

**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT  
HWY 40 UNDERPASS (SGT. M. J. EVE MEMORIAL BRIDGE)  
HIGHWAY 401/40 INTERCHANGE ONTARIO  
SITE NO. 13-238  
G.W.P. 3093-09-00  
  
MTO GEOCRES NO. 40J8-55**

**Prepared for:**

**Ministry of Transportation Ontario**

**By:**

**SPL CONSULTANTS LIMITED**

Project: 919-1101 (13-238)  
December 2011



**SPL Consultants Limited**  
Geotechnical Environmental Materials Hydrogeology

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*Project: 919-1101 (13-238)*

*Preliminary Foundation Investigation and Design Report*

*Hwy 40 Underpass (Sgt. M. J. Eve Memorial Bridge) – Hwy 40/401 interchange, Ontario*

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**PART A**  
**PRELIMINARY FOUNDATION INVESTIGATION REPORT**  
**HWY 40 UNDERPASS (SGT. M. J. EVE MEMORIAL BRIDGE)**  
**HIGHWAY 401/40 INTERCHANGE ONTARIO**  
**SITE NO. 13-238**

## **1. INTRODUCTION**

SPL Consultants Limited (SPL) was retained by the Ministry of Transportation to conduct a foundation investigation at the Hwy 40 Underpass (Sgt. M. J. Eve Memorial Bridge) at the Highway 40/401 interchange near Chatham-Kent, Ontario.

The Terms of Reference (TOR) for this investigation are outlined in the Request for Proposal (RFP) issued by the Ministry of Transportation (MTO) under Agreement No. 3011-E-0005 dated May 2011 and SPL's subsequent Proposal No. P11.06.024 dated June 2011.

The purpose of the preliminary foundation investigation was to obtain subsurface information at the site by means of a single exploratory borehole. This report presents the factual findings of the foundation investigation carried out at the site, as well as preliminary comments and recommendations related to the design and construction of the proposed new structure.

The investigation forms part of the larger Highway 401/40 interchange project. The project includes a total of six preliminary foundation investigations; the remaining five are submitted under separate cover. As part of this project a geotechnical (pavement) investigation was also carried out at the site concurrent with the foundation investigations. The results of the pavement investigation are also presented under separate cover.

## **2. SITE DESCRIPTION**

The site is located on Highway 401 at Highway 40 in the Geographical Township of Harwich, County of Kent, Ontario. The interchange is situated on the generally flat terrain of the St. Clair Clay Plain.

The existing structure is a 4-span concrete tee interchange structure over a 4-lane freeway. Site photos are included in Appendix A.

## **3. INVESTIGATION PROCEDURES**

The foundation investigation was carried out in August 2011. The scope of work for this assignment included a desk study, field investigations, laboratory testing, analysis and preparation of this report.

### **3.1 Desk Study**

Surficial geology in the area comprises fine-textured glacio-lacustrine and modern alluvial deposits, overlying glacial till.

Bedrock in the general area is black, non-calcareous shale with silty shale interbeds of the upper Devonian Kettle Point formation.

The GEOCRE database includes the results of several previous investigations at the Highway 401/40 interchange including a previous investigation at Highway 40 Underpass which is the subject of this report. The existing foundation information at the site is found in the following previous reports:

**Table 1 – Previous Foundation Reports at Highway 401/40 Interchange**

<b>GEOCRE No.</b>	<b>Location</b>
40J8-15	Highway 40 Underpass – Highway 401/40 Interchange <sup>1</sup>
40J8-14	McGregor Creek Bridge – Highway 40 south of Highway 401
40J8-24	McGregor Creek Bridge – Highway 40 north of Highway 401
40J8-13	McGregor Creek Bridges (EBL and WBL) – Highway 401 East of Highway 40

These investigation results included in the various reports suggest the general area is underlain by a layer of very stiff, grey, silty clay till. A layer (or layers) of water-bearing sand and gravel was also encountered in some of the boreholes in the general area of the 401/40 interchange (including at the subject site).

The previous report for the subject bridge (40J8-15, dated 1960) includes the records of four boreholes (Borehole Nos. 1, 2, 4, and 5) and one dynamic cone penetration test hole (Borehole No. 3) drilled as part of the proposed Highway 401 underpass at Highway 40 (at that time County Road No. 14). The four boreholes were drilled on either side of the proposed underpass; Borehole Nos. 1 and 2 were drilled on the east side to depths of 15.2 m (50') and 11.3 m (37'), respectively; and Borehole Nos. 4 and 5 were drilled on the west side of the underpass to depths of 10.7 m (35') and 10.2 m (33.5'), respectively. Each borehole encountered stiff to hard silty clay till underlain by water-bearing sand or sand and gravel to the depth of drilling.

The report recommends the bridge structure be founded on spread footings within the clay till layer at or below 181.5 m elevation (595'). The actual foundation construction, however, cannot be confirmed based on the information available.

A copy of the previous geotechnical report is included in Appendix B of this report.

<sup>1</sup> Subject of this report

### **3.2 Field Investigation**

The field investigation for this site was carried out in August 2011 and included drilling a single borehole (Borehole 13-238) in the median of Highway 401 on the east side of the underpass. Additional shallow boreholes were advanced at the same time for the geotechnical (pavement) portion of the work; the results of these boreholes are submitted with the geotechnical (pavement) investigation report under separate cover.

The borehole was advanced using a truck-mounted drill rig supplied and operated by London Soil Test Ltd., London, Ontario. Borehole 13-238 was advanced using hollow-stem auger drilling as well as rock coring techniques (using “N” size triple tube core barrels) to a depth of 29.7 m below the existing ground surface. During drilling, sampling and in-situ testing including Standard Penetration (SPT) Testing and Dynamic Cone Penetration (DCPT) Testing were carried out.

A standpipe piezometer was installed in the borehole to allow for subsequent measurement of the stabilized groundwater level at the site. The borehole was backfilled with bentonite and was sealed at the ground surface.

The borehole location is shown in Drawing 2. Borehole records are included in Appendix C of this report.

### **3.3 Laboratory Testing**

Upon completion of drilling and in-situ testing, soil samples were returned to SPL’s laboratory for further examination and classification. A laboratory testing program, including determination of natural water content, soil unit weight, Atterberg limits (plasticity) and grain size distribution (sieve and hydrometer) was carried out on selected representative soil samples.

The results of natural water content tests are included on the borehole log in Appendix C. The results of plasticity testing are included on the borehole log, and presented in the Plasticity Chart included as Drawing 3. The results of determination of grain size distribution are summarized on the borehole log and are presented in Drawings 4 to 7.

## **4. SUBSURFACE CONDITIONS**

The subsurface conditions at the site are discussed in the following sections. Detailed descriptions of the soil and groundwater conditions encountered at the borehole location are included in the borehole log in Appendix C.

## 4.1 Soil & Rock Conditions

### 4.1.1 Fill

Immediately at the surface, the borehole encountered a layer of granular fill material. The fill extended to a depth of 0.6 m and comprised compact gravelly sand, trace silt, trace clay.

Grain size analysis was carried out on one sample of the granular fill and the results are presented in Drawing 4, and are summarized in Table 2 below.

**Table 2 – Results of Grain Size Analyses for Granular Fill**

Borehole No.	Sample No.	Grain Size Distribution			
		% Gravel	% Sand	% Silt	% Clay
BH13-238	SS1	28	61	6	5

### 4.1.2 Silty Clay

Underlying the granular fill a deposit of silty clay was encountered and extended to a depth of 2.1 m below grade (182.1 m elevation) in borehole 13-238. The silty clay material contained sandy silt seams, trace gravel, trace topsoil, and was brown in colour. As inferred from SPT “N” values of 12 and 15 blows for 0.3 m penetration, the consistency of this deposit is stiff. Natural water contents in the silty clay material were found to range from 17 to 21.

### 4.1.3 Upper Silty Clay Till

The soils below the silty clay include a thick deposit of silty clay till. The clay till was present from 2.1 m depth (182.1 m elevation) to 12.2 m depth (172 m elevation) in borehole 13-238 as part of this current investigation and extended to depths of 9.5 m (173.8 m elevation) to 10.1 m (173.2 m elevation) in the boreholes drilled in 1959.

The results of Atterberg limits (plasticity) testing on one sample of the silty clay till yielded a plastic limit of 15% and a liquid limit of 30% indicating a low plasticity silty clay (CL). The result of the plasticity testing is presented on the Plasticity Chart in Drawing 3.

Natural water contents ranged from 8 % to 20%. Similar values are reported for the upper portion of the till in the 1960 report.

The grain size distribution of one sample of the upper silty clay till is presented in Drawing 5, and is summarized in Table 3 below.

**Table 3 – Results of Grain Size Analyses for Silty Clay Till**

Borehole No.	Sample No.	Grain Size Distribution			
		% Gravel	% Sand	% Silt	% Clay
13-238	SS5	3	46	27	24

Rock fragments (possible cobble or boulder) were encountered in borehole 13-238 at 9.2 m depth ( at about 175 m elevation).

Unit weight measurements on samples of the silty clay till obtained in both the current and 1959 investigation yielded values of 20.8 kN/m<sup>3</sup> to 22.4 kN/m<sup>3</sup>.

SPT “N” values measured during the current investigations range from 11 to 30. SPT “N” values reported in the previous geotechnical investigation range from 12 to in excess of 50 blows per 0.3 m penetration. Laboratory undrained shear strengths presented in the 1960 investigation range from 152 kPa to 245 kPa. Based on these values the consistency of the silty clay till would be described as stiff to hard.

#### 4.1.4 Sand/Sand and Gravel/Gravelly Sand

Underlying the clay till, there is a water-bearing non-cohesive deposit of gravelly sand between 12.2 m depth (172 m elevation) to 18.6 m depth (165.6 m elevation) in borehole 13-238. In the 1960 investigation, the boreholes contacted the cohesionless deposit at depths varying between 9.5 m (173.8 m elevation) to 10.1 m (173.2 m elevation). The gravelly sand contained some silt and trace gravel. Natural water contents in the limited number of samples tested ranged from 10 % to 13%.

The grain size distribution of one sample of the granular deposits is presented in Drawing 6, and is summarized in Table 4 below.

**Table 4 – Results of Grain Size Analyses for Gravelly Sand**

Borehole No.	Sample No.	Grain Size Distribution			
		% Gravel	% Sand	% Silt	% Clay
13-238	SS11	24	58	11	7

SPT “N” values measured within the gravelly sand deposits during the current investigations range from 40 to in excess of 50 blows per 300 mm penetration. Based on these values the relative density of the sandy soils is dense to very dense.

