

GEOCRES No. 30M 4-84DIST. CR REGION W.P. No. 278/279-99-01CONT. No. W. O. No. STR. SITE No. 36-491 / 36-492HWY. No. 6 NEWLOCATION Hwy 53

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT  
FOR  
HIGHWAY 6 NEW AT HIGHWAY 53 STRUCTURES, WP 9-91-02  
ANCASTER, ONTARIO

WP 278/279-99-01

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Job No. 99HF073

November, 1999

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## FOUNDATION INVESTIGATION REPORT

For

Highway 6 New at Highway 53 Structures, WP 9-91-02

Ancaster, Ontario

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### INTRODUCTION

This report summarizes the results of the foundation investigation carried out for construction of twin ramp structures for the proposed Highway 6 (New) alignment connecting Highway 403 over Highway 53 in Ancaster, Ontario. The investigation was conducted for the Ministry of Transportation Pavements and Foundation Section.

The report pertains to the proposed bridge structures and the approaches within about 20 m of the abutments. The approximate limits are as follows:

<u>Ramp</u>	<u>Stations</u>
Hwy 403W – Hwy 6 (New)S	11+045 to 11+120
Hwy 403E – Hwy 6 (New)S	24+550 to 24+622
Hwy 6 (New)S – Hwy 403W	24+550 to 24+622
Hwy 6 (New)S – Hwy 403E	10+980 to 11+052

### SITE DESCRIPTION

The site is located on Highway 53, approximately 1.0 km east of Fiddlers Green Road intersection in the Town of Ancaster. The proposed structure will carry Highway 6 (New) traffic over the existing section of Highway 53. At the proposed location of the twin structures, Highway 6 (New) runs roughly north-south.

The lands adjacent to the site are primarily residential/recreational and agricultural.

The site is located in the physiographic region known as the Norfolk Sand Plain. In general, the topography on the plain is relatively flat to undulating. The overburden is some 30 m thick and typically comprises deposits of glaciolacustrine silt and sand. Bedrock consists of dolostone of the Guelph Formation.

### **INVESTIGATION PROCEDURES**

The fieldwork was carried out during the period October 13 to November 4, 1999 and comprised four boreholes extended to bedrock at depths of 25.9 to 28.0 m and four boreholes drilled to depths of 4.3 m. Two of the four deep boreholes were extended a further 3.0 m into bedrock by coring. The borehole locations are shown on Drawing 1. The boreholes are designated by "W and E" series (e.g. W1 to W4) to differentiate between the west (southbound) and east (northbound) structures.

The borehole locations were selected by Peto MacCallum Ltd., subject to access limitations in the field. The locations of and ground surface elevations at the boreholes were subsequently determined by The Ministry of Transportation. An "A" designation was attached to boreholes requiring relocation from the programmed locations.

The boreholes were advanced using continuous flight solid and hollow stem augers, as well as NXL and NQ rock coring equipment, powered by truck and track-mounted CME-75 drillrigs, supplied and operated by specialist drilling contractors, working under the full-time supervision of a member of our engineering staff.

Representative samples of the overburden were recovered at frequent depth intervals using a conventional split spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata.

Dynamic cone penetration testing was also carried out at locations adjacent to the boreholes to further assess the relative density of the soils.

The groundwater conditions in the boreholes were closely monitored during the course of the fieldwork.

All of the recovered samples were returned to our laboratory for detailed visual examination, classification and routine moisture content determinations. Grain size distribution analyses and Atterberg Limits tests were carried out on selected samples.

### **SUMMARIZED SUBSURFACE CONDITIONS**

Reference is made to the appended Log of Borehole sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, elevations, standard penetration test "N" values, dynamic cone penetration values, and groundwater observations. The results of laboratory grain size distribution analyses and moisture content determinations are also shown. Stratigraphic profiles prepared from the borehole data are presented on Drawing 2.

The subsurface stratigraphy revealed at the bridge site generally comprised a discontinuous topsoil layer overlying native very loose to dense silts and sands, underlain by very stiff to compact silts and clays mantling dolostone bedrock. The strata encountered are summarized below:

#### **Topsoil**

A discontinuous layer of clayey silt topsoil was encountered in all boreholes except borehole W1 and W2 located at the south side of the west structure. The topsoil layer ranged from 200 to 250 mm in thickness.

### Fill

A 2.9 and 3.6 m thick layer of well-compacted non-cohesive sand fill was encountered surficially in boreholes W1 and W2. A 1.9 m thick layer of non-cohesive silt fill was encountered beneath the topsoil in boreholes W3A and W4. In borehole W4, the silt fill was underlain by 0.5 m of very loose sand fill. Moisture contents of 5% for the sand and 13 to 22% for the silt were determined.

The fill was penetrated at elevations 238.5 to 240.8 in boreholes for the west bridge structure.

### Silt

A deposit of silt was encountered below the topsoil fill in boreholes E1A to E4, and W3A to W4. The silt ranged in thickness from 0.5 to 3.5 m. The moisture content ranged from 6 to 27%, typically 20 to 24%. The silt was generally loose to compact (non-cohesive) with occasional stiff to very stiff (cohesive) zones.

The results of grain size distribution analyses conducted on samples of the silt are presented on Figure 1. The results of Atterberg Limits tests conducted on samples exhibiting plasticity are presented on Figure 4. The deposit is essentially non-plastic with zones of slight plasticity.

The silt was penetrated at depths of 2.1 to 3.7 m (elevation 239.0 to 241.0).

### Layered Silts and Sands

An extensive unit of layered non-cohesive silts and sands of glaciolacustrine origin was encountered in the testholes. This unit ranged in thickness from 16.3 to 20.3 m. The silts and sands are generally compact to dense, with localized loose zones. At the eastern bridge structure, the unit alternated from predominantly

sands to a depth of 9.5 m, silts to a depth of 11.0 m, sand to a depth of 17.0 m, then again became predominantly silts. At the western bridge structure, it comprised predominantly sand to depths ranging from 9.3 to 11.0 m, and predominantly silts below this level. The moisture content ranged from 5 to 23%, typically 18 to 22%; the sand/silt was generally saturated below depths of 3.5 m to 5.6 m.

The results of grain size distribution analysis conducted on the silts and sands are presented in Figure 2.

Drilling was terminated within the silts and sands layer in approach boreholes E1A, E4, W1 and W4 at 4.3 m depth. The sand/silt was penetrated at depths of 20.1 to 23.2 m (elevation 220.5 to 222.0) in the deep boreholes.

#### Layered Silts and Clays

The silts and sands deposit was underlain by a layered non to slightly cohesive silts and cohesive clays unit at depths of 20.1 to 23.2 m, approximate elevation 220.5 to 222.0. The silts and clays were compact/stiff to very dense/hard in consistency. The unit became predominantly silts at a depth of 23.2 to 26.2 m. The moisture content of the unit ranged from 14 to 27%, typically 22 to 27%. The results of grain size distribution analyses and Atterberg Limits tests conducted on the silts/clays are presented on Figures 3 and 5, respectively. The unit mantled bedrock/probable bedrock.

#### Bedrock

Bedrock/probable bedrock was contacted below the layered silts and clays in deep testholes W2, W3A, E2A and E3A at depths of 25.9 to 28.0 m. The elevation of the bedrock surface ranges from 215.6 to 216.0.

A description of the rock cores recovered from testholes W3A and E2A is provided in Table I. The bedrock consists of dolostone. The core recovery ranged from 93 to 100%. The RQD ranged from 73 to 87% (fair to good quality).

#### Groundwater

Free water was observed in the deep boreholes at the following depths/elevations:

<u>Borehole</u>	<u>Depth to Free Water (m)</u>	<u>Elevation</u>
W2 (upon completion)	3.6	238.5
W3A (during drilling)	3.5	238.4
E2A (upon completion)	5.5	238.2
E3A (upon completion)	5.5	238.2

Free water was not observed in the shallow testholes. Observed groundwater levels are subject to seasonal fluctuations and rainfall patterns.

**CLOSURE**

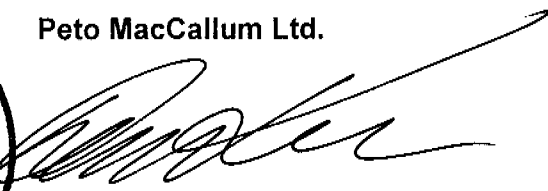
The fieldwork was carried out under the supervision of Mr. M. Rapsey and direction of Mr. D.W. Kerr, P.Eng. The equipment was supplied by Elite Drilling and Malone's Soil Sampling.

The report was prepared by Mr. P. Cullen, B.Eng., and Mr. M.R. Anderson, P.Eng., Project Engineer. It was reviewed by Mr. D.W. Kerr, P.Eng., Manager of Geotechnical and Geo-Environmental Services, Hamilton.

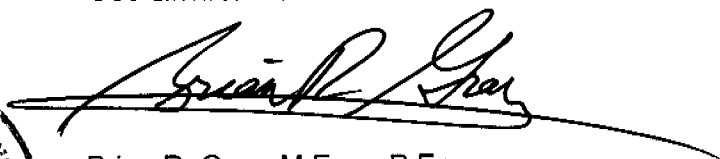
Yours very truly

Peto MacCallum Ltd.



  
Dennis W. Kerr, M.Eng., P.Eng.  
Manager Geotechnical and  
Geo-Environmental Services



  
Brian R. Gray, M.Eng., P.Eng.  
Vice-President  
Geotechnical and  
Geo-Environmental Services

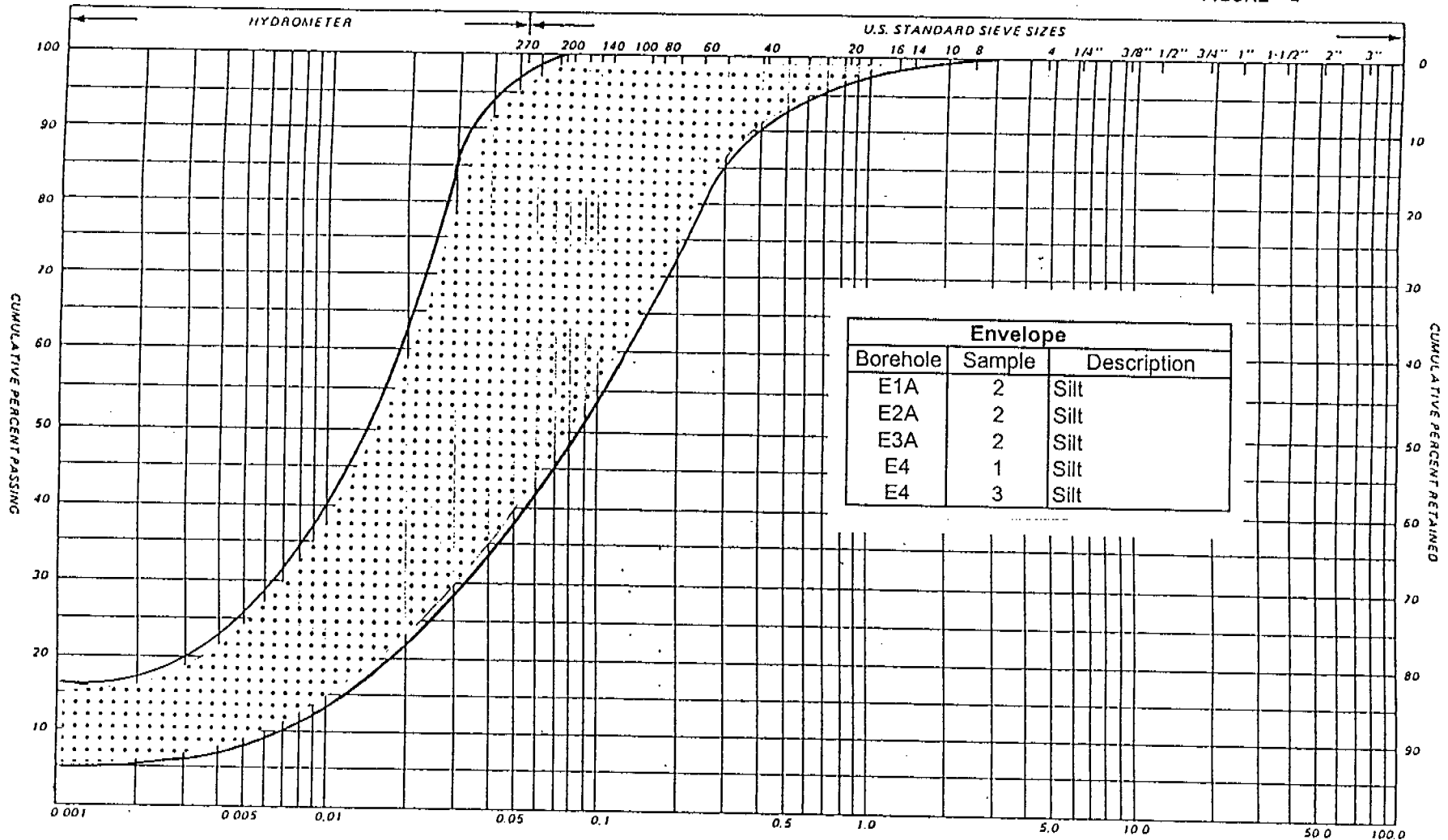
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**TABLE I**

