

**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT  
PROPOSED MCGREGOR CREEK BRIDGE, NORTH WEST-BOUND ON RAMP  
HIGHWAY 40, NORTH OF HIGHWAY 401  
HIGHWAY 401/40 INTERCHANGE ONTARIO  
SITE NO. 13-524  
G.W.P. 3093-09-00**

**MTO GEOCREs NO. 40J8-53**

**Prepared for:**

**Ministry of Transportation Ontario**

**By:**

**SPL CONSULTANTS LIMITED**

Project: 919-1101 (13-524)  
December 2011



**SPL Consultants Limited**  
Geotechnical Environmental Materials Hydrogeology

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**PART A**  
**PRELIMINARY FOUNDATION INVESTIGATION REPORT**  
**PROPOSED MCGREGOR CREEK BRIDGE N-W RAMP**  
**HIGHWAY 40 NORTH OF HIGHWAY 401**  
**HIGHWAY 401/40 INTERCHANGE ONTARIO**  
**SITE NO. 13-524**

## **1.0 INTRODUCTION**

SPL Consultants Limited (SPL) was retained by the Ministry of Transportation to conduct a foundation investigation at the McGregor Creek Crossing (Site No. 13-524) located on Highway 40 north of Highway 401 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.

## **2.0 SITE DESCRIPTION**

The site is located where Highway 40 crosses McGregor Creek, north of Highway 401 in the Geographical Township of Harwich, County of Kent, Ontario. The crossing is situated on the generally flat terrain of the St. Clair Clay Plain.

The proposed structure will form part of the west-bound 401 on-ramp. It is understood it will cross McGregor creek immediately adjacent to the existing bridge (structure 13-168), or a single structure may carry both right of ways.

The existing structure at the creek crossing is a reinforced concrete single span rigid frame slab bridge. Site photographs are included in Appendix A.

## **3.0 INVESTIGATION PROCEDURES**

The foundation investigation was carried out in September 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 GEOCREs database includes the results of several previous investigations at the Highway 401/40 interchange including a previous investigation at the McGregor Creek crossing on Highway 40 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>GEOCREs No.</b>	<b>Location</b>
40J8-15	Highway 40 Underpass – Highway 401/40 Interchange
40J8-14	McGregor Creek Bridge – Highway 40 south of Highway 401
40J8-24	McGregor Creek Bridge – Highway 40 north of Highway 401 <sup>1</sup>
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 the report at the subject crossing).

The previous report for the subject bridge (40J8-24, dated 1960) includes four borehole records drilled as part of a proposed new (at that time) bridge over McGregor Creek. Two boreholes (BH1 and BH2) appear to have been drilled on the north side of the creek (roughly 60 m to 80 m north of the creek). BH1 was drilled to the west of the road and encountered 2.9 m of very loose to loose silt and sand, overlying dense grey till which extended to 11.9 m, below which a lens of coarse sand was encountered. BH2 was drilled on or near the existing (in 1960) road and encountered 3.1 m of fill, underlain by around 2 m of clay and alluvial deposits. These soils were underlain by silty till at a depth of approximately 5.6 m. The till extended to the depth of drilling at 11.9 m.

<sup>1</sup> Site of the current investigation

The other two boreholes (BH3 and BH4) were drilled in the creek. At these locations the boreholes encountered approximately 2.3 m to 2.7 m of alluvial soils, overlying till which extended to the depth of drilling at 8.2 m.

Project correspondence included with the file recommends the bridge structure be founded on spread footings within the clay till layer at or below 177.4 m elevation (582.0'). This is approximately 2.5 m below the ground surface at the time of the investigation. The actual foundation construction, however, cannot be confirmed based on the information available.

A copy of the 1960 geotechnical investigation is included in Appendix B of this report.

### **3.2 Field Investigation**

The foundation investigation for this site was carried out in September, 2011 and included drilling two boreholes at the existing bridge crossing. BH13-524 was drilled at the McGregor Creek crossing for the purposes of preparing this report. BH13-168 was drilled for the proposed new McGregor Creek crossing of Highway 40, however as it is understood that the new structure will be immediately adjacent to the existing bridge (13-168) it has also been included in this report. As mentioned previously, 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 boreholes were advanced using a truck-mounted drill rig supplied and operated by London Soil Test Ltd. of London, ON. The boreholes were advanced using hollow-stem auger drilling as well rock coring techniques (using "N" size triple tube core barrels) to a depth of 31.8 m and 31.1 m below the existing ground surface in BH13-168 and BH13-524, respectively. 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 both boreholes to allow for subsequent measurement of stabilized groundwater levels at the site. The boreholes were backfilled with bentonite and were sealed at the ground surface.

The borehole locations are 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 density, 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 relevant borehole logs in Appendix C. The results of plasticity testing are included on the borehole logs, and presented in the Plasticity Chart included as Drawing 3. The results of determination of grain size distribution are summarized on the borehole logs and are presented in Drawings 4 through 6.

## 4.0 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 Asphalt

Both boreholes were drilled on the shoulder of the existing highway. A layer of asphalt 100 mm to 125 mm thick was present at the ground surface.

#### 4.1.2 Fill

Immediately underlying the asphalt the boreholes (which were drilled on the north and south approach embankments) encountered a layer of fill material. The uppermost fill extended to a depth of 1.0 m and 0.6 m in BH13-168 and BH13-524, respectively and comprised very dense sand and gravel, which is inferred to be the pavement structure of the highway.

Grain size analysis was carried out on two samples of the granular fill (one from each side of the creek). The results are presented in Figure 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
BH13-168	SS1	34	59	7
BH13-524	SS11	32	58	10

Underlying this granular fill the remainder of the embankment fill includes firm to stiff (as inferred from SPT “N” values) clayey silt which extended to a depth of 1.8 m below the existing road surface at BH13-168 on the south side of the bridge/creek and 2.9 m at BH13-524 on the north side of the bridge/creek. Similar fine-grained fill was noted in BH-2 drilled in 1960 on Highway 40. Natural water contents in the clayey silt fill material were found to range from about 14% to 18%.

#### 4.1.3 Clay, Silt and Sand

Underlying the fill material a variable deposit of clay, silt and sand was encountered at most of the locations investigated.

In the four boreholes drilled in 1960 deposits of alluvial silt and sand were encountered in all four boreholes. Three of the boreholes (BH-1, BH-3 and BH-4) were drilled in the creek bottom and at these locations the thickness of the alluvial soils was found to be 2.3 m to 2.9 m thick. At BH-2 (drilled on the highway) similar soil was encountered below the fill embankment.

BH13-168 drilled on the south side of the existing structure as part of the current investigation encountered a deposit of stratified clayey silt and sand with trace gravel which extended from the base of the fill embankment to approximately 9.2 m below the existing ground surface. Only BH13-524 on the north side of the existing structure did not encounter this soil deposit.

Grain size analysis was carried out on one sample of the coarser soils within this deposit. The results are summarized in Table 3 below.

**Table 3 – Results of Grain Size Analyses for Silty Sand**

Borehole No.	Sample No.	Grain Size Distribution			
		% Gravel	% Sand	% Silt	% Clay
BH13-168	SS8	20	64	11	5

Based on SPT “N” values the soil deposit would be described as firm to stiff (cohesive soils) or loose to compact (cohesionless soils). A field vane test was carried out at BH13-168 within this layer and yielded an undrained shear strength of approximately 85 kPa, indicating a stiff consistency.

#### 4.1.4 Silty Clay/Clayey Silt Glacial Till

Underlying the upper stratified soils a thick deposit of clayey silt and silty clay till was encountered. The till extended to a depth of 21.4 m to 22.8 m depth in the boreholes drilled as part of this current investigation, to a depth of 11.9 m in the Borehole BH-1 drilled in 1960, and to the depth of drilling in the remaining three 1960 boreholes.

Based the results of in-situ and laboratory testing there is an upper till layer which extends to approximately 15 m to 17 m depth (in the boreholes drilled as part of this investigation) and a lower till unit which is typically stiffer and has a lower natural water content.

A layer of sand and gravel was encountered within the till layer from 15.2 m depth to 16.7 m depth in Borehole BH13-524. Sand layers were also encountered at a similar depth in BH-1 drilled in 1960. Sand lenses may be present at other locations as well.

The results of Atterberg limits (plasticity) testing on representative samples of the silty clay till yielded liquid limits of 20 to 40% and plasticity indices of 10 to 20% indicating a low to medium plastic silty clay (see Drawing 3). Natural water contents were typically around 20% above 15 m to 17 m depth and were around 10% below that depth.

The grain size distributions of selected samples of the silty clay till are presented in Drawing 4, and are summarized in Table 4 below.

**Table 4 – Results of Grain Size Analyses for Silty Clay/Clayey Silt Till**

Borehole No.	Sample No.	Grain Size Distribution			
		% Gravel	% Sand	% Silt	% Clay
13-168	SS13	4	32	33	31
13-168	SS15	4	47	32	17
13-524	SS5	2	34	37	27
13-524	SS9	3	23	42	32
13-524	SS14	4	58	22	16

Measurements of unit weight carried out on samples of the silty clay till obtained in both the current and 1960 investigation yielded values of 20.8 kN/m<sup>3</sup> to 22.6 kN/m<sup>3</sup>.

SPT “N” values measured during the current investigations are generally between 10 and 20 in the upper 15 m to 16 m of the deposit (indicating a stiff to very stiff consistency) and between 30 and 50 below that depth (indicating a very stiff to hard consistency). A field vane test was carried out at BH13-524 within the till and yielded an undrained shear strength of 100 kPa, indicating a stiff to very stiff consistency. Laboratory undrained shear strengths presented in the 1960 investigation for the upper till range from 85 kPa to 150 kPa (which again would be considered stiff to very stiff).

#### 4.1.5 Sand and Gravel

The glacial till is underlain by a layer of compact to dense sand and gravel, which was encountered in the both of the boreholes drilled as part of the current investigations. The sand and gravel was encountered



at 21.4 m and 22.8 m depth in Boreholes BH13-168 and BH13-524, respectively and ranged in thickness from 4.2 m to 4.4 m.

Heaving and flowing conditions were encountered in this layer and drilling was found to be relatively difficult. SPT testing could not be carried out in this layer due to the heaving/flowing sand.

#### 4.1.6 Bedrock

Bedrock was encountered at 25.9 m and 27.0 m depth (159.1 m and 159.4 m elevation) in Boreholes BH13-168 and BH13-524. At Borehole BH13-168 the rock was augered from 25.9 m to 29.0 m at which point auger refusal was encountered. At Borehole BH13-524 the rock could be augered from 27.0 m to 28.0 m before auger refusal was encountered.

At both locations the boreholes were cored using “N” size coring equipment from that depth. Approximately 100% recovery was obtained during coring. 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 range from 74% to 100%, indicating good to excellent quality rock.

## 4.2 Groundwater Conditions

Standpipe piezometers were installed in both of the boreholes drilled as part of the current investigation. The groundwater elevation at the site was measured in October 2011 and found to be at 10.0 m and 11.6 m depth in Boreholes BH13-168 and BH13-524, respectively. These depths correspond to 175.0 and 174.8 m elevation. Groundwater levels were obtained in some boreholes drilled in the creek in the 1960 investigation and were similar to the level of the creek at the time (which is approximately 5 m higher than the groundwater levels measured in the till during the current investigation).

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, and in particular for this site in response to sustained changes in the level of the creek. If construction is carried out at a time when the creek level is higher than the level at the time of the foundation investigation, a corresponding increase in groundwater levels should be anticipated.

## 4.3 Summary

A summary of the soil and groundwater conditions encountered at the McGregor Creek crossing location is presented in Table 5 below.<sup>2</sup>

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<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.

**Table 5 – Simplified Stratigraphy and Groundwater Elevations**

BH No.	Elev.	Simplified Stratigraphy (Depth, m)						Ground Water Elevation
		Asphalt & Granular Fill	Silt & Clay Fill	Clay, Silt & Sand	Silty Clay / Clayey Silt Till	Sand & Gravel	Shale Bedrock	
13-168 (2011)	185.0	0.0 – 1.0	1.0 – 5.0	5.0 – 9.2	9.2 – 21.4	21.4 – 25.9	25.9 – 31.8	175.0 m
13-524 (2011)	186.4	0.0 – 0.6	0.6 – 2.9	--	2.9 – 22.8 <sup>1</sup>	22.8 – 27.0	27.0 – 31.1	174.8 m
BH-1 (1960)	180.3	--	--	0.0 – 2.9	2.9 – 11.9	11.9 – 13.7	--	179.9 m
BH-2 (1960)	182.6	--	0.0 – 3.0	3.0 – 5.6	5.6 – 11.9	--	--	180.1 m
BH-3 (1960)	179.4	--	--	0.0 – 2.3	2.3 – 9.3	--	--	--
BH-4 (1960)	179.6	--	--	0.0 – 2.4	2.4 – 7.6	--	--	--

<sup>1</sup>Includes a layer of sand and gravel from 15.2 m to 16.7 m depth.

## 5.0 CLOSURE

Field investigations for this project were supervised by Naeem Ehsan, P.Eng. This report was prepared by 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.




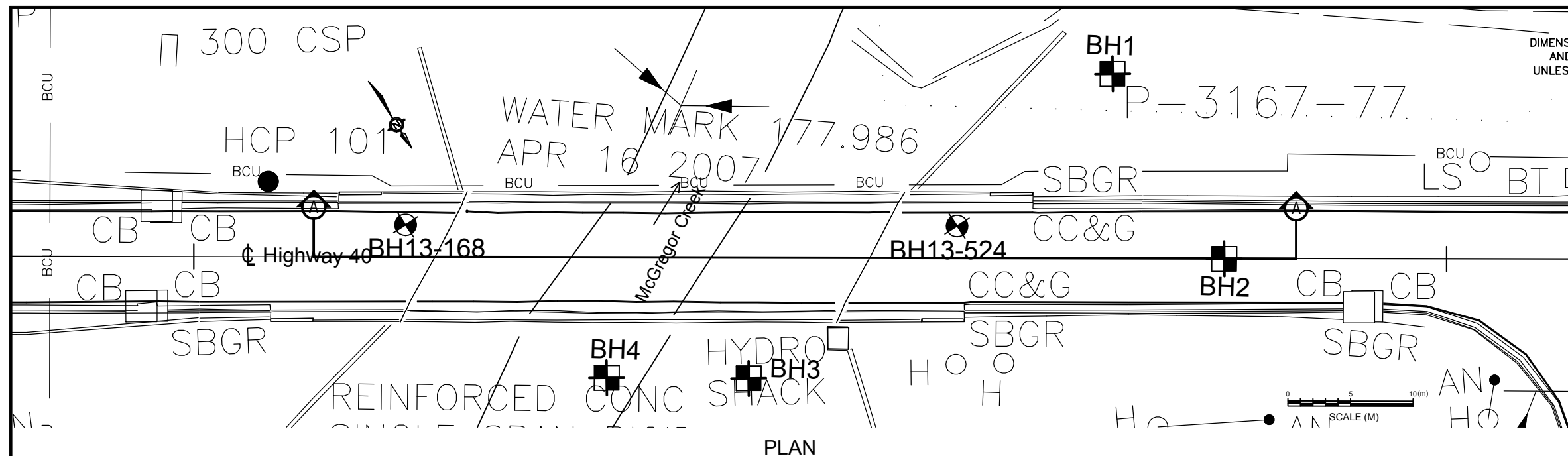

Shaheen Ahmad, M.A.Sc., P.Eng.