#### 4.1.5 Lower Silty Clay Till

The soil below the water bearing granular deposit consists of a lower deposit of silty clay till. The lower clay till was present from 18.6 m depth (165.6 m elevation) to 24.4 m depth (159.8 m elevation) in

borehole 13-238. The boreholes drilled in 1959 did not contact this deposit as they did not extend deep enough. Sand seams/layers were observed throughout this deposit.

The results of Atterberg Limits (plasticity) testing on one sample of the silty clay till yielded a plastic limit of 9 and a liquid limit of 19 indicating a low plasticity silty clay (CL). The result of the plasticity testing is presented on the Plasticity Chart in Drawing 3.

Natural water contents ranged from 9 % to 10% in the lower silty clay till.

The grain size distribution of one sample of the lower clay till is presented in Drawing 7, and is summarized in Table 5 below.

**Table 5 – Results of Grain Size Analyses for Lower Clayey Silt Till**

Borehole No.	Sample No.	Grain Size Distribution			
		% Gravel	% Sand	% Silt	% Clay
13-238	SS17	5	52	26	17

Unit weight measurement on one sample of the lower clay till yielded a value of 23 kN/m<sup>3</sup>.

SPT “N” values measured during the current investigations were in excess of 50 blows per 0.3 m penetration. Based on these values the consistency of the lower clay till would be described as hard.

#### 4.1.6 Bedrock

Weathered shale was contacted in borehole 13-238 at 24.4 m depth (159.8 m elevation). The shale could be augered from 24.4 m to 26.7 m depth. The borehole was then cored using “N” size coring equipment from 26.7 m depth (157.5 m).

The bedrock comprises dark grey fresh to slightly weathered shale. The shale is very thinly bedded with closely spaced discontinuities. RQD values for the shale bedrock below 26.7 m range from 75% to 100%, indicating fair to excellent quality rock.

## 4.2 Groundwater Conditions

A standpipe piezometer was installed in the borehole drilled as part of the current investigation. The groundwater elevation at the site was measured in October 2011 and found to be at 7.86 m depth (176.34 m elevation) in borehole 13-238.

It should be noted that the groundwater levels can vary and are subject to seasonal fluctuations as well as fluctuations in response to major weather events.



### 4.3 Summary

A summary of the soil and groundwater conditions encountered at the Hwy 40 Underpass (Sgt. M. J. Eve Memorial Bridge) location is presented in Table 6 below.<sup>2</sup>

**Table 6 – Simplified Stratigraphy and Groundwater Elevations**

Borehole No.	Ground Surface Elevation	Simplified Stratigraphy (Depth, m)						Groundwater Elevation
		Granular Fill	Silty/Sandy Clay	Upper Silty Clay Till	Gravelly Sand/Sand and Gravel	Lower Silty Clay Till	Shale Bedrock	
13-238 (2011)	184.2	0.0 – 0.6	0.6 – 2.1	2.1 – 12.2	12.2 – 18.6	18.6 – 24.4	24.4 – 29.7	176.34 m
1 (1960)	183.3	--	0.0 – 2.7	2.7 – 10.1	10.1 – 15.2	--	--	177.5 m
2 (1960)	183.3	--	0.0 – 2.1	2.1 – 10.1	10.1 – 11.3	--	--	177.8 m
4 (1960)	183.3	--	0.0 – 2.1	2.1 – 10.1	10.1 – 10.7	--	--	177.8 m
5 (1960)	183.3	--	0.0 – 9.4		9.4 – 10.2	--	--	177.5 m

<sup>2</sup> The values presented for the 1960 investigation have been obtained from a copy of the investigation report which was made available to us. The accuracy of this data has not been verified as part of this study. It is recommended that these values be treated with caution.

## 5. CLOSURE

Field investigations for this project were supervised by Philip Resendes, B.Sc. This report was prepared by Ms. Eva Papp, P.Eng. and Mr. Chris Hendry, P.Eng. Mr. Fanyu Zhu, P.Eng., SPL's project manager and designated MTO Contact, and Mr. Shaheen Ahmad, P.Eng., SPL's quality control auditor provided independent review and quality control.

### SPL CONSULTANTS LIMITED



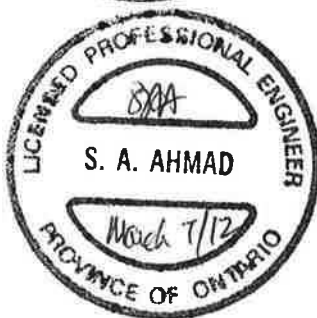
Chris Hendry, M.Eng., P.Eng.



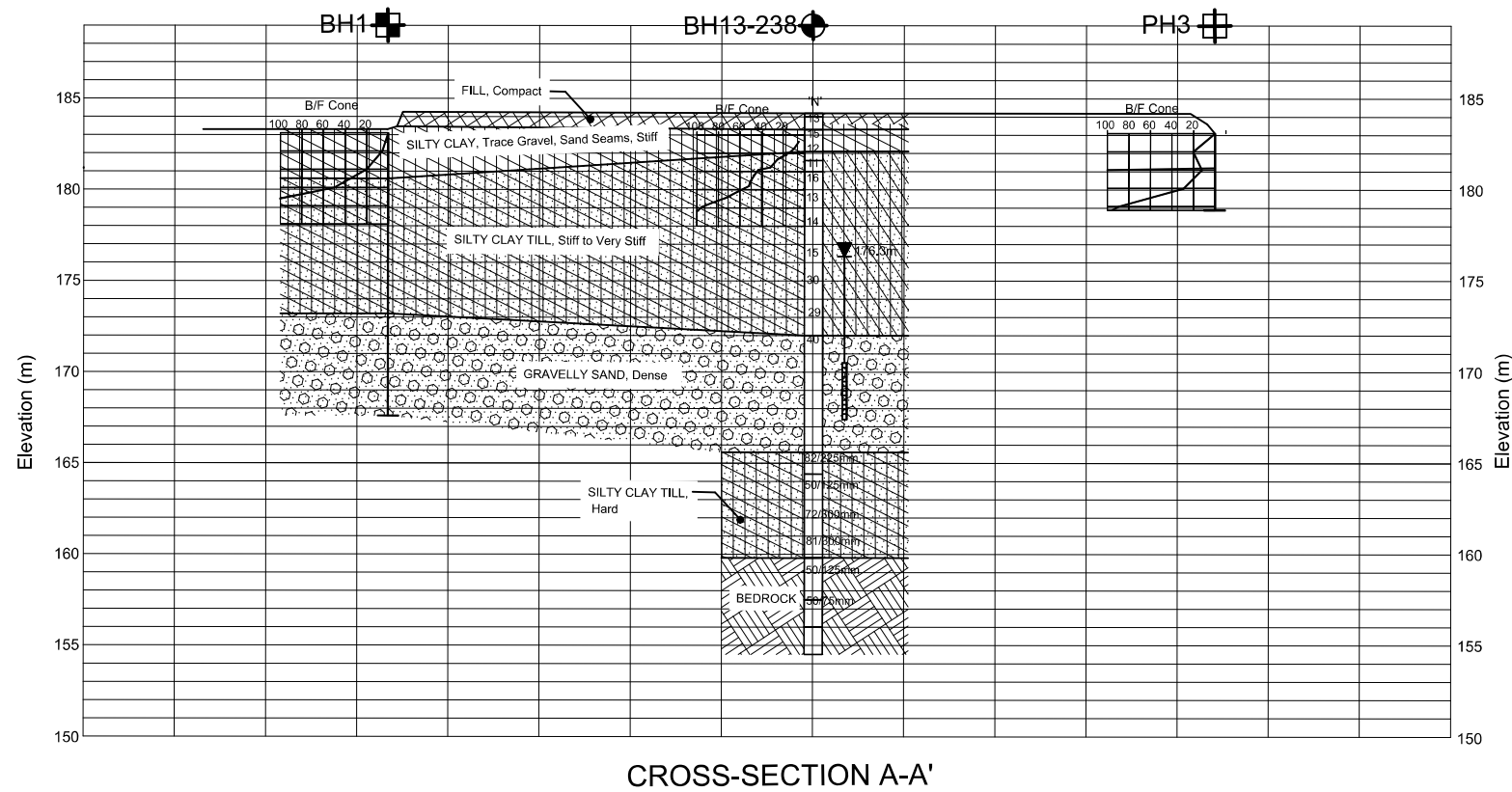
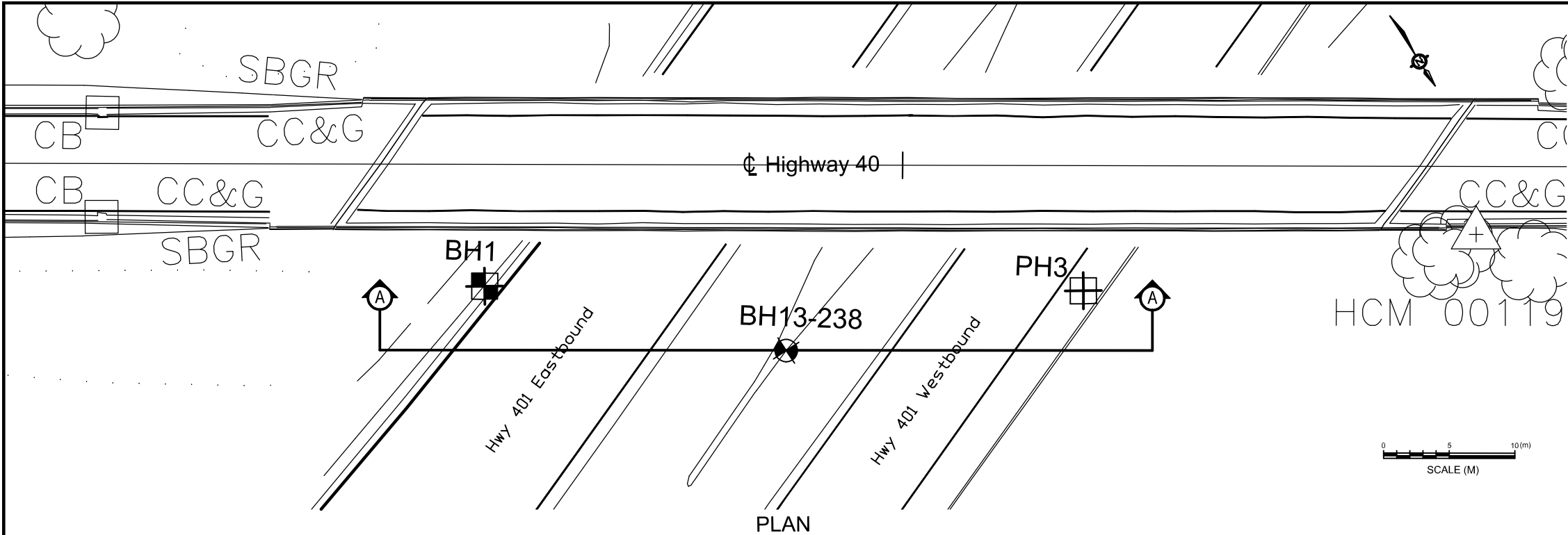
Fanyu Zhu, Ph.D., P.Eng.