**ROCK CORE DESCRIPTION  
HIGHWAY 6 NEW AT HIGHWAY 53 STRUCTURES, WP 9-91-02  
ANCASTER, ONTARIO**

CORE RECOVERY					CORE DESCRIPTION	
BOREHOLE	CORE NO.	RUN (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
E2A	15	28.00 – 29.50	93	83	28.00 - 31.00	<b>DOLOSTONE:</b> Grey to buff, aphanitic to fine grained; medium to high strength; unweathered; close to moderate spaced flat partings, rough planar, tight; occ. stylitic partings, occ. voids with calcite crystals and quartz encrustations, occ. bituminous or shaley partings; good quality.
	16	29.50 – 31.00	100	83		
W3A	15	25.90 - 27.45	95	87	25.90 - 28.90	<b>DOLOSTONE:</b> Grey to buff, aphanitic to fine grained, medium to high strength, unweathered, close to moderate spaced flat partings, rough planar, tight; occ. stylitic partings, occ. voids with calcite crystals and quartz encrustations, occ. bituminous or shaley partings; good to fair quality.
	16	27.45 - 28.90	97	73		

# PARTICLE SIZE DISTRIBUTION CHART



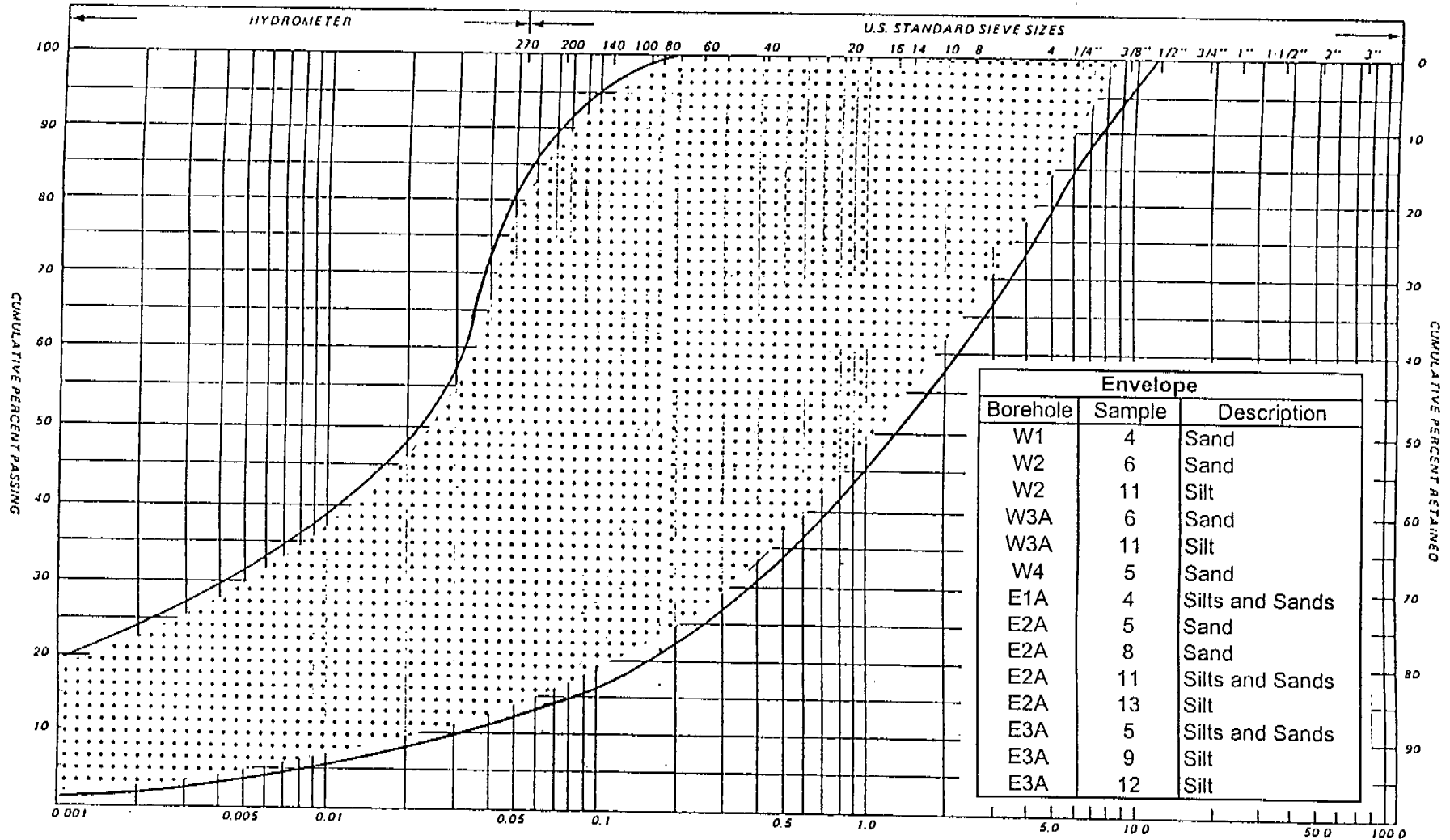
Envelope		
Borehole	Sample	Description
E1A	2	Silt
E2A	2	Silt
E3A	2	Silt
E4	1	Silt
E4	3	Silt

GRAIN SIZE IN MILLIMETERS												UNIFIED  A.I.T.  U.S. BUREAU	
SILT & CLAY				FINE		MEDIUM		COARSE		GRAVEL			
CLAY	FINE		MEDIUM SILT		COARSE		FINE		MEDIUM SAND		COARSE		
CLAY		SILT		V. FINE		FINE		MED.		COARSE			GRAVEL

REMARKS SILT

# PARTICLE SIZE DISTRIBUTION CHART

PML REF. 99HF073  
REPORT NO. 1  
FIGURE 2



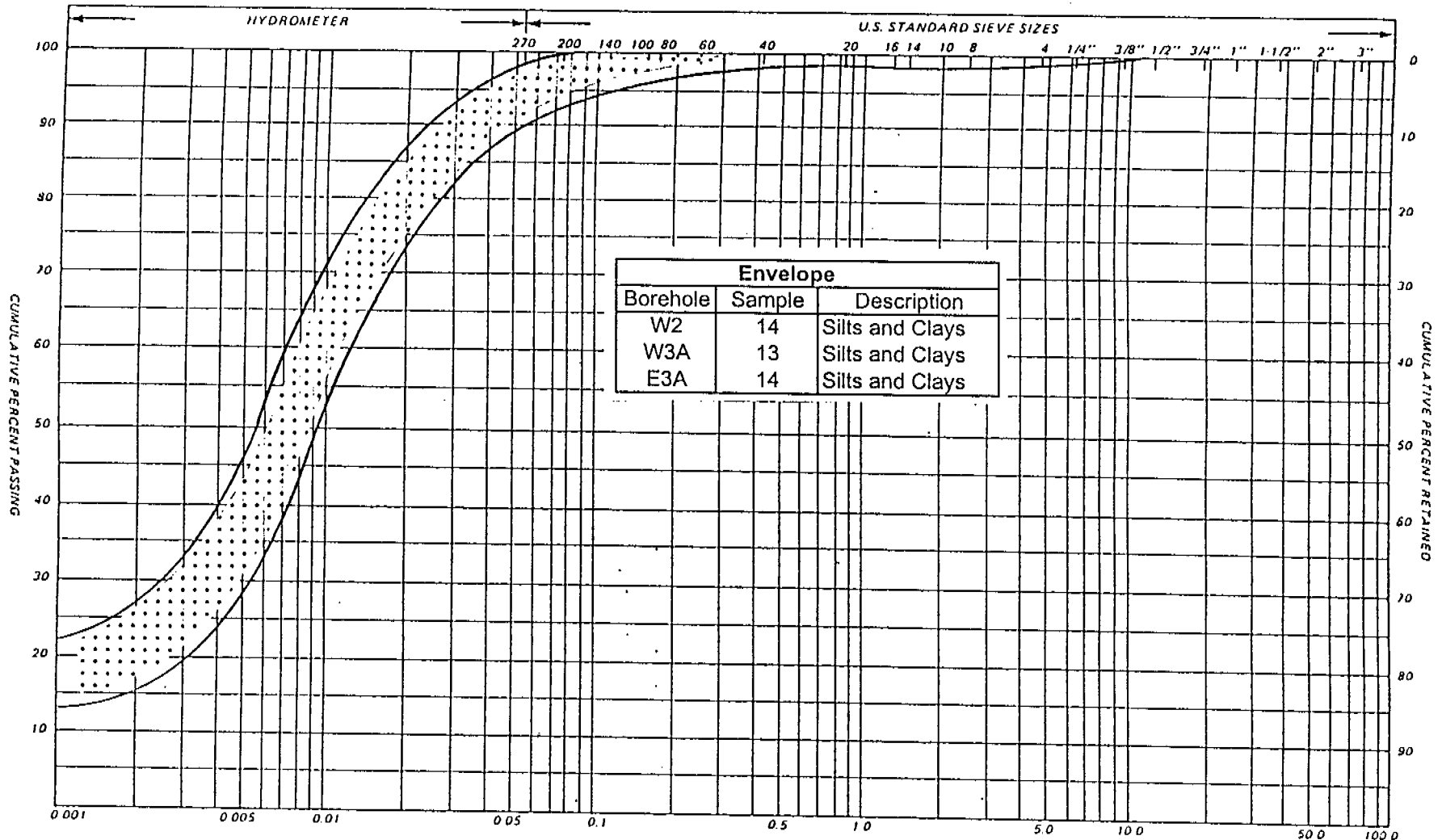
Envelope		
Borehole	Sample	Description
W1	4	Sand
W2	6	Sand
W2	11	Silt
W3A	6	Sand
W3A	11	Silt
W4	5	Sand
E1A	4	Silts and Sands
E2A	5	Sand
E2A	8	Sand
E2A	11	Silts and Sands
E2A	13	Silt
E3A	5	Silts and Sands
E3A	9	Silt
E3A	12	Silt

GRAIN SIZE IN MILLIMETERS													UNIFIED		
SILT & CLAY				FINE		MEDIUM SAND		COARSE		GRAVEL				COBBLES	
CLAY	FINE		MEDIUM SILT		COARSE		FINE		MEDIUM SAND		COARSE		GRAVEL		
CLAY		SILT			V. FINE		FINE		MED.		COARSE		GRAVEL		

