

GEOCRES No. 30M11-207

DIST. \_\_\_\_\_ REGION \_\_\_\_\_

W.P. No. 176-00-01

CONT. No. \_\_\_\_\_

W. O. No. \_\_\_\_\_

STR. SITE No. \_\_\_\_\_

HWY. No. QEWLOCATION Proposed Retaining WallAlong the West Side of Brown's LineNo. of Pages - AT QEW INTERCHANGE=====  
OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. \_\_\_\_\_REMARKS: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

GEORECS No  
30M11-207

**FOUNDATION INVESTIGATION REPORT  
PROPOSED RETAINING STRUCTURE  
ALONG THE WEST SIDE OF BROWN'S LINE  
AT Q.E.W. INTERCHANGE  
TORONTO, ONTARIO  
W.P. 176-00-01**

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**Project: SP3232L  
July 5, 2000**

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## Table of Contents

### FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION	1
2. PHYSIOGRAPHY	1
3. AVAILABLE INFORMATION	2
4. SUBSURFACE CONDITIONS	4
4.1 PAVEMENT.....	4
4.2 TOPSOIL.....	4
4.3 EMBANKMENT FILL .....	4
4.4 CLAYEY SILT TILL.....	5
4.5 TILL/SHALE COMPLEX.....	5
4.6 SHALE BEDROCK.....	6
4.7 GROUNDWATER CONDITIONS.....	8

### DRAWINGS

Borehole Location Plan

Drawing No. 1

### APPENDICES

Borehole Log Sheets

Appendix A

Laboratory Test Results

Appendix B

Explanation of Terms Used in Report

Appendix C

Core Logs and Photographs

Appendix D

Logs of Boreholes Drilled in 1960's

Appendix E

**FOUNDATION INVESTIGATION REPORT  
PROPOSED RETAINING STRUCTURE  
ALONG THE WEST SIDE OF BROWN'S LINE AT QEW INTERCHANGE  
TORONTO, ONTARIO  
W.P. 176-00-01**

**1. INTRODUCTION**

Gardiner Expressway/Q.E.W./Highway 427/Brown's Line Interchange modifications will necessitate the construction of a new retaining structure on the west side of Brown's Line at the Queen Elizabeth Way (Q.E.W.) interchange. The new retaining wall will be constructed in an approximately north-south direction, starting immediately north of the existing FGGE (Gardiner Expressway) E-Brown's Line S Bridge and will extend southerly past the existing Q.E.W. (EBL and WBL) Bridge over the Brown's Line. This will enable the construction of a new lane to shift Brown's Line SBL traffic to the west. Shaheen & Peaker Limited (S&P) was retained by DS-Lea Associates Limited, Consulting Engineers, to carry out a foundation investigation for the proposed structure.

The purpose of the investigation was to compile the existing borehole information and present the information in a report.

The findings of the investigation are presented in this report.

**2. PHYSIOGRAPHY**

The site is located in the physiographic region known as the Iroquois Plain, which comprises the lowlands bordering Lake Ontario. During the retreat of the Late Wisconsinian glaciers, this area was occupied by Lake Iroquois. The shoreline of Lake Iroquois corresponded with approximately Dundas Street, which is located about 2 km to the north. During the time Lake Iroquois was present, a large delta formed at the mouth of the former Humber River. This is located about 5 km to the east.

The geological mapping for this area shows that the surficial deposits at this site consist of deltaic and shallow water lacustrine deposits comprised primarily of gravelly sand and silty sand. The stratigraphy for the site indicates that the deltaic and lacustrine deposits were deposited during the Late Wisconsinian times by glaciers advancing towards the northwest out of the Lake Ontario Basin. The predominant overburden in the area consists of a glacial till deposit known as the Halton till. This deposit contains frequent shale and limestone fragments.

Bedrock consisting of shale with interbedded limestone and sandstone underlies the Halton Till. Available information indicates that the surface of the bedrock of the site can be expected at about Elevation 108 m to 109 m.

### 3. AVAILABLE INFORMATION

Boreholes were drilled by S&P for proposed new structures for Ramp FGGE E-Sherway Gardens Road over Brown's Line and for Ramp Brown's Line N-FGGE(E) over Brown's Line. The results of these investigations were reported under our Reference No. SP3232B and SP3232C, respectively. The pertinent boreholes from these two investigations are B1-1, B1-2, B1-3, B2-1, B2-2 and B2-3. The positions of these boreholes at the site are shown on Drawing No. 1.

The boreholes were put down during the period of February 11 through 25, 2000. The depths of the boreholes ranged from 2.9 to 10.1 m, below the ground surface. No boreholes were advanced at the actual site.

The boreholes were advanced using track and truck mounted drilling rigs, equipped with solid stem augers and standard testing equipment, under the full time supervision of technical personnel from S&P. Sampling in the boreholes was effected at frequent intervals of depth (i.e. generally at 0.76 m intervals of depth, starting at the ground surface) by the Standard Penetration Test Method (SPT), as specified in ASTM Method D 1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter O.D. split barrel (split-spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the 'N'-value of the

soil and this gives an indication of the consistency or the compactness condition of the soil deposit.

Boreholes B1-2, B2-1 and B2-2 were extended by augering until refusal, probably on limestone layers in the shale bedrock, at depths of 5.8, 3.2 and 2.9 m, respectively. In Boreholes B1-1, B1-3 and B2-3, augering was stopped within the bedrock and these boreholes and Borehole B2-1 were extended deeper by diamond drilling (rock coring), using NQ-size core barrel to depths of between 5.6 and 10.1 m.

The soil samples and rock cores were shipped to our laboratory in Toronto for further examination and classification. A laboratory testing programme, consisting of natural moisture content, bulk unit weight and Atterberg Limit tests and grain-size analyses, was performed on selected, representative soil samples. The results of the laboratory tests are presented on the appropriate Borehole Log sheets (Appendix A) and also in Appendix B.

