	274764.1	10+800 M	186.23	3.05
BS-3	4677894.1	275238.8	11+275 M	186.34	3.05
BS-4	4677798.7	277461.7	13+500 M	186.38	3.05
BS-5	4677781.3	277861.3	13+900 M	186.02	3.05
BS-6	4677688.8	279984.3	16+025 M	184.01	3.05
Overhead Signs					
OH-1	4677667.9	280559.4	16+600 M	183.84	11.13
OH-2	4677656.5	282509.8	18+550 M	185.06	6.55
OH-3	4677692.5	281500.5	17+540 M	184.90	6.55
OH-4	4677981.6	274422.8	10+456 M	186.47	6.55
OH-5	4677971.9	273490.9	19+700 SS	185.02	6.55
OH-6	4678016.8	272516.9	18+725 SS	186.24	6.55

The investigation was carried out using an all terrain vehicle mounted power auger owned and operated by a specialist drilling contractor. 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. In addition, in situ vane shear strength testing was carried out in the softer cohesive strata, where feasible. The boreholes for the overhead signs were advanced to 6.5 metres depth and the boreholes for the breakaway signs were advanced to 3 metres depth. Groundwater conditions in the boreholes were observed throughout the drilling operations and these observations are provided on corresponding Record of Borehole sheets. All of the boreholes were backfilled in accordance with current regulations and MTO recommended procedures.

The field work was supervised on a full-time basis by experienced members of our engineering staff who arranged for utility locates, directed the drilling, sampling and in-situ testing operations, logged the boreholes and cared for the samples obtained. The soil samples were identified in the field, placed in labeled containers and transported to Golder Associates' 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 field and laboratory testing are given on the Record of Borehole sheets and in Appendix A.

Temporary traffic control was carried out in accordance with the Ontario Traffic Manual, Temporary Conditions, Book 7, dated March 2001.

The as-drilled borehole locations and ground surface elevations were determined by others and were provided to this office in digital format. The locations of the boreholes are noted above and are shown on the Record of Borehole sheets and on Drawings 1 through 4, attached.

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 and 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 stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling or observations of drilling resistance and represent transitions between soil types rather than exact planes of geological change. Subsurface conditions will vary between and beyond the borehole locations.

In general, the boreholes drilled at the proposed breakaway and overhead sign locations generally encountered topsoil and fill materials underlain by an extensive deposit of silty clay till.

The locations of the boreholes are shown on the attached Drawings 1 through 4, inclusive. 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.

4.1.1 Topsoil and Fill

Topsoil was encountered at ground surface in all of the boreholes. The topsoil ranged in thickness from 90 to 790 millimetres with an average thickness of about 325 millimetres.

Beneath the topsoil in borehole OH-2 at elevation 184.3 metres, OH-3 at elevation 184.8 metres, OH-6 at elevation 186.0 metres, BS-1 at elevation 184.6 metres, BS-3 at elevation 185.9 metres and BS-5 at elevation 185.9 metres, fill materials were encountered. The fill thicknesses ranged from 0.3 to 1.3 metres with an average thickness of about 0.7 metres. The fill had measured N values, as determined in the standard penetration testing, of 10 to 11 blows per 0.3 metres of penetration and had in situ water contents between 17 and 23 per cent with an average water content of about 21 per cent. The fill consisted primarily of silty clay and clayey silt with varying amounts of topsoil.

4.1.2 Sand

Within the silty clay till in borehole OH-1, a layer of sand some 0.1 metres thick was encountered at elevation 180.4 metres.

4.1.3 Sandy Silt Till

Beneath the topsoil in borehole BS-2 at elevation 185.8 metres, a layer of sandy silt till about 1.0 metres thick was encountered. The sandy silt till had an N value of 32 blows per 0.3 metres and a natural water content of about 8 per cent.

4.1.4 Silty Sand

A layer of silty sand some 0.1 metres thick was encountered within the silty clay till in borehole BS-1 at elevation 182.0 metres. The silty sand had a natural water content of about 8 per cent.

Borehole OH-1 encountered silty sand at depth at elevation 173.6 metres, beneath the silty clay. Borehole OH-1 was terminated in the silty sand after exploring it for some 0.9 metres. The silty sand had a measured N value of 18 blows per 0.3 metres and a natural water content of about 19 per cent. A grain size distribution curve for a sample of the silty sand recovered from the standard penetration testing in borehole OH-1 is provided on Figure A-1.

4.1.5 Silty Clay

Beneath the silty clay till in borehole OH-1 at elevation 175.2 metres, a layer of firm silty clay some 1.5 metres thick was encountered. The silty clay had a measured N value of 4 blows per 0.3 metres and a natural water content of 20 per cent.

4.1.6 Silty Clay Till

Boreholes BS-1 through BS-6, drilled for the breakaway signs, were terminated in an extensive layer of firm to hard silty clay till after exploring it for some 1.7 to 2.9 metres. The silty clay till had measured N values between 8 and 35 blows per 0.3 metres. Natural water contents of the silty clay till ranged from 14 to 21 per cent with an average water content of about 17 per cent.

The surface of the silty clay till was encountered at the following elevations:

<u>BOREHOLE</u>	<u>ELEVATION (m)</u>
BS-1	184.0
BS-2	184.7
BS-3	185.3
BS-4	185.9
BS-5	185.2
BS-6	183.9

In all of the boreholes drilled for the overhead signs, an extensive layer of stiff to very stiff silty clay till was encountered. The upper crust of the silty clay till was some 3.3 to 6.3 metres thick with an average thickness of about 5.2 metres. The silty clay till crust had measured N values between 9 and 40 blows per 0.3 metres with an average N value of about 25 blows per 0.3 metres. The natural water contents in the silty clay till crust ranged from 14 to 21 per cent with an average water content of about 16 per cent.

The surface of the silty clay till was encountered at the following elevations:

<u>BOREHOLE</u>	<u>ELEVATION (m)</u>
OH-1	183.7
OH-2	183.8
OH-3	183.5
OH-4	185.7
OH-5	184.8
OH-6	184.9

All of the boreholes drilled for the overhead signs, except for borehole OH-1, were terminated in firm to very stiff silty clay till beneath the crust after exploring it for some 5.2 to 6.3 metres. Where fully penetrated in borehole OH-1 the silty clay till was some 5.1 metres thick. The lower silty clay till had measured N values between 7 and 17 blows per 0.3 metres with an average N value of about 12 blows per 0.3 metres. Natural water contents of the lower silty clay till ranged from 14 to 21 per cent with an average water content of about 19 per cent. In situ vane shear strength testing carried out in the softer portions of the silty clay till at depth indicated undrained shear strengths of 80 and 92 kilopascals.

The silty clay till encountered in the boreholes had corresponding average plastic and liquid limits of 16 and 37 per cent, respectively. The results of the Atterberg limits determinations are shown on the Plasticity Chart Figure A-2 and indicate that the silty clay till is of low to intermediate plasticity.

Typical grain size distribution curves for the samples of the silty clay till recovered from the standard penetration testing are shown Figure A-3.

4.2 Groundwater Conditions

Groundwater conditions were observed in the open boreholes during drilling. Groundwater was encountered within the silty sand during drilling in borehole OH-1 at a depth of 10.4 metres below existing ground surface or at elevation 173.5 metres. The remainder of the boreholes were dry during drilling. The long-term groundwater level is expected to be close to the interface of the brown and grey silty clay till at about elevation 183 metres.

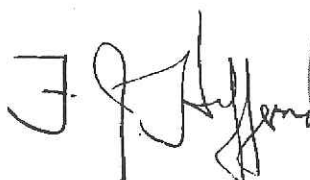
5.0 MISCELLANEOUS

The investigation was carried out using equipment supplied and operated by Lantech Drilling Services (Lantech) and Aardvark Drilling, Inc. (Aardvark). Lantech and Aardvark are both Ontario Ministry of Environment licensed well contractors. Field operations were supervised by Mr. Mike Arthur under the direction of Mr. David J. Mitchell. All laboratory testing was conducted at Golder Associates' London laboratory. This laboratory is an accredited participant in the MTO's Soil and Aggregate Proficiency program and is certified for testing Types C and D Aggregates by the Canadian Council of Independent Laboratories. This report was written by Mr. Michael E. Beadle, P. Eng. under the direction of the Project Manager, Mr. Philip R. Bedell, P. Eng. The report was reviewed by Mr. Fintan J. Heffernan, P. Eng., the Designated MTO Contact and Quality Control Auditor.

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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	kPa psf.
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 ¹
<i>Q</i>	undrained triaxial ²
<i>R</i>	consolidated undrained triaxial ²
<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

π	$\pi = 3.1416$
e	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
σ	normal stress
σ'	normal effective stress (σ is also used)
τ	shear stress
ϵ	linear strain
ϵ_{sy}	shear strain
ν	Poisson's ration (μ is also used)
E	modulus of linear deformation (Young's modulus)
G	modulus of shear deformation
K	modulus of compressibility
η	coefficient of viscosity

III. SOIL PROPERTIES

(a) Unit weight

γ	unit weight of soil (bulk density)
γ_s	unit weight of solid particles
γ_w	unit weight of water
γ_d	unit dry weight of soil (dry density)
γ'	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
κ	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

τ_f	shear strength	in terms of effective stress $\tau_f = c' + \sigma' \tan \phi$
c'	effective cohesion intercept	
ϕ'	effective angle of shearing resistance, or friction	
S_u	apparent cohesion*	in terms of total stress $\tau_f = cu + \sigma \tan \phi_u$
ϕ_u	apparent angle of shearing resistance, or friction	
μ	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 041-130054-0-2 **RECORD OF BOREHOLE No BS-1** 1 OF 1 **METRIC**
 G.W.P. 62-00-00 LOCATION N 4678055.0 ; E 272793.7 ORIGINATED BY MA
 DIST 1 HWY 401 BOREHOLE TYPE POWER AUGER (UNCASED) COMPILED BY BG
 DATUM GEODETIC DATE August 10, 2004 CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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										10 20 30		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
184.71	GROUND SURFACE																			
0.00	TOPSOIL, clayey																			
0.12	Brown																			
184.04	(FILL), silty clay, trace sand, with topsoil, Brown																			
0.67	SILTY CLAY, trace sand, trace gravel (TILL) Stiff, Mottled brown and grey becoming brown at elev. 182.9m		1	SS	8		184													
			2	SS	12		183													
182.03																				
2.68	SILTY SAND, trace gravel, Compact, Brown		3	SS	29		182													
2.80																				
3.05	SILTY CLAY, trace sand, trace gravel (TILL) Very stiff, Grey																			
	END OF BOREHOLE																			
	Borehole dry during drilling Aug. 10, 2004																			