# Drawings



Client: Ministry of Transportation Ontario		Title: SITE PLAN		Project: Foundation Investigation Structure 13-524, Hwy 40 & Hwy 401	
Date: DEC 12, 2011	Drawn: NT	Scale: N/A	Project No.: 919-1101	 <b>SPL Consultants Limited</b> Geotechnical • Environmental • Materials • Hydrogeology	
Original Size: LETTER	Approved: CH	Rev: N/A	Drawing No.: 1		

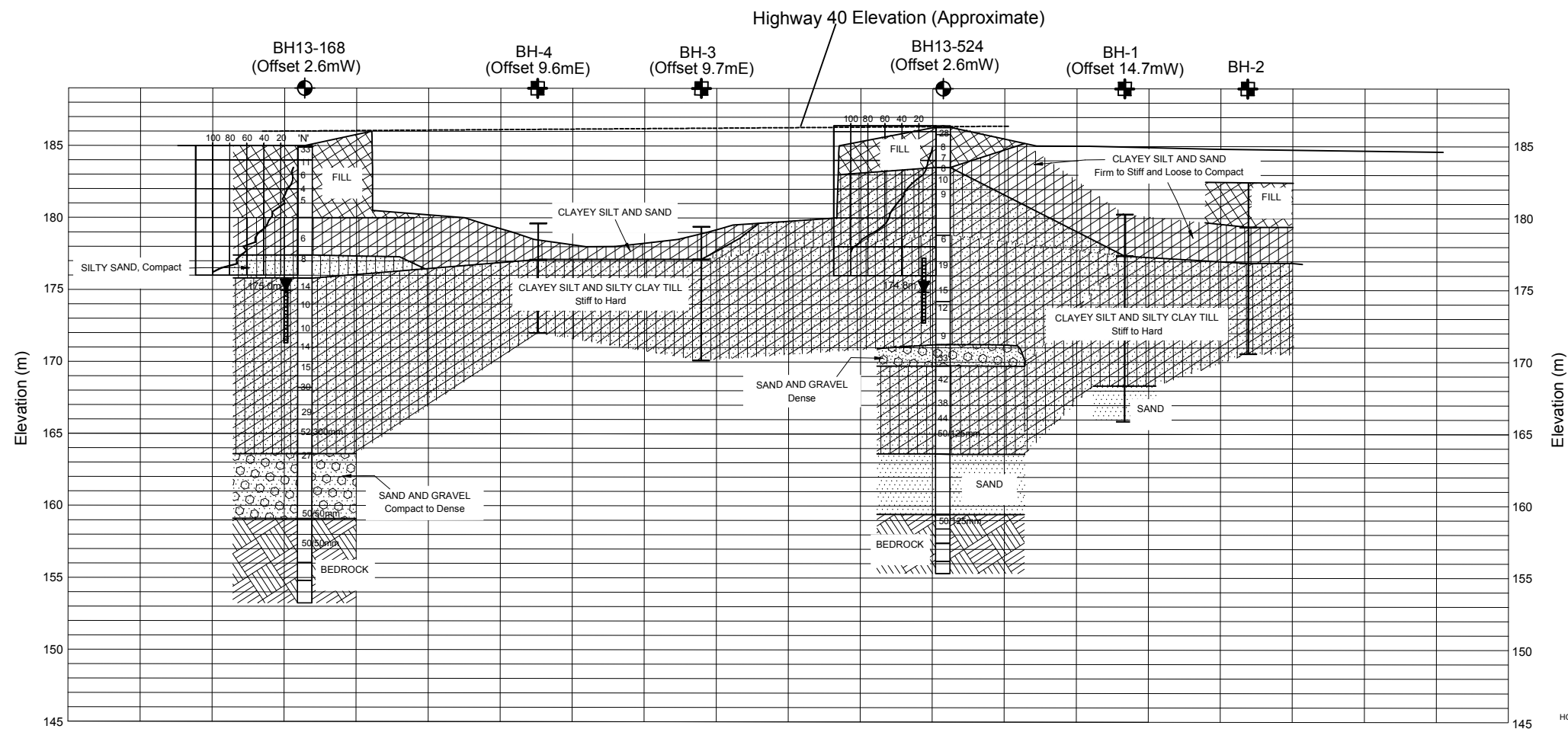


CONT No  
WP No 3093-09-00

McGregor Creek  
Bridge Widening  
Highway 40 North of 401  
BORE HOLE LOCATIONS & SOIL STRATA

SPL Consultants Limited  
Geotechnical • Environmental • Materials • Hydrogeology

KEY PLAN  
NOT TO SCALE



CROSS-SECTION A-A'

SOIL STRATA SYMBOLS

- GRANULAR FILL
- CLAYEY SILT AND SILTY CLAY TILL
- SAND AND GRAVEL
- SILTY SAND
- CLAYEY SILT AND SAND
- SAND
- BEDROCK

LEGEND

- Bore Hole Drilled in 2011
- Bore Hole drilled in 1960
- 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	ELEV:	NORTHING	EASTING
13-168	185.0	4693806	338175
13-524	186.4	4693830	338138

NOTES

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

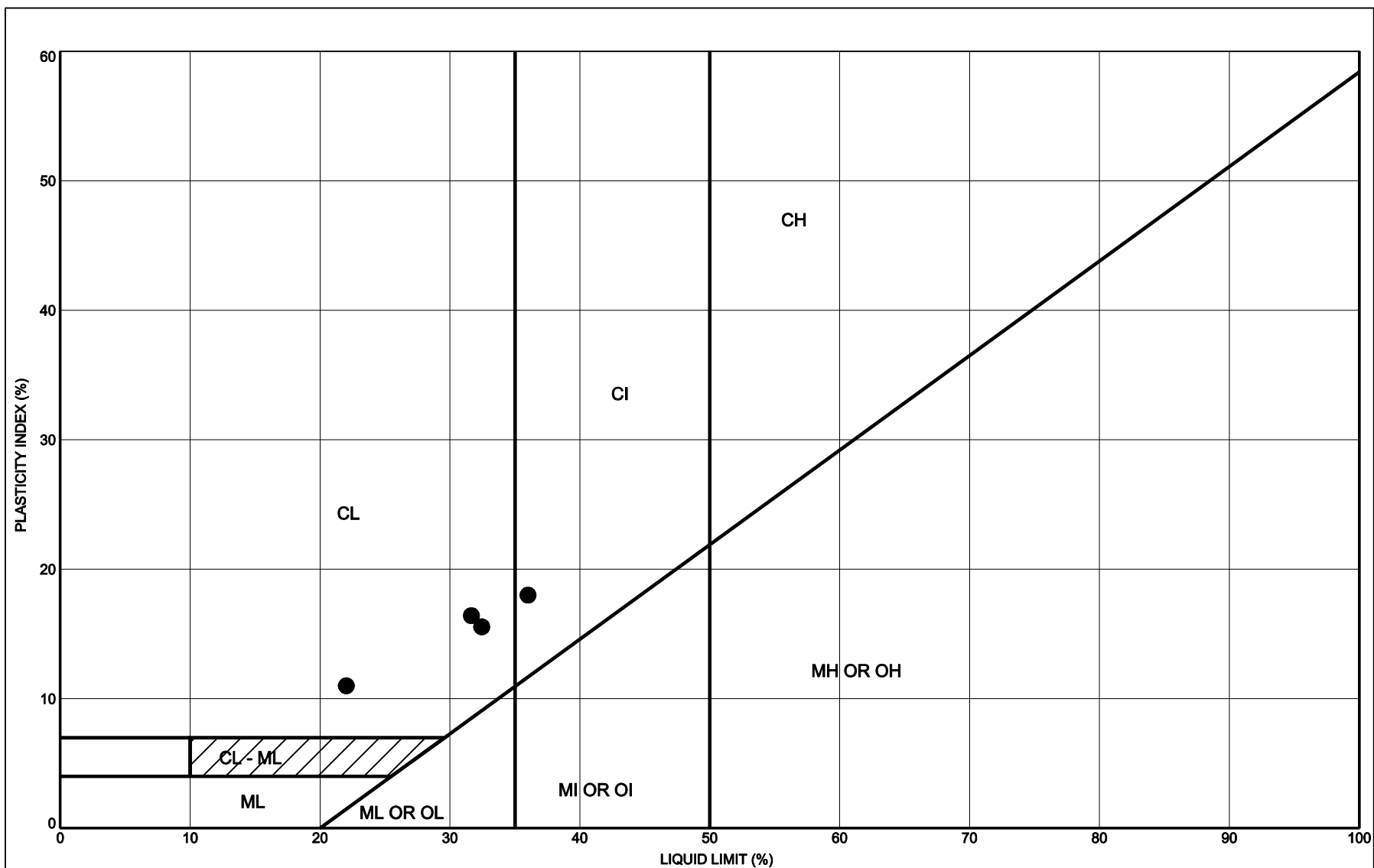
Locations and Elevations of Boreholes Drilled in 1960 are approximate only and have not been verified.