Groundwater conditions in the open boreholes were observed during the drilling and at completion of each borehole. In addition, in Boreholes B1-2 and B2-2, piezometers were installed to enable us to monitor the groundwater level over a prolonged period of time, without interference from surface water.

The borehole locations were established in the field by our engineering staff, in relation to the centerline stakes. The borehole geodetic elevations and coordinates were later taken and provided to us by surveyors from Waylaw Technical Services of Paris, Ontario.

The logs of boreholes that were available to us (put down by the Ministry in 1960's) in the vicinity of the proposed retaining structure site are given in Appendix E. The locations of these boreholes (i.e. northing and easting) are shown on each borehole log sheet.

#### **4. SUBSURFACE CONDITIONS**

In general below some fill, the boreholes drilled by our firm show the presence of clayey silt till, underlain by a transition zone into the bedrock (i.e. till-shale complex) immediately overlying the bedrock.

Details of the subsurface conditions encountered in the boreholes are given on the individual Record of Borehole Sheets presented in Appendix A. The following paragraphs are only meant to complement and amplify these data.

##### **4.1 PAVEMENT**

Boreholes B1-3 and B2-3 were drilled from the paved median shoulder and these boreholes contacted a 100 mm thick asphaltic concrete layer, underlain by granular pavement fill to 0.6 m and 0.45 m, respectively.

The grain size distribution of a sample from the granular pavement fill is given in Appendix B.

##### **4.2 TOPSOIL**

Boreholes drilled outside the paved areas contacted a 75 to 300 mm thick topsoil layer.

##### **4.3 EMBANKMENT FILL**

Boreholes drilled outside the paved areas encountered below the topsoil, fill extending to depths ranging from 0.5 to 2.3 m below the ground surface or to Elevations ranging from 110.6 to 108.8 m. The composition of these embankment fill deposits was variable, but in general it consisted of clayey silt with shale fragments.

We would like to point out that the thickness of topsoil and the thickness and the composition of manmade fill deposits can vary in between and beyond borehole locations.

#### 4.4 CLAYEY SILT TILL

In general, the uppermost natural overburden in the boreholes consists of clayey silt till. Where encountered (i.e. Boreholes B1-1, B1-2 and B2-1) the thickness of the clayey silt till ranged from 0.4 to 0.8 m and the deposit extended to elevations ranging from 109.9 to 108.5 m.

The deposit contains shale fragments and can be classified as a cohesive soil. The frequency of the shale fragments generally increases with increasing depth. The grain size distribution of a sample from the deposit is given in Appendix B.

Atterberg limits test was performed in the laboratory on a sample from the deposit and the test gave the following values (Appendix B – Figure No. 4):

Liquid limit = 25%

Plastic limit = 18%

Plasticity index = 7%

These results indicate clayey soils of low plasticity. The measured natural moisture contents are generally below the measured plastic limit value and this indicates that the material is over-consolidated.

Standard Penetration tests performed in this deposit yielded N-values ranging from 44 blows/0.3 m to 50 blows/0.15 m, indicating a hard consistency.

#### 4.5 TILL/SHALE COMPLEX

The lower portions of the overburden in the general area often resemble a highly weathered shale. This material is sometimes referred to as till/shale complex, which represents a transition zone into the underlying shale bedrock. This unit may often be described as a residual soil or a completely weathered shale bedrock. Shale and limestone slabs or layers may remain. Excavation methods should take into consideration the possible presence of hard shale or limestone slabs/layers in the till, till/shale and in the underlying bedrock.

Till/shale complex was contacted in Boreholes B1-1 and B1-2 at depths of 1.6 and 1.8 m or Elevations 109.7 and 109.9 m, respectively and extended to 2.8 and 2.9 m or to Elevations 108.5 and 108.8, respectively to the surface of the bedrock.

The grain size distribution of a sample from the till/shale complex is given in Figure No. 3 in Appendix B.

The following index values were obtained on a sample recovered from this deposit:

Liquid Limit = 28%

Plastic Limit = 21%

Plasticity Index = 7%

The till/shale is a cohesive material. Based on N-values ranging from 44 to in excess of 75 blows/0.3 m and on the basis of the observed resistance to augering during the drilling, the consistency of the unit is considered hard.

#### 4.6 SHALE BEDROCK

Shale bedrock was encountered at the following approximate elevations at the borehole locations.

##### Estimated Bedrock Depth

Borehole No.	Bedrock Depth (m)	Elevation (m)
B1-1	2.8	108.5
B1-2	2.9	108.8
B1-3	1.4	103.6*
B2-1	2.7	108.5
B2-2	2.1	108.8
B2-3	1.1	103.0*

\*Boreholes B1-3 and B2-3 were located on the road where the elevation was lowered below the surface of the bedrock when the road was first built.

In most cases, the surface of the shale bedrock should be regarded as approximate only; this is because these depths were often inferred from the observed resistance to augering only and, where possible, from split-spoon samples and auger cuttings.

The bedrock underlying the site belongs to the Georgian Bay Formation (also known as the Dundas-Meaford Formation) of the Upper Ordovician Period of the Paleozoic Era. The Georgian Bay Formation is approximately 450 million years old and is known to consist of grey shale with interbeds of relatively more competent siltstone and sandstone and harder limestone. It is also known to contain occasional thin clay seams. The hard layers/seams are usually less than about 100 to 150 mm thick but some layers are much thicker. These are actually lenses and they can vary significantly in thickness over short distances. Stress relief features, such as folds and faults are also found in the Georgian Bay Formation. In these features, the rock is heavily fractured and sheared, and contains layers of shale rubble and clay.