PROJECT <u>041-130054-0-2</u>		RECORD OF BOREHOLE No BS-2		1 OF 1 METRIC	
G.W.P. <u>62-00-00</u>		LOCATION <u>N 4677912.8 ; E 274764.1</u>		ORIGINATED BY <u>MA</u>	
DIST <u>1</u> HWY <u>401</u>		BOREHOLE TYPE <u>POWER AUGER (UNCASED)</u>		COMPILED BY <u>BG</u>	
DATUM <u>GEODETIC</u>		DATE <u>August 12, 2004</u>		CHECKED BY <u>SB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	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												
186.23	GROUND SURFACE																			
0.00	TOPSOIL, clayey Brown						186													
185.83																				
0.40	SANDY SILT, trace clay, trace gravel (TILL) Dense, Brown		1	SS	32								○							
184.86							185													
1.37	SILTY CLAY, trace sand, trace gravel (TILL) Very stiff to hard, Brown		2	SS	28								○							
							184													
183.18			3	SS	31								○							
3.05	END OF BOREHOLE Borehole dry during drilling Aug. 12, 2004																			

PROJECT <u>041-130054-0-2</u>		RECORD OF BOREHOLE No BS-3		1 OF 1	METRIC
G.W.P. <u>62-00-00</u>		LOCATION <u>N 4677894.1 ; E 275238.8</u>		ORIGINATED BY <u>MA</u>	
DIST <u>1</u> HWY <u>401</u>		BOREHOLE TYPE <u>POWER AUGER (UNCASED)</u>		COMPILED BY <u>BG</u>	
DATUM <u>GEODETIC</u>		DATE <u>August 12, 2004</u>		CHECKED BY <u>SB</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/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100		w _p w w _L				
								SHEAR STRENGTH kPa		WATER CONTENT (%)				
						○ UNCONFINED	+ FIELD VANE							
						● QUICK TRIAXIAL	× LAB VANE							
								20 40 60 80 100		10 20 30				
186.34	GROUND SURFACE													
0.00	TOPSOIL, clayey Brown													
185.91	(FILL), silty clay, trace sand, trace gravel, trace topsoil, Brown													
0.43														
0.67	SILTY CLAY, trace sand, trace gravel (TILL) Stiff to Very stiff, Mottled brown and grey becoming brown at elev. 184.9m		1	SS	12						○			
			2	SS	24						○			
			3	SS	23						○			
183.29	END OF BOREHOLE													
3.05	Borehole dry during drilling Aug. 12, 2004													

ON MTO 04-1130 054 GPJ ON MOT GDT 1224/04

PROJECT <u>041-130054-0-2</u>		RECORD OF BOREHOLE No BS-4		1 OF 1 METRIC	
G.W.P. <u>62-00-00</u>		LOCATION <u>N 4677798.7 :E 277461.7</u>		ORIGINATED BY <u>MA</u>	
DIST <u>1</u> HWY <u>401</u>		BOREHOLE TYPE <u>POWER AUGER (UNCASED)</u>		COMPILED BY <u>BG</u>	
DATUM <u>GEODETIC</u>		DATE <u>August 13, 2004</u>		CHECKED BY <u>SB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	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												
186.38	GROUND SURFACE																			
0.00	TOPSOIL, clayey Brown																			
185.92																				
0.46	SILTY CLAY, trace sand, trace gravel (TILL) Stiff to very stiff, Mottled brown & grey becoming brown at elev. 185.0m and grey at elev. 183.8m		1	SS	9															
			2	SS	27															
			3	SS	21															
183.33																				
3.05	END OF BOREHOLE																			
	Borehole dry during drilling Aug. 13, 2004																			

ON MTO 04-1130 054.GPJ ON MOT.GDT 12/24/04

RECORD OF BOREHOLE No BS-5

1 OF 1

METRIC

PROJECT 041-130054-0-2
G.W.P. 62-00-00 LOCATION N 4677781.3 : E 277861.3
DIST 1 HWY 401 BOREHOLE TYPE POWER AUGER (UNCASED)
DATUM GEODETIC DATE August 13, 2004
ORIGINATED BY MA
COMPILED BY BG
CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
186.02	GROUND SURFACE																
0.00	TOPSOIL, clayey																
0.12	Brown (FILL), silty clay, trace sand, trace gravel with topsoil, Brown																
185.23	SILTY CLAY, trace sand, trace gravel (TILL) Very stiff to hard, Mottled brown & grey becoming brown at elev. 184.6m and grey at elev. 183.6m		1	SS	16												
0.79			2	SS	32												
			3	SS	20												
182.97	END OF BOREHOLE																
3.05	Borehole dry during drilling Aug. 13, 2004																

+ 3, X 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BS-6

1 OF 1

METRIC

PROJECT 041-130054-0-2 LOCATION N 4677688.8; E 279984.3 ORIGINATED BY MA
G.W.P. 62-00-00 DIST 1 HWY 401 BOREHOLE TYPE POWER AUGER (UNCASED) COMPILED BY BG
DATUM GEODETIC DATE August 16, 2004 CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
184.01	GROUND SURFACE							20	40	60	80	100					
0.00	TOPSOIL, silty							○ UNCONFINED	+	FIELD VANE							
0.12	Brown SILTY CLAY, trace sand, trace gravel (TILL) with silt layers Very stiff to hard, Mottled brown and grey becoming brown at elev. 182.6m and grey at elev. 181.7m		1	SS	18		183										
			2	SS	35		182										
			3	SS	16		181										
180.96	END OF BOREHOLE																
3.05	Borehole dry during drilling Aug. 16, 2004																

RECORD OF BOREHOLE No OH-1

1 OF 1

METRIC

PROJECT 041-130054-0-2

G.W.P. 62-00-00

LOCATION

N 4677667.9 ; E 280559.4

ORIGINATED BY MA

DIST 1

HWY 401

BOREHOLE TYPE

POWER AUGER (HOLLOW STEM)

COMPILED BY BG

DATUM GEODETIC

DATE

July 27, 2004

CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE						
								20	40	60	80						
183.84	GROUND SURFACE																
0.00	TOPSOIL, clayey																
0.15	Black SILTY CLAY, trace sand, trace gravel (TILL) Stiff to hard, Brown and grey		1	SS	9												
			2	SS	25												
			3	SS	30												
			4	SS	32												
180.37																	
3.57	SAND, fine, trace silt, Dense, Brown SILTY CLAY, trace sand, trace gravel (TILL) Stiff to Very stiff, Brown becoming grey at elev. 179.3m		5	SS	19												
			6	SS	15												
			7	SS	7												
			8	SS	8												
175.15																	
8.69	SILTY CLAY, trace sand, Firm, Grey		9	SS	4												
173.63																	
10.21	SILTY SAND, with silty clay layers Compact, Grey																
172.71			10	SS	18												
11.13	END OF BOREHOLE																
	Groundwater encountered in borehole at elev. 173.48m during drilling July 27, 2004																

+ 3, X 3; Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No OH-2

1 OF 1

METRIC

PROJECT 041-130054-0-2

G.W.P. 62-00-00

LOCATION

N 4677656.5 ; E 282509.8

ORIGINATED BY MA

DIST 1

HWY 401

BOREHOLE TYPE

POWER AUGER (HOLLOW STEM)

COMPILED BY BG

DATUM GEODETIC

DATE

July 28, 2004

CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	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									
185.06	GROUND SURFACE						20	40	60	80	100	10	20	30					
0.00	TOPSOIL, clayey Brown																		
184.27																			
0.79	(FILL), silty clay, trace sand, Stiff,		1	SS	10								○						
183.84	Mottled brown and grey																		
1.22	SILTY CLAY, trace sand, trace gravel (TILL) Stiff to Very stiff, Mottled brown and grey becoming brown at elev. 183.1m and grey at elev. 181.4m		2	SS	14								○						
			3	SS	26								○						
			4	SS	23								○						
			5	SS	17								○		4 17 47 32				
			6	SS	13								○						
			7	SS	12								○						
			8	SS	11								○						
178.51	END OF BOREHOLE																		
6.55	Borehole dry during drilling July 28, 2004																		

+ 3, x 3

Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT 041-130054-0-2 RECORD OF BOREHOLE No **OH-3** 1 OF 1 **METRIC**
 G.W.P. 62-00-00 LOCATION N 4677692.5 E 281500.5 ORIGINATED BY MA
 DIST 1 HWY 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG
 DATUM GEODETIC DATE July 29, 2004 CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w_p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)			
								<div><div>○ UNCONFINED</div><div>● QUICK TRIAXIAL</div><div>+ FIELD VANE</div><div>× LAB VANE</div></div>								<div><div></div><div></div><div></div></div>			
184.90	GROUND SURFACE							20	40	60	80	100	10	20	30				
0.09	TOPSOIL, clayey Brown (FILL), clayey silt, trace sand, trace gravel, trace topsoil and organics, Stiff, Mottled brown and grey		1	SS	11		184												
183.53																			
1.37	SILTY CLAY, trace sand, trace gravel (TILL) Stiff to Hard, Mottled brown and grey, becoming brown at elev. 182.9m and grey at elev. 180.7m		2	SS	26		183												
			3	SS	38														
			4	SS	37		182												
			5	SS	26		181												
			6	SS	17		180												
			7	SS	12		179												
178.35			8	SS	13														
6.55	END OF BOREHOLE Borehole dry during drilling July 29, 2004																		