REVISIONS

DATE	BY	DESCRIPTION
Dec.16, 2011	PR	Final Revision

GEOCRES No 40J8-56

HWY No 401	SUBM'D CH	CHECKED CH	DATE Dec.16, 2011	DIST Chatham
DRAWN PR	CHECKED CH	APPROVED FZ	SITE 13-524	DWG 2



Client: **Ministry of Transportation Ontario**

Title: **PLASTICITY CHART - SILTY CLAY TILL**

Date: **DEC 12, 2011**

Drawn: **NT**

Scale: **N/A**

Project No.: **919-1101**

Original Size: **LETTER**

Approved: **CH**

Rev: **N/A**

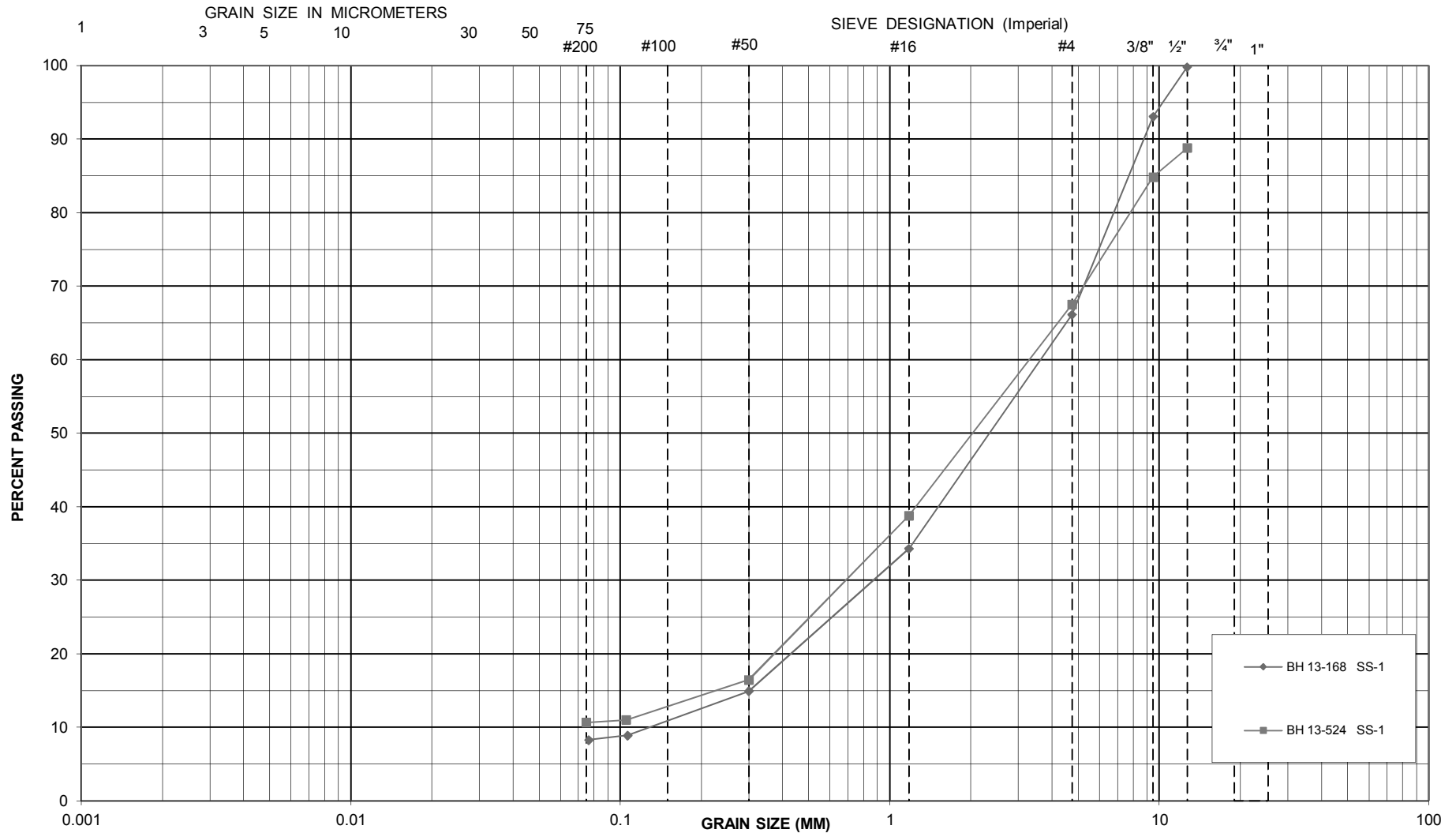
Drawing No.: **3**

Project: **Foundation Investigation  
Structure 13-524, Hwy 40 & Hwy 401**

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

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



**SPL Consultants Limited**  
Geotechnical Environmental Materials Hydrogeology

**GRAIN SIZE DISTRIBUTION - GRANULAR FILL**  
Structure 13-524, Hwy 401 & Hwy 40, Chatham, Ontario

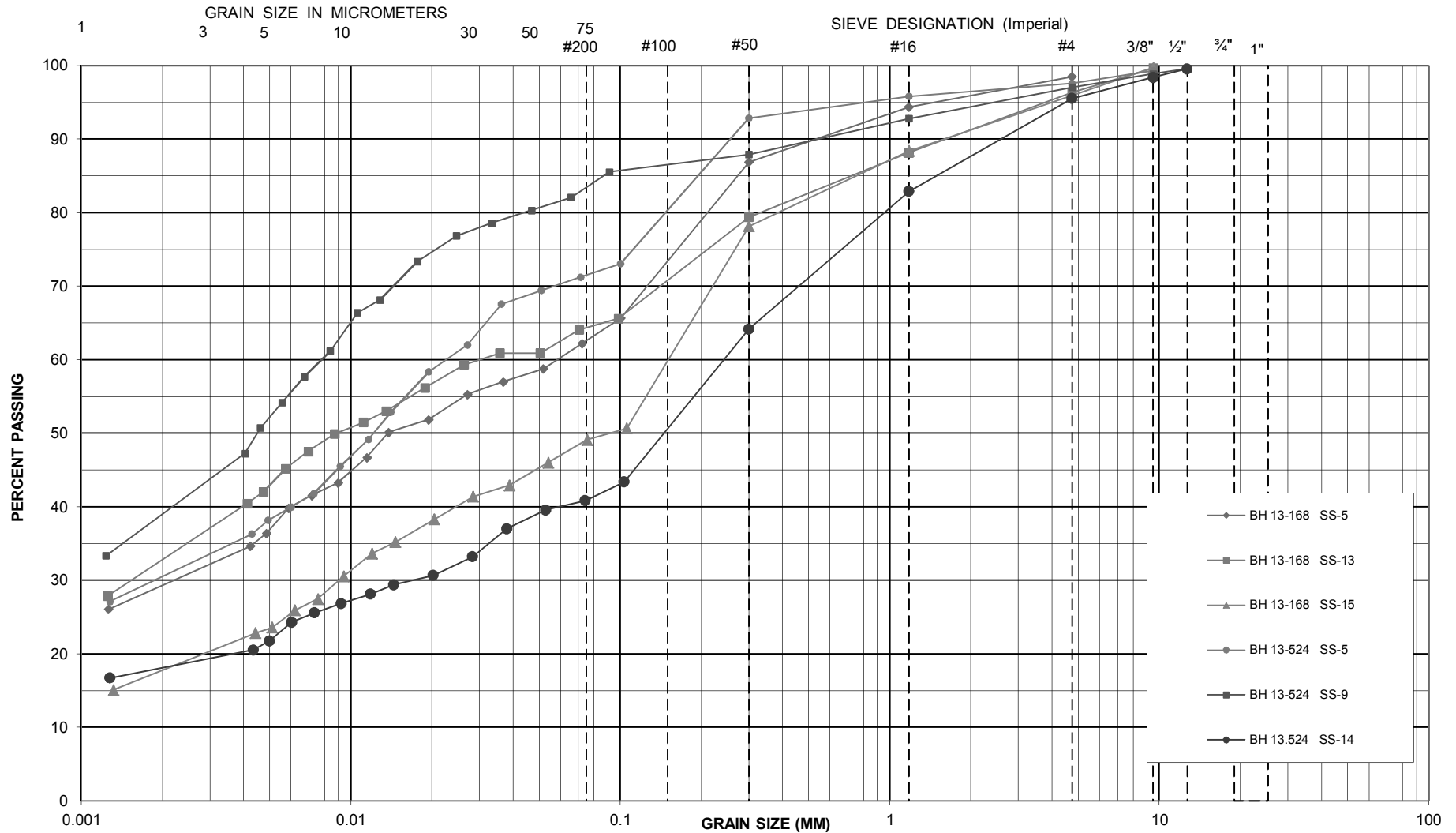
Drawing No: 4

Project No. 919-1101

Date : December 2011

# UNIFIED SOIL CLASSIFICATION SYSTEM

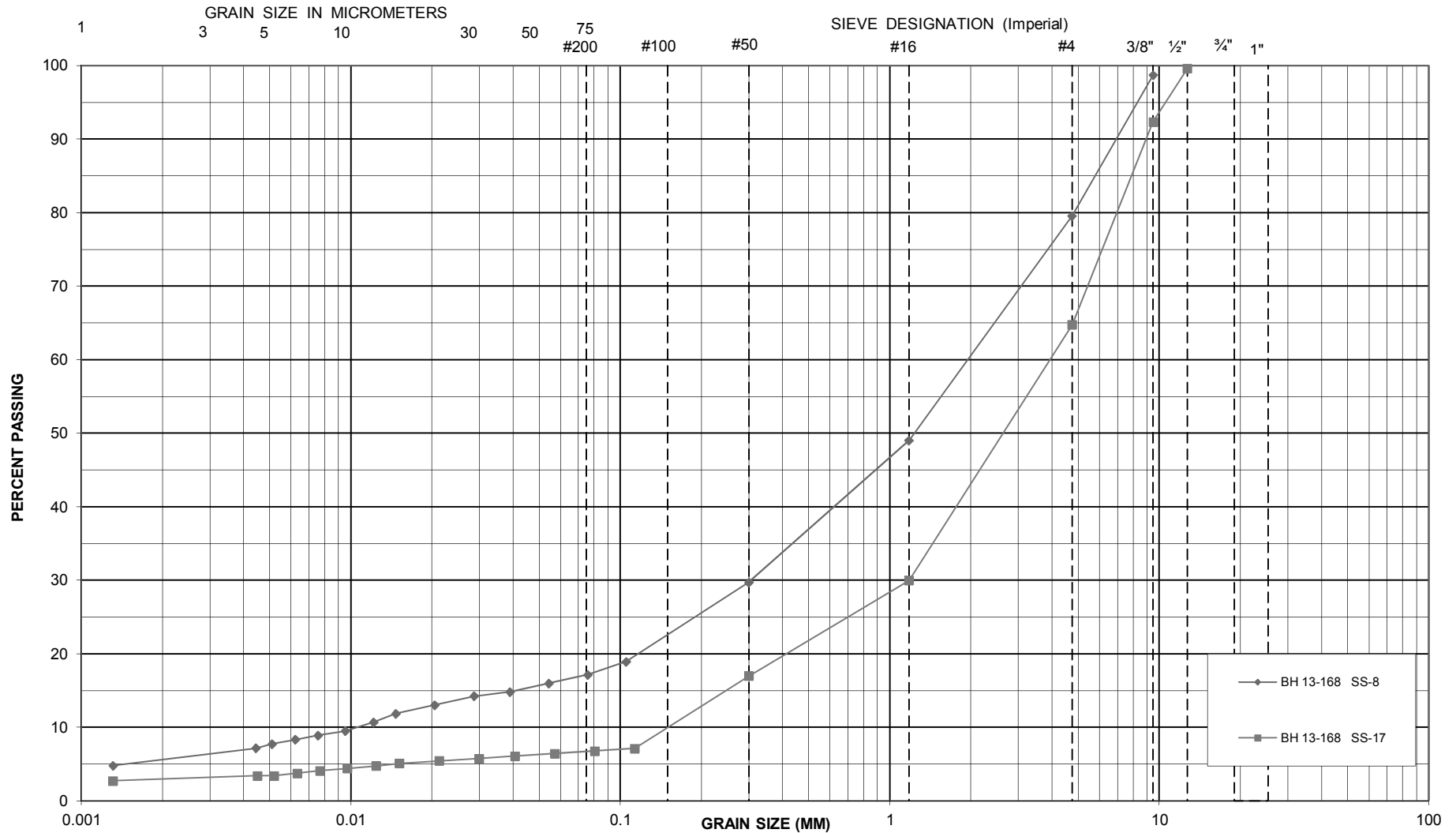
CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse





# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



**SPL Consultants Limited**  
Geotechnical Environmental Materials Hydrogeology

**GRAIN SIZE DISTRIBUTION - SAND**  
Structure 13-524, Hwy 401 & Hwy 40, Chatham, Ontario

Drawing No: 6

Project No. 919-1101

Date: December 2011

# Appendix A

## Site Photographs



Highway 40 over McGregor Creek (north of 401), facing south.



Highway 40 over McGregor Creek (north of 401), facing north.



Highway 40 over McGregor Creek (north of 401), facing south.

## Appendix B

### Previous Geotechnical Investigation

#60-F-228

W.P. # 303-59

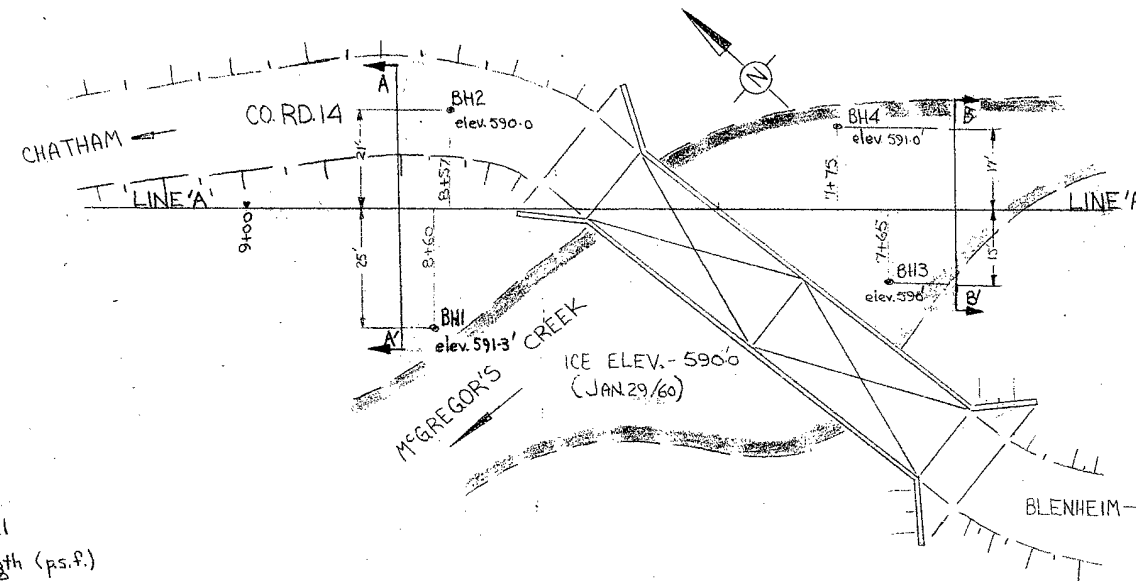
KENT CTY. RD. #14

PROP. BRIDGE

CROSSING

McGREGOR CR.

4038 E



# LEGEND:

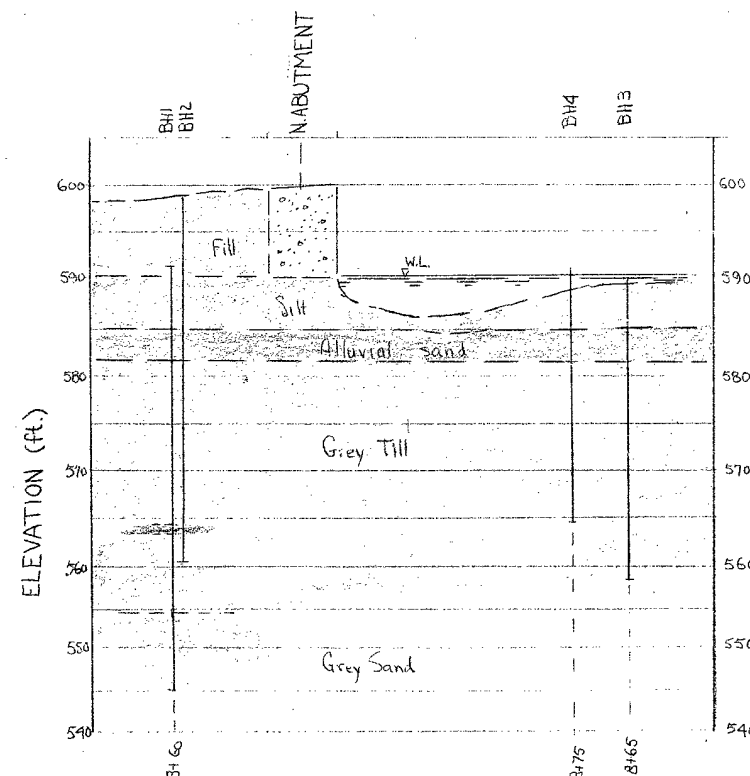
- BHL Bore hole
- WL — Free water table level
- Cv Insitu vane shear strength (p.s.f.)
- ELEVATION - Geodetic datum

## SOILS LEGEND:

- Road fill: clay, grey till, gravel, sand etc.
- Coarse grey silt (some brown d top), some sand, some organic material, iron stained.
- Loose, med., dark grey alluvial sand, some white calcareous material, traces of organic fibre.
- Med. dense grey till, predom. silt, some clay, some med. to fine sand, black shaly gravel.
- Loose coarse sand & gravel, predom. black shale.
- Dense coarse grey sand, almost stratified.