The presence of some limestone, siltstone and sandstone seams was noted in the cores obtained from the bedrock in Boreholes B1-1, B1-3, B2-1 and B2-3. These harder seams were generally 2 to 15 cm thick except for the following:

Borehole B1-1: an approximately 300 mm thick layer at  
Elevation 103.6 m

Borehole B2-1: an approximately 225 m thick seam near the  
surface of the bedrock at Elevation 107.9 m

In Boreholes B1-2 and B2-2 where the rock was not cored, the bedrock was penetrated by augering until refusal to augering was encountered at Elevation 106.7 and 108.0 m, respectively, probably on the surface of hard layers (e.g. limestone layers/lenses).

As was mentioned before, excavation methods should take into consideration the rather sporadic presence of hard shale, siltstone, sandstone and harder limestone slabs/layers in the till, till/shale and especially in the underlying shale bedrock. This can create problems especially where site restrictions (e.g. low overhead clearance) will dictate the use of smaller equipment.

#### 4.7 GROUNDWATER CONDITIONS

Groundwater levels in the open boreholes were observed during the drilling and at the completion of each borehole.

All boreholes were dry immediately upon completion of augering. In Boreholes B1-1, B1-3, B2-1 and B2-3, where the rock was cored, however, water was introduced in the boreholes to facilitate diamond drilling. In these boreholes, therefore, stabilized water levels could not be measured.

To enable us to monitor the groundwater level over a prolonged period of time without interference from surface water, a piezometer was installed in each of Boreholes B1-2 and B2-2. The water levels in the piezometers were monitored over a period time when the water level was recorded at depths of 5.1 m and 2.7 m or at Elevations 106.6 m and 108.2 m, respectively.

It should, however, be pointed out that the groundwater table would be subject to seasonal fluctuations and in response to major weather events.

#### Shaheen & Peaker Limited



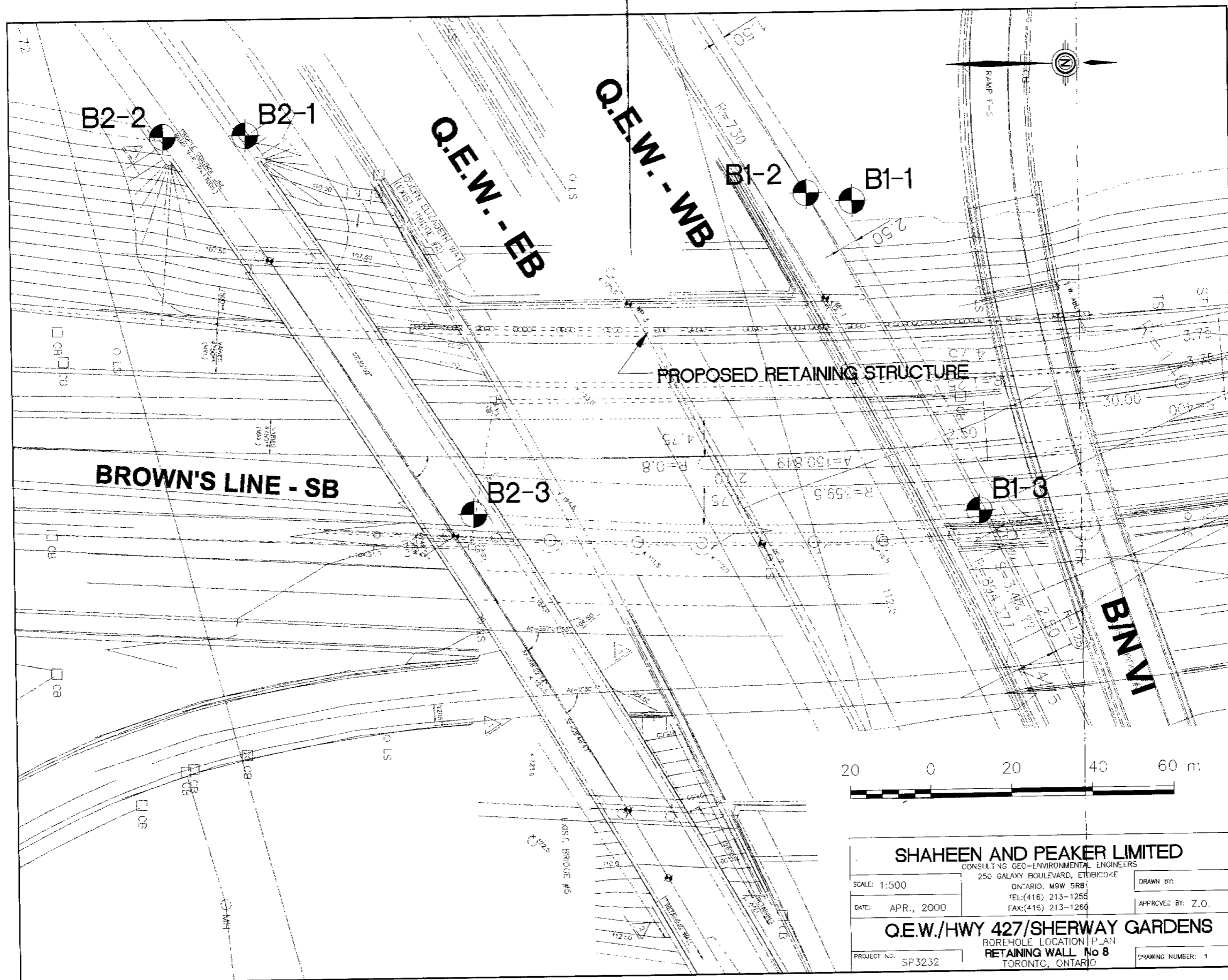
Zuhtu Ozden, P.Eng.