ON_MTO 04-1130 054.GPJ ON_MOT.GDT 12/24/04

RECORD OF BOREHOLE No OH-4

1 OF 1

METRIC

PROJECT 041-130054-0-2

G.W.P. 62-00-00

LOCATION

N 4677981.6 ; E 274422.8

ORIGINATED BY MA

DIST 1 HWY 401

BOREHOLE TYPE POWER AUGER (UNCASED)



COMPILED BY BG

DATUM GEODETIC

DATE

August 6, 2004

CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	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	30
186.47 0.00	GROUND SURFACE TOPSOIL, clayey Brown																			
185.68 0.79	SILTY CLAY, trace sand, trace gravel (TILL) Stiff to Hard, Mottled brown and grey, becoming brown at elev. 185.0m and grey at elev. 183.1m		1	SS	11															
			2	SS	24															
			3	SS	40															
			4	SS	27															
			5	SS	17															
			6	SS	12															
			7	SS	11															
179.92 6.55	END OF BOREHOLE Borehole dry during drilling Aug. 6, 2004																			

+ 3, X 3

Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No OH-5

1 OF 1

METRIC

PROJECT 041-130054-0-2

G.W.P. 62-00-00

LOCATION

N 4677971.9 E 273490.9

ORIGINATED BY MA

DIST 1

HWY 401

BOREHOLE TYPE

POWER AUGER (UNCASED)

COMPILED BY BG

DATUM GEODETIC

DATE

August 11, 2004

CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE							● QUICK TRIAXIAL	x LAB VANE	
185.02	GROUND SURFACE							20 40 60 80 100										
0.00	TOPSOIL, clayey																	
0.21	Brown																	
	SILTY CLAY, trace sand, trace gravel (TILL)																	
	Stiff to hard, Mottled brown and grey, becoming brown at elev. 182.9m and grey at elev. 181.9m		1	SS	14													
			2	SS	24													
			3	SS	36													
			4	SS	14													
			5	SS	12													
			6	SS	8													
			7	SS	9													
178.47	END OF BOREHOLE																	
6.55	Borehole dry during drilling Aug. 11, 2004																	

ON_MTO 04-1130 054.GPJ ON_MOT.GDT 12/24/04

RECORD OF BOREHOLE No OH-6

1 OF 1

METRIC

PROJECT 041-130054-0-2

G.W.P. 62-00-00

LOCATION

N 4678016.8 :E 272516.9

ORIGINATED BY MA

DIST 1

HWY 401

BOREHOLE TYPE

POWER AUGER (HOLLOW STEM)

COMPILED BY BG

DATUM GEODETTIC

DATE

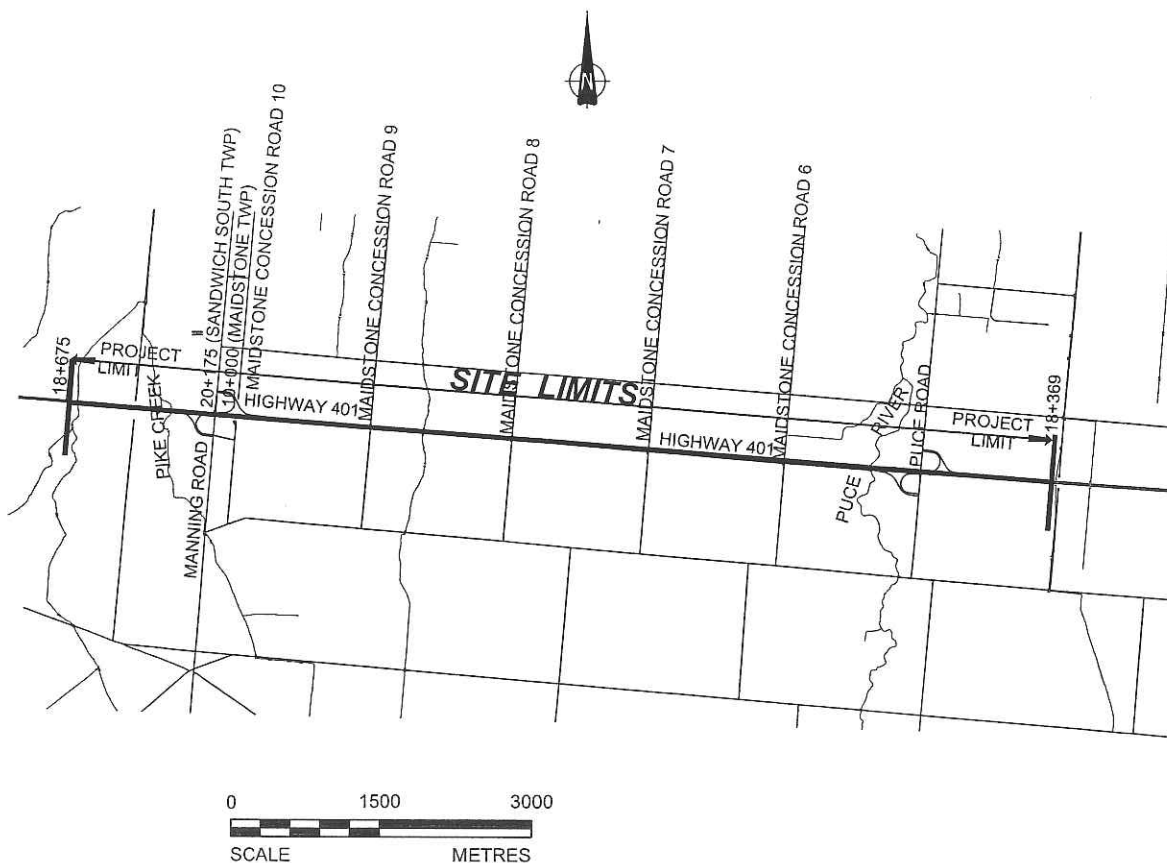
August 4, 2004

CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	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 (%)												
186.24	GROUND SURFACE						20	40	60	80	100						
0.00	TOPSOIL, clayey																
0.21	Brown (FILL), silty clay, trace sand, trace gravel, trace topsoil, Stiff, Mottled brown and grey		1	SS	10												
184.87																	
1.37	SILTY CLAY, trace sand, trace gravel (TILL) Firm to very stiff, Mottled brown and grey, becoming brown at elev. 184.1m and grey at elev. 181.0m		2	SS	23												
			3	SS	27												
			4	SS	23												
			5	SS	16												
			6	SS	18												
			7	SS	10												
			8	SS	7												
179.69																	
6.55	END OF BOREHOLE																
	Borehole dry during drilling Aug. 4, 2004																