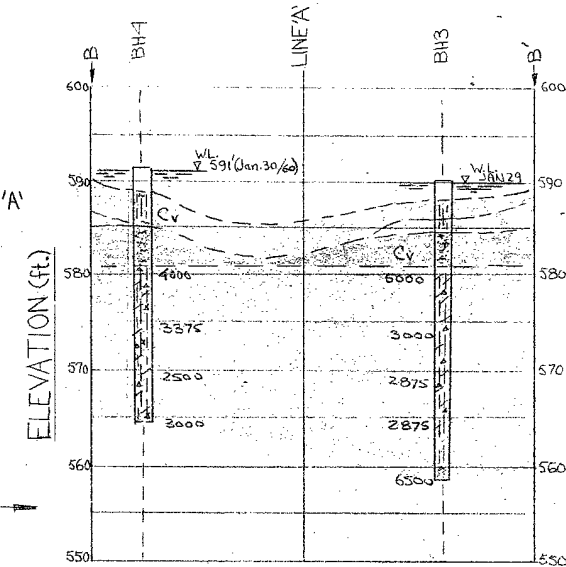
## LOCATION OF BOREHOLES

SCALE 1"=20'



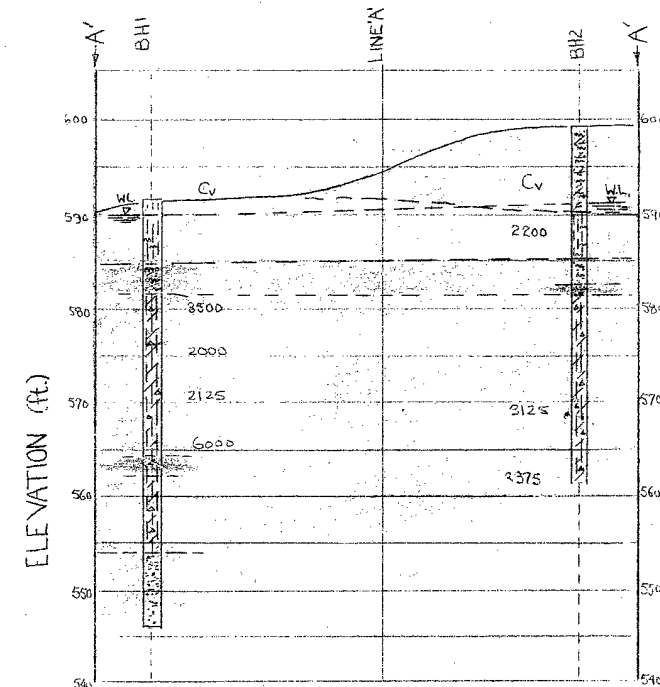
## SUBSURFACE PROFILE ALONG LINE 'A'

HORIZONTAL SCALE 1"=20'  
VERTICAL SCALE 1"=10'



## SUBSURFACE SECTION ALONG B-B'

SCALE 1"=10'



## SUBSURFACE SECTION ALONG A-A'

SCALE 1"=10'

ONTARIO DEPARTMENT OF HIGHWAYS  
MATERIALS & RESEARCH SECTION

M<sup>c</sup> GREGORS CREEK BRIDGE - KENT CO. RD. 14  
HARWICH TWP. BET'N. CONI-ECR & CONI(WCR)-LOT 26  
WP-303-59

DOMINION SOIL INVESTIGATION LTD.  
TORONTO  
FIELD SUP-PL. JOB NO. 60-106 FEB 18/60 ENCL. #1



ONTARIO  
DEPARTMENT OF HIGHWAYS

**Memo to** Mr. A. W. Toye, **Date** April 22, 1960.  
Bridge Engineer. **Subject** FOUNDATION INVESTIGATION -- by  
**From** Materials & Research Section. Dominion Soil Investigation, Ltd

Attention: Mr. S. McCombie.

Re: Proposed Bridge Across McGregor Creek,  
Kent County Rd. 14, Harwich Township,  
Conc. I, Lot 26, District No. I,  
W.P. 303-59.

We have reviewed the above mentioned Report submitted by Dominion Soil Investigation, Ltd., and have found the conclusions and recommendations in the report not adequate and, in some instances, the interpretation misleading.

By reviewing the field data, we have come to the conclusions which we suggest for you to follow in future design work:-

1. Spread footings should be used for the structure. The foundation elevation should be 582.0' - i.e., footings should be placed on top of the medium dense grey till material.
2. The allowable nett bearing capacity at the above mentioned elevation can be taken as 3.0 T/sq.ft.  
(Average unconfined compression strength = 4,500 p.s.f.)  
(Average shear strength by field vane .. = 4,000 p.s.f.)
3. Anticipated settlements will be in the order of 2 inches over a longer period of time (some 20 - 30 years). It is not expected that detrimental (greater than 3/4") differential settlement would occur.

cont'd. /2 ...



Recommendations: (cont'd.) ...

4. Settlements due to the placement of the approach embankment will take place within a short period of time, because of the silty character of the material below. Some differential settlements of the embankment must be expected because of some interbedded clay layers.

Should any queries arise with respect to the contents of the Consultant's report, or our foregoing comments, we would be pleased to discuss these further, with you.

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

Per:



(A. Stermac,  
FOUNDATION OFFICE ENGINEER)

AS/MdeF  
Attach.

cc: Messrs. A. M. Toye (2)  
H. A. Tregaskes  
D. G. Ramsay  
A. Gater  
G. U. Howell  
J. Roy  
A. Watt  
Foundations Office  
Gen. Files.

Department of Highways Ontario  
Materials and Research Section  
Downsview Ontario

REPORT ON  
FOUNDATION INVESTIGATION  
PROPOSED BRIDGE ACROSS MCGREGOR CREEK  
KENT COUNTY RD. 14 - HARWICH TWP. CONC. 1, LOT 26  
WP-303-59

Submitted by:  
DOMINION SOIL INVESTIGATION LTD  
88 Bglinton Ave. E.  
Toronto 12 Ontario  
April 1960

# DOMINION SOIL INVESTIGATION LTD.

SOIL MECHANICS • FOUNDATION ENGINEERING

TORONTO 12, ONTARIO

FOUNDATION INVESTIGATION FOR  
PROPOSED BRIDGE ACROSS MCGREGOR CREEK  
KENT COUNTY ROAD 14  
HARWICH TOWNSHIP  
CONCESSION 1, LOT 26  
WP-303-59

## INTRODUCTION

Authorization was received from the Department of Highways, Materials and Research Section, to investigate soil condition for a proposed bridge foundation. The proposed bridge will span across McGregor Creek to serve the future Kent County Road 14. It is located near Kent Centre, Ontario.

This report presents:

- (1) An account of field tests and - work
- (2) Laboratory tests and data sheets with results of tests
- (3) Interpretation of results, and
- (4) Recommendations.

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4. DESCRIPTION OF SUBSOIL. . . . .	3
5. RECOMMENDATIONS . . . . .	4

## ENGINEERING DATA SHEETS

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Borehole Logs . . . . .	Encis. 2 -	7
Subsurface Section . . . . .	Enclosure	8
Summary of Lab Test Results . . . . .	Enclosure	9
Stress & Capacity Distribution Graphs . . . . .	Enclosure	10

## 1. DESCRIPTION AND GEOLOGY OF THE SITE

There is an existing concrete and steel bridge over McGregor Creek which serves the present county road. In the future this road will be relocated, the creek diverted and a new bridge constructed (about 65' long). The present span is about 95' long and shows no visible sign of settlement.

### Geology

McGregor Creek flows slowly and meanders to the north where it empties into the Thames River at Chatham. The creek is slowly dissecting the flat Wisconsin clay till sheets of the area. Floods occur in the spring and fall creating a broad silty alluvial flood plain in the creek valley. The soil has poor ability to absorb moisture. The banks of the valley are not well wooded. A lack of boulders was also noted in the creek valley. which is shallow (about 10 feet) and broad (about 100 feet) at the site.

This flat Wisconsin plain, general elevation in the area is 600<sup>±</sup> above sea level, is underlain by stratified sands occurring at about elevation 522<sup>±</sup>.

## 2. DRILLING PROGRAM

Drilling was carried out between 27-30th January, 1960. Conventional washbore drilling was used. Elevations at every borehole were established by an engineering level. Existing bridge dock was used as benchmark. Holes were located by chainage stations along line 'A' from data supplied by D.H.O.

Water level in the creek changed rapidly due to melting ice, thus cribbing was placed on the bottom of the creek to serve as a platform for the drill. Changing water level made it impossible to place the holes three and four in their proposed positions, hence they were offset.

## 2. DRILLING PROGRAM - Continued

Sampling was carried out at regular intervals (see data sheet). Disturbed samples in the 2" split spoon and undisturbed ones in 2" shelly tubes were taken where necessary.

Vane shear tests were carried out in the clay materials of all four boreholes.

### LABORATORY TESTS

Laboratory tests were carried out and following values determined:

- (a) Natural moisture contents
- (b) Unconfined compression strength of undisturbed samples
- (c) Sensitivity
- (d) Liquid limits
- (e) Dry unit weight
- (f) Consolidation test was attempted to determine settlement factor. However, considerable gravel content made it impossible. Details of above tests are enclosed in enclosure #9.

## 4. DESCRIPTION OF SUBSOIL

From samples of subsurface materials, six soil formations were classified. A detailed description of all samples and field tests may be found on "Bore Hole Log Sheets".

### (a) Road Fill and Top Soil

Fill and top soil was found only in borehole #2 which penetrated the existing roadbed.

Fill material is highly ironstained and oxydized. It consists of clay and sand with added gravel.

Underlying the fill in borehole #2 is a 4 foot layer of sensitive (sensitivity = 6) blue clay with shear strength about 2200 p.s.f. This was determined from vane tests at elevation 587 feet.

(b) Grey Silt

Grey Silt is the surface material of McGregor Creek's flood plain, and forms the creek bed. Average thickness of this layer is about 4'. It is easily eroded.

(c) Dark Grey Sand

This about 3' thick layer, is well graded, but easily disturbed. Organic material seems to be distributed throughout the layer together with calcareous particles. Underlying this layer is 1' layer of water-bearing gravel, a possible former river bed.

(d) Grey Clay Till

This layer is medium dense. Silt content is increasing with depth. It extends from elevation 582'± in the creek valley where boreholes were taken.

At elevation 564' about a 2' thick lense of gravel was dissected in borehole #1 only.

Grey clay till in general has quite uniform physical properties. Low sensitivity (its value = 1 to 2) is prevalent, except in borehole #4 where a sensitivity of 8 was found.

Unconfined compression strength ranged from 6460 p.s.f. at elevation 580' to 3550 p.s.f. at elevation 571.5'.

(e) Grey Sand

This layer underlying till (see paragraph d) is a coarse-grained dense material. It is stratified. Resistance to penetration test rose to 49 blows per foot. Grey sand continues down from elevation 552'. At elevation 544' the drilling was stopped.

(f) Bedrock

Bedrock in this area is estimated to be about 90' below ground surface. It is a flatlying fissile black shale from Kettle Point Devonian.

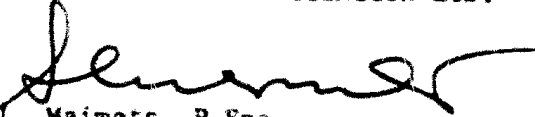
## 5. RECOMMENDATIONS

Footings could be placed on grey till at elevation 580' or below. Bearing capacity of 6170 p.s.f. was found at top of till based on unconfined compression test for 10' x 30' footing. However in borehole #4 high sensitivity (about 8) and a natural moisture content (about 18) was found. A consolidation test could not be performed because of gravel content. Due to difference in sensitivity in various boreholes a high differential settlement could be expected, thus spread or strip footings are not suitable.

For pile foundation no endbearing strata was encountered at elevations explored. High sensitivity in hole #4 outrules friction type of pile foundation. Organic content can also be considered detrimental to steel H-piles.

A culvert type of structure is most suitable for the location. Due to long span (about 65') a twin or triple culvert can be most advantageously used. Maximum bearing capacity of the soil from unconfined compression test was found to be 4080 p.s.f. for 25' x 65' culvert.

DOMINION SOIL INVESTIGATION LTD.

  
L. Maimets, P.Eng.



Order No. 60-106

Prep. By P.L.