REMARKS: LAYERED SILTS & SANDS

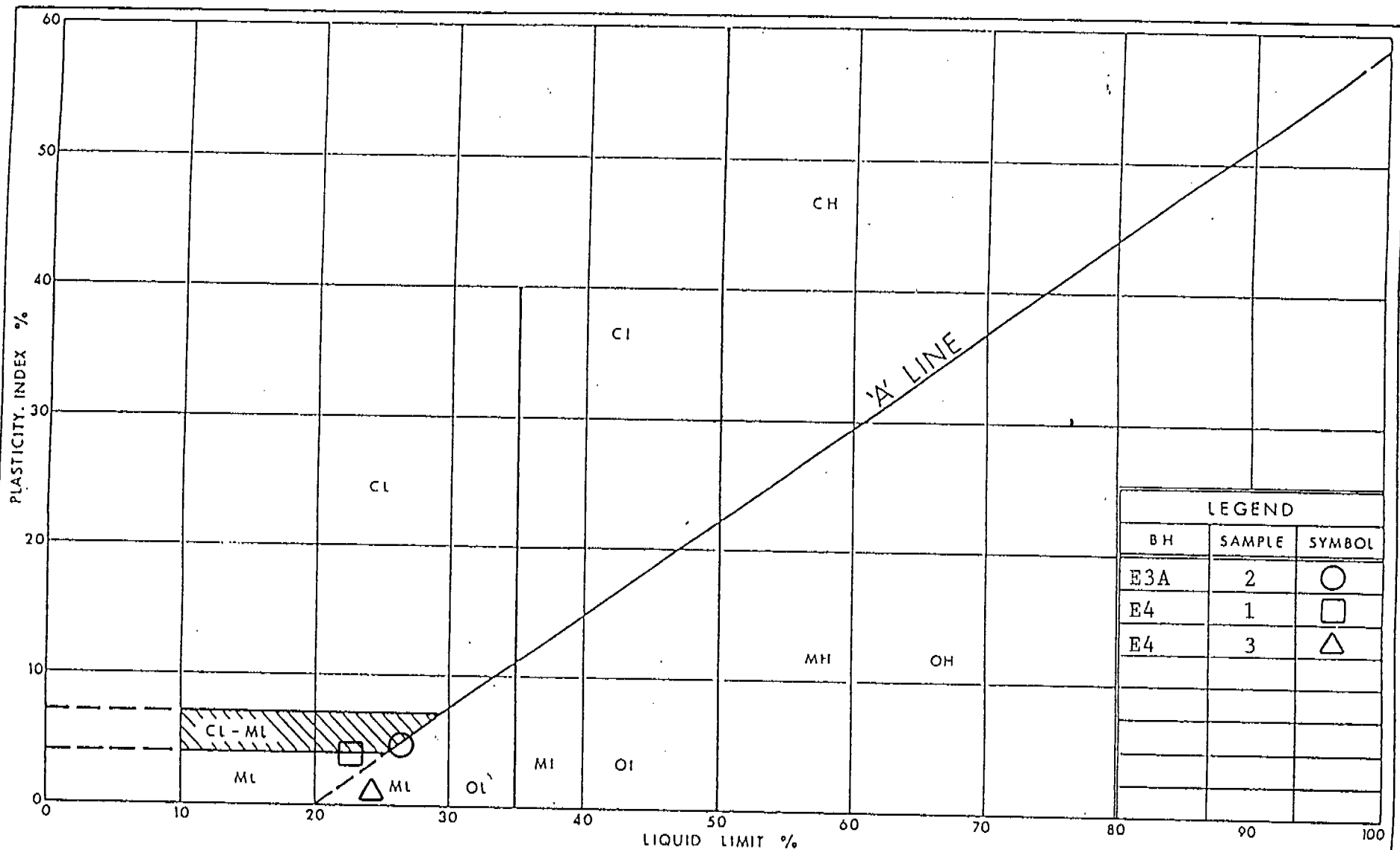
# PARTICLE SIZE DISTRIBUTION CHART

PML REF. 99HF073  
REPORT NO. 1  
FIGURE 3



GRAIN SIZE IN MILLIMETERS										COB BLES	UNIFIED				
SILT & CLAY				FINE		MEDIUM SAND		COARSE				GRAVEL			
CLAY	FINE		MEDIUM SILT		COARSE		FINE		MEDIUM SAND		COARSE		GRAVEL		
CLAY		SILT			V. FINE		FINE		MED. SAND		COARSE		GRAVEL		A I T
															US BUREAU

REMARKS LAYERED SILTS & CLAYS



Ministry of  
Transportation

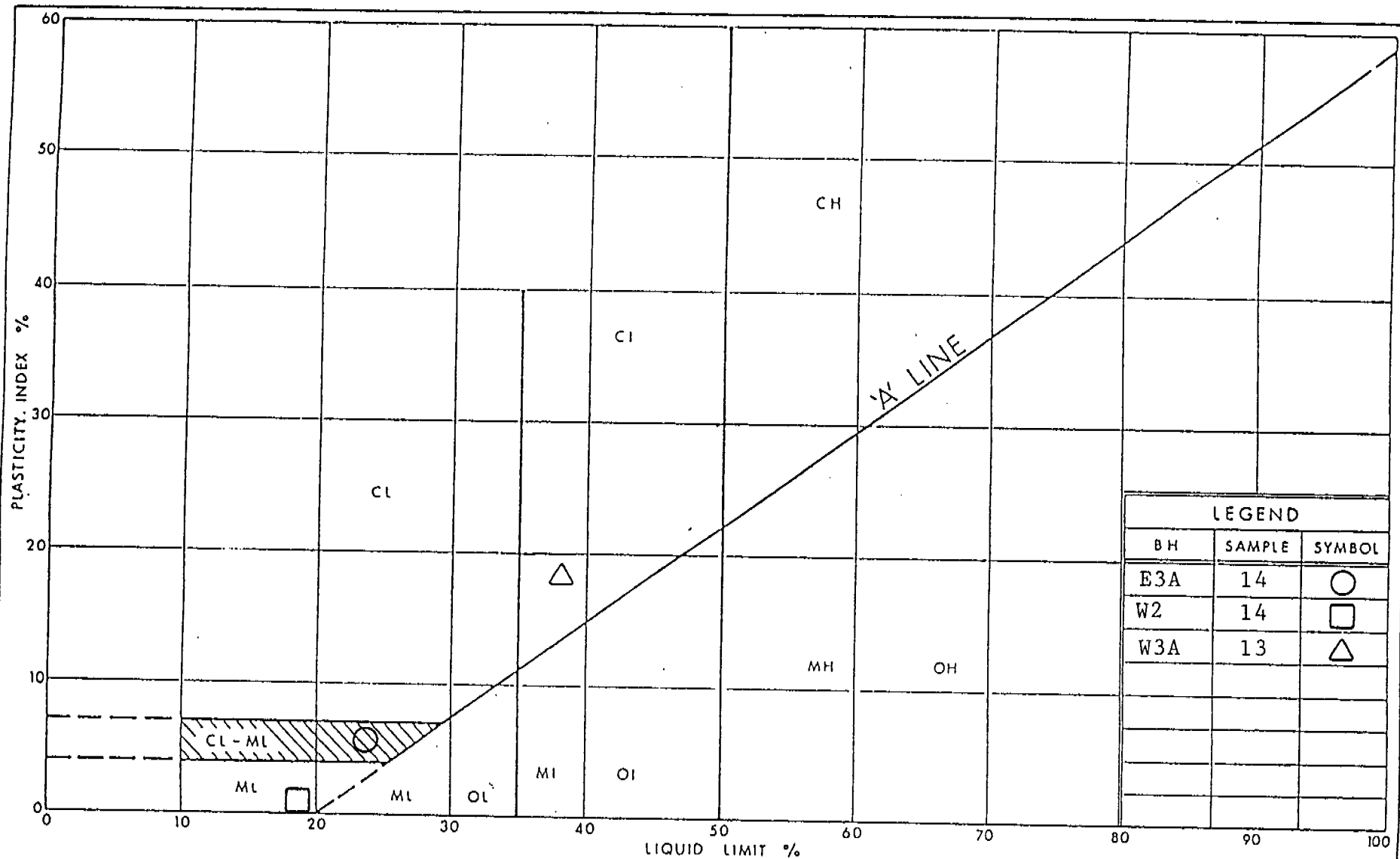
# PLASTICITY CHART

Silt

FIG No 4

WP 9-91-02

HWY 6/53



Ministry of  
Transportation

Ontario

## PLASTICITY CHART

Silts & Clays

FIG No 5

WP 9-91-02

HWY 6/53

## LIST OF ABBREVIATIONS

### PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 0.3 m INTO THE SUBSOIL. DRIVEN BY MEANS OF A 63.5 kg HAMMER FALLING FREELY A DISTANCE OF 0.76 m.

DYNAMIC PENETRATION RESISTANCE: - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 51 mm, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 0.3 m INTO THE SUBSOIL. THE DRIVING ENERGY BEING 475 J PER BLOW.

### DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS:

<u>CONSISTENCY</u>	<u>'N' BLOWS/0.3 m</u>	<u>c kPa</u>	<u>DENSENESS</u>	<u>'N' BLOWS/0.3 m</u>
VERY SOFT	0 - 2	0 - 12	VERY LOOSE	0 - 4
SOFT	2 - 4	12 - 25	LOOSE	4 - 10
FIRM	4 - 8	25 - 50	COMPACT	10 - 30
STIFF	8 - 15	50 - 100	DENSE	30 - 50
VERY STIFF	15 - 30	100 - 200	VERY DENSE	> 50
HARD	> 30	> 200		

W.T.P.L. WETTER THAN PLASTIC LIMIT                      D.T.P.L. DRIER THAN PLASTIC LIMIT  
A.P.L. ABOUT PLASTIC LIMIT

### TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
P.H.	SAMPLE ADVANCED HYDRAULICALLY		
P.M.	SAMPLE ADVANCED MANUALLY		

### SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL		

▲, Δ - UNDISTURBED AND REMOULDED SHEAR STRENGTH DETERMINED FROM IN SITU VANE TEST.

■ - UNDRAINED SHEAR STRENGTH DETERMINED FROM POCKET PENETROMETER TEST.

## LOG OF BOREHOLE NO. W1

N 4 784 778

E 266 845

PROJECT W. P. 9-91-02, HIGHWAY 6/53 STRUCTURES

OUR PROJECT 99HF073

LOCATION Ancaster, Ontario

BORING DATE October 18 & 19, 1999

ENGINEER P. Cullen

BORING METHOD Continuous Flight Solid Stem Augers

TECHNICIAN M. Rapsey

SOIL PROFILE				SAMPLES				SHEAR STRENGTH $C_u$				LIQUID LIMIT $W_L$ PLASTIC LIMIT $W_p$ WATER CONTENT $W$				GROUNDWATER OBSERVATIONS AND REMARKS			
DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES	DYNAMIC CONE PENETRATION x STANDARD PENETRATION TEST • BLOWS/0.3m	20	40	60	80	10	20	30	Grain Size Distribution %	GR	SA	SI	CL
0	GROUND ELEVATION 242.80																		
1.40	SAND FILL : Compact, dark brown to brown, fine to coarse sand, some gravel, trace of silt		242	1	SS	23													
1.5	becoming gravelly		241	2	SS	30									49	42	7	2	
2.90			240	3	SS	29													
3.0	SAND : Compact, brown fine to medium sand with gravel, some silt			4	SS	16									24	54	17	5	
4.30			239	5	SS	28													
4.5	BOREHOLE TERMINATED AT 4.30m		238												Upon completion of augering, no free water, no cave.				
6.0																			

NOTES:

CHECKED BY 

## LOG OF BOREHOLE NO. W2

N 4 784 797  
E 266 835

PROJECT W.P. 9-91-02, HIGHWAY 6/53 STRUCTURES

OUR PROJECT 99HF073















LOCATION Ancaster, Ontario

BORING DATE October 13, 1999

ENGINEER P. Cullen

BORING METHOD Continuous Flight Hollow Stem Augers

TECHNICIAN M. Rapsey

SOIL PROFILE				SAMPLES		SHEAR STRENGTH $C_u$				LIQUID LIMIT $W_L$			GROUNDWATER OBSERVATIONS AND REMARKS		
DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - 1 VALUES	DYNAMIC CONE PENETRATION x STANDARD PENETRATION TEST •				WATER CONTENT %				
							BLOWS/0.3M				WATER CONTENT %				
	GROUND ELEVATION 242.11						20	40	60	80	10	20	30	Grain Size Distribution %	
														GR SA SI CL	
0															
	<u>SAND FILL</u> : Compact, brown fine to coarse sand, trace of gravel and silt, dry			241	1	SS	18								
1.40	-----														
	becoming sand and gravel			240	2	SS	25								64 26 8 0
															
3.00	-----		239	3	SS	14									
3.60	with black sand and gravel			4	SS	27									
															
	<u>SAND</u> : Loose, brown fine sand, some silt, saturated			238	5	SS	7								
4.40	-----														
	becoming compact, trace of clay			237	6	SS	14								0 85 10 5
															
6.0			236	7	SS	12									
															
7.5				8	SS	13									
															
8.60	-----														
	with trace of silt, grey		233	9	SS	22									
															
11.00															
	<u>SILT</u> : Dense, brown fine sandy silt, wet			231											
12.0			230												
															
															
13.5															
14.00	-----		228												
	becoming compact, some sand, trace of clay, saturated														
															
15.0			227												
															
															
16.50			226	11	SS	12								0 13 83 4	
															
16.5															
	continued on next page														

NOTES: Dynamic Cone Test carried out 3.0m west of Borehole.