+ 3, X 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

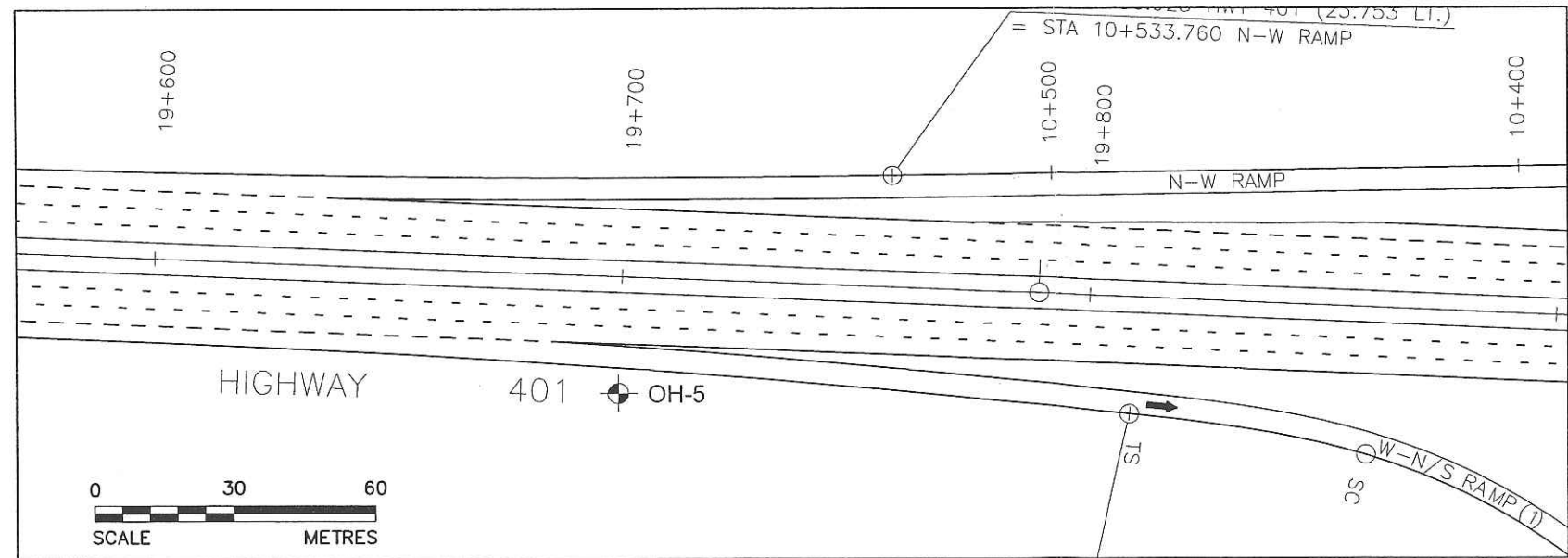
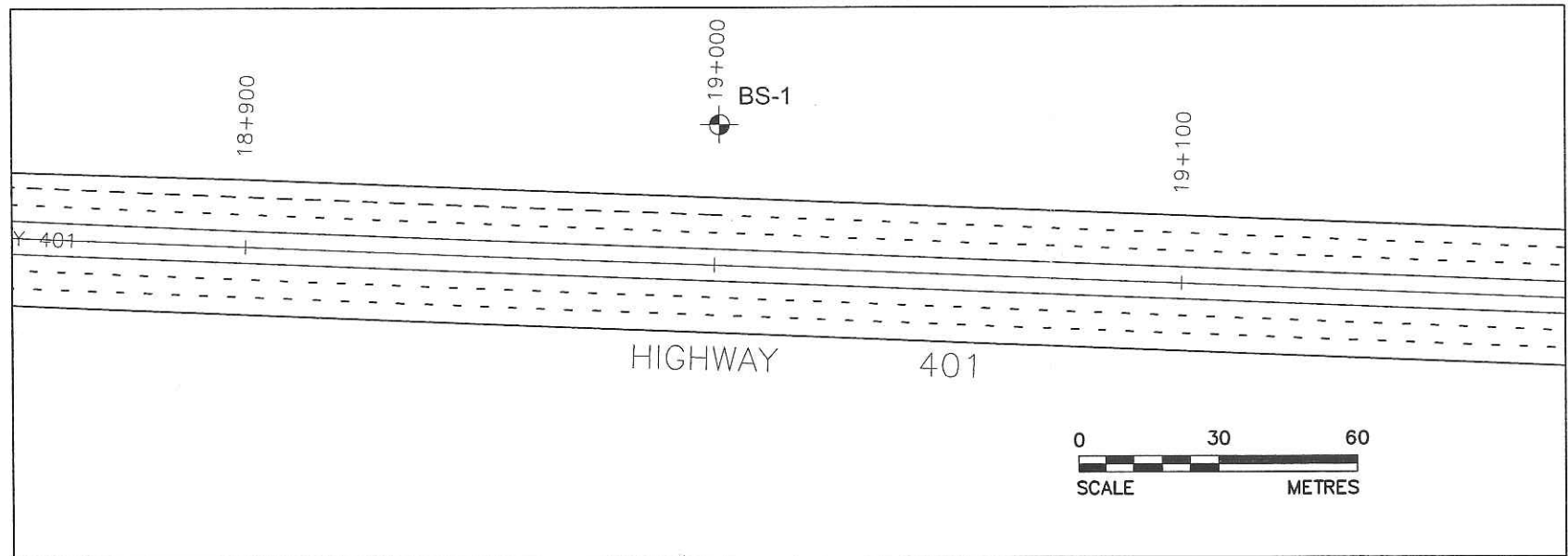
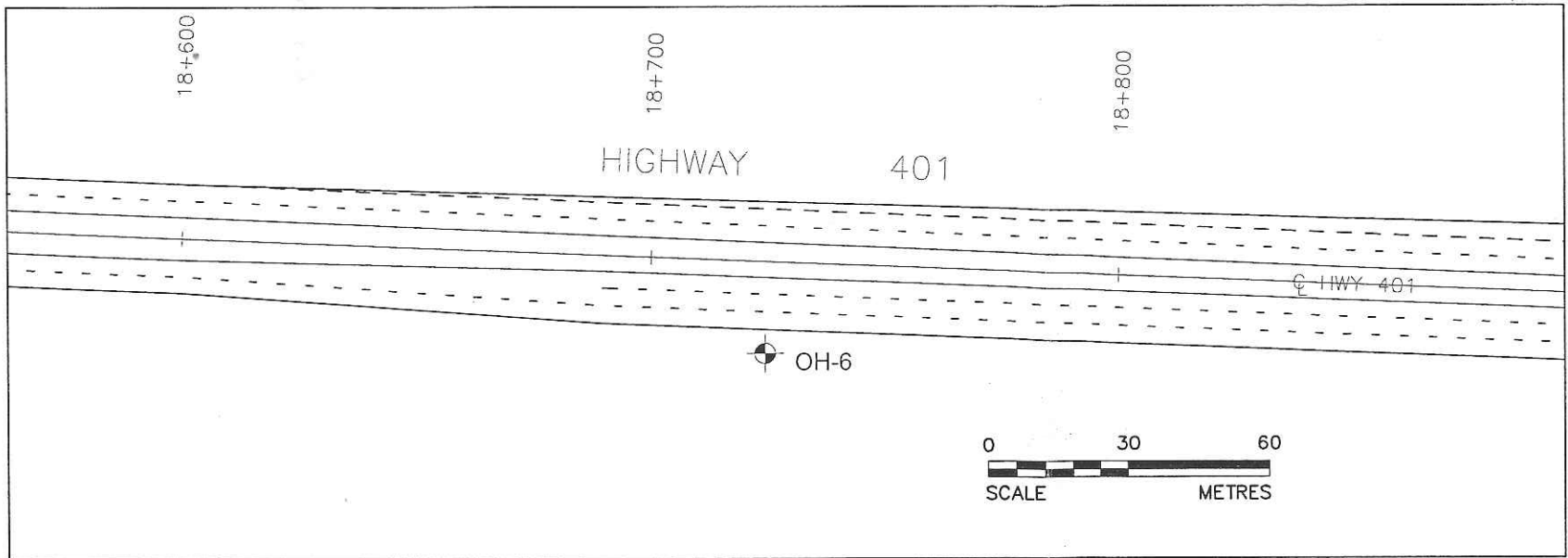


PROJECT		GWP 62-00-00 HIGHWAY 401	
TITLE		KEY PLAN	
PROJECT No. 041-130054		FILE No. 041-130054D001	
CADD BG DEC. 04		SCALE AS SHOWN REV. 0	
CHECK MEB DEC. 04		FIGURE 1	



D size dwg 22" x 32" 11" x 17" plot half scale
1 = 1 metric

0013225D001.DWG



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

DIST HWY. 401
CONT. No.
WP No. 62-00-00



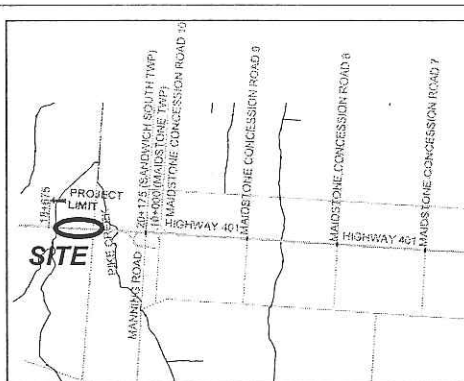
HIGHWAY 401
BOREHOLE LOCATIONS

SHEET



Golder Associates Ltd.
LONDON, ONTARIO, CANADA

REFERENCE
DRAWING SUPPLIED BY DILLON CONSULTING ENTITLED
HWY 401, PAVEMENT MARKINGS
SCALE: 1:1000
DATED: 2004



KEY PLAN

LEGEND

Borehole

No.	ELEVATION (metres)	CO-ORDINATES	
		NORTH	EAST
BS-1	184.71	4678055.0	272793.7
OH-6	186.24	4678016.8	272516.9
OH-5	185.02	4677971.9	273490.9