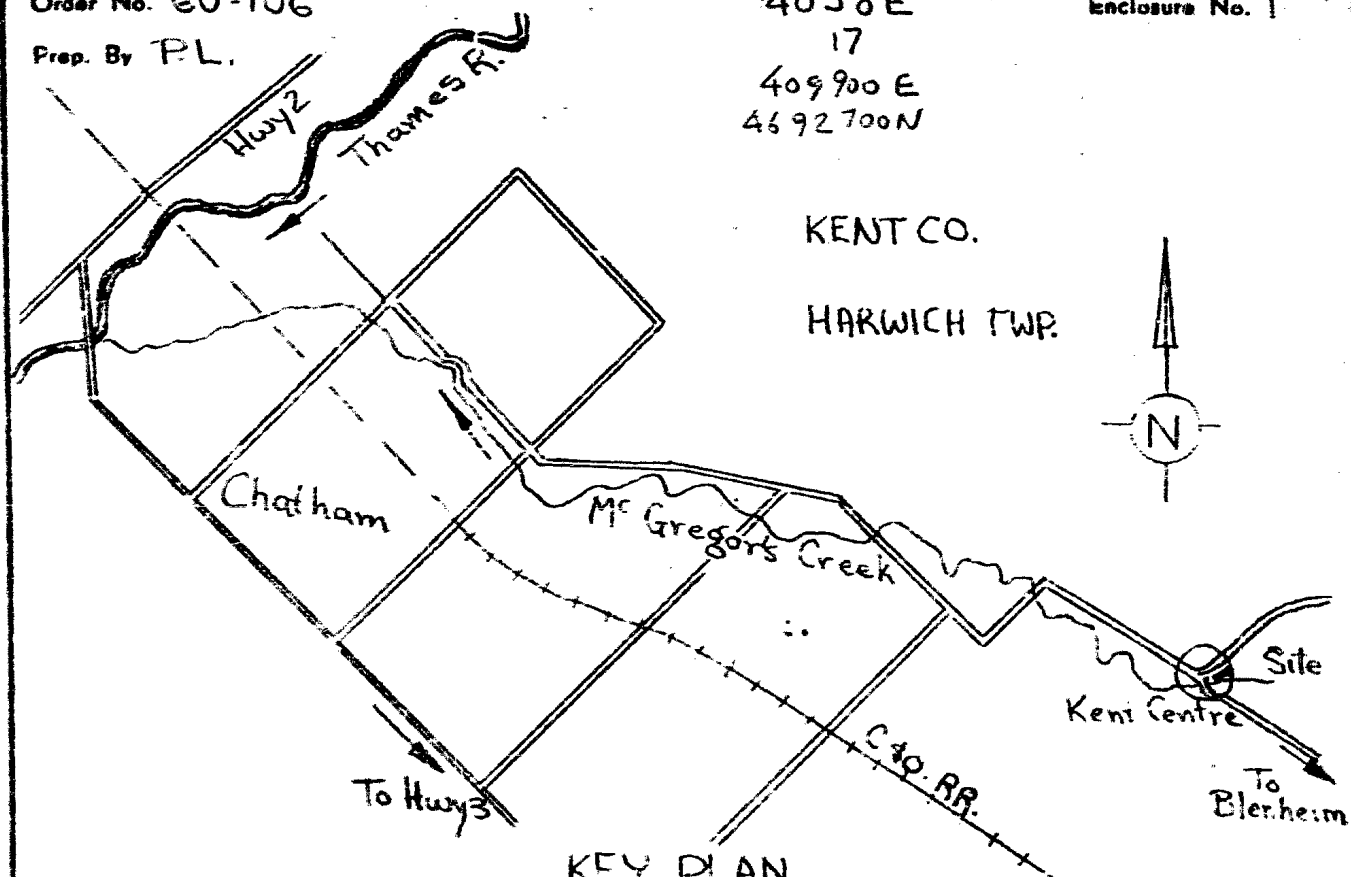
4038 E

17

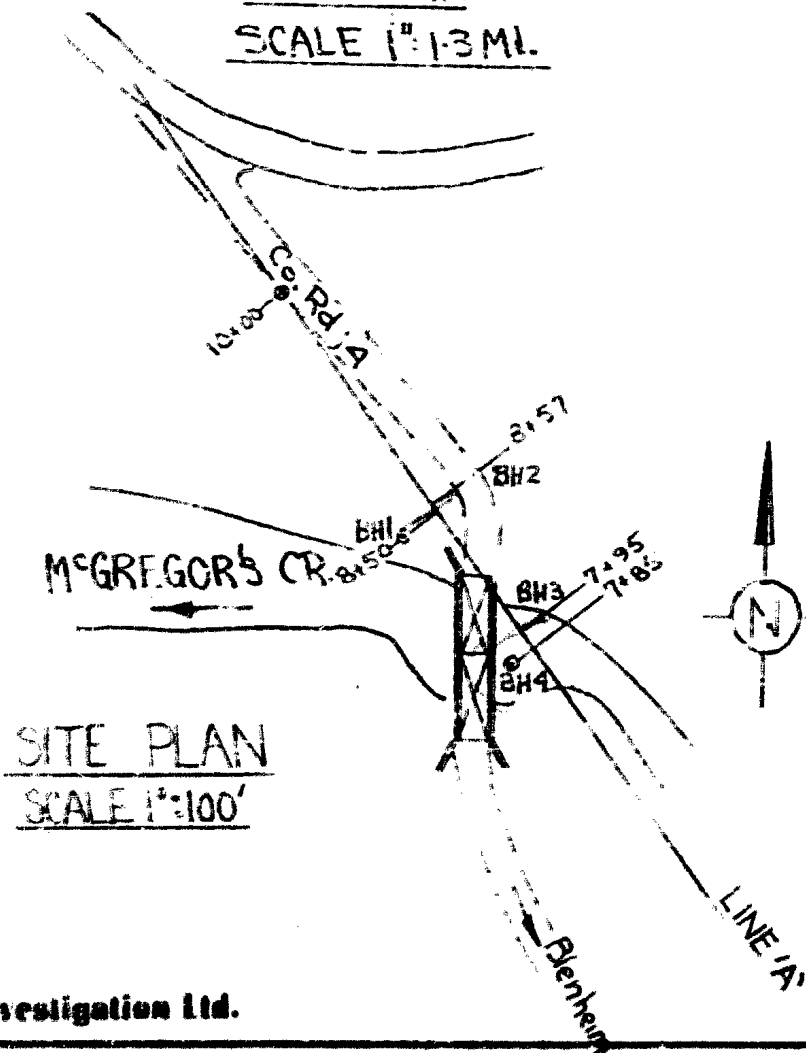
409900 E

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Enclosure No. 1



KEY PLAN  
SCALE 1"=13 MI.



SITE PLAN  
SCALE 1"=100'

## Dominion Soil Investigation Ltd.

## Dominion Soil Investigation Ltd.

Engineering Data Sheet for Borehole:

Engineering Data Sheet for Borehole: 1 of 4 - Sheet 1 of 2

Date: Jan. 27, 1960.

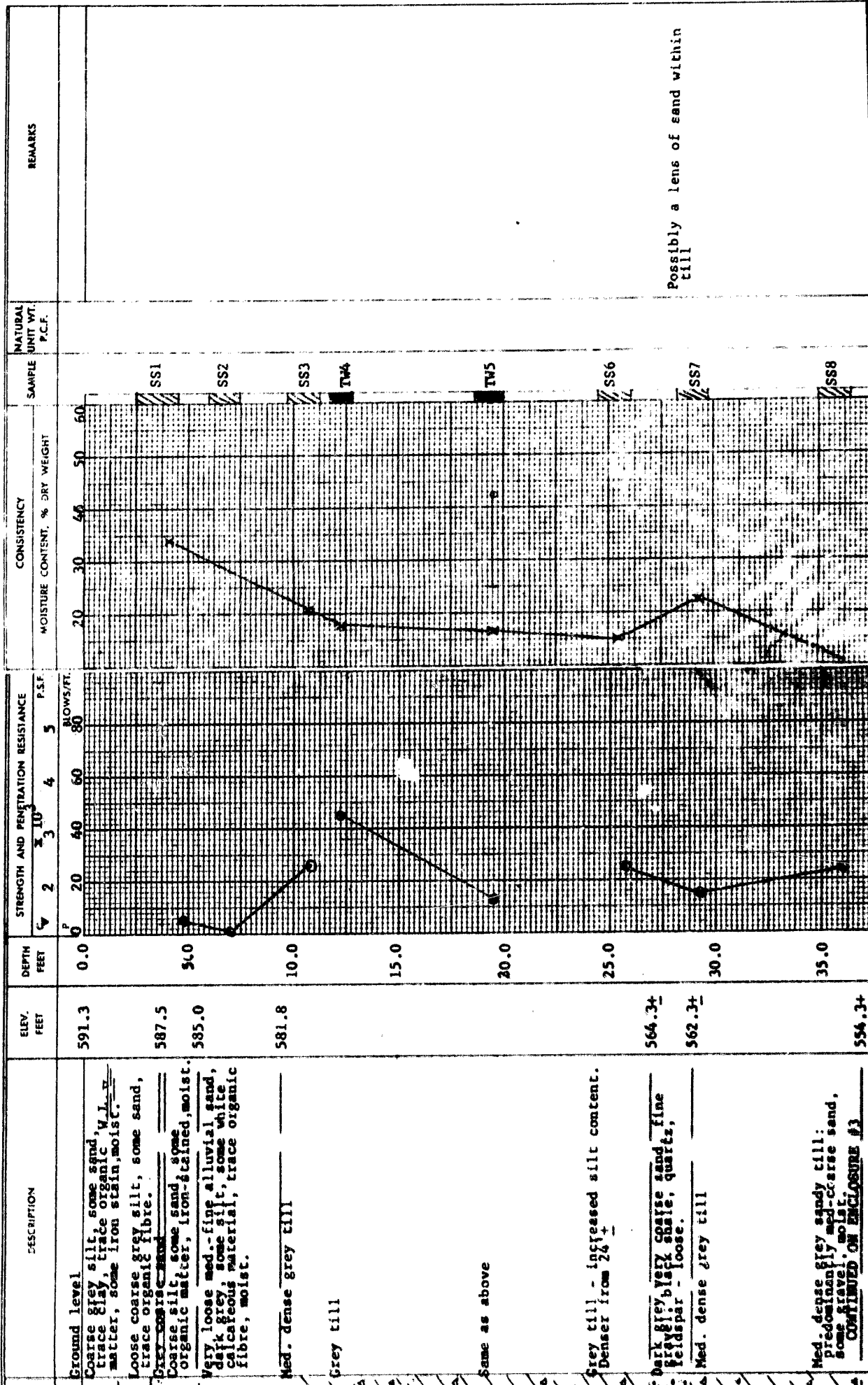
## LEGEND

Project: Bridge across McGregor's Creek  
 Location: Co. Rd. 14, Harwich Twp., Kent  
 Hole Location: Sta. 8+60 - 25' Lft.  
 Hole Elevation and Datum: 591.3  
 Field Supervisor: P.L. & A.K. Prep.: P.L.  
 Driller: C.I. Checked:

Unconfined compression  
 Shear Strength (C)  
 Vane test and sensitivity (S)  
 Penetration Resistance (P)  
 2" Split tube  
 2" Dia. Cone  
 Casing

Consistency  
 Natural moisture and  
 Liquid dry Index (LI)  
 Liquid limit  
 Plastic limit

Sampling Method  
 2" Dia. split tube  
 2" Shelby tube



## Dominion Soil Investigation Ltd.

## Dominion Soil Investigation Ltd.

Engineering Data Sheet for Borehole: 1 of 4 - Sheet 2 of 2

Engineering Data Sheet for Borehole:

Date: Jan. 27, 60.

Project: Bridge across McGregor's Creek  
Location: Co. Rd. 14, Harwich Centre, Ont.  
Hole Location: Sta. 8+60 - 25' Lft.  
Hole Elevation and Datum: 591.3  
Field Supervisor: P.L. & AK Prep.: P.L.  
Driller: C.I. Checked: \_\_\_\_\_

## LEGEND

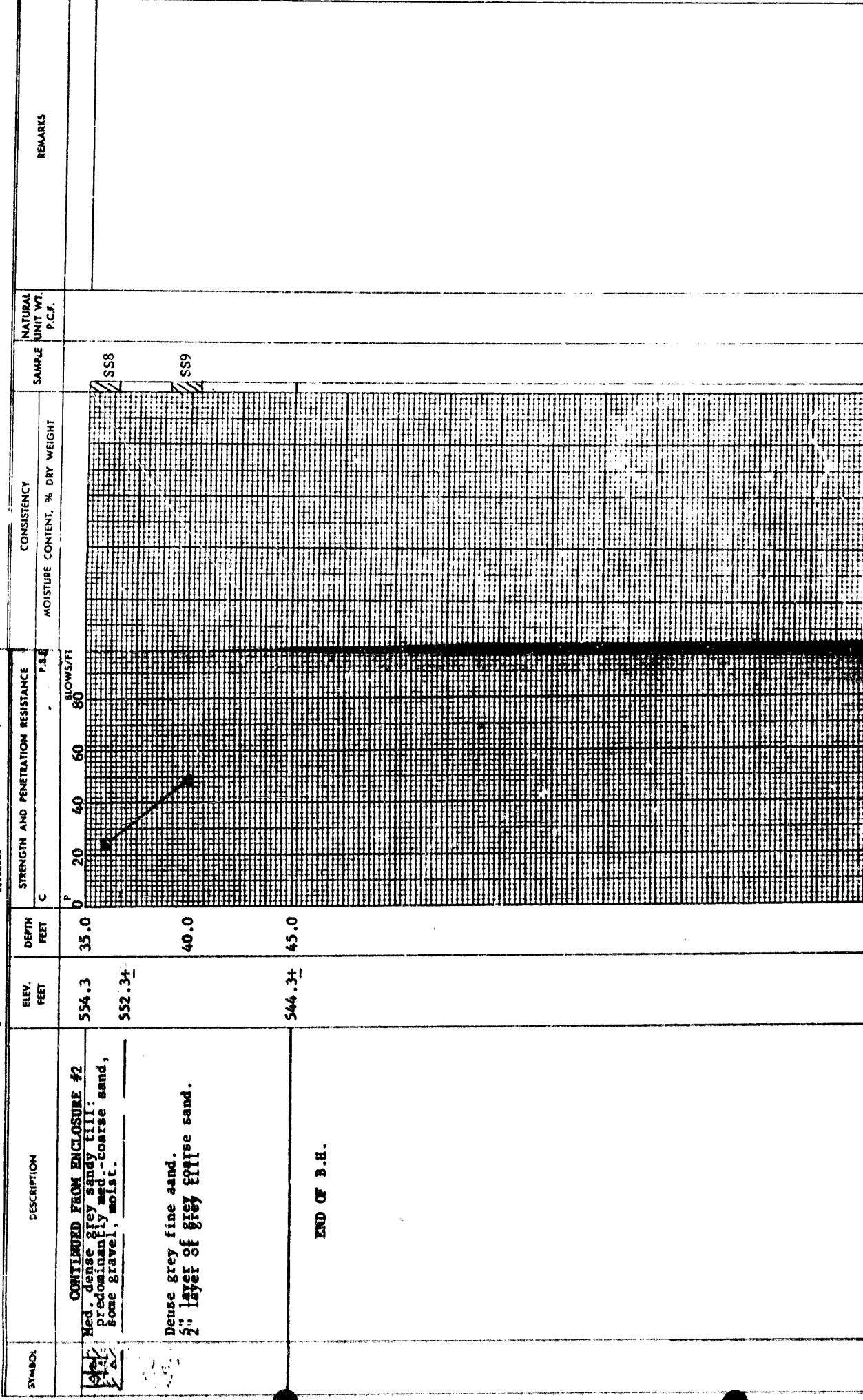
Shear Strength (C)  
Vane test and sensitivity (S)  
Penetration Resistance (P)  
2" Split tube  
2" Dia. Cone  
Casing

## Consistency

Natural moisture content  
Liquidity Index (LI)  
Liquid limit  
Plastic limit

Sampling Method  
2" Dia. split tube  
2" Shelby tube

Sampling Method  
2" Dia. split tube  
2" Shelby tube



## Dominion Soil Investigation Ltd.

## Dominion Soil Investigation Ltd.

Engineering Data Sheet for Borehole:

Engineering Data Sheet for Borehole: 2 - Sheet 1 of 2

Date: Jan. 23, 60.