CHECKED BY: 

## LOG OF BOREHOLE NO. W2 (con't)

N 4 784 797  
E 266 835

PROJECT W.P. 9-91-02, HIGHWAY 8/53 STRUCTURES

OUR PROJECT 99HF073

LOCATION Ancaster, Ontario

BORING DATE October 13, 1999

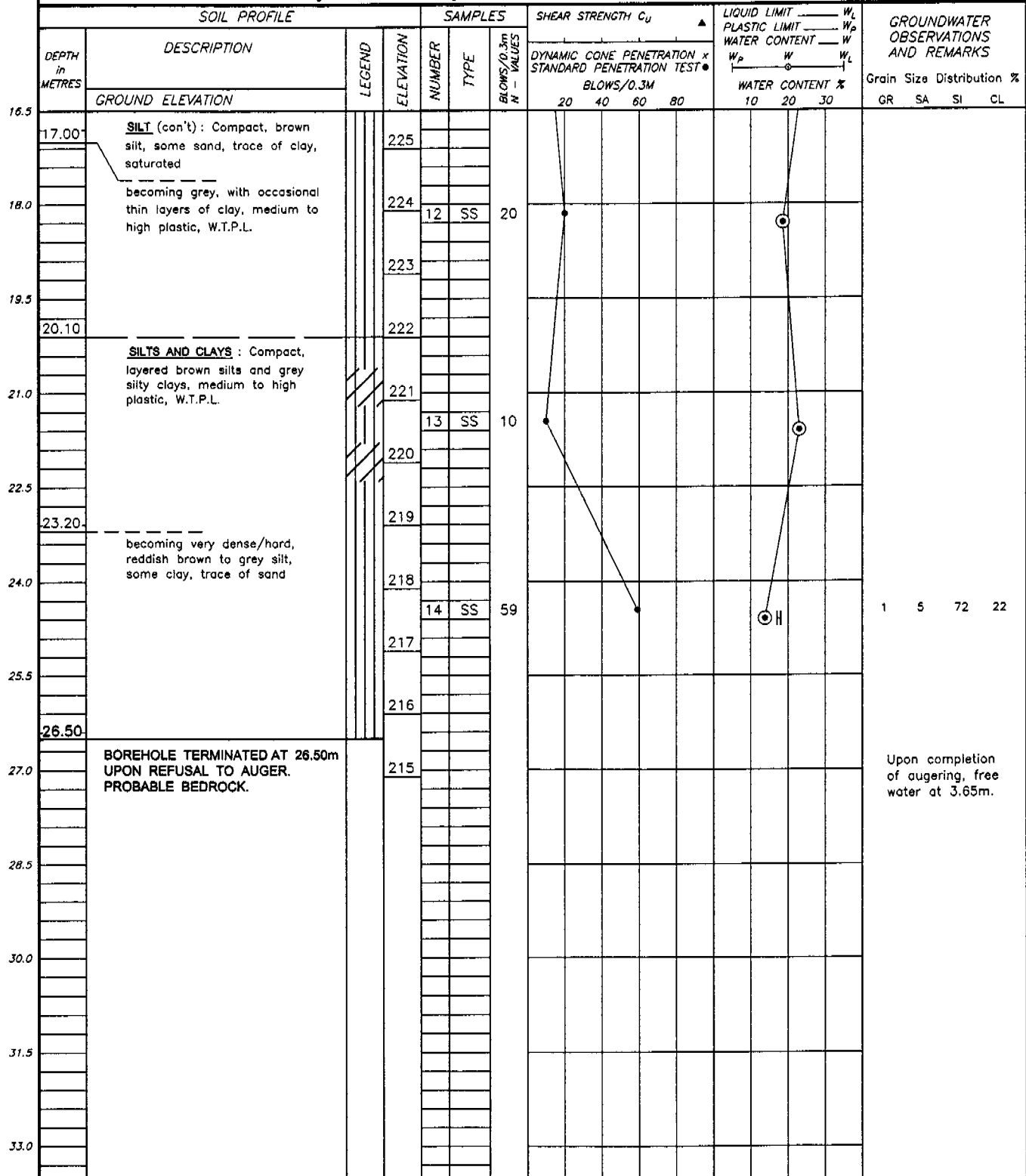
ENGINEER

P. Cullen

BORING METHOD Continuous Flight Solid Stem Augers

TECHNICIAN

M. Rapsey



NOTES:

CHECKED BY: 

## LOG OF BOREHOLE NO. W3A

N 4 784 833  
E 266 825

PROJECT W.P. 9-91-02, HIGHWAY 8/53 STRUCTURES

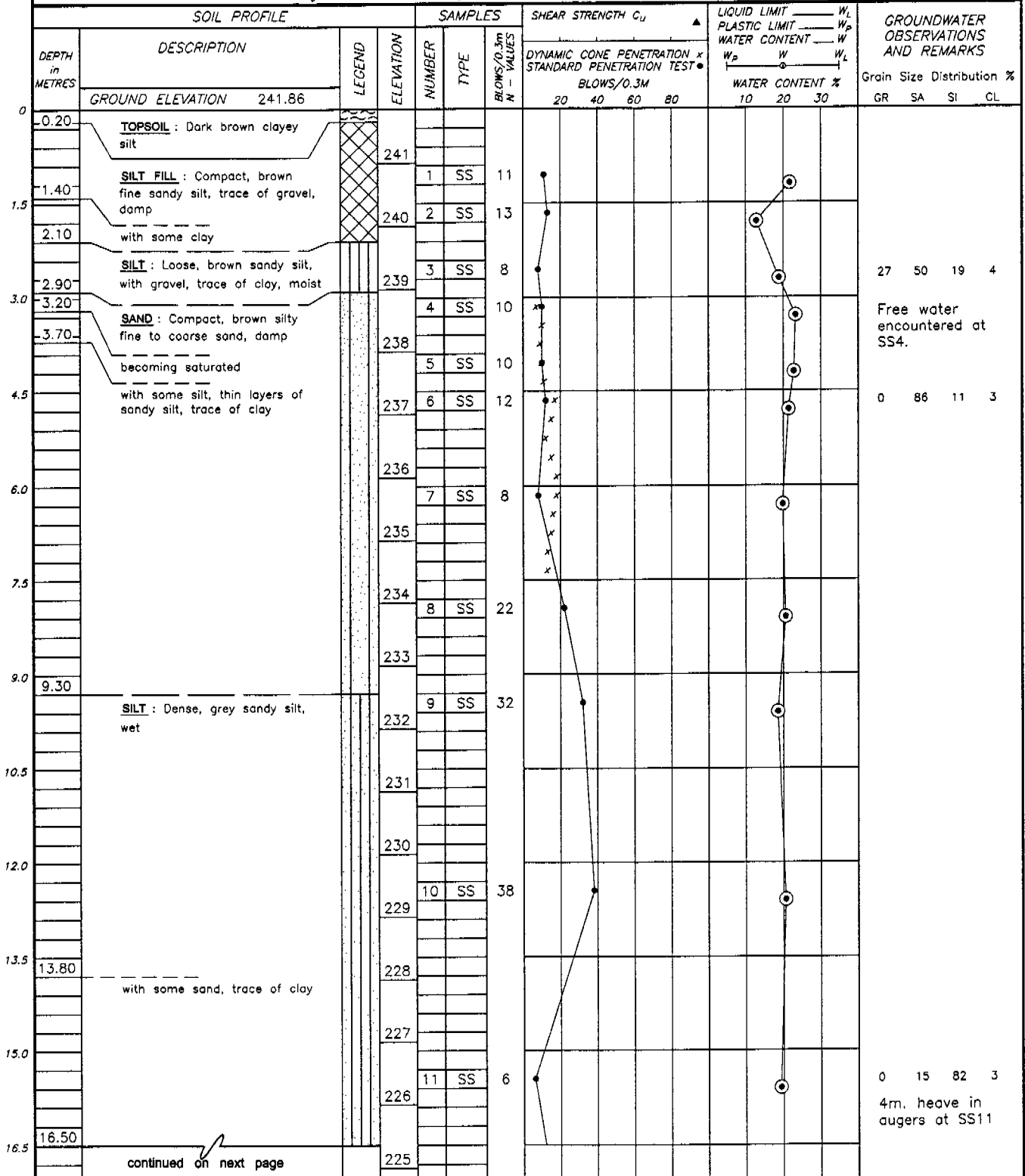
OUR PROJECT 99HF073

LOCATION Ancaster, Ontario

BORING DATE November 3 & 4, 1999 ENGINEER P. Cullen

BORING METHOD Continuous Flight Hollow Stem Augers and NQ Coring

TECHNICIAN M. Rapsey



NOTES:

Dynamic Cone Test carried out 3.0m west of borehole.

CHECKED BY: *[Signature]*

## LOG OF BOREHOLE NO. W3A (con't)

N 4 784 833  
E 266 825

PROJECT W.P. 9-91-02, HIGHWAY 6/53 STRUCTURES

OUR PROJECT 99HF073

LOCATION Ancaster, Ontario

BORING DATE November 3 & 4, 1999

ENGINEER P. Cullen

BORING METHOD Continuous Flight Solid Stem Augers and NQ Coring

TECHNICIAN M. Rapsey

SOIL PROFILE				SAMPLES				SHEAR STRENGTH $C_u$				LIQUID LIMIT $W_L$			GROUNDWATER OBSERVATIONS AND REMARKS			
DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES	25 50 75 100 ▲				PLASTIC LIMIT $W_p$			WATER CONTENT $W$				
							DYNAMIC CONE PENETRATION x STANDARD PENETRATION TEST ●				WATER CONTENT %							
							GROUND ELEVATION				BLOWS/0.3M				10 20 30			
16.5							20	40	60	80							Grain Size Distribution %	
17.00	<b>SILT</b> (con't): Dense, grey silt, some sand, trace of clay, wet becoming compact, saturated with trace of fine sand		225															
			224															
18.0			223	12	SS	21												
			222															
19.5			221														0 1 47 52	
20.10	<b>SILTS AND CLAYS</b> : Stiff, grey silts and silty clays, layered, medium to high plastic, W.T.P.L.		220	13	SS	12												
21.0			219															
22.5			218															
23.20			217	14	SS	44												
24.0	becoming dense, predominantly reddish brown to grey silts, non plastic, with occasional inclusions of grey silty clay, wet		216														Upon completion of augering, no free water, no cave.	
25.5			215	15	RC		1550	95	87	100								
25.90			<b>BEDROCK</b> : Dolostone		214				End of Run Start of Run									
27.0					213	16	RC		1450	97	73	100						
28.5	212																	
28.90	BOREHOLE TERMINATED AT 28.90m																	
30.0																		
31.5																		
33.0																		

Upon completion of augering, no free water, no cave.

NOTES:

CHECKED BY: 

TECHNICIAN M. Rapsey

CHECKED BY:

N 4 784 786

E 266 873

OUR PROJECT 99HF073

BORING DATE October 18 & 19, 1999

ENGINEER P. Cullen

TECHNICIAN

P. Cullen

M. Rapsey

Grain Size Distribution %			
GR	SA	SI	CL

Upon completion  
of augering,  
no free water,  
no cave.

NOTES:

CHECKED BY:

## LOG OF BOREHOLE NO. E2A

N 4 784 803  
E 266 865

PROJECT W.P. 9-91-02, HIGHWAY 6/53 STRUCTURES

OUR PROJECT 99HF073

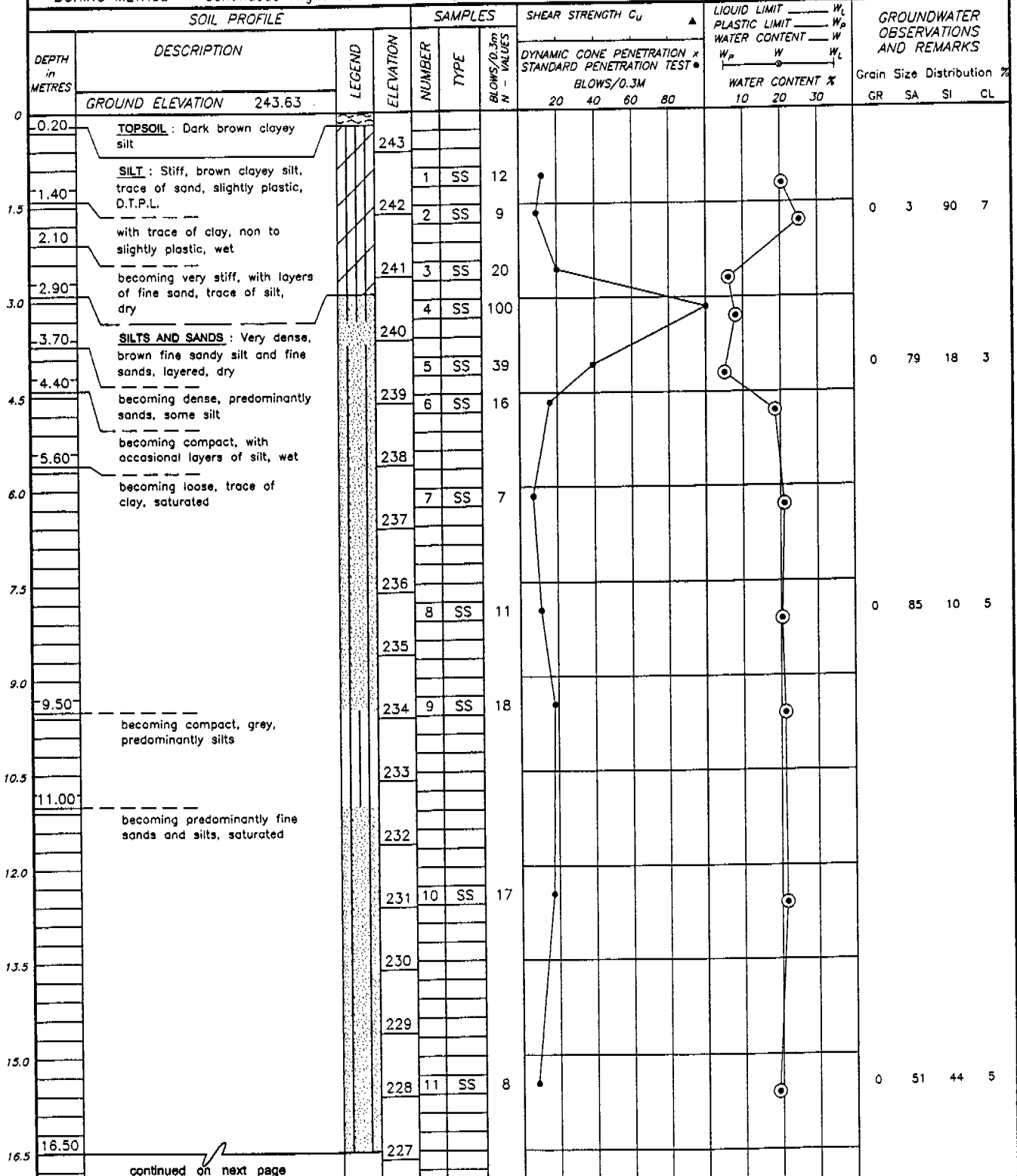
LOCATION Ancaster, Ontario

BORING DATE October 18 & 19, 1999

ENGINEER P. Cullen

BORING METHOD Continuous Flight Hollow Stem Augers and NXL Coring

TECHNICIAN M. Rapsey



NOTES:

CHECKED BY: *[Signature]*

## LOG OF BOREHOLE NO. E2A (con't)

N 4 784 803  
E 266 865

PROJECT W.P. 9-91-02, HIGHWAY 6/53 STRUCTURES

OUR PROJECT 99HF073

LOCATION Ancaster, Ontario

BORING DATE October 18 & 19, 1999

ENGINEER P. Cullen

BORING METHOD Continuous Flight Solid Stem Augers and NXL Coring

TECHNICIAN M. Rapsey

SOIL PROFILE				SAMPLES		SHEAR STRENGTH $C_u$		LIQUID LIMIT $W_L$		GROUNDWATER OBSERVATIONS AND REMARKS	
DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES	DYNAMIC CONE PENETRATION x STANDARD PENETRATION TEST •		WATER CONTENT %		
							BLOWS/0.3M		WATER CONTENT %		
							20	40	60		80
16.5	GROUND ELEVATION										Grain Size Distribution %
17.00	<b>SILTS AND SANDS</b> (con't): Compact, grey, fine sands and silts, saturated		226								GR SA SI CL
	becoming predominantly silts										
18.0				12	SS	18					
			225								
19.5			224								
20.10	becoming dense, with fine silty sands, trace of clay		223								
21.0			222	13	SS	38					0 50 45 5
22.5			221								
23.20	<b>SILTS AND CLAYS</b> : Very stiff, brown silts, with distorted layers of grey silty clays, medium plastic, W.T.P.L.		220								
24.0			219	14	SS	24					
25.5			218								
26.20	becoming predominantly silts		217								
27.0			216								Upon completion of augering, free water at 5.47m.
28.00				15	SS	70					
28.5	<b>BEDROCK</b> : Dolostone		215	16	RC		1500	93	83	100	
			214				End of Run Start of Run				
30.0				17	RC		1500	100	83	100	
31.00	BOREHOLE TERMINATED AT 31.00m		213								
31.5			212				RUN ( mm )	RECOVERY ( % )	ROD ( % )	DRILL WATER RETURN ( % )	
33.0											

Upon completion  
of augering, free  
water at 5.47m.

NOTES:

CHECKED BY: 

## LOG OF BOREHOLE NO. E3A

N 4 784 840  
E 266 861

PROJECT W.P. 9-91-02, HIGHWAY 6/53 STRUCTURES

OUR PROJECT 99HF073

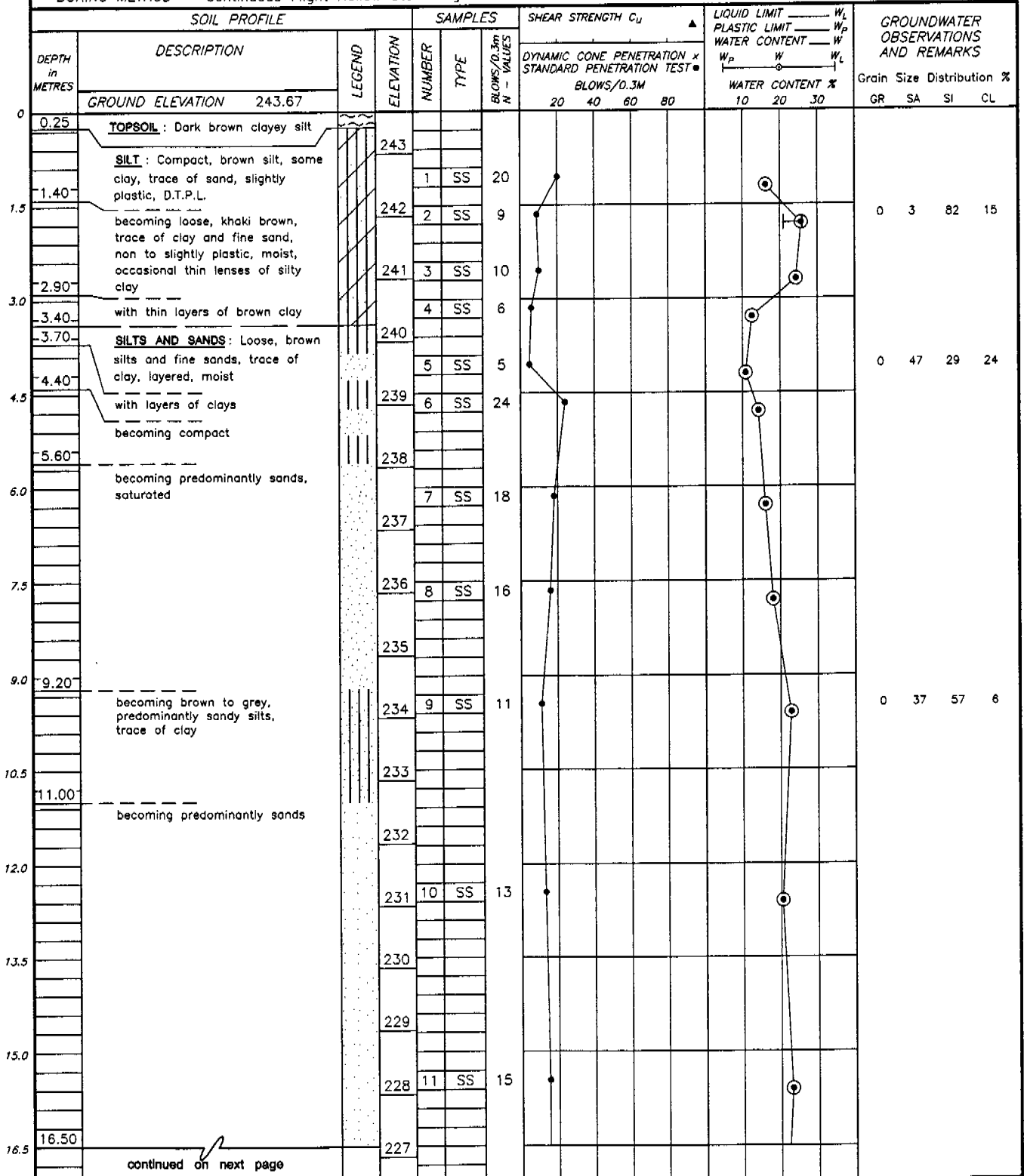
LOCATION Ancaster, Ontario

BORING DATE October 15, 1999

ENGINEER P. Cullen

BORING METHOD Continuous Flight Hollow Stem Augers

TECHNICIAN M. Rapsey



NOTES:

continued on next page

CHECKED BY: 

## LOG OF BOREHOLE NO. E3A (con't)

N 4 784 840  
E 266 861

PROJECT W.P. 9-91-02, HIGHWAY 6/53 STRUCTURES

OUR PROJECT 99HF073

LOCATION Ancaster, Ontario

BORING DATE October 13, 1999

ENGINEER P. Cullen

BORING METHOD Continuous Flight Hollow Stem Augers

TECHNICIAN M. Rapsey

SOIL PROFILE				SAMPLES		SHEAR STRENGTH $C_u$				LIQUID LIMIT $W_L$			PLASTIC LIMIT $W_P$			WATER CONTENT $W$			GROUNDWATER OBSERVATIONS AND REMARKS			
DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES	DYNAMIC CONE PENETRATION x STANDARD PENETRATION TEST •				WATER CONTENT %			Grain Size Distribution %								
							BLOWS/0.3M				WATER CONTENT %			GR SA SI CL								
16.5	GROUND ELEVATION						20	40	60	80	10	20	30									
17.10	<b>SILTS AND SANDS</b> (con't) : Compact, brown to grey silts and fine sands, layered, saturated  becoming predominantly silts, trace of sand and clay		226																			
18.0				12	SS	15													0	6	88	6
				225																		
				224																		
19.5			223																			
20.10	becoming dense, brownish grey, some fine sand		222	13	SS	32																
21.0				221																		
22.5				220																		
23.20				219	14	SS	26													0	0	72
24.0	<b>SILTS AND CLAYS</b> : Very stiff, layered grey silts and silty clays, high plastic		218																			
25.5				217																		
27.0				216																		
28.00				215																		
28.5	BOREHOLE TERMINATED AT 28.00m UPON REFUSAL TO AUGER. PROBABLE BEDROCK																					
30.0																						
31.5																						
33.0																						

NOTES:

CHECKED BY: 