K. R. Peaker, Ph.D., P. Eng.

trzip#hd





# APPENDIX A

## Borehole Log Sheets

# RECORD OF BOREHOLE No B1-1

1 OF 1

METRIC

W.P. 171-00-01 LOCATION Ramp FGGE(E)-Sherway Gardens Road, 4 830 431.2 N; 300 814.9 E ORIGINATED BY G.I.  
DIST HWY 427 & QEW BOREHOLE TYPE Solid Stem Augers, NQ Rock Core COMPILED BY G.T.  
DATUM Geodetic DATE 12.02.00 14.02.00 CHECKED BY Z.O.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100		
111.3	Ground surface												
111.1	175 mm Topsoil		1	SS	12	111							
0.2	FILL : Clayey Silt, some sand and gravel & shale fragments, grey		2	SS	58	110							12 22 49 17
110.5	CLAYEY SILT TILL grey, hard		3	SS	50/8	109							
109.7	TILL/SHALE Complex grey, hard		4	SS	50/13	108							
108.5	SHALE BEDROCK occasional limestone seams, grey  Weathered		5	SS	50/8	107							*part of rock core not recovered Auger from 3.9 to 5.3 m
2.8			6	SS	50/8	106							
			7	NQ RC	Rec. 49%*	105							R.Q.D. =30%
			8	NQ RC	Rec. 92%	104							R.Q.D.=67%
	0.3 m thick limestone layer @ 7.7 m		9	NQ RC	Rec. 100%	103							R.Q.D.=51%
102.2	End of borehole Borehole dry before coring Water level not stabilized		10	NQ RC	Rec. 100%								N=50/8 denotes 50 blows for 8 cm penetration

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No B1-2

1 OF 1

METRIC

W.P. 171-00-01 LOCATION Ramp FGGE(E)-Sherway Gardens Road, 4 890 425.5 N; 300 813.9 E ORIGINATED BY G.I  
DIST HWY 427 & QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY G.T  
DATUM Geodetic DATE 11.02.00 CHECKED BY Z.O

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									
111.7	Ground surface							20	40	60	80	100					
111.8	150 mm Topsoil		1	SS	12		111									20.3	
0.1	FILL : Fine Sand with silt, some gravel & shale pieces		2	SS	27												
110.6																	
1.1	CLAYEY SILT TILL																
109.9	very stiff to hard, brown to 1.5 m, grey below		3	SS	44		110										
1.8	(possible fill)																
	TILL/SHALE Complex		4	SS	75/28		109									21.2	16 24 46 14
108.8	grey, hard																
2.9			5	SS	50/4												
	SHALE BEDROCK		6	SS	60/3		108										Auger refusal @ 5.0 m. Hole moved 2.0 m North and redrilled. Auger refusal @ 5.8 m
	grey		7	SS	50/5		107										
105.9			8	SS	50/NP		106										
5.8	Auger refusal at 5.8 m probably on a limestone layer Borehole dry on completion Piezometer installed to 5.8 m Water level in piezometer Feb.20 - 5.3 m Feb.24 - 5.3 March. 2 - 5.1 m																N.P denotes no penetration

# RECORD OF BOREHOLE No B1-3

1 OF 1

METRIC

W.P. 171-00-01 LOCATION Ramp FGGE(E)-Sherway Gardens Road, 4 830 446.6 N; 300 853.4 E ORIGINATED BY G.I  
DIST HWY 427 & QEW BOREHOLE TYPE Solid Stem Augers, NQ Rock Core COMPILED BY G.T  
DATUM Geodetic DATE 20.02.00 25.02.00 CHECKED BY Z.O

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								
105.0	Ground surface							20	40	60	80	100				
104.9	100 mm Asphalt		1	SS	50/15											34 52 (14)
104.4	FILL : Sand with Gravel, some silt															
0.8	FILL : Sandy Silt with shale		2	SS	50/15											
104.0	fragments & Gravel															
1.0	Completely disintegrated															
103.6	SHALE		3	SS	50/5											
1.4	grey		4	SS	50/15											
			5	NQ RC	Rec. 100%											R.Q.D.=70%
	SHALE BEDROCK occasional limestone seams, grey		6	NQ RC	Rec. 98%											R.Q.D.=70%
			7	NQ RC	Rec. 100%											R.Q.D.=93%
89.4																
5.6	End of borehole Borehole dry before coring Water level not stabilized															

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No B2-1

1 OF 1

METRIC

W.P. 172-00-01 LOCATION Ramp Brown's Line N - FGGE(E) 4 830 356.4 N; 300 805.9 E ORIGINATED BY G.I  
DIST HWY 427 & QEW BOREHOLE TYPE Solid Stem Augers - NQ Rock Core COMPILED BY G.T  
DATUM Geodetic DATE 11.02.00 CHECKED BY Z.O

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
111.2	Ground surface		1	AS			111										
110.9	300 mm Topsoil		2	SS	60/25		110									19.0	
0.3	FILL -Clayey Silt with shale fragments, grey, damp		3	SS	8		109									18.1	
108.9			4	SS	6		108									21.0	
108.5	CLAYEY SILT TILL with shale (possible fill)		5	SS	50/15		107										limestone layer @ 3.2 m refusal to augering
2.7			6	SS	50/13		106										
	225 mm limestone seam		7	NQ RC	Rec. 100%		105										R.Q.D. =65%
			8	NQ RC	Rec. 100%		104										R.Q.D. =45%
	SHALE BEDROCK grey some limestone seams		9	NQ RC	Rec. 100%												R.Q.D. =75%
103.3																	
7.9	End of borehole Borehole dry prior to coring Water level not stabilized																AS- Auger sample