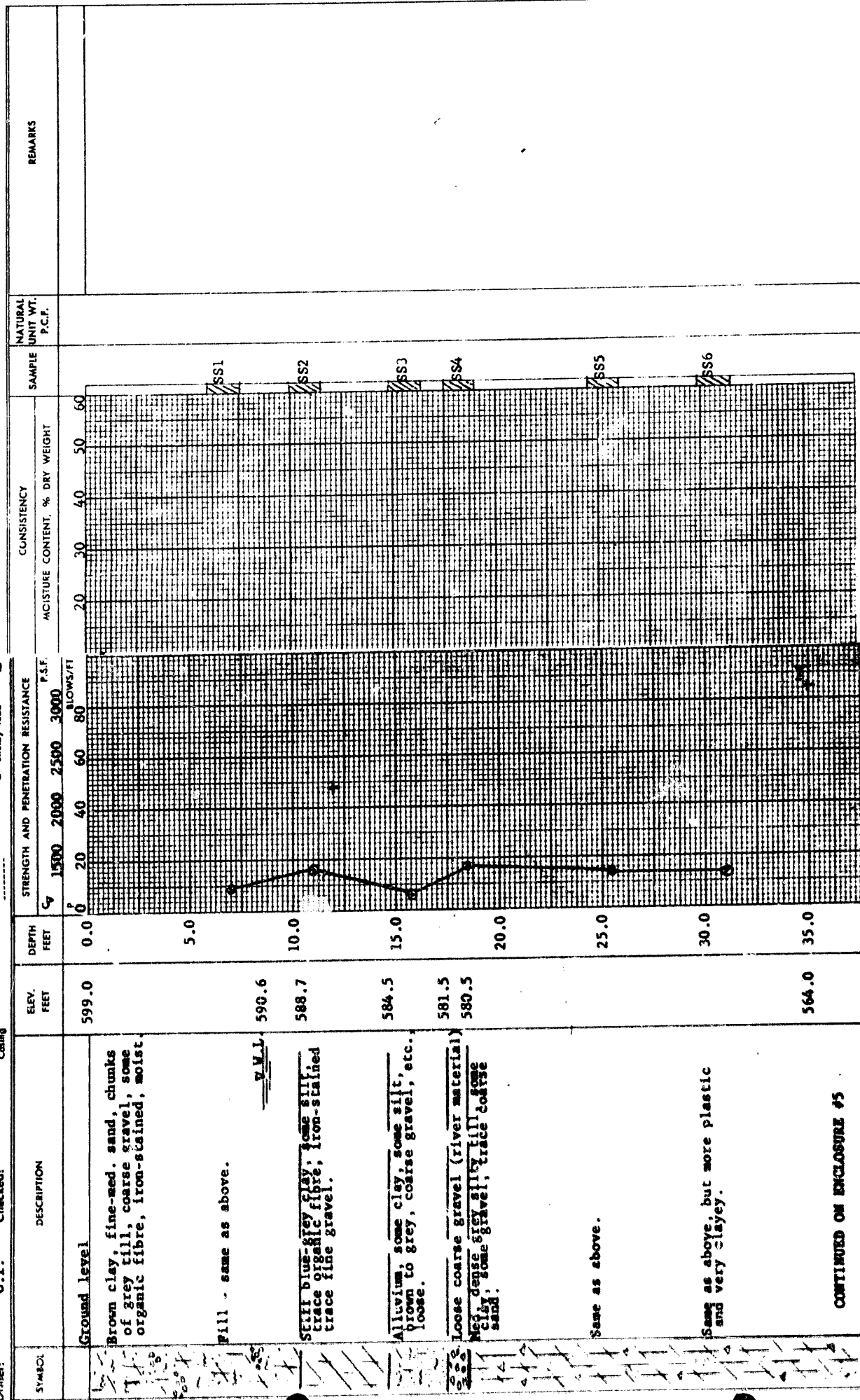
Project: McGregor's Creek Bridge  
Location: Co. Rd. 14, Harwich, Kent  
Hole Location: Sta. 8+57 - 21' Rt. of Line 'A'  
Hole Elevation and Datum: 599.0 P.L.  
Field Supervisor: P.L. & A.K. Prep.:  
Driller: C.I. Checked:

LEGEND  
Shear Strength (C)  
Unconfined compression  
Vane test and sensitivity (S)  
Penetration Resistance (P)  
2" Split tube  
2" Dia. Cone  
Casing

Consistency  
Natural moisture and  
Liquid limit (LL)  
Liquid limit  
Plastic limit

Sampling Method  
2" Dia. split tube  
2" Shelby tube

Sampling Method  
2" Dia. split tube  
2" Shelby tube



## Dominion Soil Investigation Ltd.

## Dominion Soil Investigation Ltd.

Engineering Data Sheet for Borehole:

Engineering Data Sheet for Borehole: 2 - Sheet 2 of 2

Date: Jan. 28, 60.

Project: McGregor's Creek Bridge  
Location: Co. Rd. 14, Hawick, Ont.  
Hole Location: Sta. 8457 - 21' R.C. Line 'A'  
Hole Elevation and Datum: 599.0  
Field Supervisor: PL & AK Prep: P.L.  
Driller: C.I. Checked:

## LEGEND

Shear Strength (C)  
Undrained compression  
Vane test and sensitivity (S)  
Penetration Resistance (P)  
2" Split tube  
2" Dia. Cone  
Casing

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STRENGTH AND PENETRATION RESISTANCE

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DEPTH

FEET

35.0

40.0

45.0

50.0

55.0

60.0

65.0

70.0

75.0

80.0

85.0

90.0

95.0

100.0

105.0

110.0

115.0

120.0

125.0

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205.0

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245.0

250.0

255.0

260.0

265.0

270.0

275.0

280.0

285.0

290.0

295.0

300.0

ELEV.

FEET

564.0

560.0

556.0

552.0

548.0

544.0

540.0

536.0

532.0

528.0

524.0

520.0

516.0

512.0

508.0

504.0

500.0

496.0

492.0

488.0

484.0

480.0

476.0

472.0

468.0

464.0

460.0

456.0

452.0

448.0

444.0

440.0

436.0

432.0

428.0

424.0

420.0

416.0

412.0

408.0

404.0

400.0

396.0

392.0

388.0

384.0

380.0

376.0

372.0

368.0

364.0

360.0

356.0

352.0

DESCRIPTION

CONTINUED FROM ENCLOSURE #4

Med. dense grey till, very clayey.

SYMBOL

REMARKS

SS7

NATURAL UNIT WT. P.C.F.

SAMPLE

CONSISTENCY

MOISTURE CONTENT, % DRY WEIGHT

SAMPLING METHOD

2" Dia. split tube

2" Shelby tube

LEGEND

Natural moisture and

Liquidity Index (LI)

Liquid limit

Plastic limit

X LI

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## Dominion Soil Investigation Ltd.

## Dominion Soil Investigation Ltd.

Engineering Data Sheet for Borehole: 3

Engineering Data Sheet for Borehole:

Date: Jan. 29, 60.

## LEGEND

Project: McGregor's Creek Bridge  
Location: Co. Rd. 14, Harvick Twp., Kent  
Hole Location: Sta. 7+85 - 15' Left of Centre, Ont.  
Hole Elevation and Datum: 590.0  
Field Supervisor: P.L. & A.E. Prep.: P.L.  
Driller: C.I. Checked: \_\_\_\_\_

Shear Strength (C)  
Unconfined compression  
Vane test and sensitivity (S)  
Penetration Resistance (P)  
2" Split tube  
2" Dia. Cone  
Coring

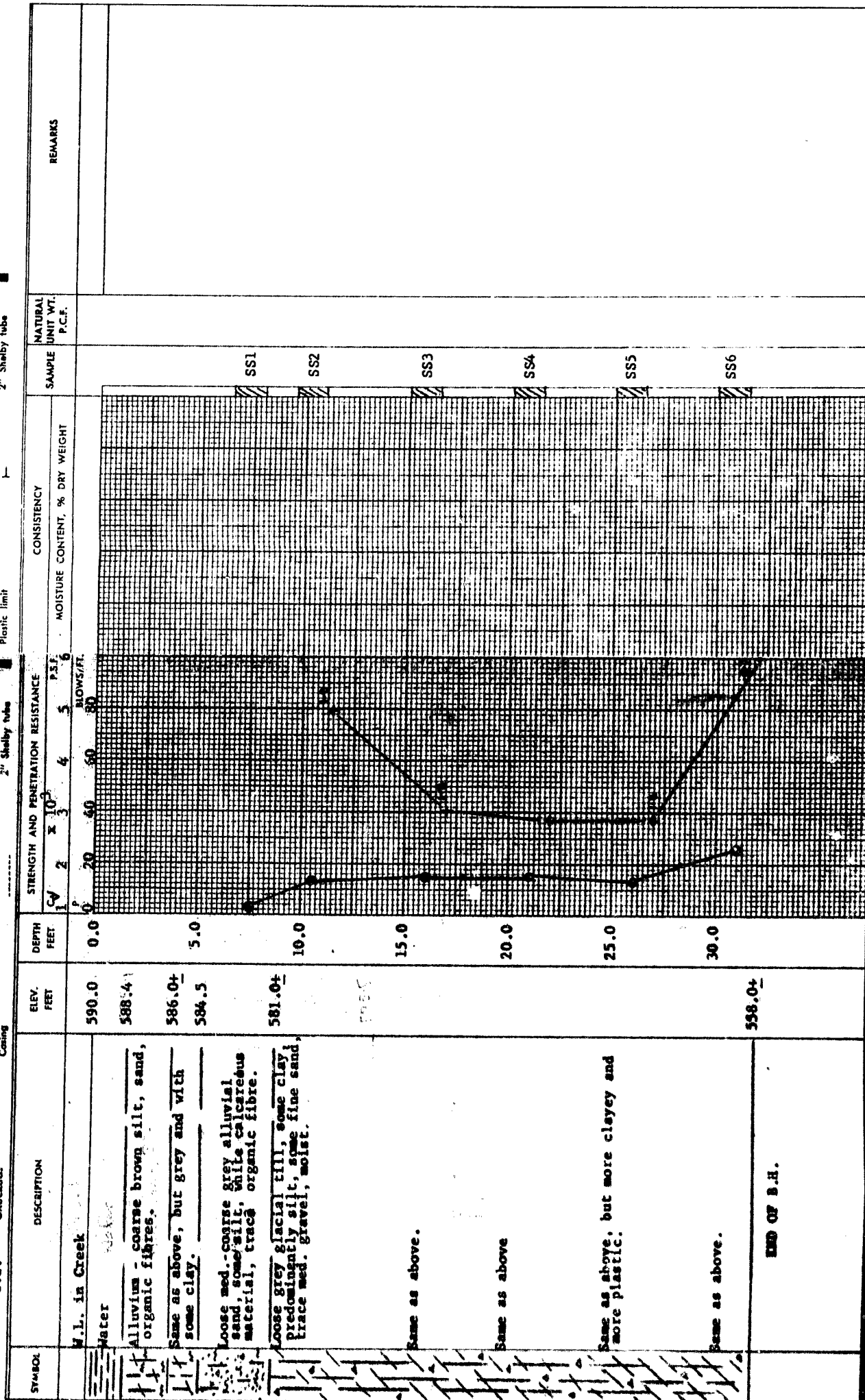
## LEGEND

Sampling Method  
2" Dia. split tube  
2" Shelby tube

Natural moisture and  
Liquidity Index (LI)  
Liquid limit  
Plastic limit

Consistency  
X LI  
- O  
- T

Natural Unit Wt.  
P.C.F.





# Dominion Soil Investigation Ltd.

Engineering Data Sheet for Boreholes: 4054

Project: McGregor's Creek Bridge

Location: Co. Rd. 14, Barville, Kent

Hole Location: Sta. 7+95 - 17' E of line A

Hole Elevation and Datum: 591.0

Field Supervisor: PL &amp; AK Prep.: P.L.

Driller: C.I. Checked:

Date: Jan. 30, 60.

## LEGEND

Shear Strength (C)

Unconfined compression

Vane test and sensitivity (S)

Penetration Resistance (P)

2" Split tube

2" Dia. Cone

Casing

## LEGEND

Consistency

Natural moisture and

Liquidity Index (LI)

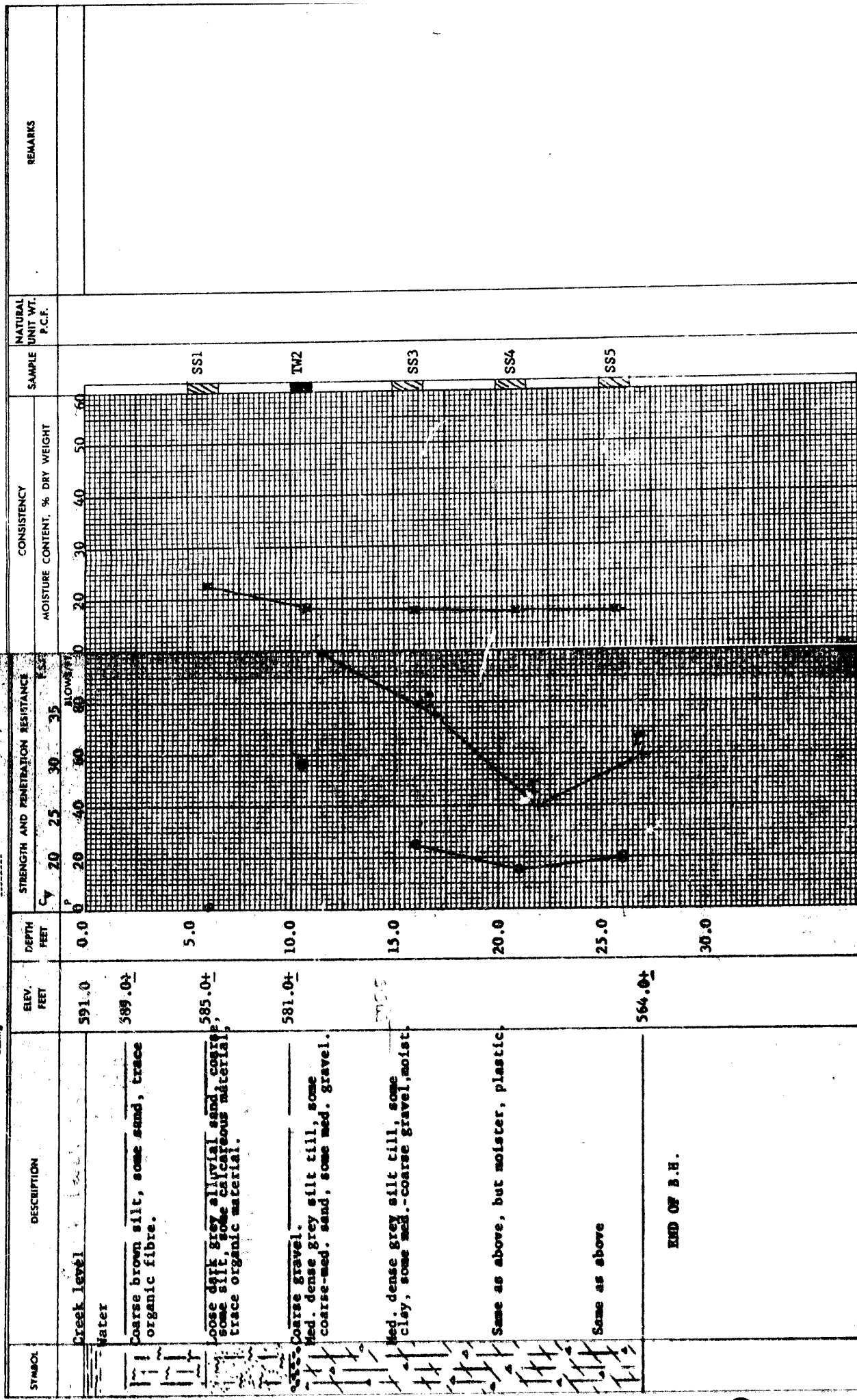
Liquid limit

Plastic limit

Sampling Method

2" Dia. split tube

2" Shelby tube



END OF B.H.