Shaheen Ahmad, M.A.Sc., P.Eng.



# Drawings



SOIL STRATA SYMBOLS

- GRANULAR FILL   SILTY CLAY TILL   GRAVELLY SAND
- SILTY CLAY   BEDROCK

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

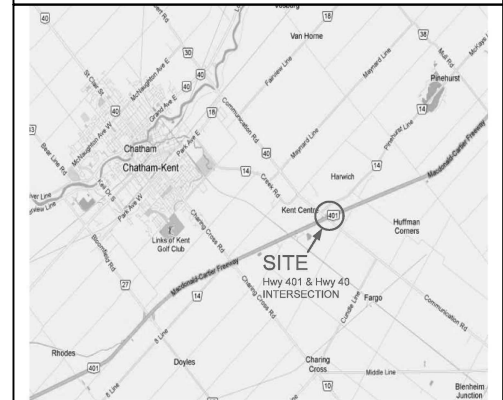
CONT No  
WP No 3093-09-00



Highway 40 Underpass  
Hwy 401 / Hwy 40 Interchange  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET  
-

**SPL Consultants Limited**  
Geotechnical • Environmental • Materials • Hydrogeology



KEY PLAN  
NOT TO SCALE

LEGEND

- ◆ Bore Hole Drilled in 2011  
⊠ Bore Hole drilled in 1959  
⊞ Penetration Hole advanced in 1959  
N Blows/0.3m (Std Pen Test, 475 J/blow)  
CONE Blows/0.3m (60° Cone, 475 J/blow)  
▼ WL in Piezometer  
| Piezometer

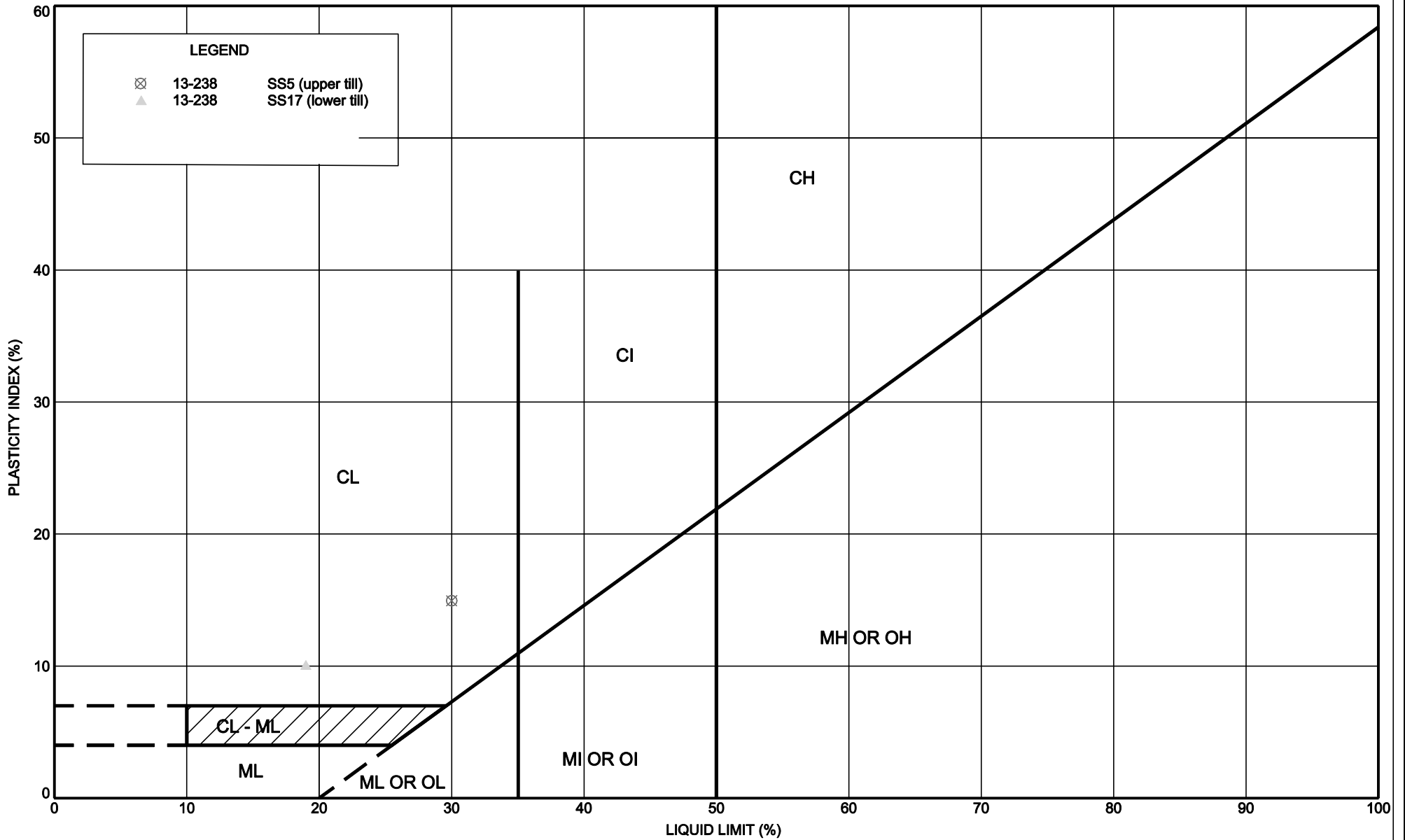
BH No	ELEVATION	NORTHING	EASTING
13-238	184.2	4693696	338373


NOTES

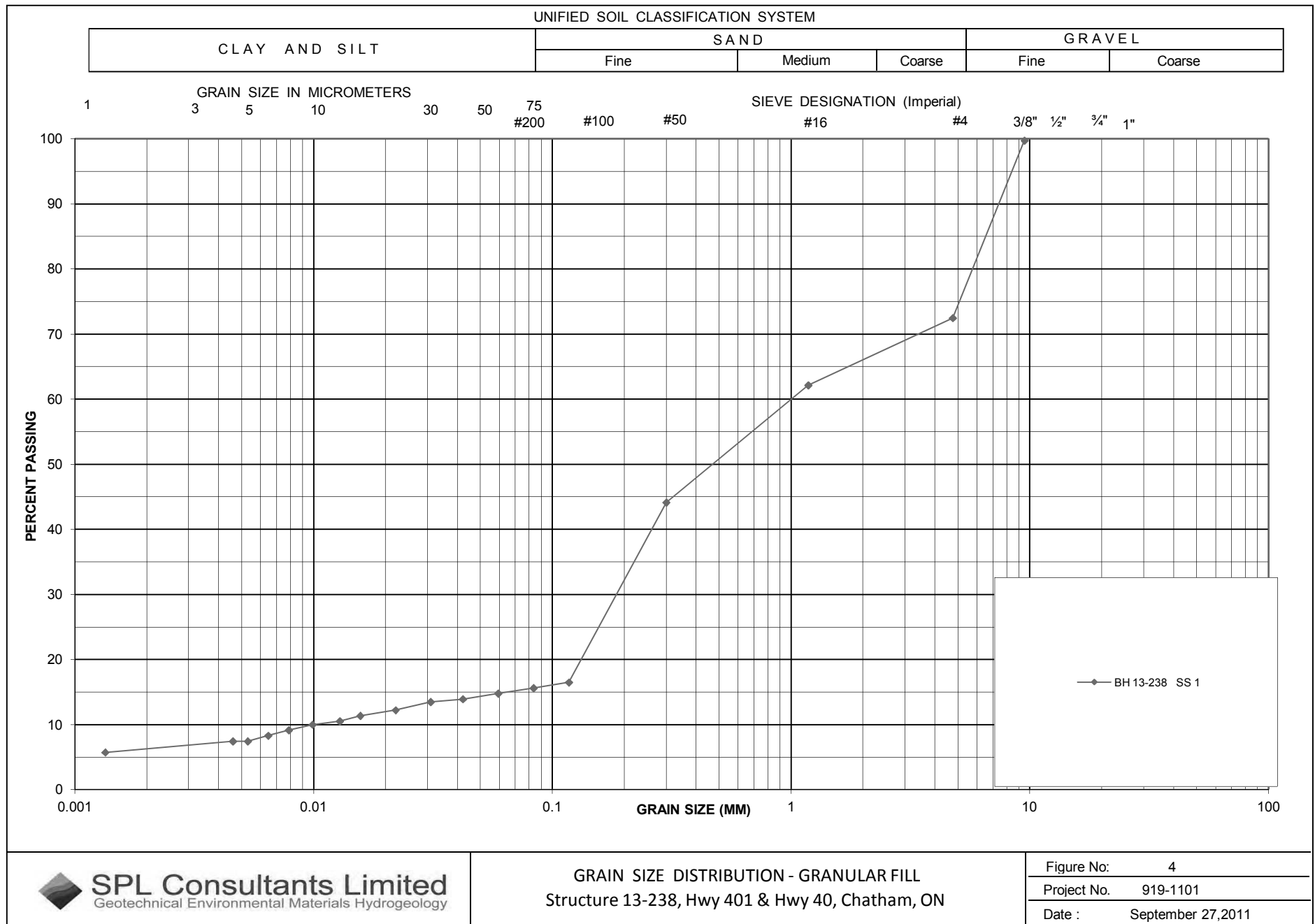
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.

Locations and Elevations of Boreholes Drilled in 1959 are approximate only and have not been verified.