## LOG OF BOREHOLE NO. E4

N 4 784 856

E 266 856

PROJECT W.P. 9-91-02, HIGHWAY 6/53 STRUCTURES

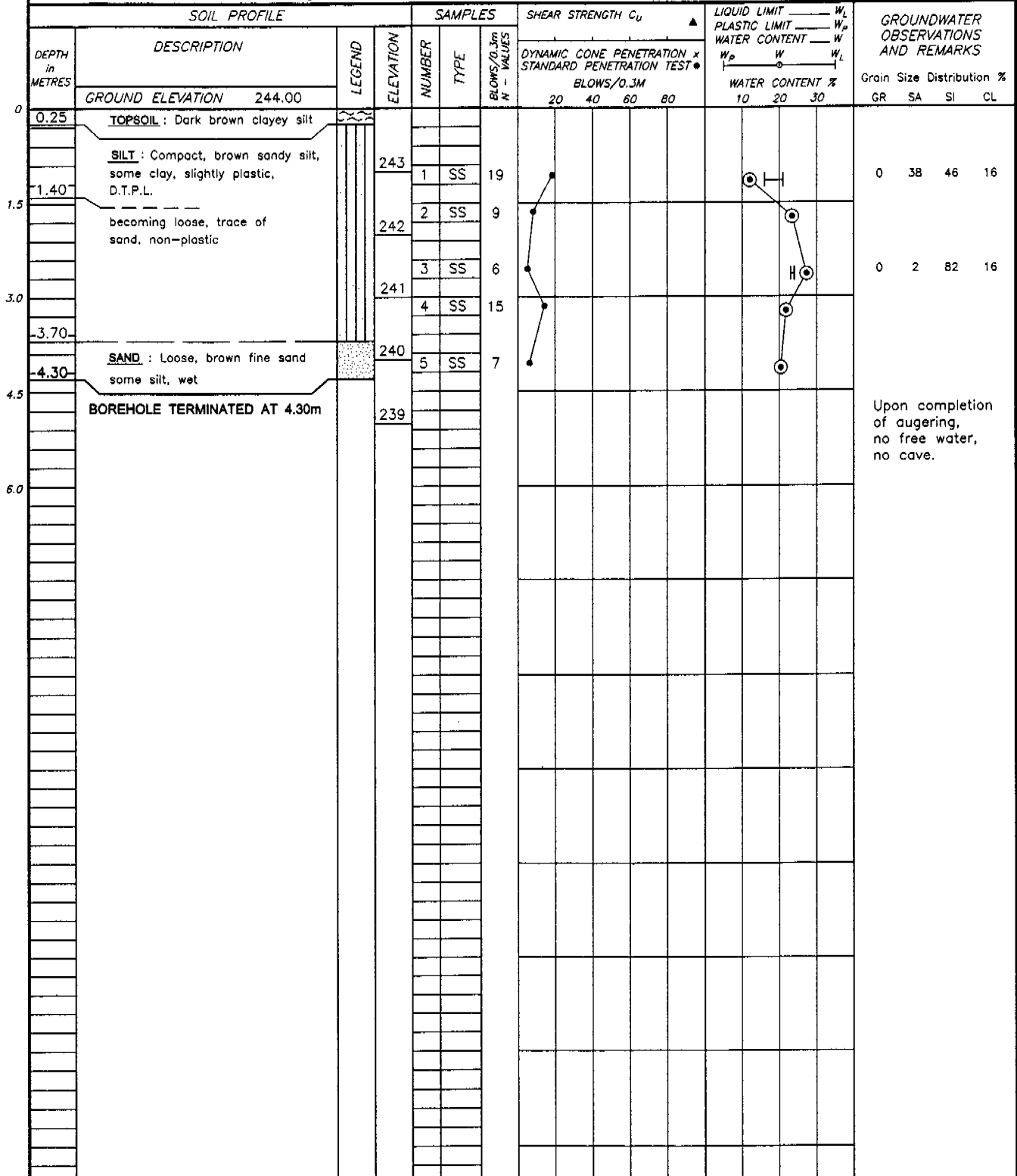
OUR PROJECT 99HF073

LOCATION Ancaster, Ontario

BORING DATE October 15, 1999 ENGINEER P. Cullen

BORING METHOD Continuous Flight Solid Stem Augers

TECHNICIAN M. Rapsey

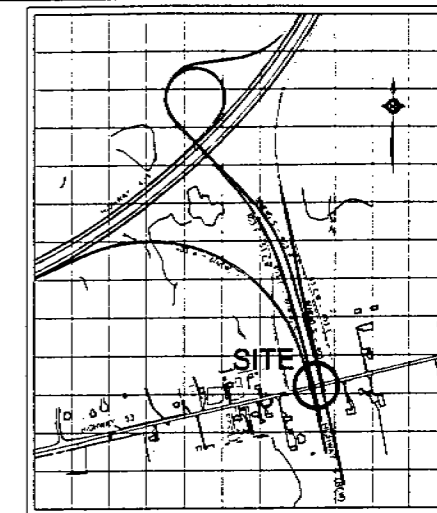


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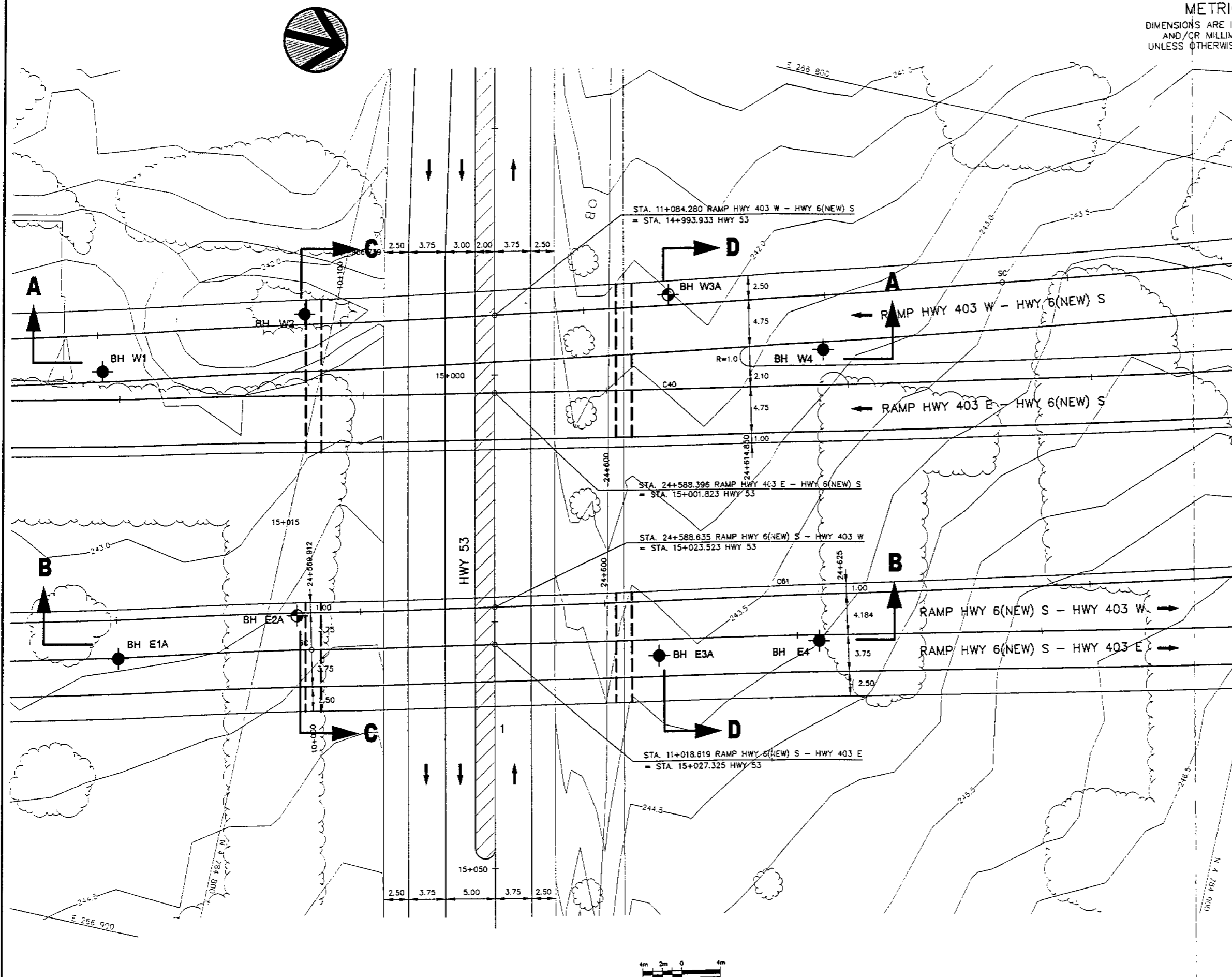
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W.P. 9-91-02

METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

KEY PLAN

SCALE  
1 : 10 000

BOREHOLE	NORTHING	EASTING	ELEVATION
BH W1	N 4 784 778	E 268 845	242.80
BH W2	N 4 784 797	E 268 835	242.11
BH W3A	N 4 784 833	E 268 825	241.86
BH W4	N 4 784 850	E 268 827	243.37
BH E1A	N 4 784 786	E 268 873	243.14
BH E2A	N 4 784 803	E 268 865	243.83
BH E3A	N 4 784 840	E 268 861	243.67
BH E4	N 4 784 856	E 268 856	244.00

## LEGEND

BOREHOLE

BOREHOLE &amp; ROCK CORE

## NOTE

1. PLAN REPRODUCED FROM DRAWING PLAN E-85-SNEW-2 TITLED "BRIDGE SITE PLAN" DATED MAY 1999, PROVIDED BY MINISTRY OF TRANSPORTATION.
2. REFER TO DRAWING 2 FOR SOIL PROFILES AND SECTIONS.

## PROPOSED CROSSING

AT

HIGHWAY 53

AND

RAMP HWY 403 W/E - HWY 6 (NEW) S  
& RAMP HWY 6(NEW) S - HWY 403 W/E

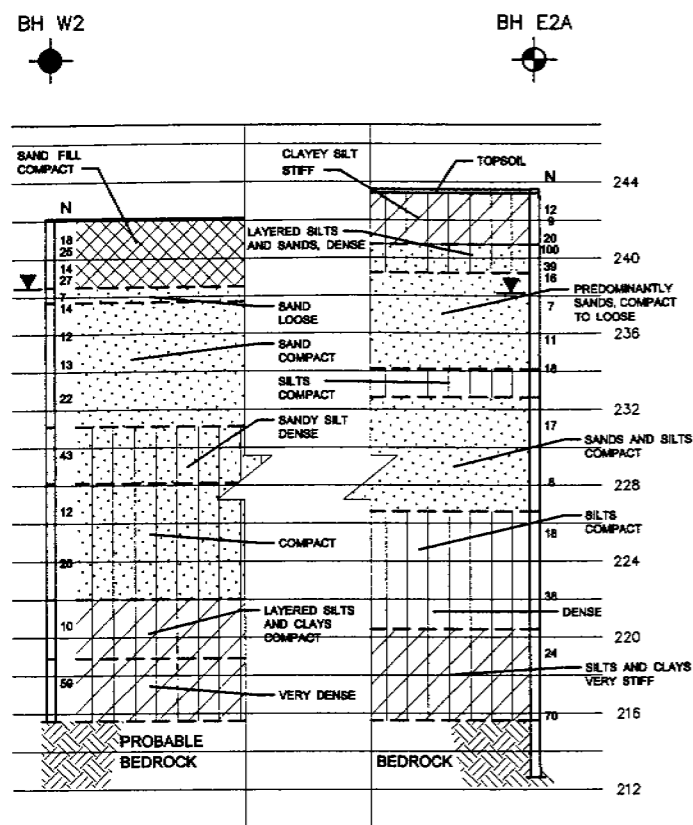
GEOGRAPHIC TWP ANCASTER, MUNICIPALITY - TOWN OF ANCASTER  
REGIONAL MUNICIPALITY HAMILTON-WENTWORTH

**Peto MacCallum Ltd.**  
CONSULTING ENGINEERS

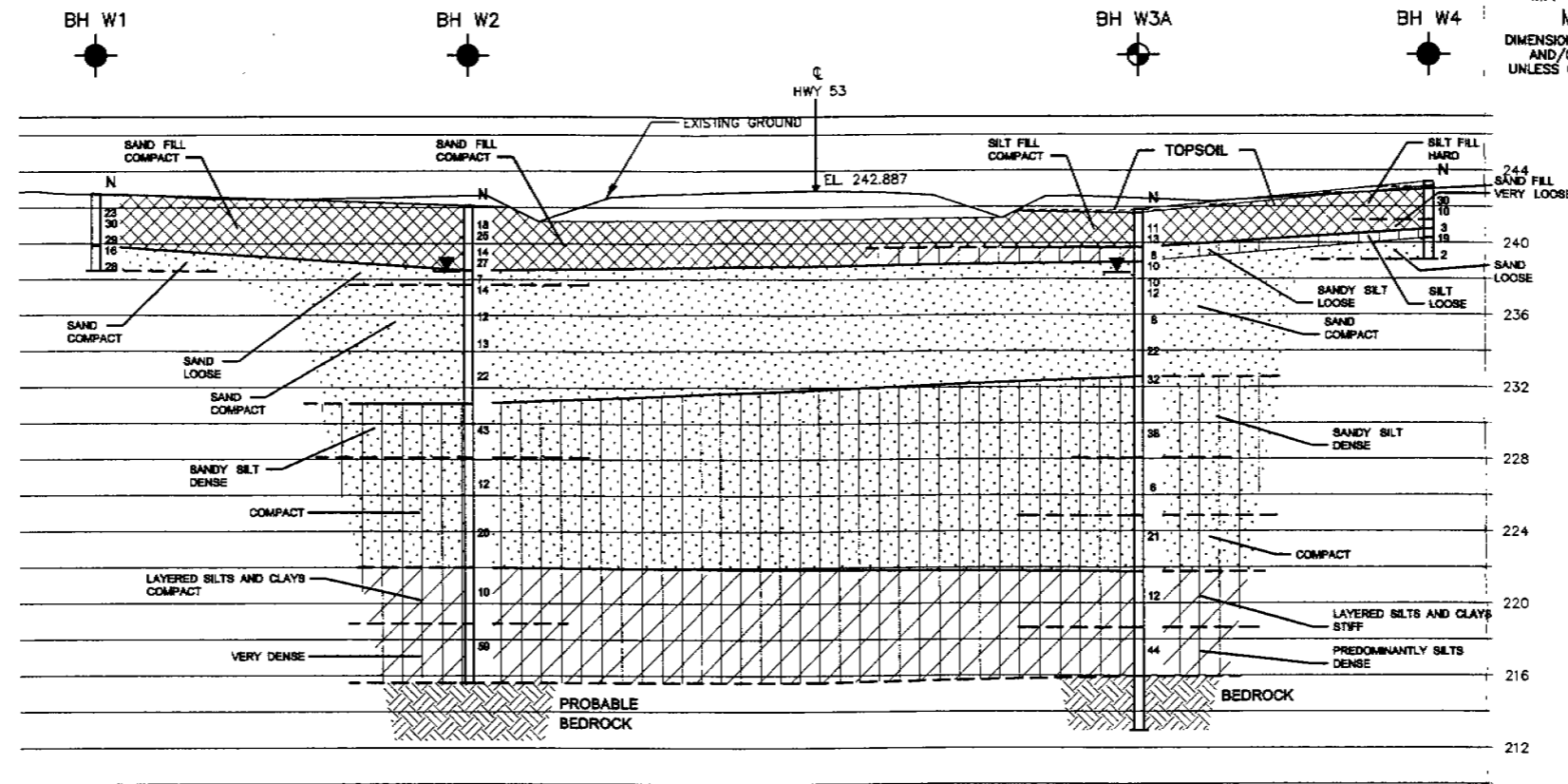
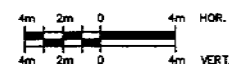
45 BURFORD ROAD, HAMILTON, ONTARIO L8E 3G5