NOTES

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

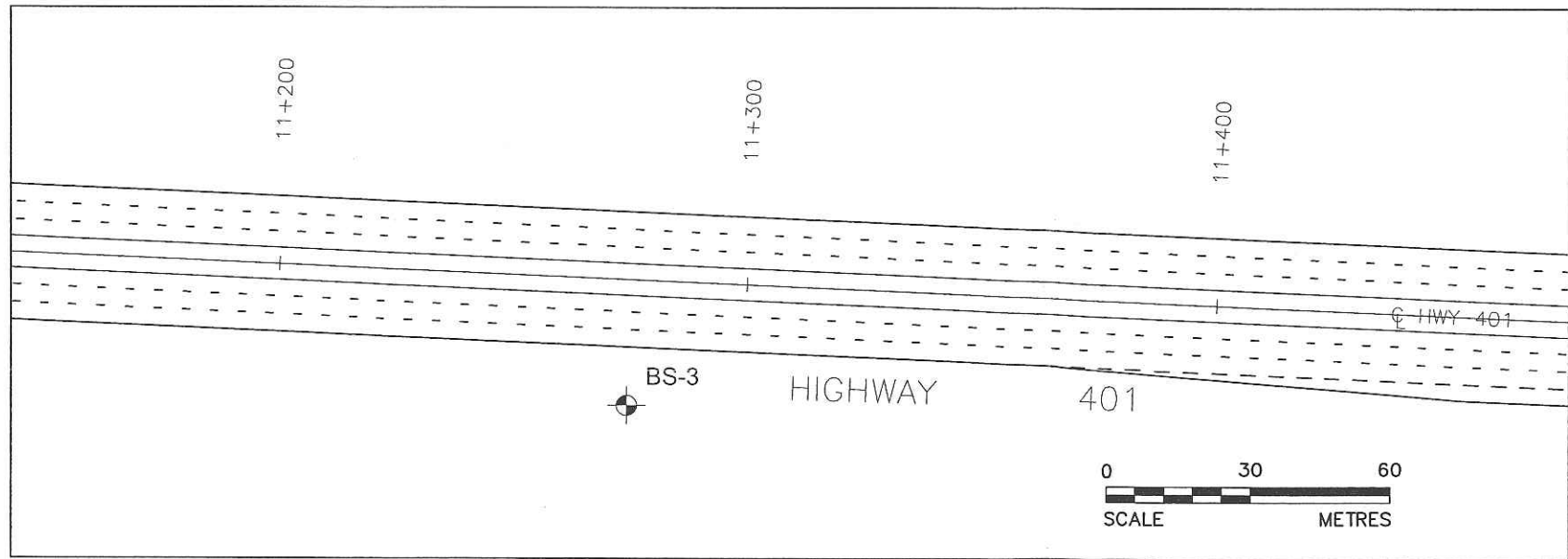
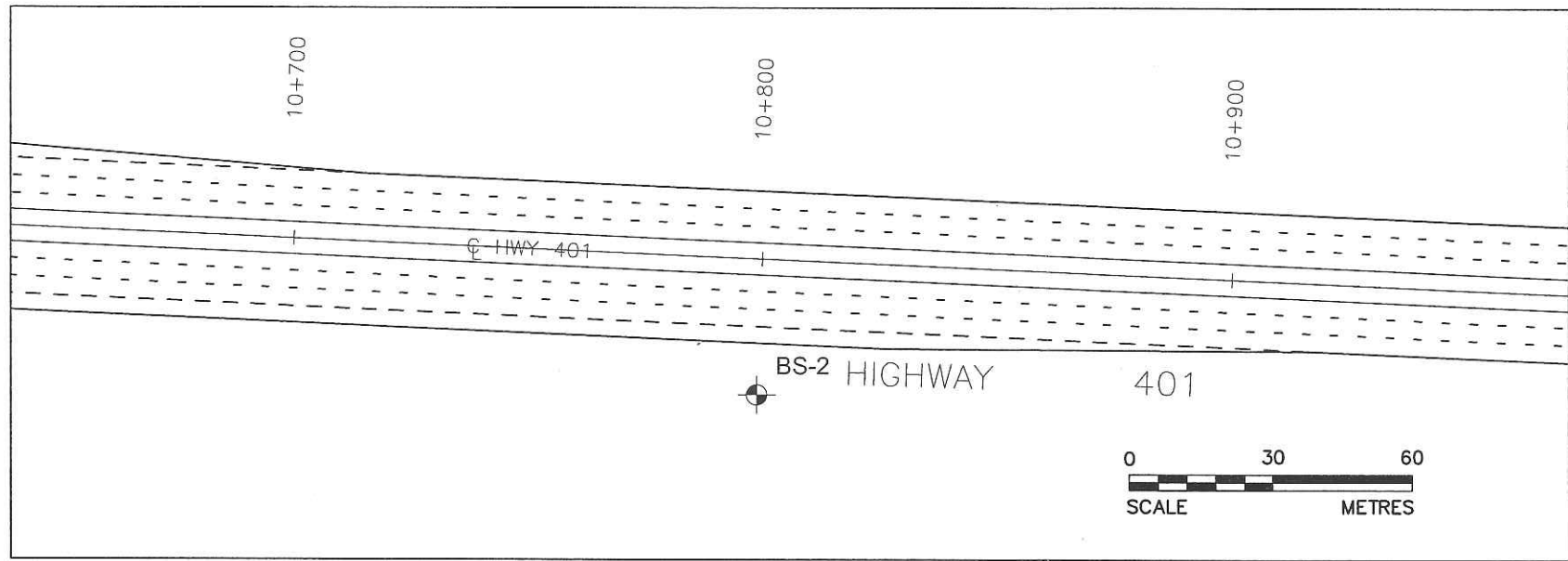
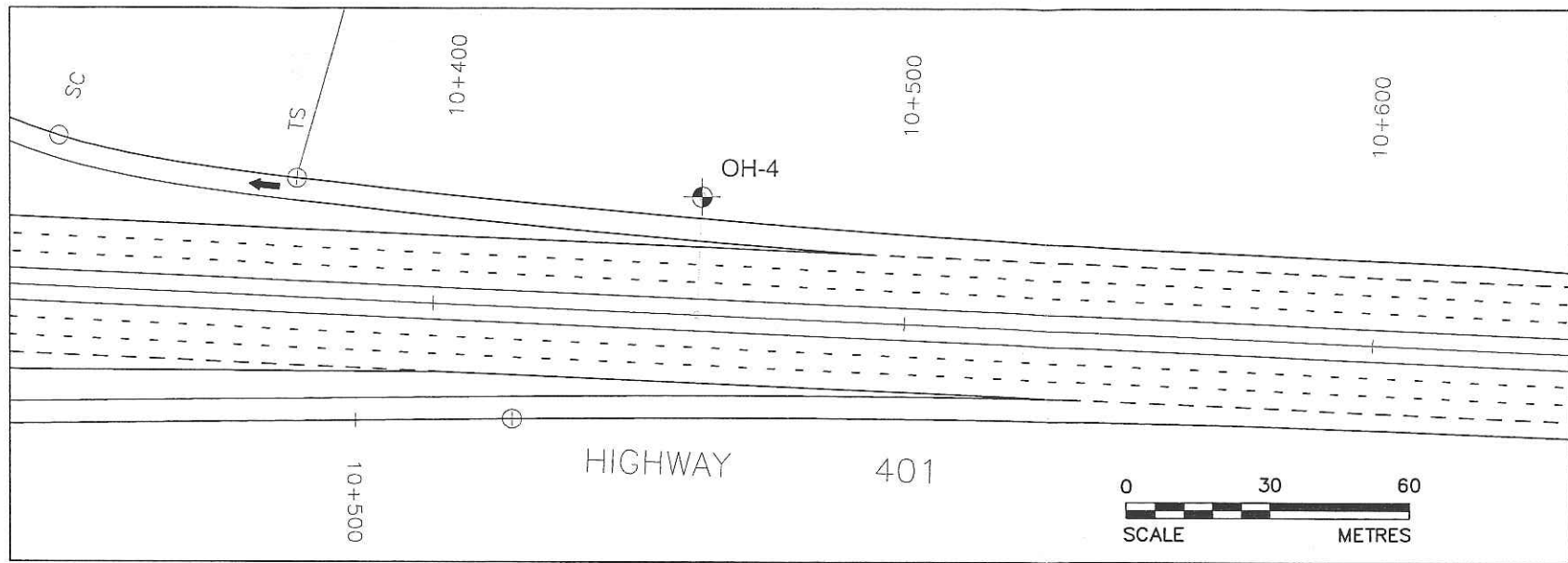
NO.	DATE	BY	REVISION

Geocres No. 40J2-62

HWY. No.	401	PROJECT NO.	D41-130054-0-2
SUBM'D.	-	CHKD.	-
DRAWN:	BG	CHKD.	SB
DATE:	DEC. 20, 2004	APPD.	
DWG.	1		

1 = 1 metric
D size dwg 22" x 32" 11" x 17" plot half scale

001325D001.DWG



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

DIST HWY. 401
CONT. No.
WP No. 62-00-00



HIGHWAY 401

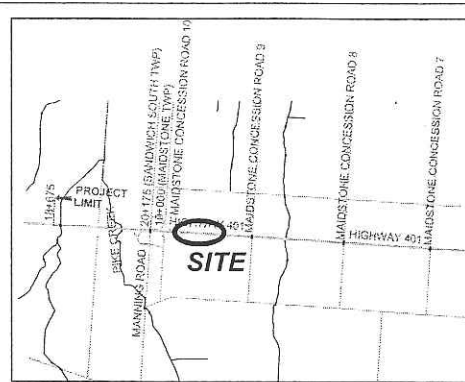
SHEET

BOREHOLE LOCATIONS



Golder Associates Ltd.
LONDON, ONTARIO, CANADA

REFERENCE
DRAWING SUPPLIED BY DILLON CONSULTING ENTITLED
HWY 401, PAVEMENT MARKINGS
SCALE: 1:1000
DATED: 2004



KEY PLAN

LEGEND

Borehole

No.	ELEVATION (metres)	CO-ORDINATES	
		NORTH	EAST
OH-4	186.47	4677981.6	274422.8
BS-2	186.23	4677912.8	274764.1
BS-3	186.34	4677894.1	275238.8