REVISIONS			
Dec16,2011	PR		Final Revision
DATE	BY		DESCRIPTION
GEOCREs No 40J8-55			
HWY No 401			DIST Chatham
SUBM'D CH	CHECKED CH	DATE Dec16, 2011	SITE 13-238
DRAWN PR	CHECKED CH	APPROVED FZ	DWG 2



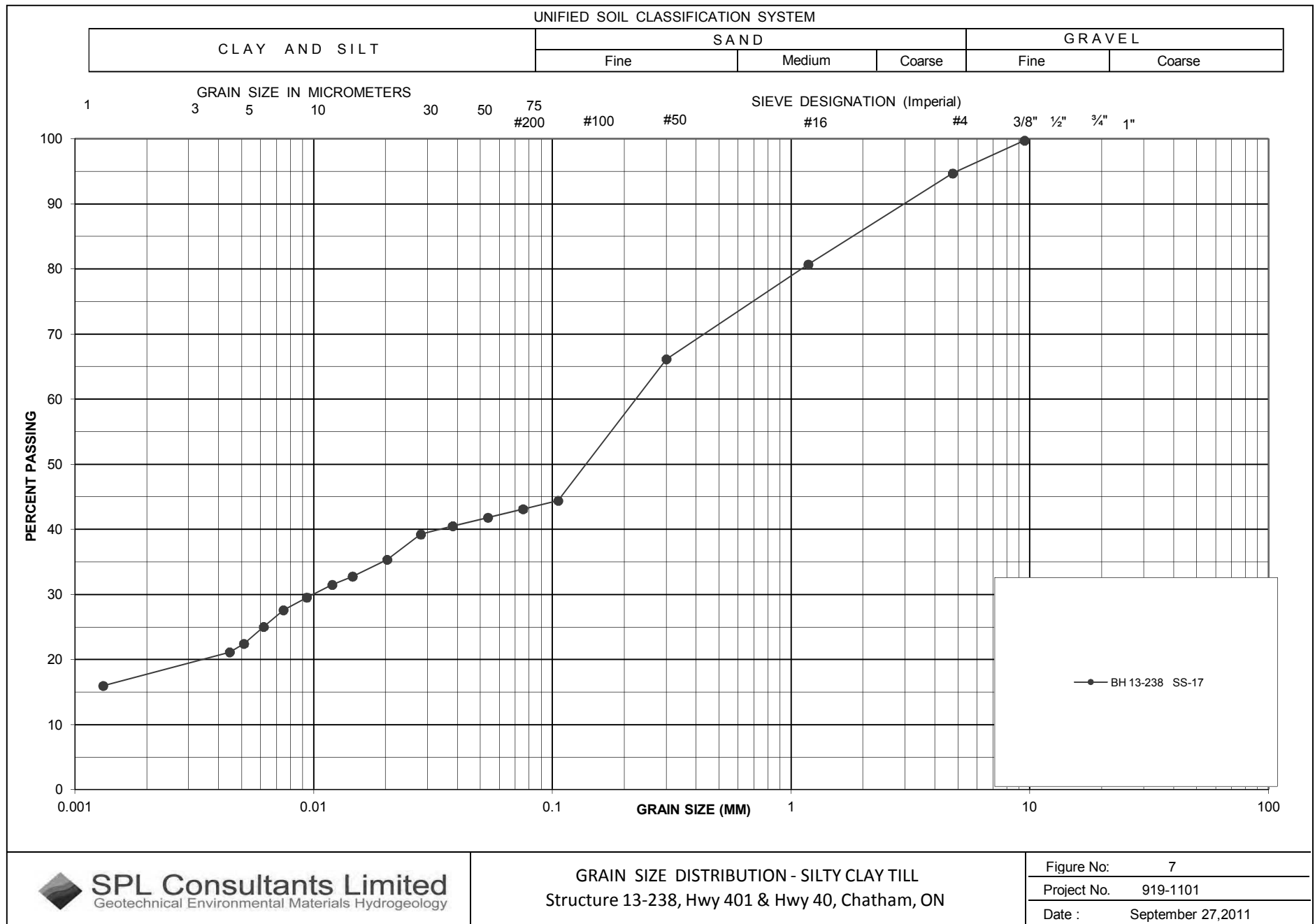
Client: Ministry of Transportation Ontario		Project No.: 919-1101	Drawing No.: 3
Drawn: EH	Approved: EP	Title: PLASTICITY CHART	
Date: December 18, 2011	Scale: N/A	Project: Preliminary Geotechnical Investigation Structure 13-238, Hwy 40 & Hwy 401, Chatham, Ontario	
Original Size: LETTER	Rev: N/A	 <b>SPL Consultants Limited</b> Geotechnical • Environmental • Materials • Hydrogeology	











**SPL Consultants Limited**  
Geotechnical Environmental Materials Hydrogeology

GRAIN SIZE DISTRIBUTION - SILTY CLAY TILL

Structure 13-238, Hwy 401 & Hwy 40, Chatham, ON

Figure No: 7

Project No. 919-1101

Date: September 27, 2011

# Appendix A

## Site Photographs



Highway 40 over Highway 401, facing south.



Highway 40 over Highway 401, facing north.



Highway 401 under Highway 40, facing south.

## Appendix B

### Previous Geotechnical Investigation

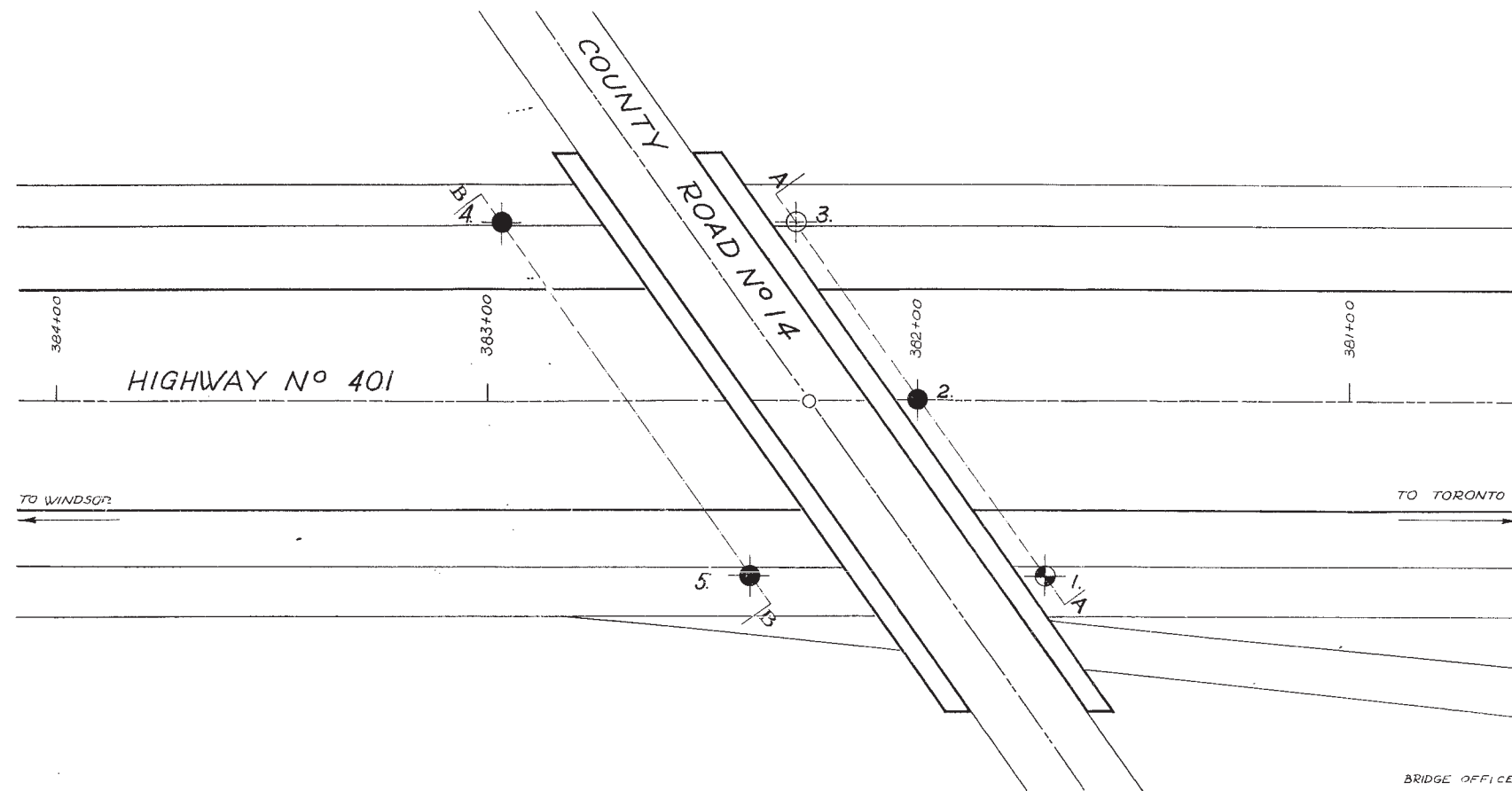
#59-F-76

W.P. 82-59

HWY. #401 E

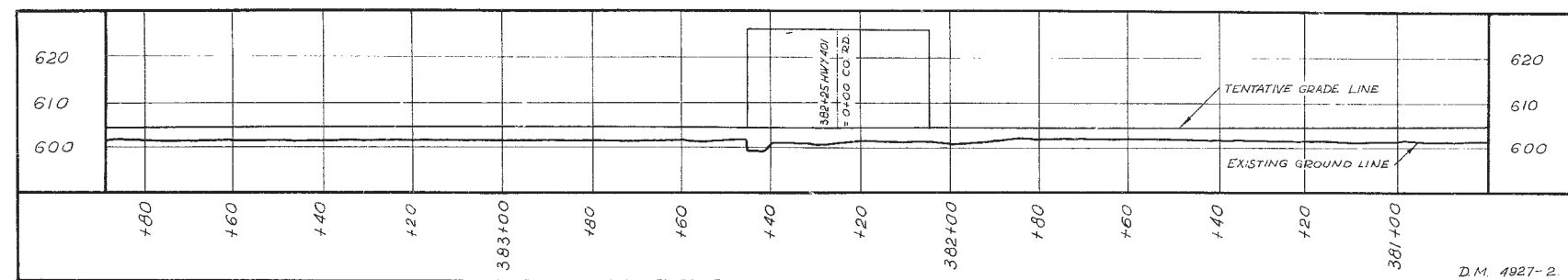
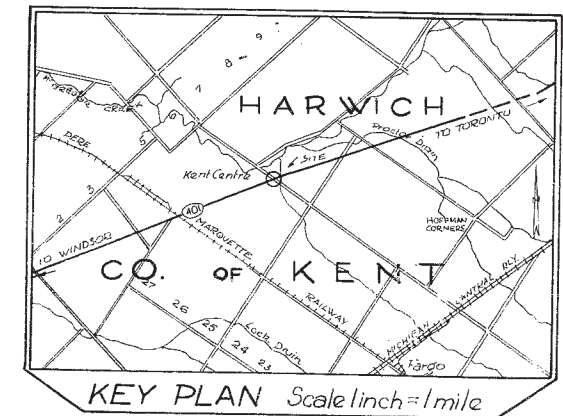
CTY. RD. #14