SUMMARY OF LABORATORY TEST RESULTS

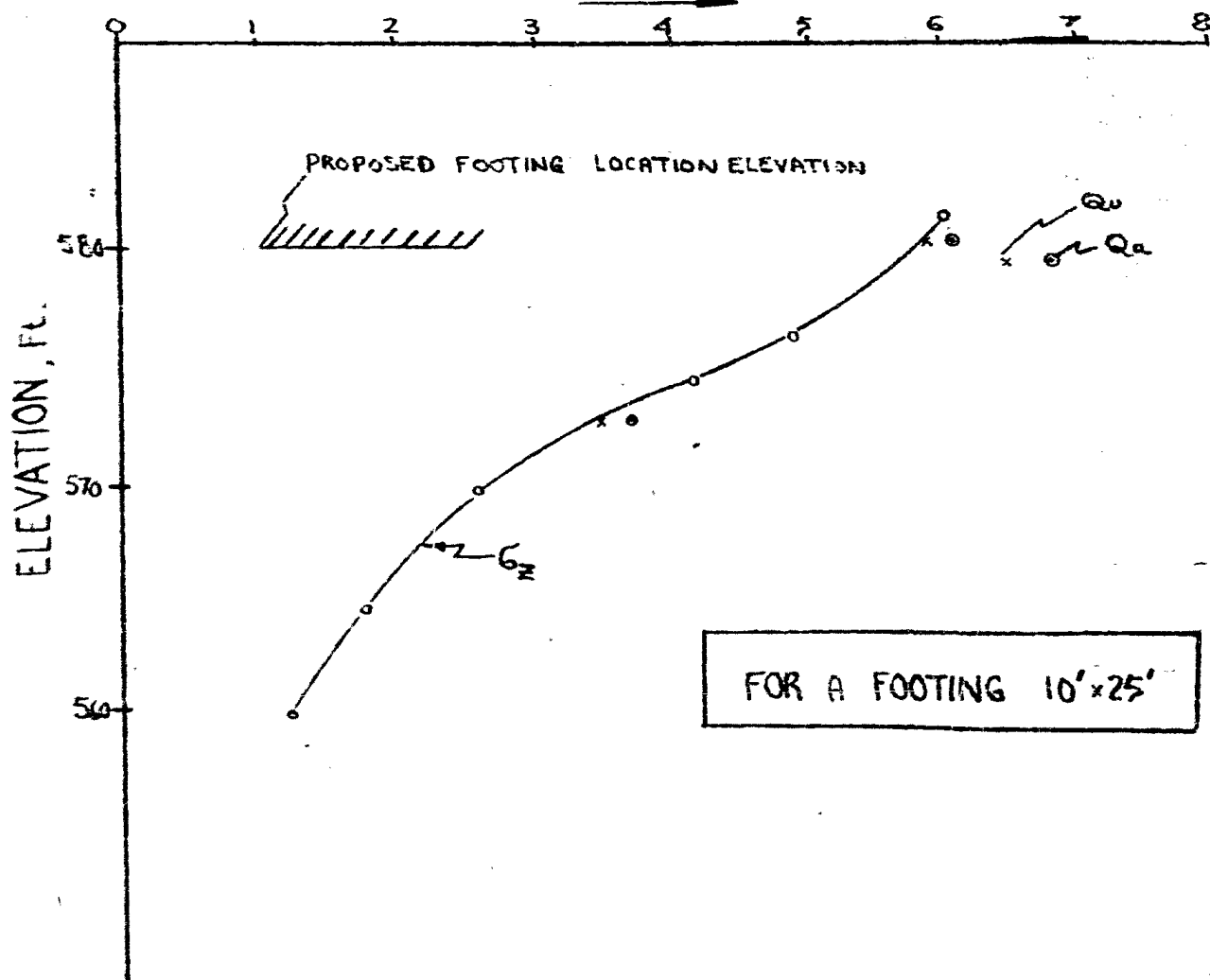
Borehole & Sample No.	Elevation	Moisture Content%	W-pec	Uu (psf)	Strain	Liquid Limit	Plastic Limit	Plasticity Index
<b>Borehole 1</b>								
Sample 1	588.8	34.3						
" 2	585.3	52.0						
" 3	581.4	20.2						
" 4	579.55	17.4	133.0	6460	20%	42.3	25.1	17.2
" 5	572.80	18.1	130.6	3550	20%			
" 6	566.80	15.6						
" 7	563.05	22.8						
" 8	556.3	8.9						
<b>Borehole 4</b>								
Sample 1	586	22.7						
" 2	581	18.3	132.0	5825	20%			
" 3	576	17.7						
" 4	571	17.3						
" 5	566	17.9						



Prep. By

STRESS & CAPACITY DISTRIBUTION GRAPH

STRESS VS ELEVATION

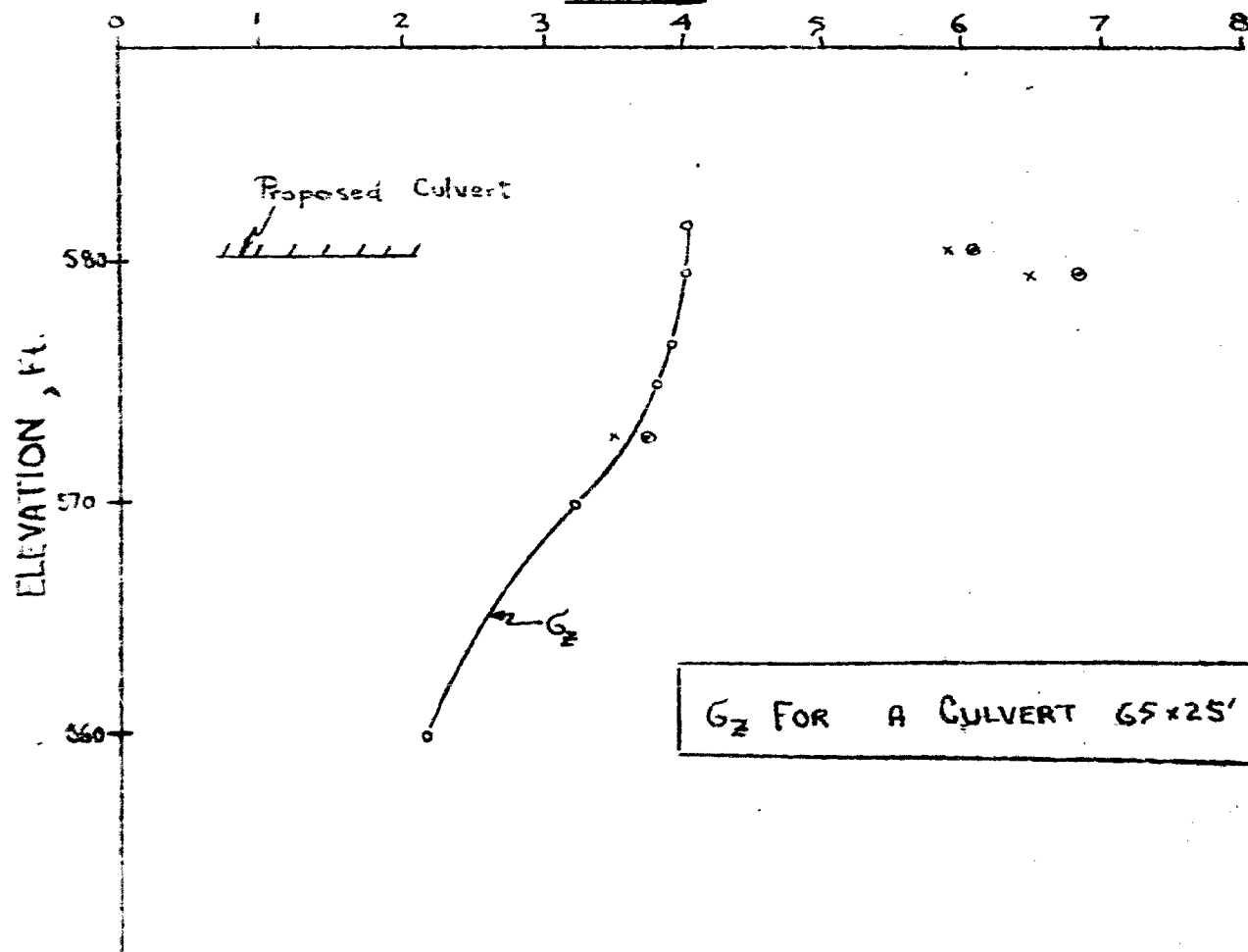
STRESS, PSF  $\times 10^3$ LEGEND:

- o -  $G_z$  - Boussinesq Vertical Stress Distribution Curve, psf.
- x  $Q_u$  - Unconfined Compression Results, psf.
- $Q_a$  - Safe Allowable Bearing Capacity  
 $= 0.95 Q_u (1 + 0.3 \frac{B}{L})$  where  $\frac{B}{L} = \frac{10}{25}$

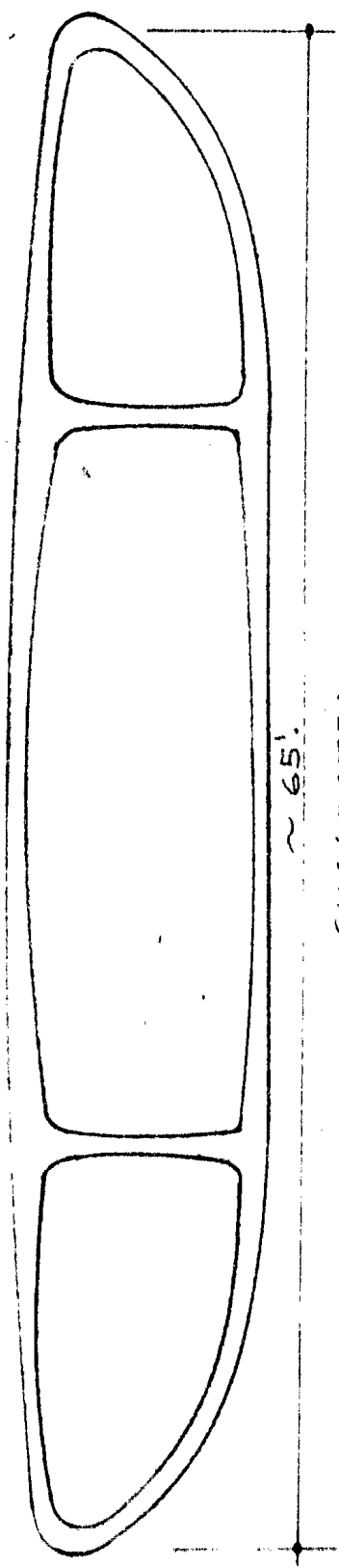
Prep. By

STRESS & CAPACITY DISTRIBUTION GRAPH

STRESS VS ELEVATION

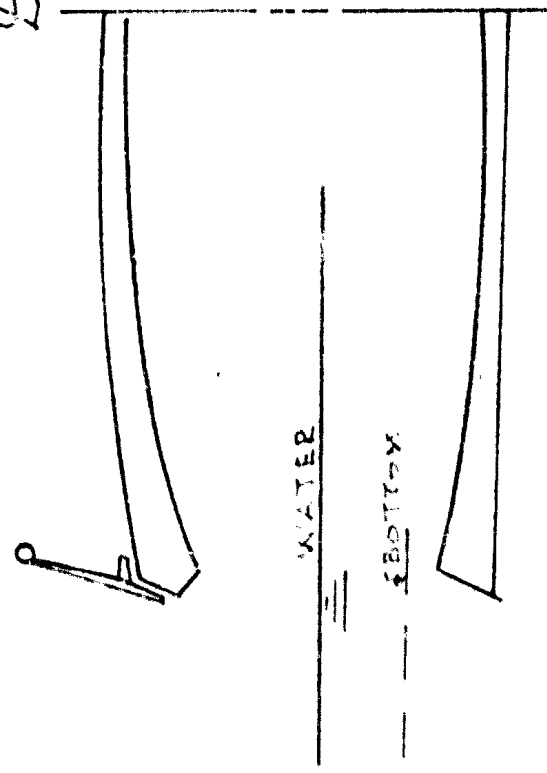
STRESS, PSF  $\times 10^3$ 

- o  $G_z$  - Boussinesq Vertical Stress Distribution Curve, psf.
- x  $Q_u$  - Unconfined Compression Results, psf.
- o  $Q_a$  - Safe Allowable Bearing Capacity  
 $= 0.95 Q_u (1 + 0.3 \frac{B}{L})$  where  $\frac{B}{L} = \frac{25}{65}$



SUGGESTED  
TRIPLE CULVERT.

1/2



SECTION.

See also  
60-106

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88 EGLINTON AVE. E.

FOUNDATION CALCULATIONSExplanation:

#1. Safe Allowable Bearing Capacity,  $Q_a$ , was calculated from the formula  $Q_a = 0.95 Q_u (1 + 0.3 \frac{B}{L})$  where  $Q_u$  = unconfined compression test results.

#2. The Bearing Capacity was checked, based on a minimum  $Q_a$  i.e. Minimum  $Q_a$  was set =  $G_z$  in Boussinesq's Formula. The smaller bearing value of ① & ② was taken as safe bearing capacity under the footing.