NOTES

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

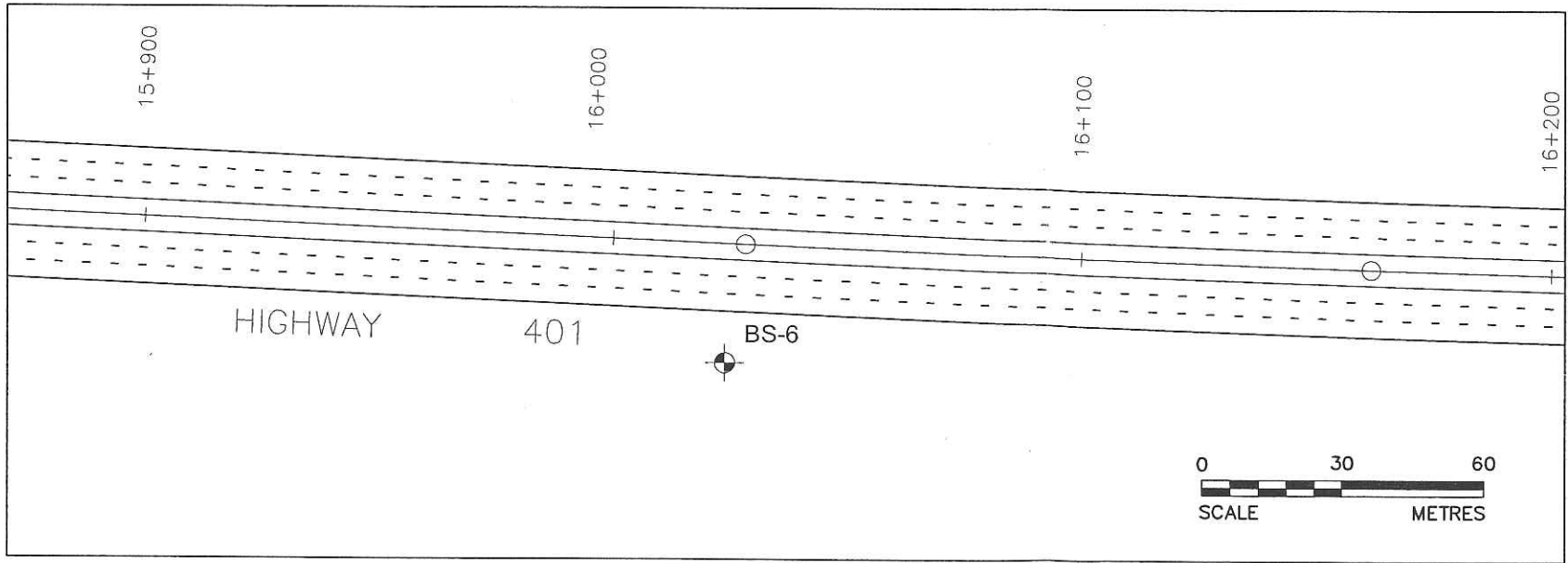
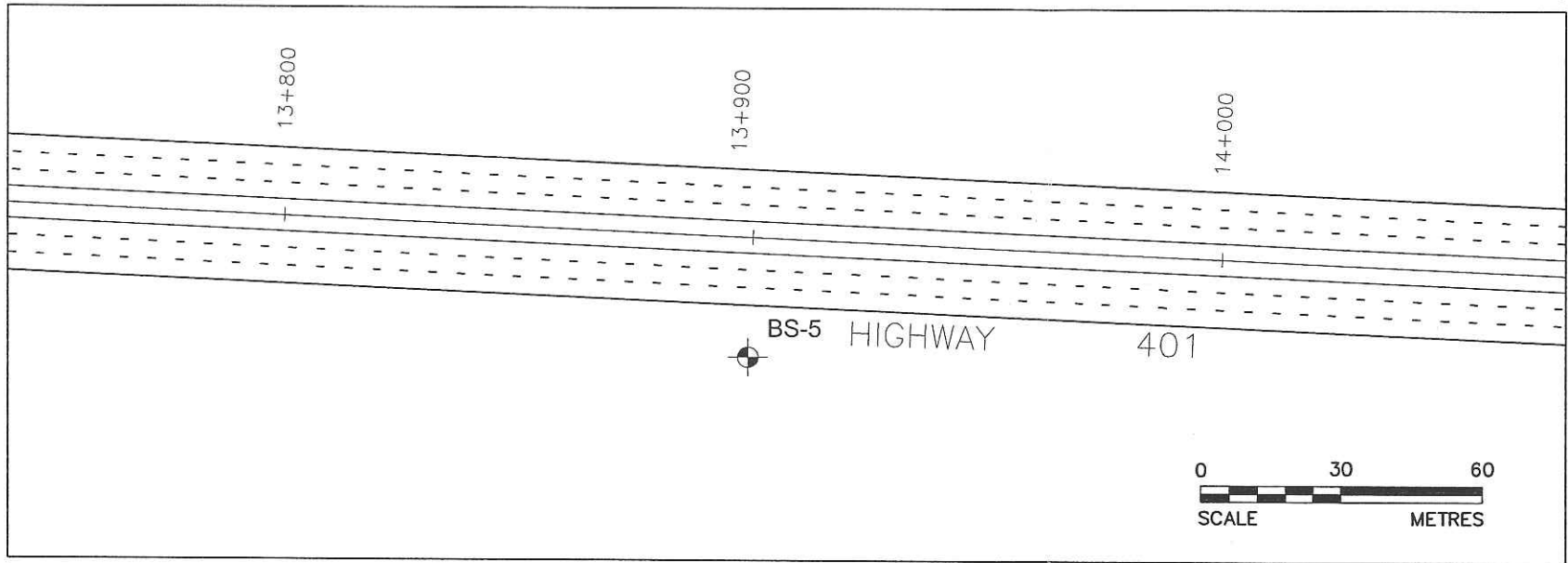
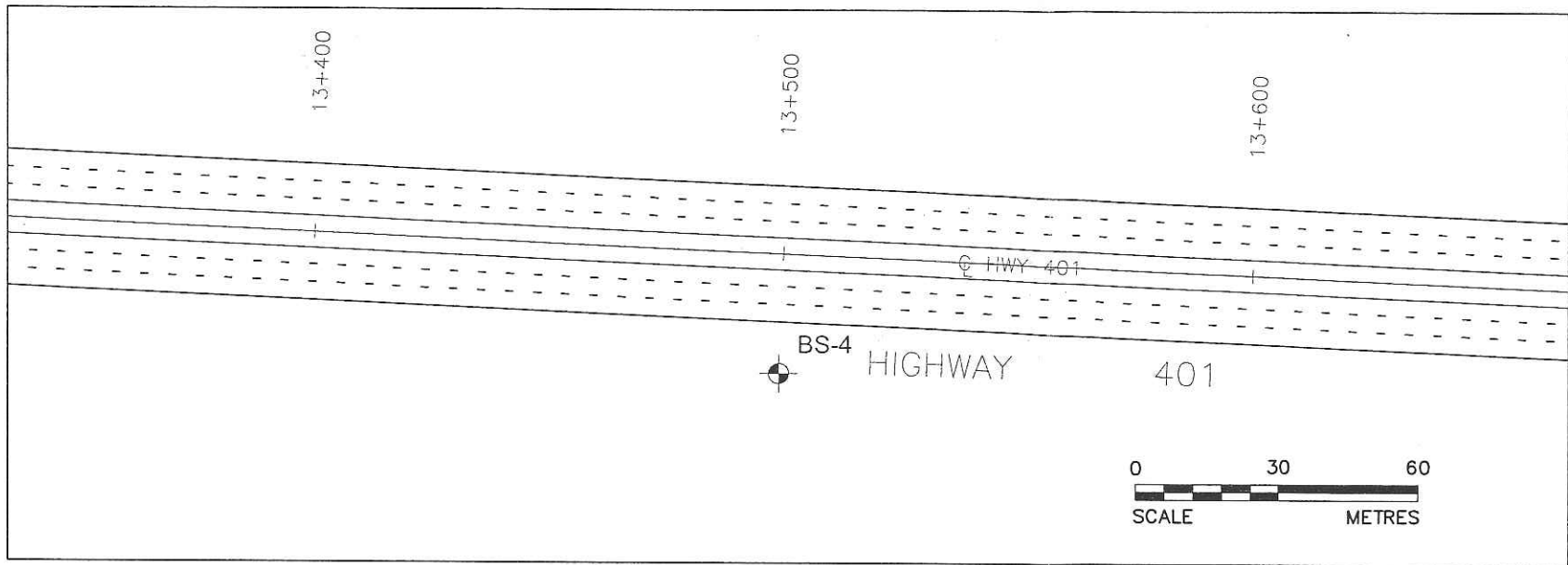
NO.	DATE	BY	REVISION

Geocres No. 40J2-62

HWY. No.	401	PROJECT NO.	041-130054-0-2
SUBM'D.	-	CHKD.	-
DRAWN:	BG	CHKD.	SB
DATE:	DEC. 20, 2004	APPD.	
DWG.	2		

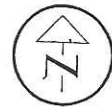
1 = 1 metric
D size dwg 22" x 32" 11" x 17" plot half scale

0013225D001.DWG



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

DIST HWY. 401
CONT. No.
WP No. 62-00-00



HIGHWAY 401

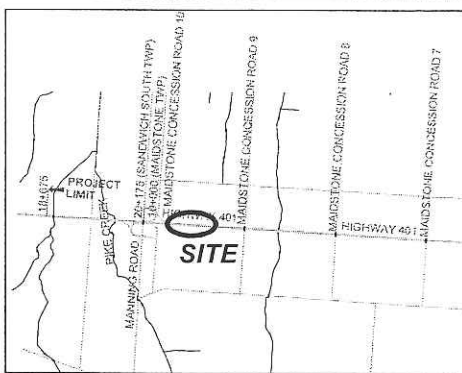
SHEET

BOREHOLE LOCATIONS



Golder Associates Ltd.
LONDON, ONTARIO, CANADA

REFERENCE
DRAWING SUPPLIED BY DILLON CONSULTING ENTITLED
HWY 401, PAVEMENT MARKINGS
SCALE: 1:1000
DATED: 2004



KEY PLAN

LEGEND

Borehole

No.	ELEVATION (metres)	CO-ORDINATES	
		NORTH	EAST
BS-4	186.38	4677798.7	277461.7
BS-5	186.02	4677781.3	277861.3
BS-6	184.01	4677688.8	279984.3