CROSSING



PLAN

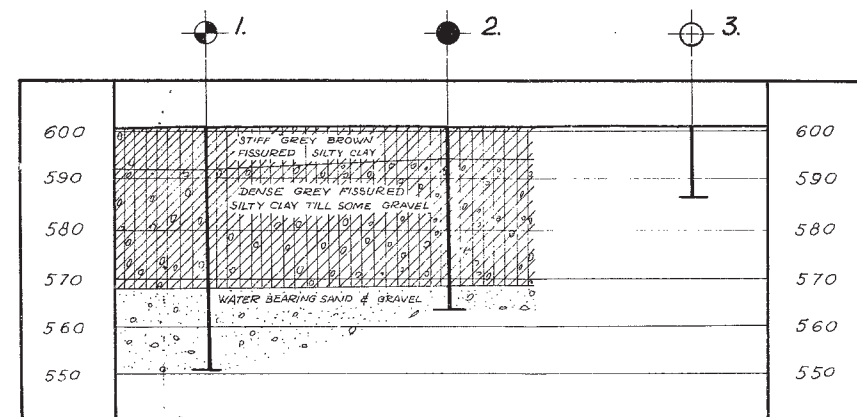
BRIDGE OFFICE  
DRAWING BW-285



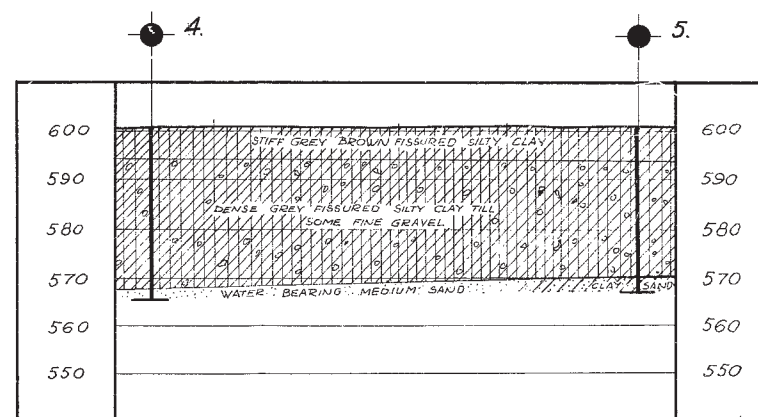
PROFILE

D.M. 4927-2

LEGEND			
BORE HOLE			
PENETRATION HOLE			
BORE & PENETRATION HOLE			
HOLE NO.	ELEVATION	STATION	DISTANCE FROM E.
1.	601.0	381+70	40' LT.
2.	601.0	382+00	£
3.	601.0	382+26	41' RT.
4.	601.0	382+96	41' RT.
5.	601.0	382+38	40' LT.



A - A



B - B

- NOTE -  
THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BORE HOLE LOCATIONS. BETWEEN BORE HOLES THE BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE AND MAY BE SUBJECT TO CONSIDERABLE ERROR.

DEPARTMENT OF HIGHWAYS - ONTARIO			
MATERIALS & RESEARCH SECTION			
COUNTY ROAD NO 14 PROPOSED CROSSING			
SHOWING POSITIONS & ELEVATIONS OF HOLES			
HWY 401	DISTRICT 1	COUNTY KENT	
TOWNSHIP HARWICH	LOT 25-26	CON I.W.C.R.-E.C.R.	
LOCATION KENT CENTRE			
DRAWN BY T. Szegvary		CHECKED BY	W.P. 82-59
DATE 21 AUG. 1959		APPROVED BY	DRAWING NO.
SCALE 1 inch = 20 Feet			F59-76 A.

cc: Mr. A. M. Toye (2nd copy)

Mr. A. M. Toye,  
Bridge Engineer.  
Materials & Research Section.  
Attention: Mr. S. McCombie.

February ., 1960.  
D.H.O. FOUNDATION REPORT -  
W.P. 82-59 -- W.J. F-59-76.

Re: Hwy. 401 & County Road No. 14 Crossing  
at Kent Centre -- District No. 1.

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We have completed a subsoil investigation at the above noted structure location where proposed Hwy. 401 underpasses County Road No. 14 at Kent Centre. Presented herein are the results of our field and laboratory findings, as well as our recommendations for the foundation of the structure.

SITE INVESTIGATION:

During the period of the 14th and 17th of July, 1959, 4 sampled boreholes and one separate cone test were carried out by a trailer-mounted continuous flight auger, adapted for soil sampling. Conventional auger boring procedures were followed and samples were recovered by means of a split barrelled spoon sampler, or using thin-walled Shelby tubes. The dimensions of the spoon sampler and the energy used in driving it, conform to the requirements of the Standard Penetration Test. Upon recovery, samples were visually examined and classified at the site and wax-sealed or placed in moisture proof containers for transport to our laboratory. Upon receipt in the laboratory, samples were visually examined and identified. Triaxial shear and routine index tests were performed on selected representative samples. Results of our field and laboratory tests have been presented in

cont'd. /2 ...



SITE INVESTIGATION: ( cont'd. ) ...

the borehole logs and are summarized in Table No. 1. The locations of the boreholes as well as their subsoil profile, are shown in the accompanying Drawing No. F-59-76A.

Subsoil consists of a dense clay till stratum underlain by a layer of water-bearing sand and gravel. According to our boring data in the vicinity of this site, this layer of water-bearing sand and gravel is, in turn, underlain by dense clay till, which extends a considerable depth to bedrock. The upper portion of the silty clay till has been subjected to oxidation, resulting in its present brownish colour. Below the oxidized zone, the colour is predominantly grey. The silty clay till exists in a dense condition with shear strengths well in excess of 3000 p.s.f. measured in the laboratory. It contains some gravel and occasional boulders and is fissured throughout the stratum. The average unit weight and moisture content were found to be 134 p.c.f. and 15%, respectively. Atterberg Limit tests show that the silty clay till is of very low plasticity.

An artesian water condition was noted at approximately Elev. 568' in each of the sampled boreholes where the layer of sand and gravel was encountered during the exploration programme. The excess hydrostatic head reached Elev. 582' in each of the sampled boreholes. The critical elevation below which 'piping' will occur during footing excavations, has been estimated to be at 575'.

FOUNDATION CONSIDERATIONS:

The dense clay till stratum is competent to provide satisfactory foundation support for the structure. Strength and compressibility characteristics are such that spread footing support can be obtained in the clay till at Elev. 595' or below. At this elevation or below, for footings typically 7' to 10' wide, an allowable bearing pressure of at least 3 t.s.f. can be used for design. Little settlement of any consequence, need be anticipated.

cont'd. /3 ...

FOUNDATION CONSIDERATIONS: (cont'd.) ...

The impermeable nature of the clay till will allow footing excavations to be carried out in the dry. To avoid 'piping' during footing excavations, footings should not be placed below Elev. 575'.

Under the proposed grade line of County Road No. 14, the maximum height of fill is approximately 25 ft. The subsoil can safely support this proposed embankment loading.

CONCLUSIONS & RECOMMENDATIONS:

- (1) The site is underlain by a dense clay till stratum followed by a layer of water-bearing sand and gravel, which, according to our previous boring data, in this locality, is in turn, underlain by a dense clay till stratum extending to bedrock.
- (2) Subsoil conditions are such that spread footing support can be obtained at Elev. 595' or below. For footings typically 7' to 10' in width, an allowable footing pressure of at least 3 t.s.f. is recommended. Little settlement of any consequence, need be anticipated.
- (3) No ground water seepage problems during footing excavations are anticipated if footings are placed above Elev. 575'.
- (4) No approach fill stability problems are anticipated.

If there are any queries concerning the contents of this report, please contact the Foundation Section.

AKL/MdeF  
Encls.

cc: Messrs. A. M. Teye (2)  
H. A. Tregaskes  
D. G. Ramsay  
A. Gater  
G. U. Howell  
J. Roy  
A. Watt  
Foundation Section  
Gen. Miles.

L. G. Soderman,  
PRINCIPAL SOILS & FOUNDATIONS ENGR.  
per:

*AKGL*  
(A. K. Loh,  
PROJECT FOUNDATION ENGR.)

APPENDIX I.

## SUMMARY OF FIELD & LABORATORY TESTS

[illegible]

TABLE NO. 1.

SUMMARY OF FIELD & LABORATORY TESTS

JOB F 59-76

W.P. 82-59

HOLE NO	SAMP NO	SAMPLE DEPTH (FEET)	MATERIAL DESCRIPTION	PENETIN (H.F. 101) BLOWS/FT	MOIST. CONT. %	PLASTIC LIMIT %	LIQUID LIMIT %	SHEAR STRENGTH P.S.F.	UNIT WEIGHT P.C.F.	REMARKS
5	S1	5' - 6.5'	Dense grey fissured silty clay	14	27.2	-	-	-	123.6	Occasional boulders in the clay till throughout
	S2	10'-11.5'	" " " "	20	16.1	-	-	-	137.1	
	S3	15'-16.5'	" " " "	24	-	-	-	-	136.1	
	S4	20'-21.5'	" " " "	28	13.2	-	-	-	136.1	
	S5	25'-26.5'	" " " "	32	15.2	-	-	-	127.5	
	S6	32.5'-33.5'	Water bearing clay sand	85	12.6	-	-	-	-	
			S - Denotes Split Spoon Sample							
			T - Denotes Thin-walled Shelby Sample							
			C - Denotes Chunk Sample							