#3. Curves were plotted, elevation vs stress -  $G_z$ ,  $Q_u$ ,  $Q_a$

\* Reference - Tschebotarioff, "Soil Mechanics, Foundations and Earth Structures" - p 217

For a 10' x 30' Footing

$$Q_a = 0.95 \times 6460 (1 + 0.3 \times \frac{10}{30}) = 6740 \text{ psf at elev. 580}$$

$$Q_a = 0.95 \times 3550 (1 + 0.3 \times \frac{10}{30}) = 3650 \text{ psf at elev. 573}$$

$$Q_a \text{ at elev. 582.5} = 6080 \text{ psf at elev. 581}$$

For a Culvert 65' x 25'

$$\text{where } \frac{B}{L} = \frac{25}{65}$$

$$Q_a \text{ at elev. 580} = 6340 \text{ psf}$$

$$Q_a \text{ at elev. 573} = 3760 \text{ psf}$$

$$Q_a \text{ at elev. 581} = 6170 \text{ psf}$$

Testing Minimum  $Q_a$  from above

- Footing placed at 582 or below

$$Z = 582 - 573 = 9'$$

$$b = 3'$$

$$a = 15'$$

$$\frac{a}{b} = 3$$

$$\frac{Z}{b} = \frac{9}{3} = 1.8$$

$$4 \times G_z = 3650 \text{ psf}$$

$$G_z = 913 \text{ psf}$$

$$\frac{G_z}{P} = 0.14$$

$$\text{Capacity, } P = \frac{G_z}{0.14} = \frac{913}{0.14} = 6520 \text{ psf.}$$

∴ Use 6080 as capacity for area at elev. 582.

For 65' x 25' Culvert -

Culvert bottom at 582'

$$z = 9' \quad b = 12.5 \quad \frac{q}{b} = 2.6 \quad \frac{z}{b} = \frac{9}{12.5} = .72$$

$$4 \times G_z = 3760 \text{ psf.}$$

$$G_z = 940 \text{ psf.}$$

$$\frac{G_z}{P} = 0.23$$

$$\text{Capacity, } P = \frac{940}{0.23} = 4080 \text{ psf.}$$

∴ Use 4080 as capacity for area at elev. 582

Boussinesq's Stress Distribution - 60-106

A Footing 10 x 20'

Elev.	z	z/b	$G_z/P$	$4 \times G_z$ psf
582	0	0	.25	6170 psf.
580	2	0.4	.242	5980 psf
577	5	1.0	.200	4920 "
575	7	1.4	.170	4200 "
570	12	2.4	.108	2660 psf
565	17	3.4	.075	1850 "
560	22	4.4	.056	1230 "

B Culvert 65' x 25'

Elev	z	z/b	$G_z/P$	$4 \times G_z$
582	0	0	0.25	4080 psf
580	2	0.16	0.250	4050 psf
577	5	0.40	0.242	3950 "
575	7	0.56	0.238	3880 "
570	12	0.96	0.205	3340 "
565	17			
560	22	1.76	0.140	2280 "

## Appendix C

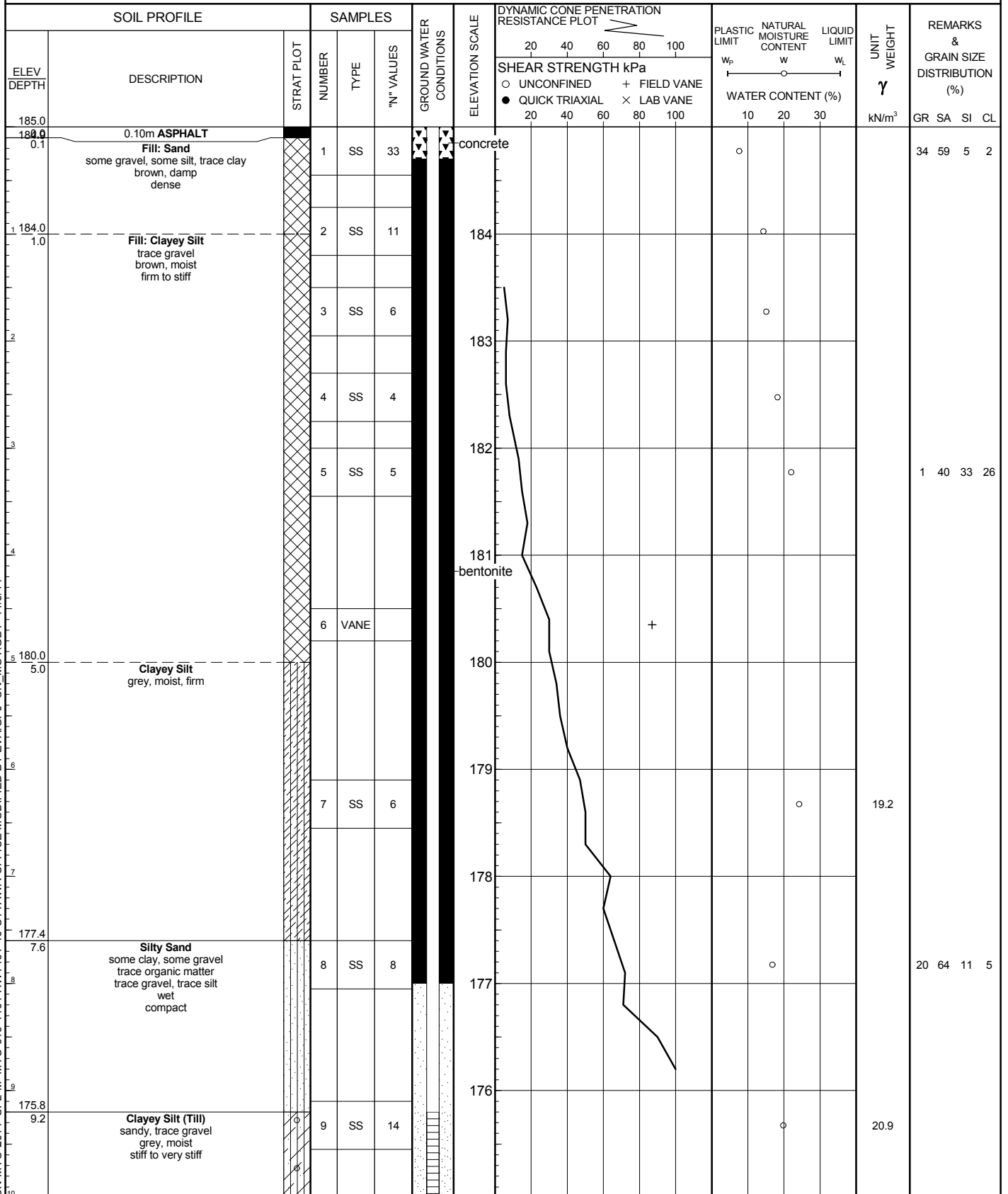
### Borehole Logs (Record of Borehole Sheets)



# RECORD OF BOREHOLE No BH13-168

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 Sep/06/2011 CHECKED BY EP



Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

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

919-1101

ONL-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 BH13-168

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 Sep/06/2011 CHECKED BY EP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)			
	Clayey Silt (Till) sandy, trace gravel grey, moist stiff to very stiff (continued)					W. L. 175.0 m							
11		10	SS	10		sand 174							
12						screen 173							
13		11	SS	10									
14		12	SS	14								21.0	
15													
16		13	SS	15									4 32 33 31
168.2													
16.8	Clayey Silt (Till) some gravel grey, moist hard	14	SS	30									
18													
19		15	SS	29									4 47 32 17
20													

Continued Next Page

## GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, x 3: Numbers refer to Sensitivity

○  $\epsilon=3\%$  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 BH13-168

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 Sep/06/2011 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 $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>				
21	Clayey Silt (Till) some gravel grey, moist hard (continued)		16	SS	52									
163.6														
21.4	Sand and Gravel brown, wet compact to dense		17	SS	27									35 58 4 3
22														
23	disturbed due to flowing sand SPT test not possible													
24														
25														
159.1	Shale weathered, black extremely weak to weak		19	SS	50 for 50mm									
25.9														
27														
28														
29	Auger refusal at 29.0m, switched to coring		20	SS	50 for 50mm									
156.0	Shale: fresh to slightly weathered, black  TCR=100% SCR=100% RQD=80%													
29.0														
30														

Continued Next Page

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

## GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

919-1101



# RECORD OF BOREHOLE No BH13-168

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 Sep/06/2011 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 $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
154.8 30.2	<b>Shale</b> fresh to slightly weathered, black  TCR=100% SCR=100% RQD=100%																
153.2 31.8	<b>End of Borehole</b>  Notes: 1) Piezometer installed to 13.7m upon completion of drilling. 2) Water level in Piezometer Date _____ Depth (m) _____ Elevation (m) _____																

## GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

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

919-1101





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	Sep/07/2011	CHECKED BY	EP

[illegible]

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## GROUNDWATER ELEVATIONS

	1st	2nd	3rd	4th
Measurement				

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

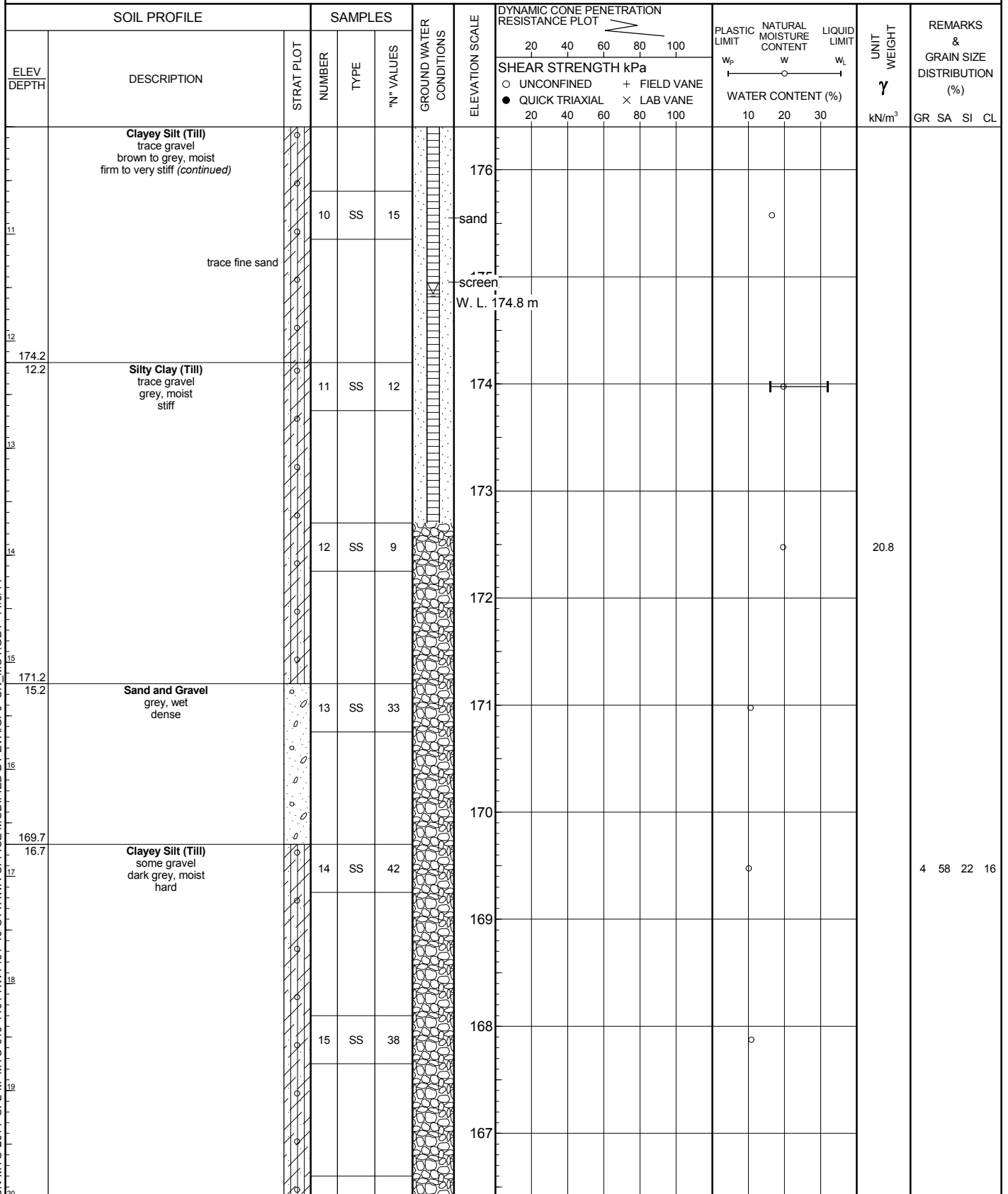
919-1101



## RECORD OF BOREHOLE No BH13-524

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 Sep/07/2011 CHECKED BY EP



Continued Next Page

## GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, x 3: Numbers refer to Sensitivity

○  $\epsilon=3\%$  Strain at Failure

919-1101



## RECORD OF BOREHOLE No BH13-524

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 Sep/07/2011 CHECKED BY EP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W		
	Clayey Silt (Till) some gravel dark grey, moist hard (continued)		16	SS	44							22.6	
21													
22			17	SS	50/ 125mm								
163.6													
23	Coarse Sand trace gravel  SPT testing not possible due to flowing sand												
24													
25													
26													
27	Shale extremely weak to weak weathered, grey		21	SS	50/ 125mm								
28	Auger refusal at 28.0m, switched to coring Shale TCR=100% SCR=100% RQD=74%												
29	Shale TCR=100% SCR=100% RQD=82%												
30													

Continued Next Page

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

## GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

919-1101



# RECORD OF BOREHOLE No BH13-524

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 Sep/07/2011 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 $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			WATER CONTENT (%)				
156.1	Shale TCR=100% SCR=100% RQD=89%						156	<p>SHEAR STRENGTH kPa</p> <p>○ UNCONFINED + FIELD VANE</p> <p>● QUICK TRIAXIAL × LAB VANE</p>					<p>WATER CONTENT (%)</p> <p>10 20 30</p>									
30.3																						
155.3																						
31.1	END OF BOREHOLE																					
<p>Notes:</p> <p>1) Piezometer installed to 13.7m upon completion of drilling.</p> <p>2) Water level in Piezometer</p> <table border="1"> <thead> <tr> <th>Date</th> <th>Depth (m)</th> <th>Elevation (m)</th> </tr> </thead> <tbody> <tr> <td>10/18/11</td> <td>11.56</td> <td>174.84</td> </tr> </tbody> </table>																	Date	Depth (m)	Elevation (m)	10/18/11	11.56	174.84
Date	Depth (m)	Elevation (m)																				
10/18/11	11.56	174.84																				

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

## GROUNDWATER ELEVATIONS

Measurement

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

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## 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