# RECORD OF BOREHOLE No B2-2

1 OF 1

METRIC

W.P. 172-00-01 LOCATION Ramp Brown's Line N - FGGE(E) 4 830 346.1 N; 300 805.9 E ORIGINATED BY M.J.  
 DIST HWY 427 & GEW BOREHOLE TYPE Solid Stem Augers COMPILED BY G.T.  
 DATUM Geodetic DATE 15.02.00 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
110.9	Ground surface						20	40	60	80	100						
110.8	75 mm Topsoil		1	SS	14											21.0	
110.4	FILL: Silty Sand, some clay																
0.5	FILL highly weathered Shale pieces, some clay, sand and gravel		2	SS	10											21.1	
			3	SS	12												
108.8	SHALE BEDROCK some limestone seams, grey		4	SS	50/6												
2.1			5	AS													
108.0																	
2.9	End of borehole Refusal to augering @ 2.9 m Piezometer installed to 2.9 m Water level in piezometer Feb. 20 - dry Feb. 22 - dry Feb. 24 - 2.8 m March. 2 - 2.7 m															Moved 1.0 m SE and re-drilled Refusal to augering again @ 2.9 m probably on a limestone layer	

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No B2-3

1 OF 1

METRIC

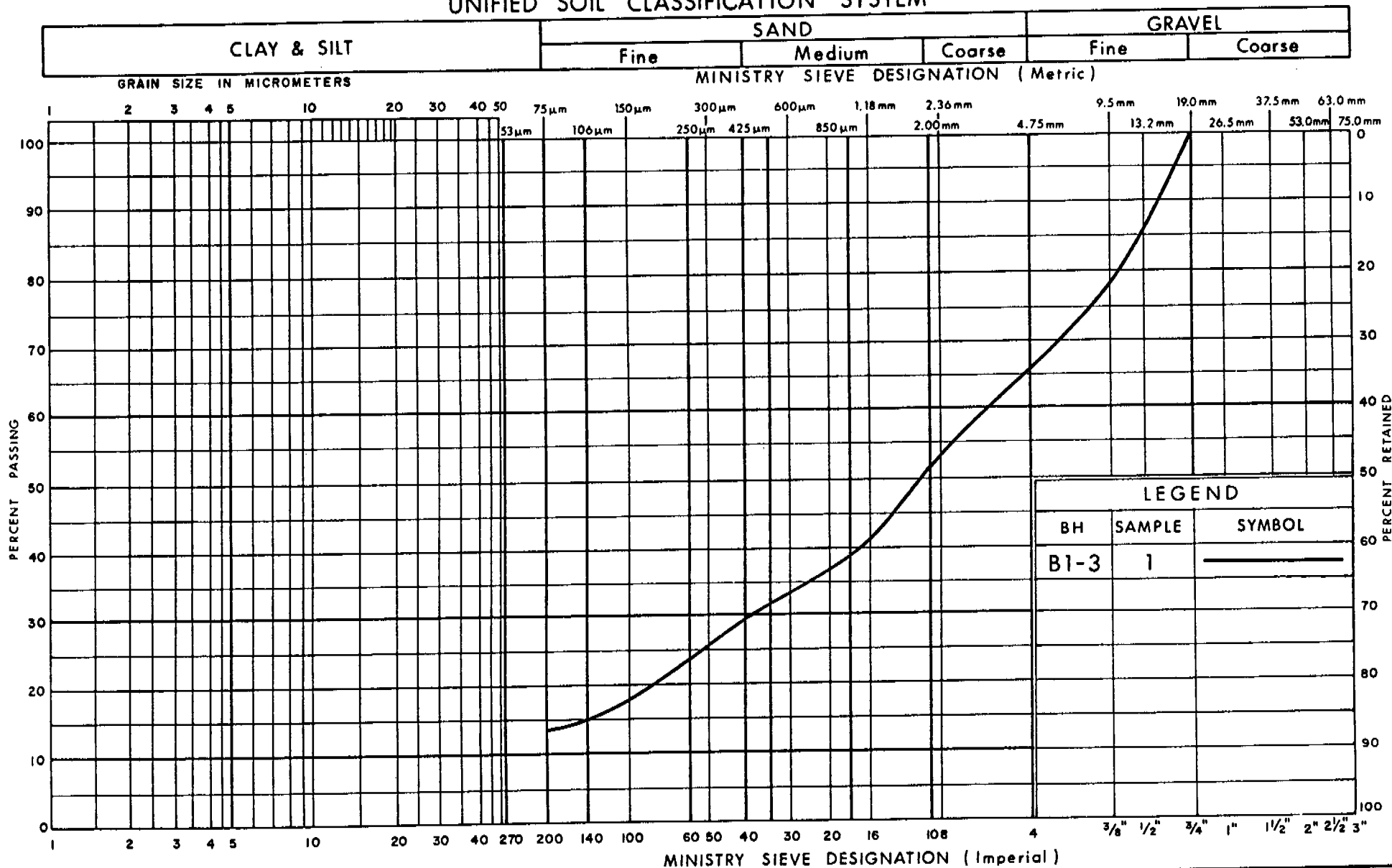
W.P. 172-00-01 LOCATION Ramp Brown's Line N - FGGE(E) 4 830 383.9 N; 300 853.1 E ORIGINATED BY G.I.  
 DIST HWY 427 & QEW BOREHOLE TYPE Solid Stem Augers, NQ Rock Core COMPILED BY G.T.  
 DATUM Geodetic DATE 25.02.00 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
104.1	Ground surface																
104.0	100 mm Asphalt	XXXX															
103.6	FILL: Sand with gravel, brown,	XXXX	1	SS	18												
0.5	Completely																
103.0	disintegrated shale	Y	2	SS	27												
1.1			3	SS	50/14												
			4	SS	50/10												
	SHALE BEDROCK		5	SS	50/8												
	grey		6	SS	50/8												
	highly weathered to 5.0 m		7	SS	50/8												
			8	SS	50/8												
			9	NQ RC	Rec. 100%												
	frequent limestone		10	NQ RC	Rec. 100%												
	seams		11	NQ RC	Rec. 100%												
	280 mm limestone		12	NQ RC	Rec. 100%												
	seam																
94.0																	
10.1	End of borehole																
	Borehole dry prior coring																
	Water level not stabilized																