## DEPARTMENT OF HIGHWAYS - ONTARIO

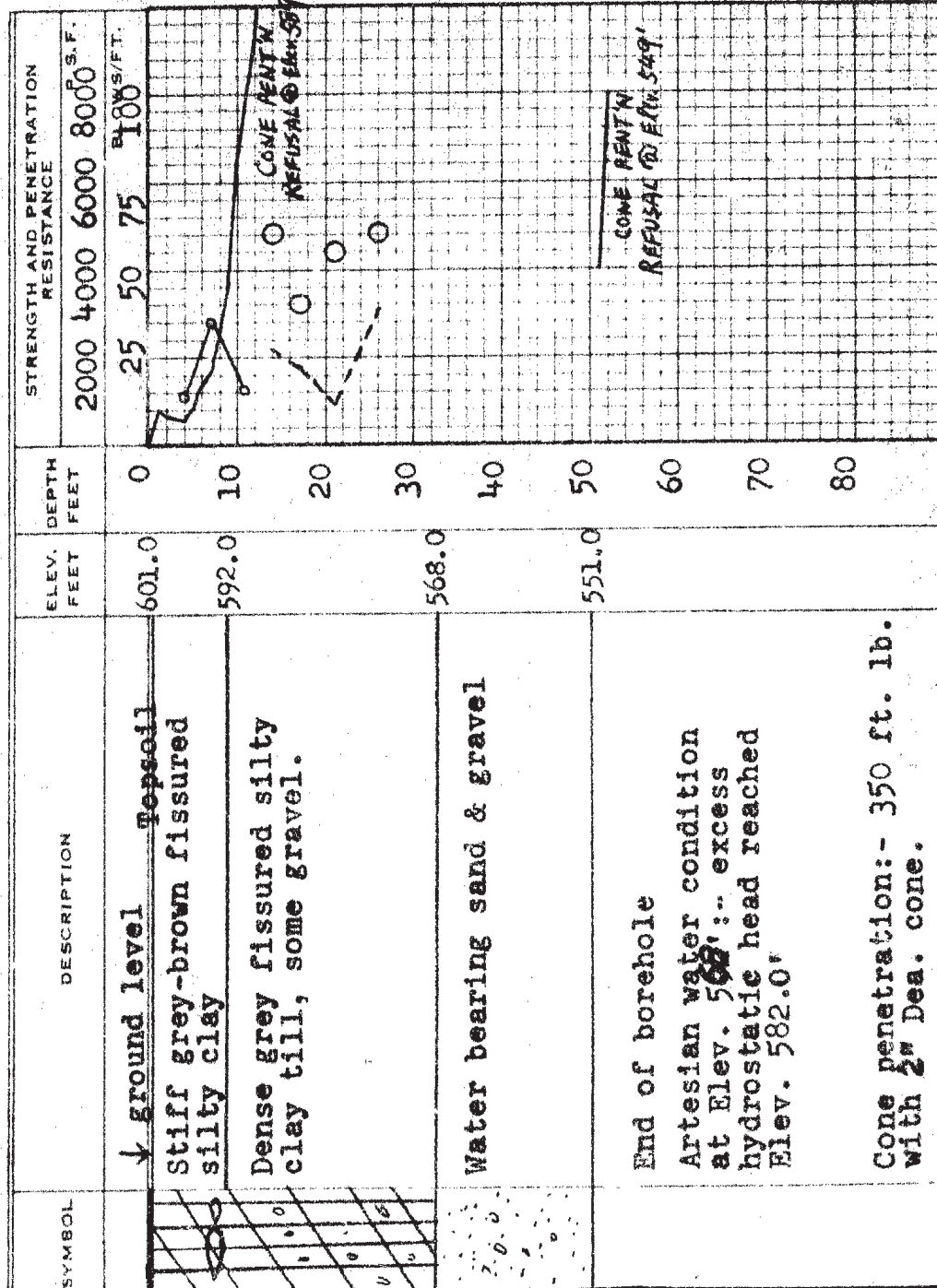
## MATERIALS AND RESEARCH SECTION

W.P. 82-59 BORE HOLE NO. 1  
JOB F 59-76 STATION See Drawing  
DATUM 601.0' COMPILED BY BK  
BORING DATE July 14/59 CHECKED BY AL

## LEGEND

2" DIA. SPLIT TUBE  
2" SHELBY TUBE  
2" SPLIT TUBE  
2" DIA. CONE  
2" SHELBY  
CASING

1/2 UNCONFINED COMPRESSION (Qu)  
VANE TEST (C) AND SENSITIVITY (S)  
NATURAL MOISTURE AND  
LIQUIDITY INDEX  
LIQUID LIMIT  
PLASTIC LIMIT










CONSISTENCY	SAMPLE	NATURAL UNIT WT. P.C.F.
MOIST. CONTENT - % DRY WT.		
10 20 30	S1	131.8
	S2	133.6
	S3	133.7
	T4	138.0
	T5	134.6
	T6	130.1
	T7	
	S8	

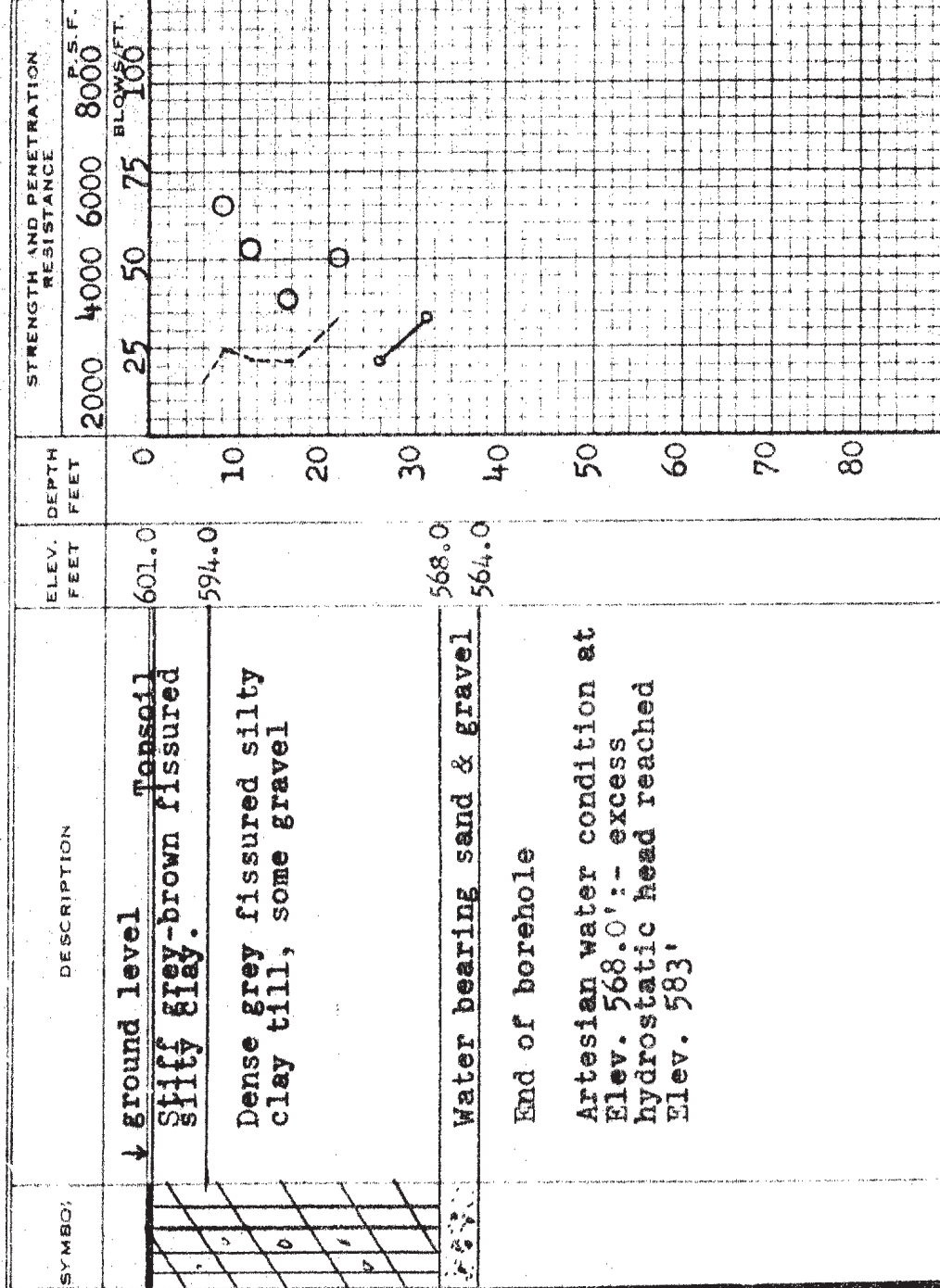
# DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS AND RESEARCH SECTION

W.P. 82-59 BORE HOLE NO. 2  
 JOB F 59-76 STATION See Drawing  
 DATUM 601.0' COMPILED BY BK  
 BORING DATE JULY 15/59 CHECKED BY AL

## LEGEND

2" DIA. SPLIT TUBE   
 2" SHELBY TUBE   
 2" SPLIT TUBE   
 2" DIA. CONE   
 2" SHELBY CASING 

1/2 UNCONFINED COMPRESSION (Qu)   
 VANE TEST (C) AND SENSITIVITY (S)   
 NATURAL MOISTURE AND LIQUIDITY INDEX   
 LIQUID LIMIT   
 PLASTIC LIMIT 



CONSISTENCY	SAMPLE	NATURAL UNIT WT. P.C.F.
MOIST. CONTENT - % DRY WT.		
	T1	136.6
	T2	134.2
	T3	
	T4	
	T5	132.5
	S6	-
	S7	-

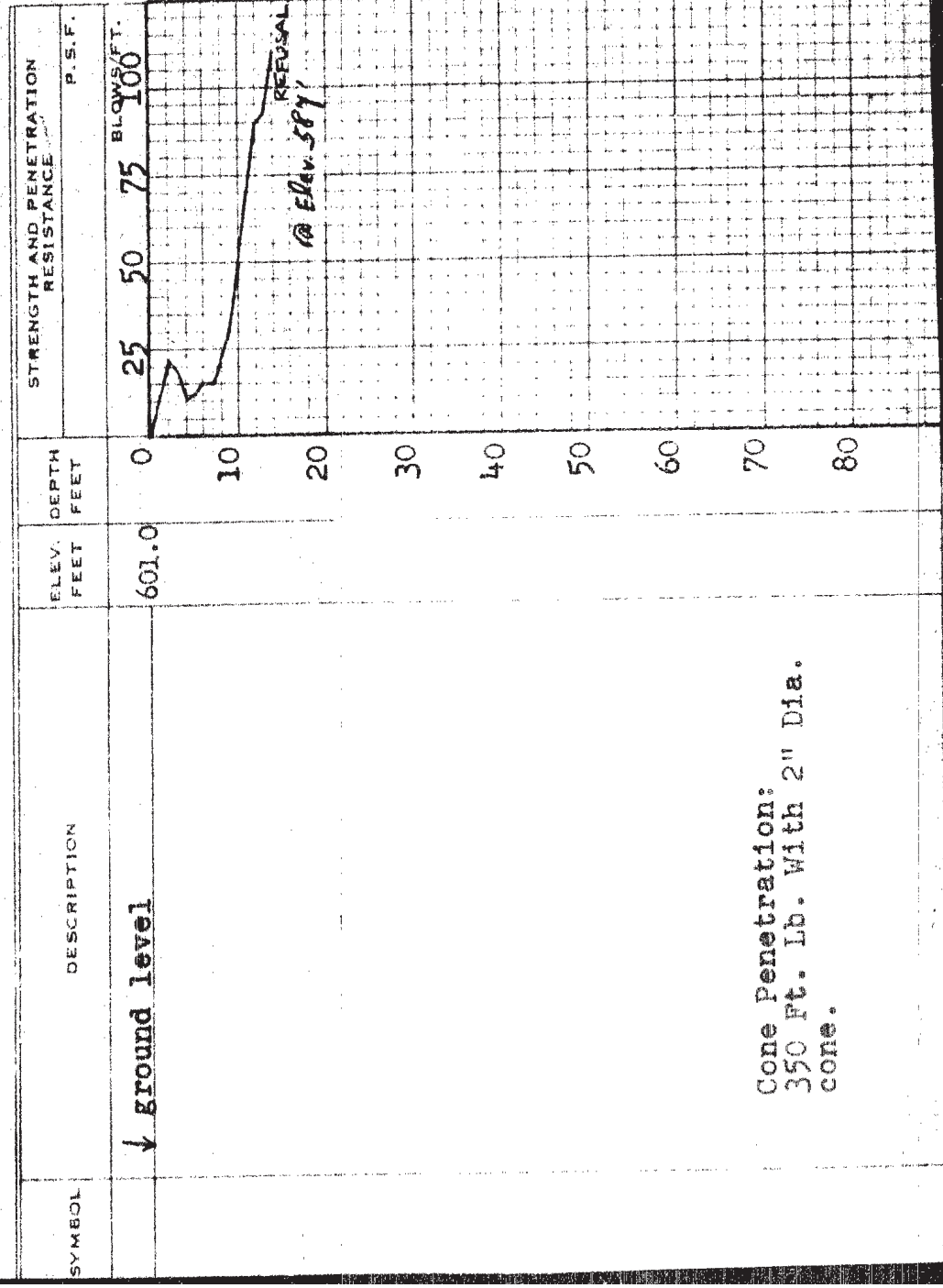
DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS AND RESEARCH SECTION