DRAWN	CB	DATE	SCALE	JOB NO.	DRAWING NO.
CHECKED	PC	NOV. 1999	AS SHOWN	99HF073	1
APPROVED	DWK				

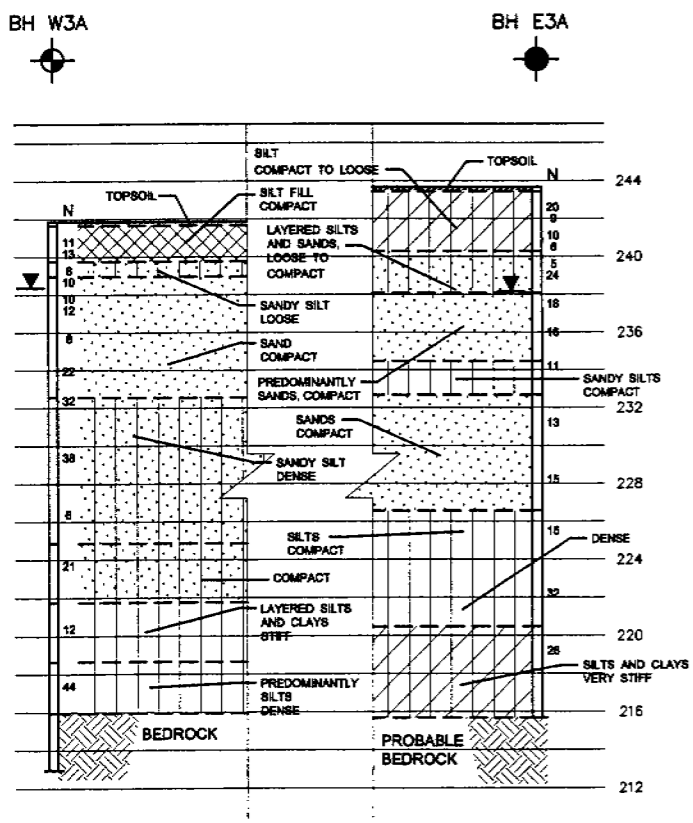
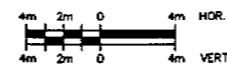
## BOREHOLE LOCATION PLAN



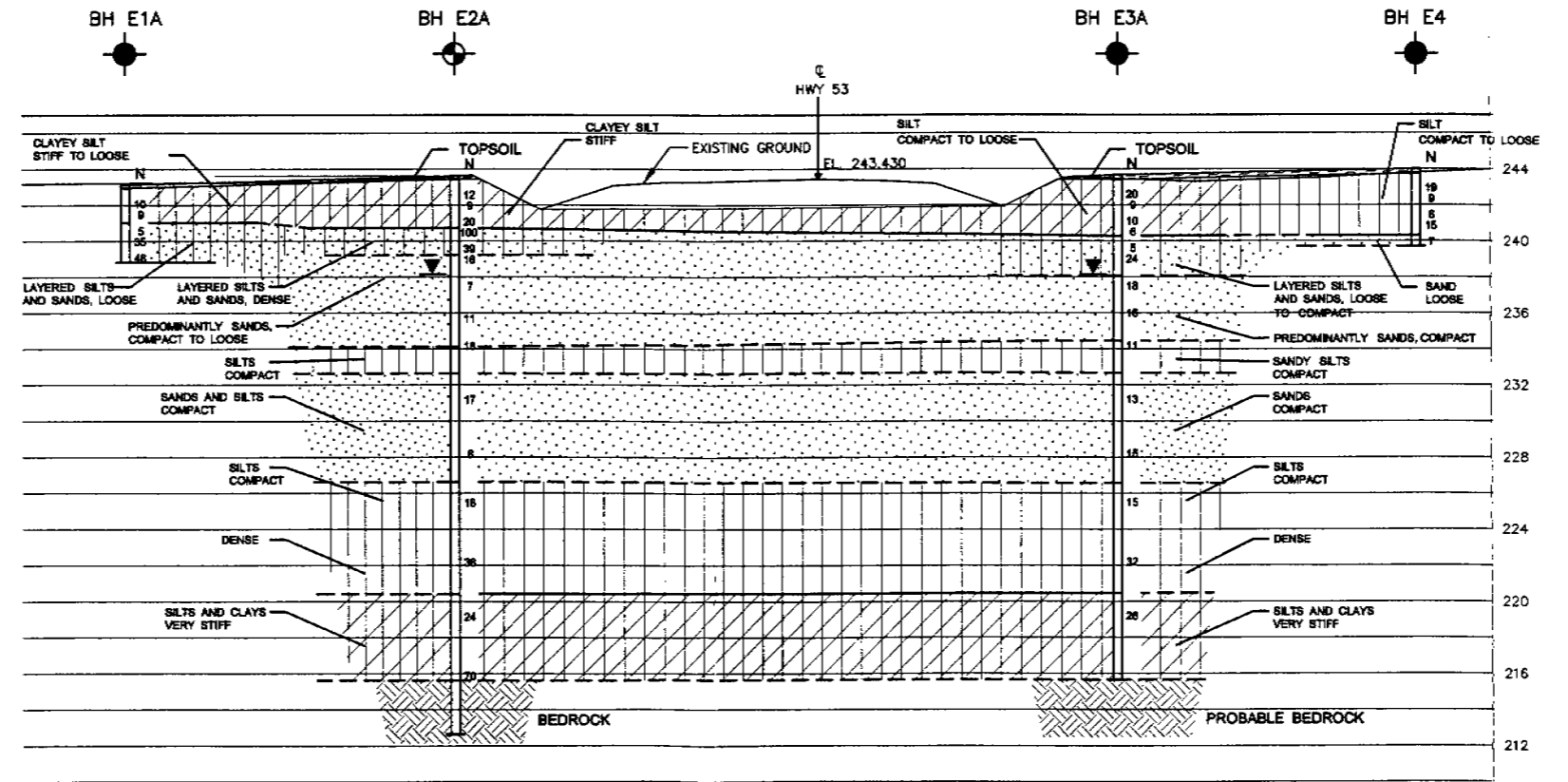
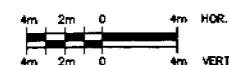
SECTION C - C



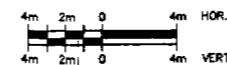
SECTION A - A



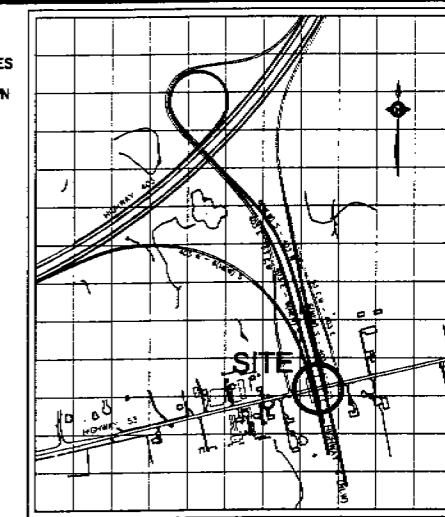
SECTION D - D



SECTION B - B



W.P. 9-91-02  
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN



KEY PLAN

SCALE  
1 : 10 000

BOREHOLE	NORTHING	EASTING	ELEVATION
BH W1	N 4 784 778	E 266 845	242.80
BH W2	N 4 784 797	E 266 835	242.11
BH W3A	N 4 784 833	E 266 825	241.86
BH W4	N 4 784 850	E 266 827	243.37
BH E1A	N 4 784 786	E 266 873	243.14
BH E2A	N 4 784 803	E 266 865	243.63
BH E3A	N 4 784 840	E 266 861	243.67
BH E4	N 4 784 858	E 266 856	244.00

LEGEND

- ◆ BOREHOLE
- ◆ BOREHOLE & ROCK CORE
- ▽ OBSERVED WATER LEVEL  
( DURING OR UPON COMPLETION OF DRILLING )

NOTE

1. REFER TO LOG OF BOREHOLE SHEETS FOR DETAILED SUBSURFACE CONDITIONS.
2. THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES, THE BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE.
3. REFER TO DRAWING 1 FOR BOREHOLE AND SECTION LOCATIONS.

PROPOSED CROSSING  
AT  
HIGHWAY 53  
AND  
RAMP HWY 403 W/E - HWY 6 (NEW) S  
& RAMP HWY 6(NEW) S - HWY 403 W/E  
GEOGRAPHIC TWP ANCASTER, MUNICIPALITY - TOWN OF ANCASTER  
REGIONAL MUNICIPALITY HAMILTON-WENTWORTH

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CONSULTING ENGINEERS  
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DRAWN	CB	DATE	SCALE	JOB NO.	DRAWING NO.
CHECKED	PC	NOV. 1999	AS SHOWN	99HF073	2
APPROVED	DWK				

SOIL PROFILES

FOUNDATION DESIGN REPORT  
FOR  
HIGHWAY 6 NEW AT HIGHWAY 53 STRUCTURES, WP 9-91-02  
ANCASTER, ONTARIO

Distribution:

5 cc: Ministry of Transportation Pavements and Foundation Section  
1 cc: PML Hamilton  
1 cc: PML Toronto

Job No. 99HF073

November, 1999

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## FOUNDATION DESIGN REPORT

For

Highway 6 New at Highway 53 Structures, WP 9-91-02  
Ancaster, Ontario

---

### INTRODUCTION

This report provides geotechnical comments and recommendations regarding design and construction of foundations, abutments and approaches for the twin ramp structures for the proposed Highway 6 (New) alignment connecting Highway 403 over Highway 53 in Ancaster, Ontario. The report was prepared for the Ministry of Transportation Pavements and Foundation Section.

The proposed structures will be single span with a span length of 34 m and an approximate width of 16 m for the west structure and 11 m for the east structure. Approach embankment heights are approximately 7 m.

The subsurface stratigraphy revealed at the proposed twin structure site generally comprised a surficial discontinuous topsoil layer overlying native silts and sands, underlain by silts and clays mantling dolostone bedrock contacted at depths of 25.9 to 28.0 m, elevation 215.6 to 216.0.

### FOUNDATIONS

#### Integral Abutments on Piles

Construction of integral abutments supported on steel H-piles is considered feasible. The piles should be driven to refusal on bedrock at depths anticipated at 25.9 to 28.0 m (elevation 215.6 to 216.0). The recommended axial resistances for selected pile sections are as follows:

<u>H-Pile Section</u>	<u>Factored Resistance at ULS (kN)</u>
HP 310 x 79	1450
HP 310 x 110	2000

The resistance at serviceability limit states normally allows for 25 mm of compression of the pile and founding medium. Considering the bedrock to be non-yielding and the pile length required, the design is not expected to be governed by settlement since the loading required to produce deformation of the pile will be much larger than the factored capacity at ULS.

The soil adjacent to the upper portion of the piles is expected to comprise well compacted approach fill placed on loose to compact silt/sand fill or silt and sand. To accommodate movement of the integral abutment, it is recommended that a 600 mm diameter pre-augered hole be provided around the pile to a depth of 3 m below the bottom of the abutment. The pre-augered hole should be filled with loose sand meeting the gradation requirements shown on Table I. Alternately, two concentric CSPs may be placed around the pile to create an annular space; the inner CSP should be filled with cement-bentonite grout. Refer to MTO Report SO-96-01 for further details.

The type of equipment to drive the piles will be somewhat dictated by the design capacity. In general, the piles should be driven to practical refusal using a hammer which transfers at least 40 KJ of energy to the pile. Since the piles will set on hard rock, a specific set for this project is not provided.

The installation operations should be inspected on a full-time basis by qualified geotechnical personnel to confirm the founding elevation, alignment, plumbness, uniformity of set, and quality of splices.

Driving shoes should be provided (OPSD 3301) to minimize the potential for damage when driving through dense zones and setting into bedrock.

Pile caps should be provided with at least 1.2 m of earth cover or equivalent thermal insulation as protection against frost action. A 25 mm thick layer of polystyrene insulation is thermally equivalent to 600 mm of soil cover.