# APPENDIX B

## Laboratory Test Results

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

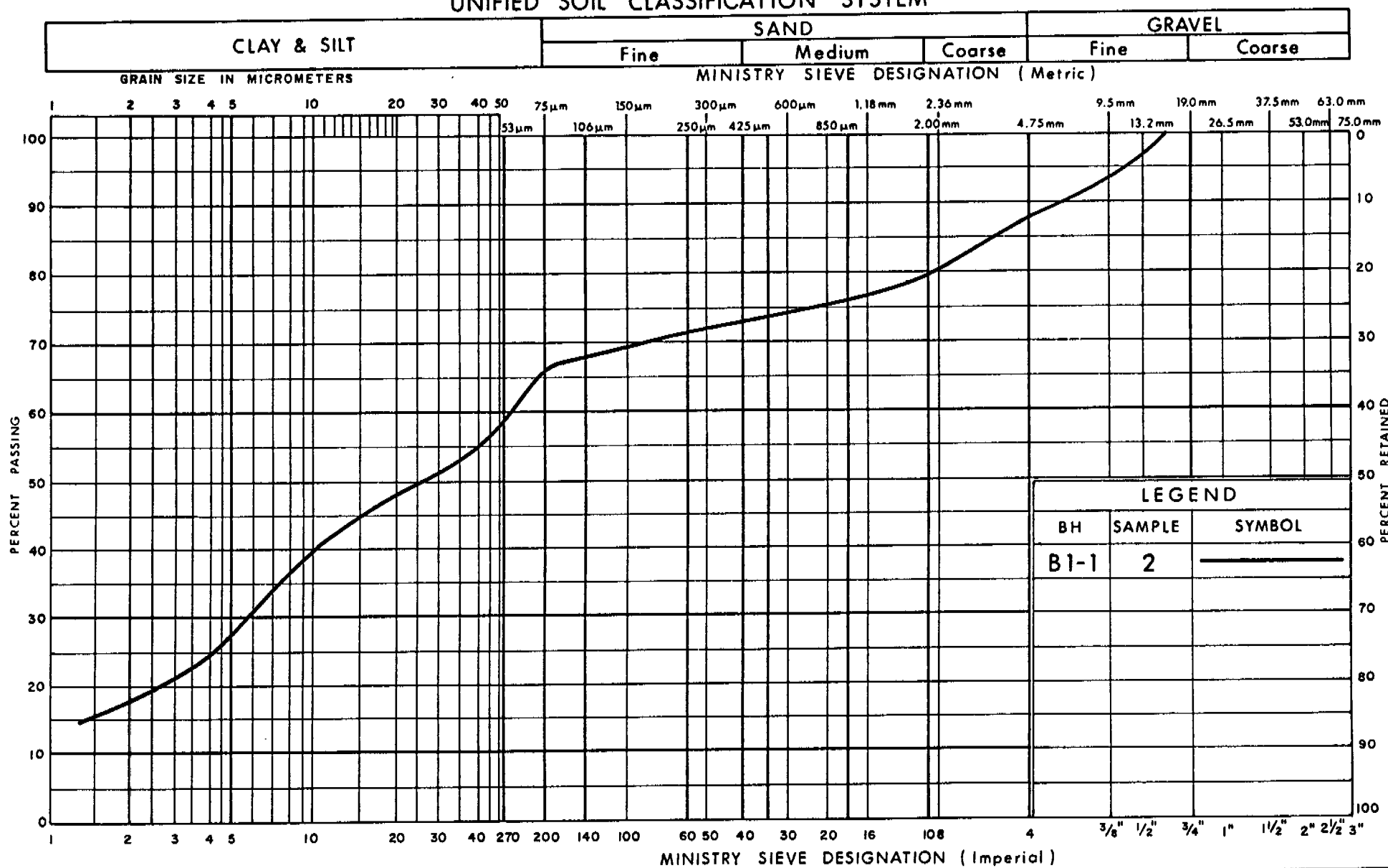
**GRAIN SIZE DISTRIBUTION**  
**SAND WITH GRAVEL, SOME SILT (GRANULAR FILL)**

FIG No 1

W P 171-00-01

SP 3232B

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

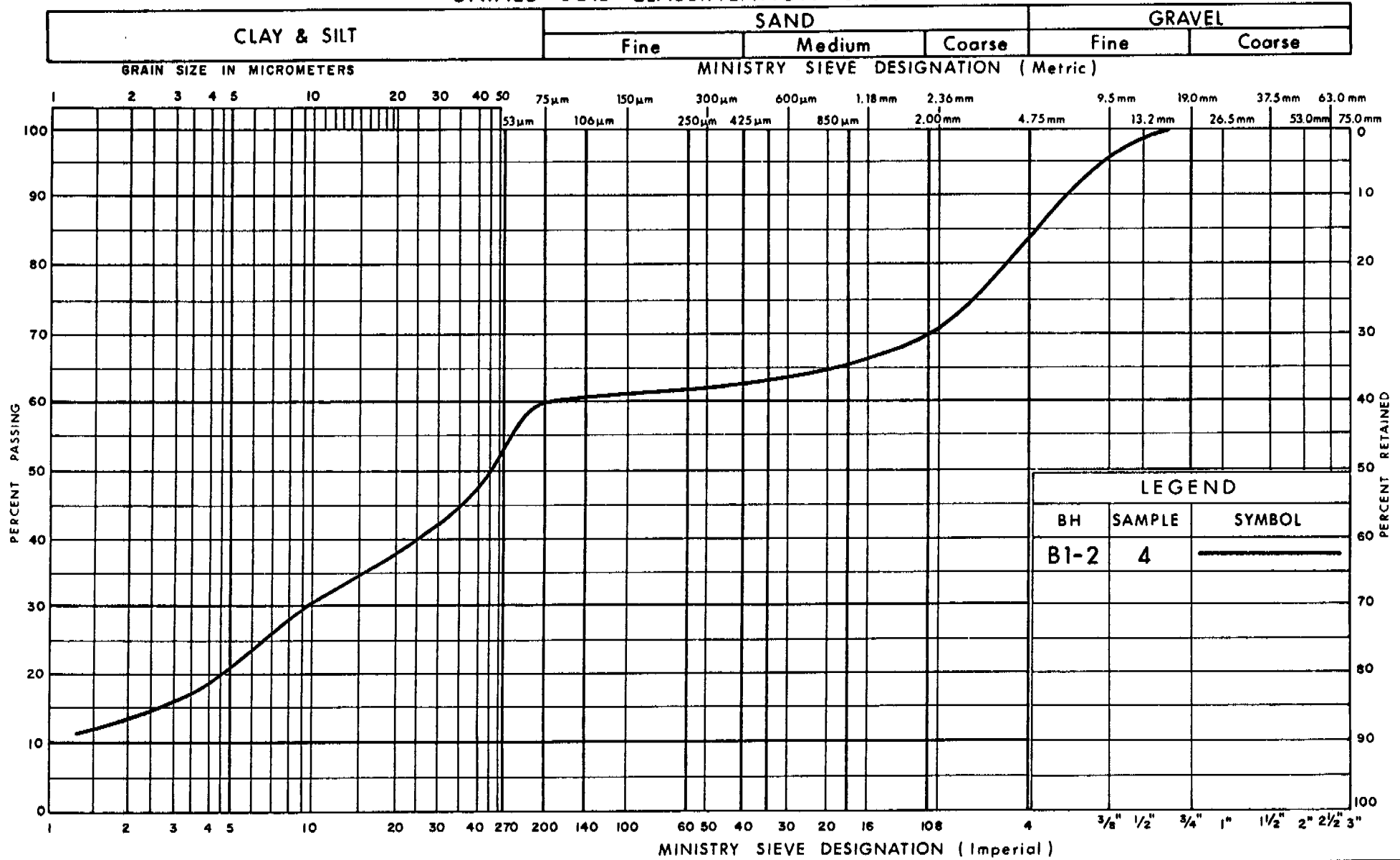
## GRAIN SIZE DISTRIBUTION CLAYEY SILT TILL