W.P. 82-59 BORE HOLE NO. 3  
JOB F 59-76 STATION See Drawing  
DATUM 601.0' COMPILED BY BK  
BORING DATE July 16/59 CHECKED BY AL

LEGEND

1/2 UNCONFINED COMPRESSION (Qu) --- O  
VANE TEST (C) AND SENSITIVITY (S) --- +  
NATURAL MOISTURE AND LIQUIDITY INDEX --- LI  
LIQUID LIMIT --- X  
PLASTIC LIMIT --- P

2" DIA. SPLIT TUBE --- S  
2" SHELBY TUBE --- T  
2" SPLIT TUBE --- O  
2" DIA. CONE --- C  
2" SHELBY CASING --- X



CONSISTENCY	SAMPLE	NATURAL UNIT WT P.C.F.
MOIST. CONTENT - % DRY WT.		



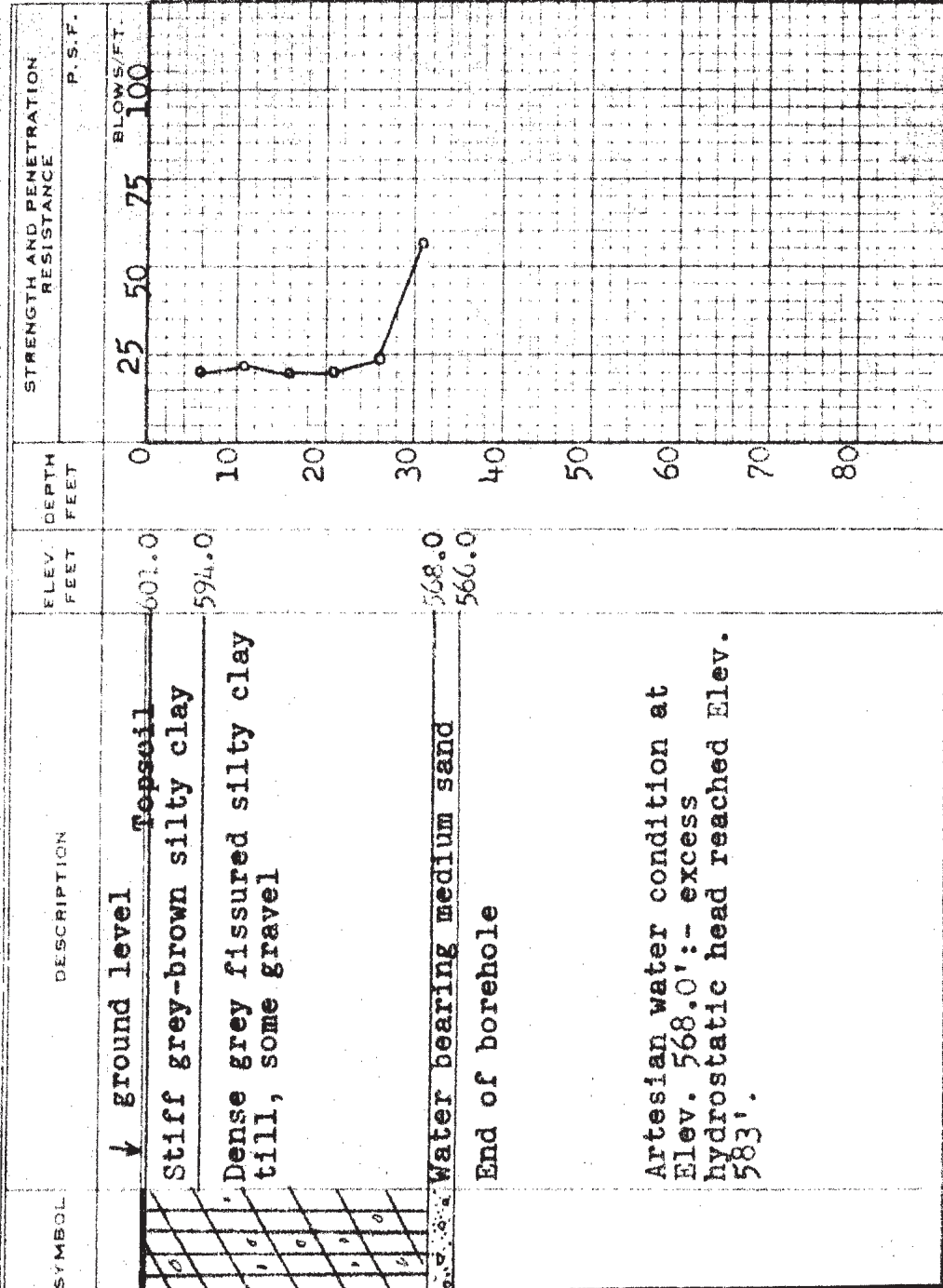
# DEPARTMENT OF HIGHWAYS - ONTARIO

## MATERIALS AND RESEARCH SECTION

W.P. 82-59 --- BORE HOLE NO. 4  
 JOB # 59-76 STATION See Drawing  
 DATUM 601.0' COMPILED BY BK  
 BORING DATE July 16/59 CHECKED BY AL

### LEGEND

2" DIA. SPLIT TUBE --- ☒  $\frac{1}{2}$  UNCONFINED COMPRESSION ( $Q_u$ )  
 2" SHELBY TUBE ---  $\circ$  VANE TEST (C) AND SENSITIVITY (S)  
 2" SPLIT TUBE ---  $\circ$  NATURAL MOISTURE AND LIQUIDITY INDEX  
 2" DIA. CONE ---  $\times$  LIQUID LIMIT  
 2" SHELBY CASING ---  $\times$  PLASTIC LIMIT



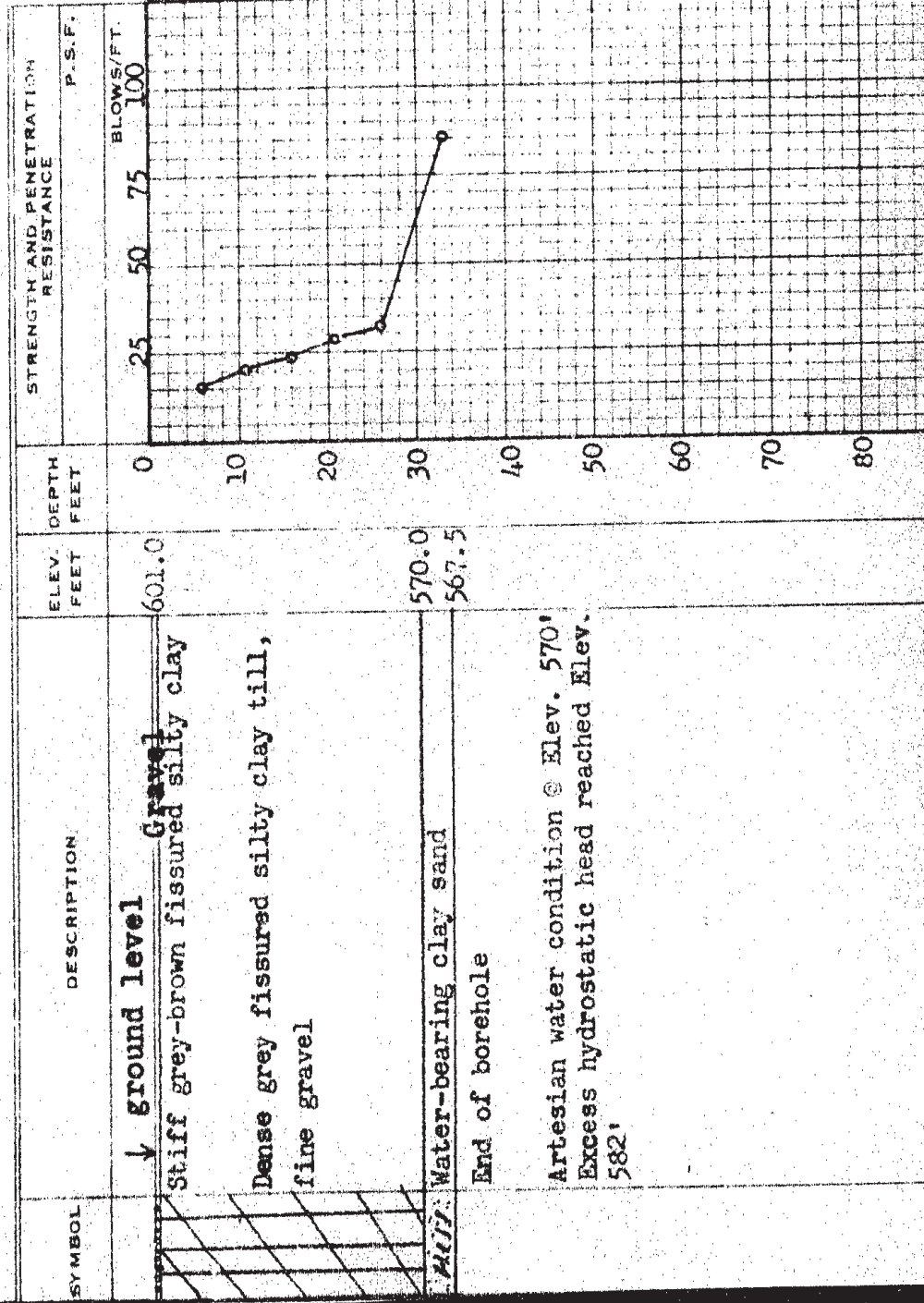
DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS AND RESEARCH SECTION