The coefficient of horizontal subgrade reaction,  $k_s$ , for Granular "A" backfill or native overburden may be computed using the following equation to evaluate the point of contraflexure:

$$k_s = n_h z/b$$

where       $z$  = depth (m)  
                  $b$  = pile width (m)

The recommended values for  $n_h$  are as follows:

	$n_h$ (kN/m <sup>3</sup> )
Granular "A" Backfill	14,000
Loose/Compact Silts and Sands	4,000

Resistance to lateral loads may be provided in part by mobilization of passive resistance along the pile below the annular space. The lateral resistances recommended for HP 310 x 110 piles are as follows:

Factored Lateral resistance at ULS	= 110 kN
Lateral Resistance at SLS	= 40 kN

### Spread Footings

Supporting the structure on conventional spread footings founded in the native overburden is not considered feasible, due to the wide variation in strength/bearing resistance available in the upper deposits of the subgrade soils exposed at each of the bridge foundation units.

Spread footings could be constructed on structural fill placed in the approaches. The engineered fill should comprise Granular "A" material placed in maximum 200 mm thick lifts, compacted to 100% standard Proctor maximum dry density, and extended laterally to a line inclined outwards at 1:1 (H:V) originating at least 1 m from the top of footing. This scheme is illustrated on Figure 1.

The bearing resistances for a minimum 2.5 m wide footing constructed on a minimum 4.5 m thick pad of structural fill are:

$$\begin{aligned}\text{Factored Bearing Resistance at ULS} &= 1200 \text{ kPa} \\ \text{Bearing Resistance at SLS} &= 350 \text{ kPa}\end{aligned}$$

The recommended resistance at SLS allows for 25 mm of total settlement; differential settlement is expected to be less than 75% of this value. A footing embedment depth of 1.2 m was assumed for computation of the ULS resistances.

Sliding will be resisted in part by the friction force developed between the underside of the footing and the silt and sand or granular fill. Unfactored friction factors of 0.35 and 0.45 are recommended for footings on silt/sand and granular fill, respectively.

All footings subject to frost action should be provided with the normal 1.2 m of earth cover or equivalent thermal insulation. A 25 mm thick layer of polystyrene insulation is thermally equivalent to 600 mm of soil cover.

Prior to placement of structural concrete, all foundation excavations should be examined by qualified geotechnical personnel to verify the competency of the founding surface.

### Caissons

Supporting the structure on caissons bearing on bedrock may be considered. Caisson installation through the saturated silts and sands, may be problematic due to potential groundwater inflow and heave, however. The depths/elevations of the bedrock are as follows:

<u>Location</u>	<u>Bedrock</u>	
	<u>Depth (m)</u>	<u>Elevation</u>
<u>West Structure</u>		
North Abutment	25.9	216.0
South Abutment	26.5	215.6
<u>East Structure</u>		
North Abutment	28.0	215.7
South Abutment	28.0	215.6

The caissons should be designed using the following end-bearing resistance:

Factored End-Bearing Resistance at ULS = 4500 kPa

Based on this value, the factored axial resistance for several caisson diameters are presented below:

Caisson Diameter (m)	0.76	0.91	1.07	1.22
Factored Axial Resistance at ULS (kN)	2000	2900	4000	5200

Considering the bedrock to be non-yielding, the design is not expected to be governed by settlement since the loading required to produce deformation will be much larger than the factored resistance at ULS.

It is anticipated that augering will be feasible to advance the caissons through the overburden. Groundwater may present some problems with the installation of the caissons; a caisson liner should be installed to minimize the potential for sloughing and groundwater inflow.

### **ABUTMENT WALLS**

The abutment walls should be designed to resist the unbalanced horizontal earth pressure imposed by the backfill adjacent to the wall. The lateral earth pressure,  $p$ , may be computed using the equivalent fluid pressures presented in Section 6-7.4 of the Ontario Bridge Design Code (OHBDC, 3rd Edition, 1991) or employing the following equation, assuming a triangular pressure distribution:

$$p = K (\gamma h + q)$$

where  $K$  = lateral earth pressure coefficient

$\gamma$  = unit weight of free-draining  
granular material ( $\text{kN/m}^3$ )

$h$  = depth below final grade (m)

$q$  = surcharge load (kPa), if present

Free-draining granular material should be used as backfill behind the wall. The following parameters are recommended for design:

	<u>Granular "A"</u>	<u>Granular "B"</u>
Angle of Internal Friction (degrees)	35	32
Unit weight ( $\text{kN/m}^3$ )	22.8	21.2
Active Earth Pressure Coefficient ( $K_a$ )	0.27	0.31
At Rest Earth Pressure Coefficient ( $K_o$ )	0.43	0.47
Passive Earth Pressure Coefficient ( $K_p$ )	3.69	3.25

Refer to MTO Report SO-96-01 for procedures to determine the earth pressure coefficient to be employed to design integral abutments. The coefficient of earth pressure at-rest should be used for design of rigid and unyielding walls, the active earth pressure coefficient for unrestrained structures.

A weeping tile system and/or weep holes should be installed to minimize the build-up of hydrostatic pressure behind the wall. The weeping tiles should be surrounded by a properly designed granular filter or geotextile to prevent migration of fines into the system. The drainage pipe should be placed on a positive grade and lead to a frost-free outlet.

A retained soil system could also be employed. The founding material is expected to comprise granular engineered fill or silt/sand. The following parameters should be employed for design of the system foundation:

	<u>Granular "A"</u>	<u>Native Silt/Sand</u>
Friction Angle (degrees)	35	32
Cohesion (kPa)	0	0
Unit weight (kN/m <sup>3</sup> )	22.8	20.4

The supplier of the retained soil system should be responsible for design of the structure (backfill, reinforcement, internal and external stability) and provide drawings to show pertinent information such as location, length, height, elevations, performance level, appearance etc.

## **APPROACHES**

Backfilling adjacent to the structure should be carried out in conformance with Ontario Provincial Standards specifications for granular backfill.

The embankments should be constructed in accordance with OPSD 200.01, 202.01 and 208.01. Embankment slopes up to 10 m high inclined at 2 horizontal to 1 vertical should be stable. These recommendations should be reviewed if fill heights exceed 10 m.

No settlement or bearing capacity problems due to placing fill on the inorganic native overburden are anticipated. If footings are placed on structural fill, the topsoil and other deleterious material should be stripped prior to placement of the approach fill. Excavation of the existing sand/silt fill is not considered necessary provided the recommended minimum thickness of structural fill is placed below the founding level.

#### **EXCAVATION AND GROUNDWATER CONTROL**

Excavation for construction of footings, if employed, is expected to be carried out within the approach fill. Excavation is expected to be relatively straightforward. The fill is classified as a Type 3 soil according to Occupational Health and Safety Act (Ontario Regulation 213/91) criteria. Temporary cut slopes inclined at 1 horizontal to 1 vertical should generally be stable. Flatter sideslopes may be required if excessively soft/wet materials or concentrated seepage zones are encountered.

Seepage or surface water which enters the excavation should be readily handled by conventional sump pumping techniques.

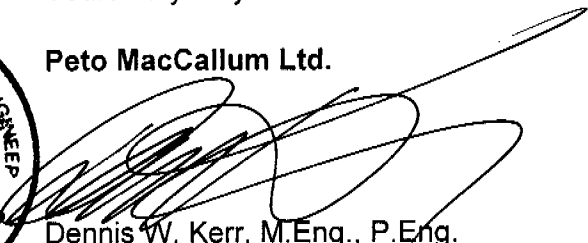
**CLOSURE**

The report was prepared by Mr. P. Cullen, B.Eng., and Mr. M.R. Anderson, P.Eng., Project Engineer. It was reviewed by Mr. D.W. Kerr, P.Eng., Manager of Geotechnical and Geo-Environmental Services, Hamilton.


Yours very truly

Peto MacCallum Ltd.



  
Dennis W. Kerr, M.Eng., P.Eng.  
Manager Geotechnical and  
Geo-Environmental Services



  
Brian R. Gray, M.Eng., P.Eng.  
Vice-President  
Geotechnical and  
Geo-Environmental Services

PC/MRA:ld

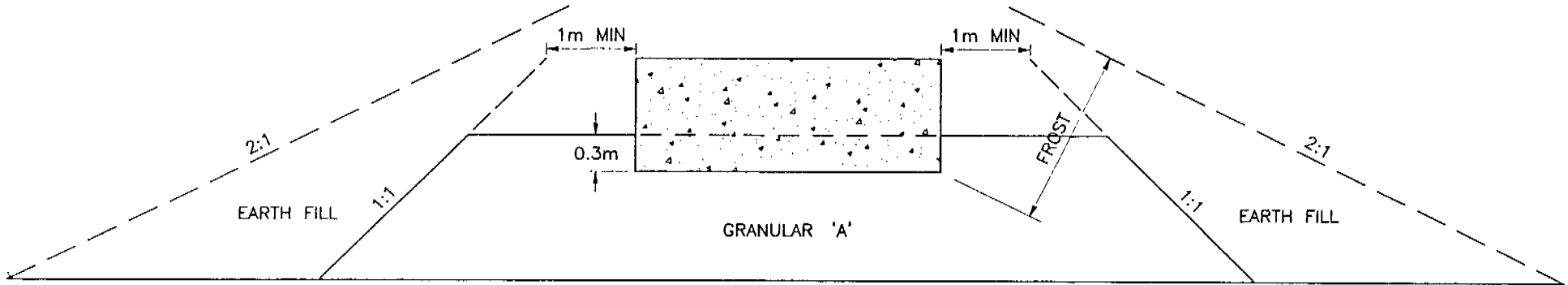
TABLE 1

**Gradation Specifications for Sand Fill in  
Pre-Augered Holes at Integral Abutments**

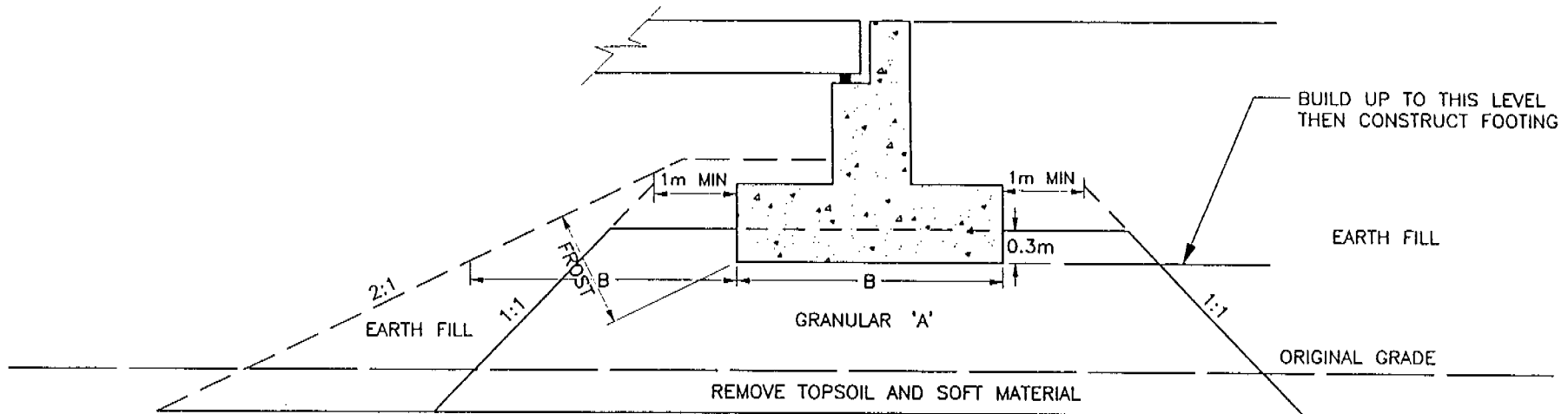
MTO Sieve Designation		Percentage Passing by Mass
2 mm	#10	100
600 $\mu\text{m}$	#30	80 - 100
425 $\mu\text{m}$	#40	40 - 80
250 $\mu\text{m}$	#60	5 - 25
150 $\mu\text{m}$	#100	0 - 6

From MTO Report S0-96-01, Revision 1 – July , 1996

## ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE



CROSS SECTION



LONGITUDINAL SECTION

### NOTES

1. REMOVE TOPSOIL AND/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' AND EARTH FILL.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M.T.O. STANDARDS.
3. CONSTRUCT CONCRETE FOOTING
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED
5. REFER TO TEXT OF REPORT FOR FROST DEPTH

**Peto MacCallum Ltd.**  
CONSULTING ENGINEERS

43 BURFORD ROAD, HAMILTON, ONTARIO L8E 3C6  
Tel: (905) 561-2231 Fax: (905) 561-6363

DATE	SCALE	JOB NO.	FIGURE NO
NOV. 1999	NTS	99HF073	1