NOTES

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

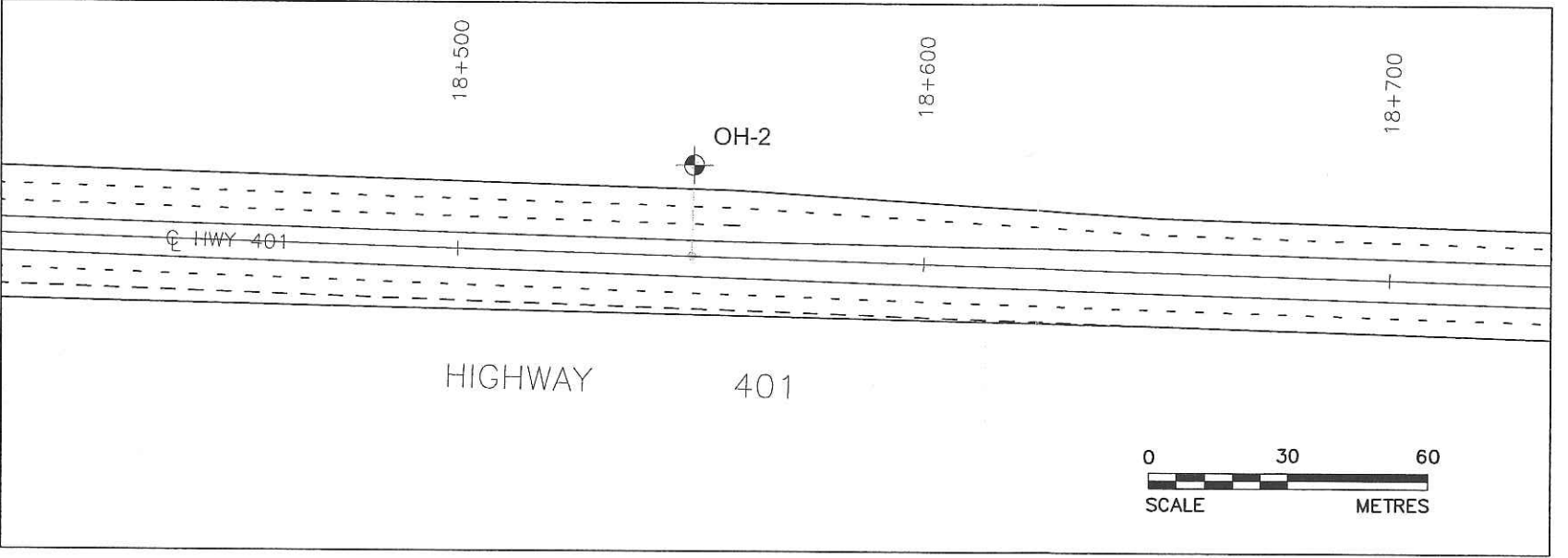
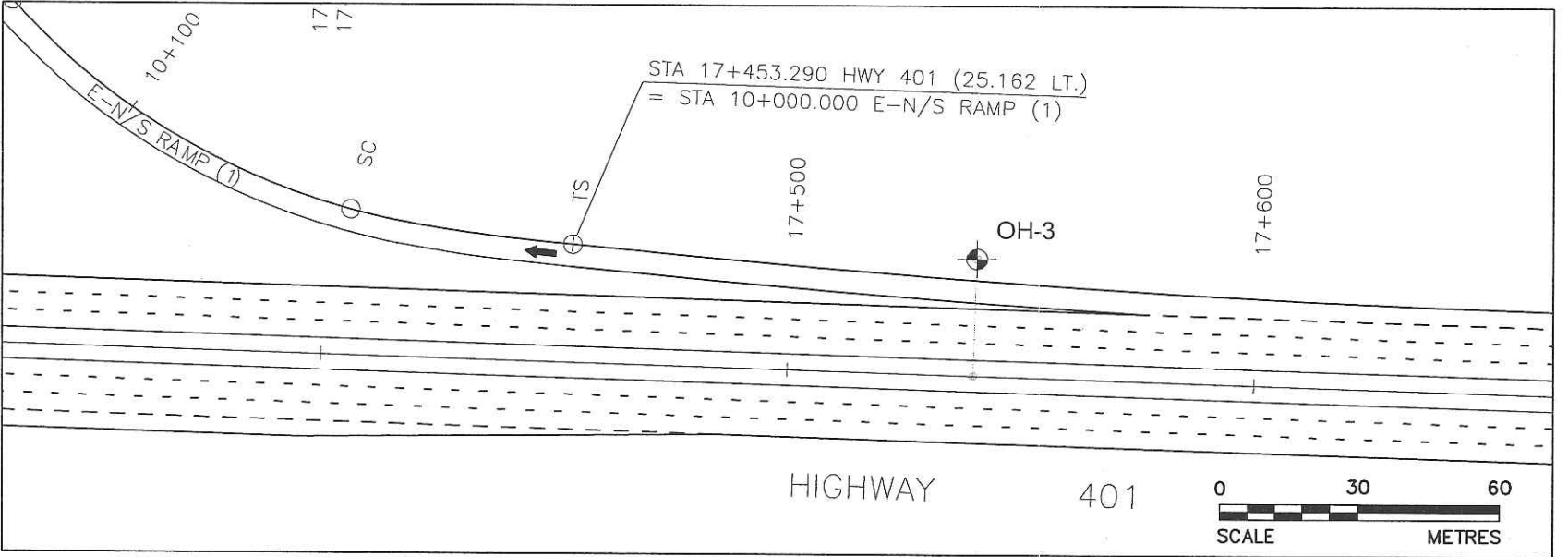
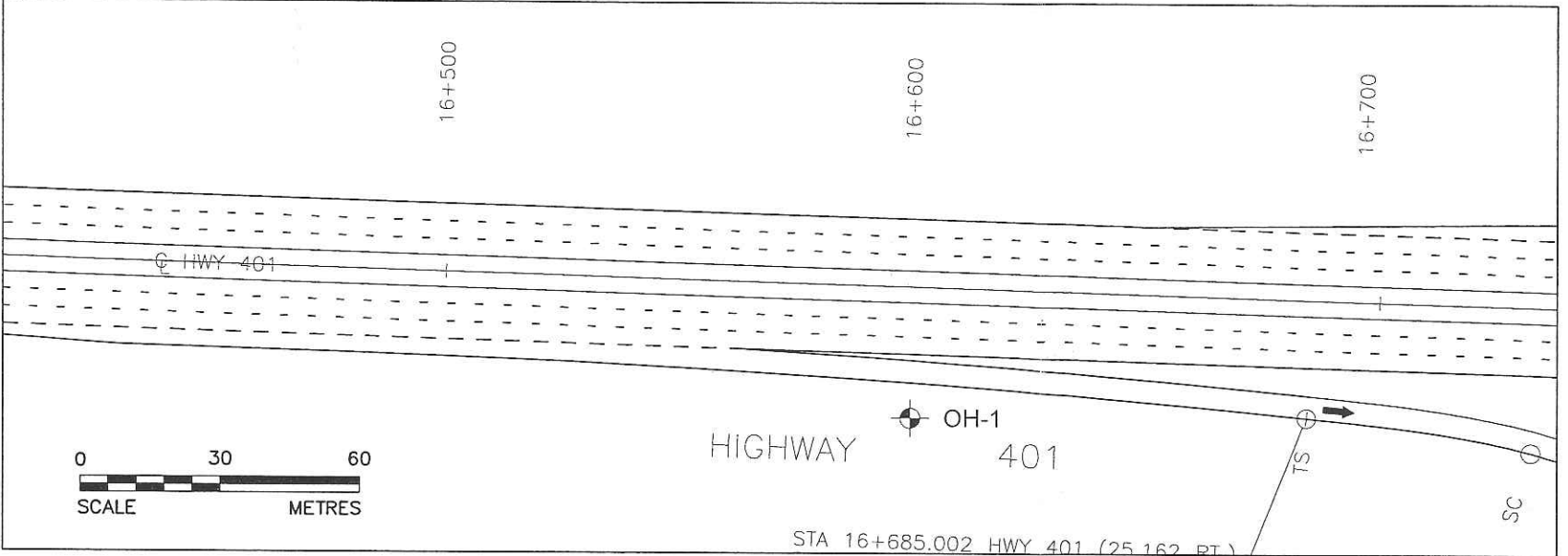
NO.	DATE	BY	REVISION

Geocres No. 40J2-62

HWY. No.	401	PROJECT NO.	041-130054-0-2
SUBM'D.	-	CHKD.	-
DRAWN:	BG	CHKD.	SB
DATE:	DEC. 20, 2004	APPD.	
DWG.	3		

1 = 1 metric
D size dwg 22" x 32" 11" x 17" plot half scale

00132250001.DWG



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

DIST
CONT. No.
WP No. 62-00-00

HWY. 401

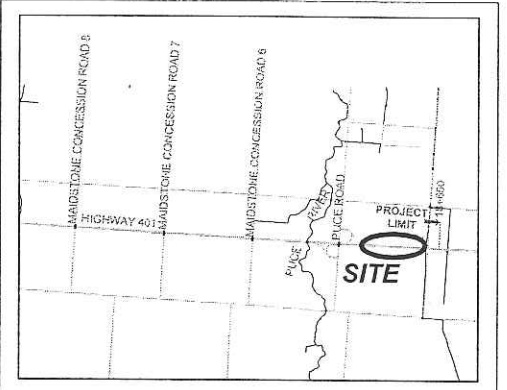
HIGHWAY 401

BOREHOLE LOCATIONS

SHEET

Golder Associates Ltd.
LONDON, ONTARIO, CANADA

REFERENCE
DRAWING SUPPLIED BY DILLON CONSULTING ENTITLED
HWY 401, PAVEMENT MARKINGS
SCALE: 1:1000
DATED: 2004



KEY PLAN

LEGEND			
Borehole			
No.	ELEVATION (metres)	CO-ORDINATES	
		NORTH	EAST
OH-1	183.84	4677667.9	280559.4
OH-3	184.90	4677692.5	281500.5
OH-2	185.06	4677656.5	282509.8

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

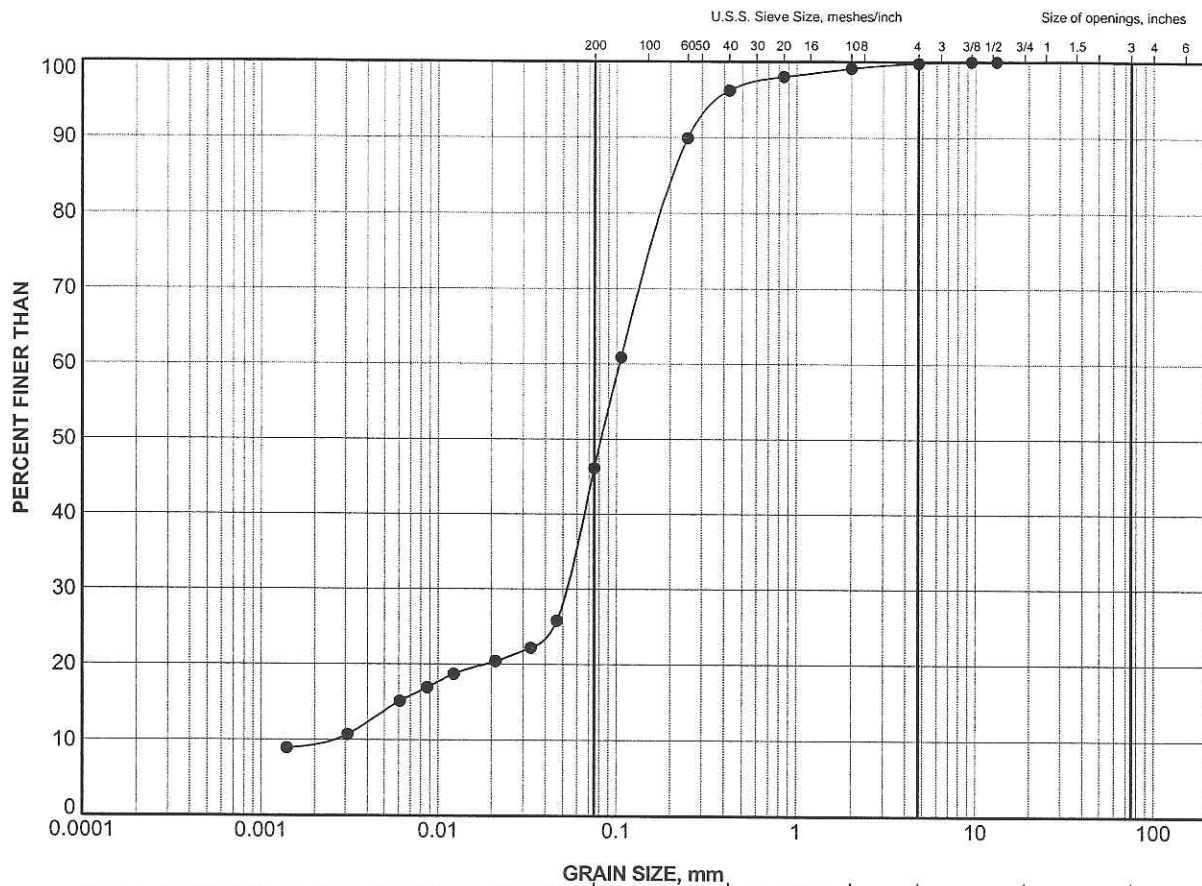
NO.	DATE	BY	REVISION

Geocres No. 40J2-62

HWY. No.	401	PROJECT NO.	D41-130054-0-2
SUBM'D.	-	CHKD.	-
DRAWN:	BG	CHKD.	SB
DATE: DEC. 20, 2004		APPD.	DWG. 4

APPENDIX A

LABORATORY TEST DATA (FIGURES A-1 TO A-3)