W.P. 82-59 BORE HOLE NO. 5  
JOB F 59-76 STATION See Drawing  
DATUM 601.0' COMPILED BY BK  
BORING DATE JULY 17/59 CHECKED BY A1

LEGEND

2" DIA. SPLIT TUBE  
2" SHELBY TUBE  
2" SPLIT TUBE  
2" DIA. CONE  
2" SHELBY  
CASING

1/2 UNCONFINED COMPRESSION (Qu) --- O  
VANE TEST (C) AND SENSITIVITY (S) --- +  
NATURAL MOISTURE AND LIQUIDITY INDEX --- LI  
LIQUID LIMIT --- X  
PLASTIC LIMIT ---



CONSISTENCY	SAMPLE	NATURAL UNIT WT. P.C.F.
MOIST. CONTENT - % DRY WT.		
10 20 30	S1	123.6
	S2	137.1
	S3	136.1
	S4	136.1
	S5	127.5
	S6	--

## Appendix C

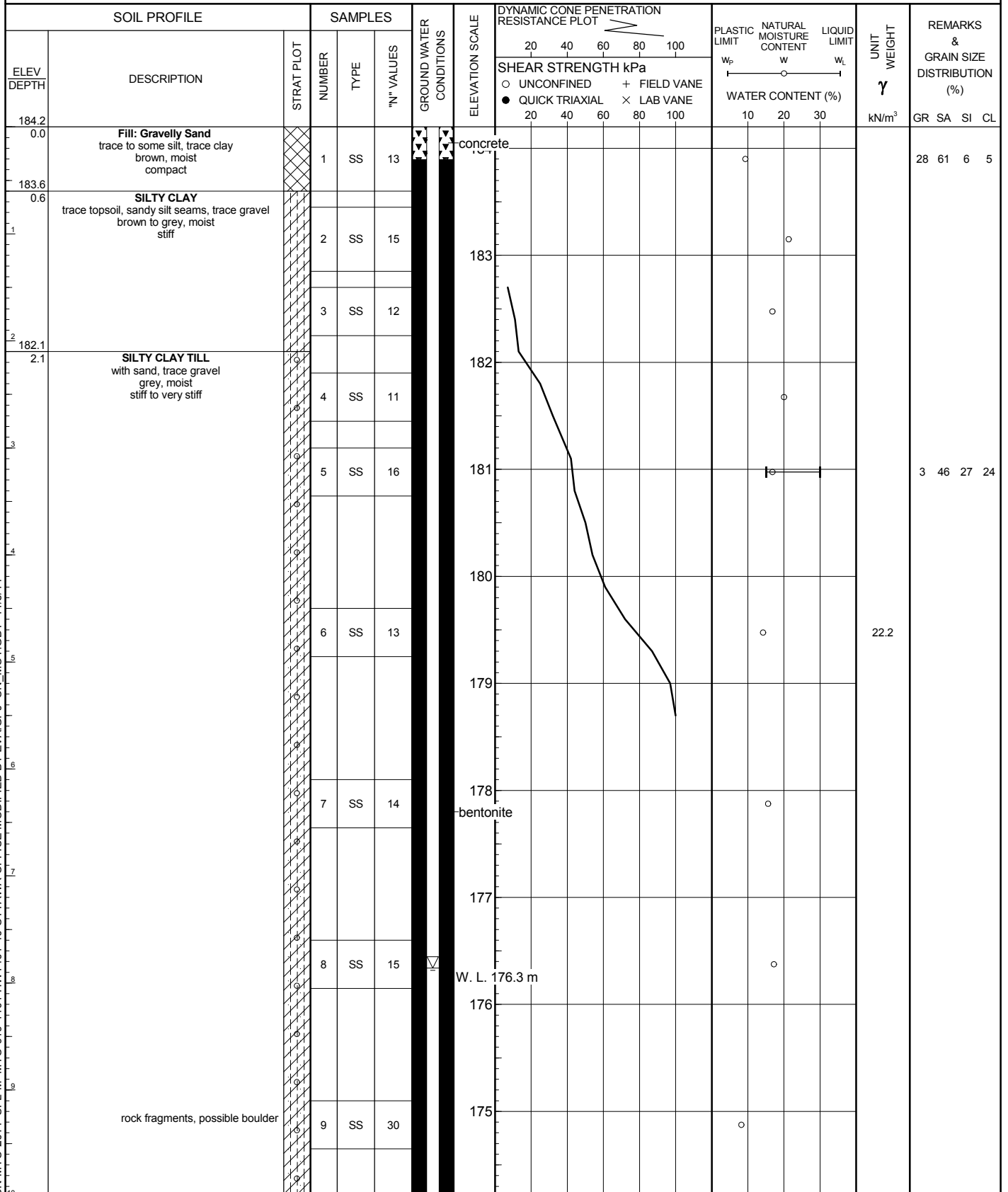
### Borehole Logs (Record of Borehole Sheets)



# RECORD OF BOREHOLE No BH13-238

METRIC 1 OF 4

W.P. 3093-09-00 LOCATION See Borehole Location Plan ORIGINATED BY PR  
 DIST West Region HWY 40 BOREHOLE TYPE Hollow Stem Augers/Rock Coring COMPILED BY NT  
 DATUM Geodetic DATE Aug/30/2011 CHECKED BY EP



Continued Next Page

## GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

919-1101

ON-MTO-2014 SPL-M-MTO-919-1101-HWY401-40-OTTAWA-OFFICE MODIFIED BY EVA.GPJ ON MOT.GDT 11/3/14

# RECORD OF BOREHOLE No BH13-238

**METRIC** 2 OF 4





W.P.	3093-09-00	LOCATION	See Borehole Location Plan	ORIGINATED BY	PR
DIST	West Region HWY 40	BOREHOLE TYPE	Hollow Stem Augers/Rock Coring	COMPILED BY	NT
DATUM	Geodetic	DATE	Aug/30/2011	CHECKED BY	EP

[illegible]

ON-MTO-2014 SPL-M -MTO-919-1101-HWY401-40-OTTAWA-OFFICE MODIFIED BY EVA.GPJ ON MOT.GDT 11/3/14

Continued Next Page

## GROUNDWATER ELEVATIONS

	1st	2nd	3rd	4th
Measurement				

+ 3, × 3: Numbers refer to Sensitivity      ○  $\epsilon=3\%$  Strain at Failure

919-1101



# RECORD OF BOREHOLE No BH13-238

METRIC 3 OF 4

W.P. 3093-09-00 LOCATION See Borehole Location Plan ORIGINATED BY PR  
 DIST West Region HWY 40 BOREHOLE TYPE Hollow Stem Augers/Rock Coring COMPILED BY NT  
 DATUM Geodetic DATE Aug/30/2011 CHECKED BY EP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE	× LAB VANE	20					40	60	80				
								20	40	60	80	100											

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

GROUNDWATER ELEVATIONS  
 Measurement 1st 2nd 3rd 4th

919-1101

ON-MTO-2014 SPL-M-MTO-919-1101-HWY401-40-OTTAWA-OFFICE MODIFIED BY EVA.GPJ ON MOT.GDT 11/3/14

# RECORD OF BOREHOLE No BH13-238

METRIC 4 OF 4

W.P.	3093-09-00	LOCATION	See Borehole Location Plan	ORIGINATED BY	PR
DIST	West Region HWY 40	BOREHOLE TYPE	Hollow Stem Augers/Rock Coring	COMPILED BY	NT
DATUM	Geodetic	DATE	Aug/30/2011	CHECKED BY	EP

SOIL PROFILE					SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>	GR	SA	SI	CL								
						○ UNCONFINED			● QUICK TRIAXIAL	+								×	FIELD VANE		LAB VANE				
	Notes: 1) Piezometer installed to 16.8m upon completion of drilling. 2) Water level in Piezometer																								
	Date                  Depth (m)                  Elevation (m)																								
	10/18/11                  7.86                  176.34																								

DN-MTO-2014 SPL-M -MTO-919-1101-HWY401-40-OTTAWA-OFFICE MODIFIED BY EVA.GPJ ON MOT.GDT 11/3/14

## GROUNDWATER ELEVATIONS

	1st	2nd	3rd	4th
Measurement				

+ 3, × 3: Numbers refer to Sensitivity      ○  $\epsilon=3\%$  Strain at Failure

919-1101

## Appendix D

### Explanation of Terms used in Report



## Explanation of Terms Used in the Record of Borehole

### Sample Type

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Dimension type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Spoon sample
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

### Penetration Resistance

#### Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in) required to drive a 50 mm (2 in) drive open sampler for a distance of 300 mm (12 in).

WH – Samples sinks under “weight of hammer”

#### Dynamic Cone Penetration Resistance, $N_d$ :

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in) to drive uncased a 50 mm (2 in) diameter, 60° cone attached to “A” size drill rods for a distance of 300 mm (12 in).

### Textural Classification of Soils

Classification	Particle Size
Boulders	> 200 mm
Cobbles	75 mm - 200 mm
Gravel	4.75 mm - 75 mm
Sand	0.075 mm – 4.75 mm
Silt	0.002 mm-0.075 mm
Clay	<0.002 mm

### Coarse Grain Soil Description (50% greater than 0.075 mm)

Terminology	Proportion
Trace	0-10%
Some	10-20%
Adjective (e.g. silty or sandy)	20-35%
And (e.g. sand and gravel)	> 35%

### Soil Description

#### a) Cohesive Soils(\*)

Consistency	Undrained Shear Strength (kPa)	SPT “N” Value
Very soft	<12	0-2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very stiff	100-200	15-30
Hard	>200	>30

(\*) Hierarchy of Shear Strength prediction

1. Lab triaxial test
2. Field vane shear test
3. Lab. Vane shear test
4. SPT “N” value
5. Pocket penetrometer

#### b) Cohesionless Soils

Density Index (Relative Density)	SPT “N” Value
Very loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

### Soil Tests

w	Water content
w <sub>p</sub>	Plastic limit
w <sub>l</sub>	Liquid limit
C	Consolidation (oedometer) test
CID	Consolidated isotropically drained triaxial test
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement
D <sub>R</sub>	Relative density (specific gravity, G <sub>s</sub> )
DS	Direct shear test
ENV	Environmental/ chemical analysis
M	Sieve analysis for particle size
MH	Combined sieve and hydrometer (H) analysis
MPC	Modified proctor compaction test
SPC	Standard proctor compaction test
OC	Organic content test
U	Unconsolidated Undrained Triaxial Test
V	Field vane (LV-laboratory vane test)
γ	Unit weight