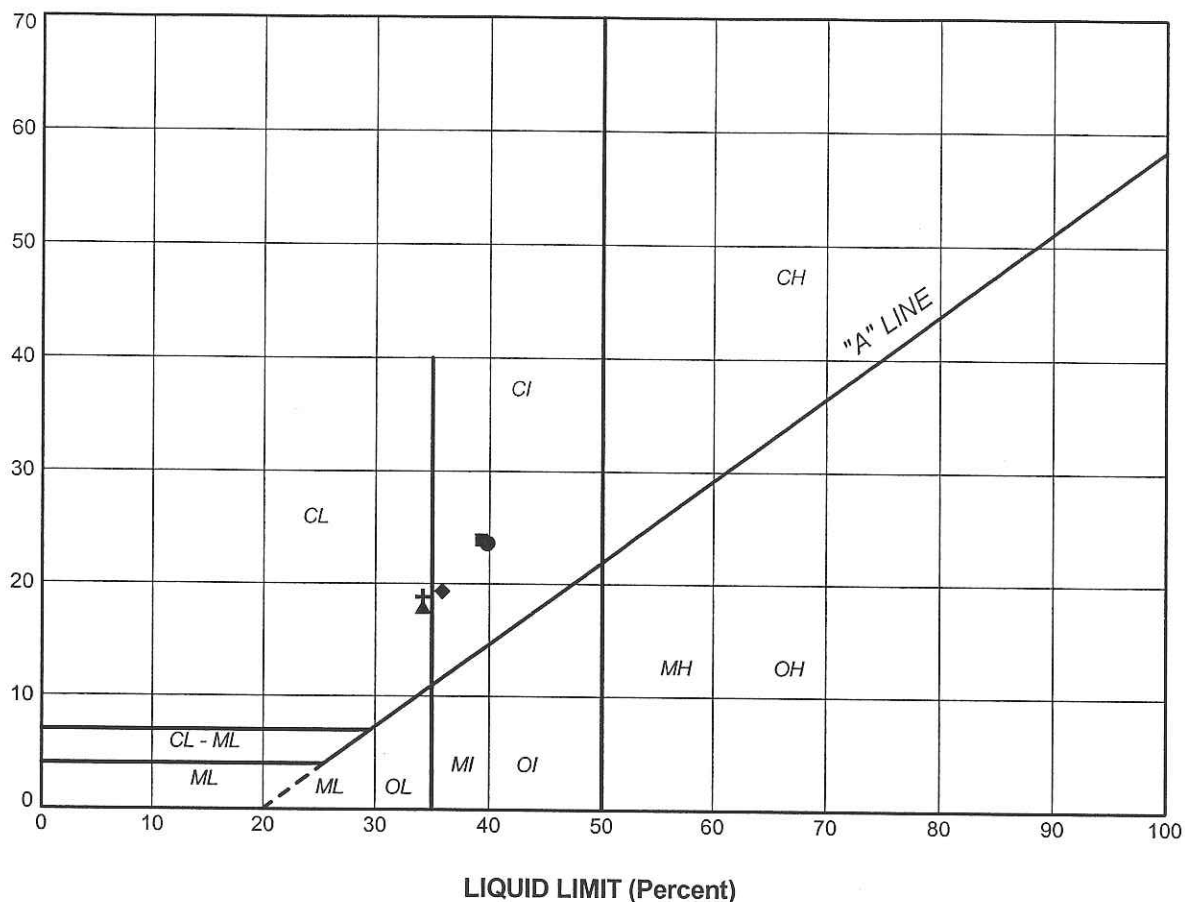
CLAY AND SILT	SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OH-1	10	172.9

PROJECT				HIGHWAY 401 GWP 62-00-00			
TITLE				GRAIN SIZE DISTRIBUTION SILTY SAND			
PROJECT No.		041-130054-0-2		FILE No.		04-1130 054-0-2.GPJ	
SCALE		N/A		REV.			
DRAWN	BG	Sep 28/04		FIGURE A-1			
CHECK	SB	Dec. 24/04					



PLASTICITY INDEX (Percent)



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)	LL(%)	PL(%)	PI
●	OH-2	4	182.0	39.8	16.2	23.6
■	OH-3	5	181.1	39.3	15.4	23.9
▲	OH-4	3	184.2	34.2	16.3	17.9
+	OH-5	4	182.0	34.2	15.4	18.8
◆	OH-6	5	182.4	35.9	16.6	19.3

PROJECT

HIGHWAY 401
GWP 62-00-00

TITLE

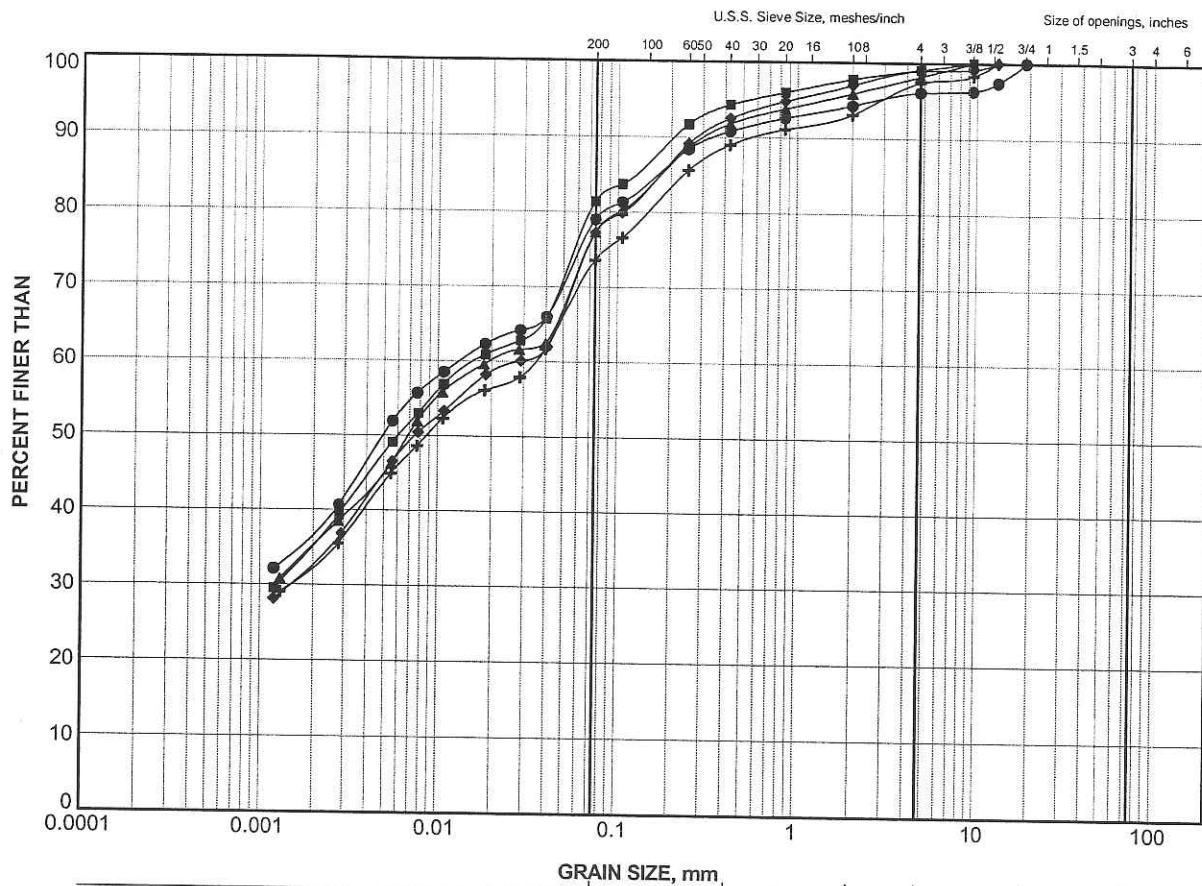
PLASTICITY CHART




**Golder
Associates**
LONDON, ONTARIO

PROJECT No.	041-130054-0-2	FILE No.	04-1130 054-0-2.GPJ
DRAWN	BG	SCALE	N/A
CHECK	SB	REV.	

FIGURE A-2



LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	OH-2	5	181.0
■	OH-3	4	181.6
▲	OH-4	4	183.2
+	OH-5	5	181.0
◆	OH-6	4	183.0

PROJECT				HIGHWAY 401 GWP 62-00-00			
TITLE				GRAIN SIZE DISTRIBUTION SILTY CLAY TILL			
PROJECT No.		041-130054-0-2		FILE No.		04-1130 054-0-2.GPJ	
DRAWN		BG		SCALE		N/A	
CHECK		SB		REV.			
		Sep 28/04					
		Dec. 24/04					
 Golder Associates LONDON, ONTARIO				FIGURE A-3			