FIG No 2

W P 171-00-01

SP 3232B

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

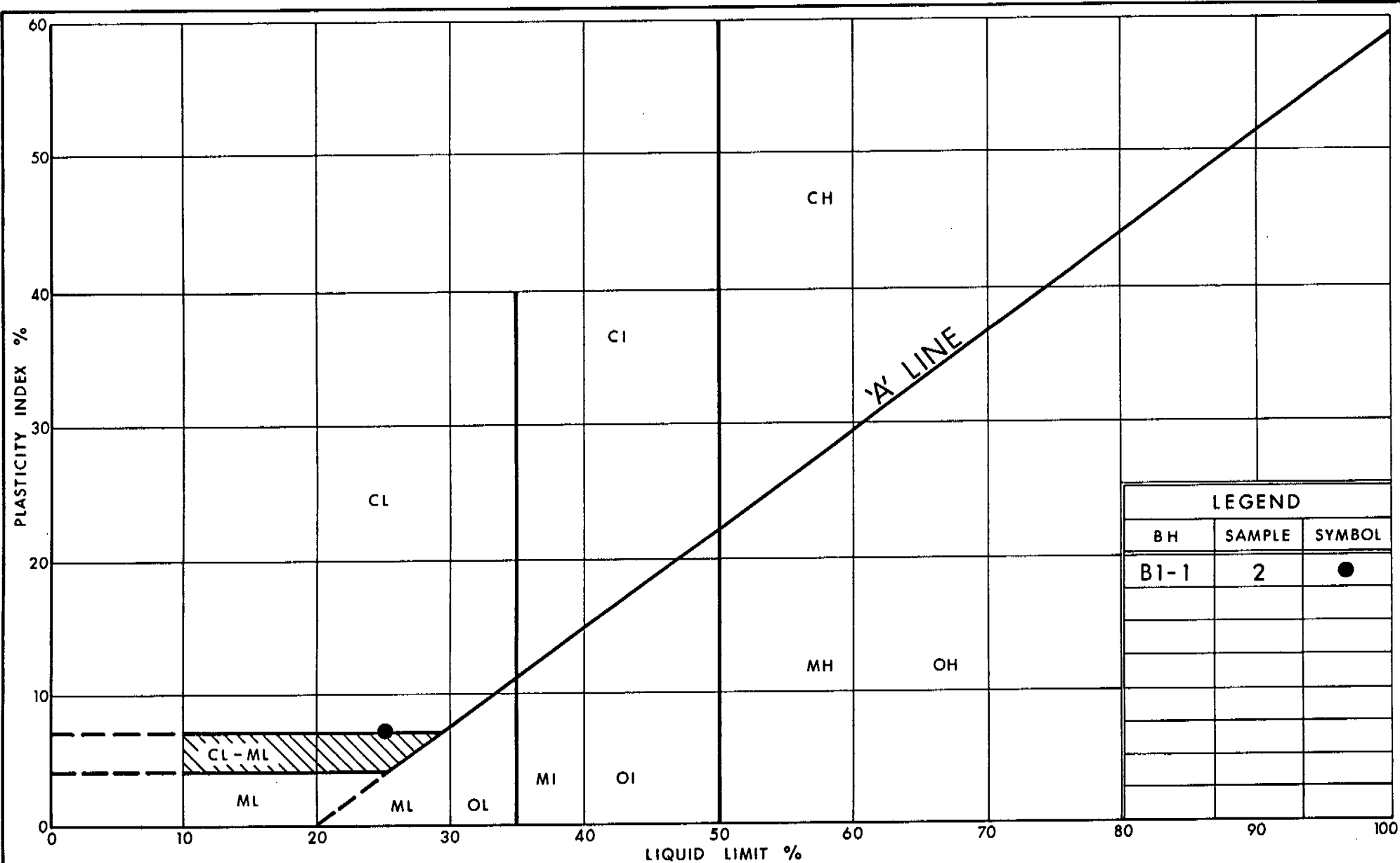
## GRAIN SIZE DISTRIBUTION

### TILL/SHALE Complex

FIG No 3

W P 171-00-01

SP 3232B



LEGEND		
BH	SAMPLE	SYMBOL
B1-1	2	●



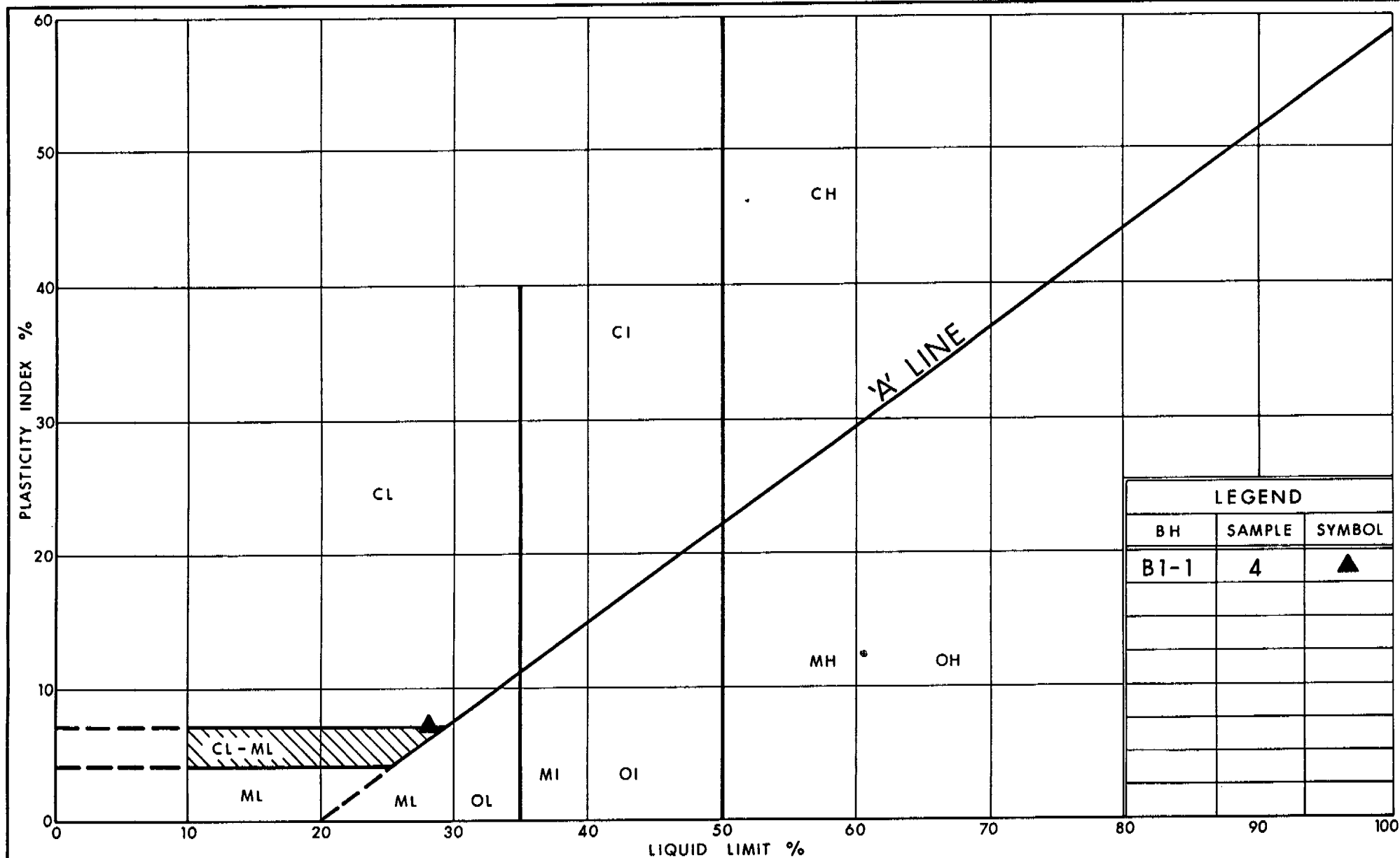
Ministry of  
Transportation  
Ontario

## PLASTICITY CHART CLAYEY SILT TILL

FIG No 4

W P 171-00-01

SP 3232B



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Transportation  
Ontario

# PLASTICITY CHART TILL/SHALE Complex

FIG No 5

W P 171-00-01

SP 3232B

## APPENDIX C

### Explanation of Terms Used in Report

## EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

SS SPLIT SPOON	TP THINWALL PISTON
WS WASH SAMPLE	OS OSTERBERG SAMPLE
ST SLOTTED TUBE SAMPLE	RC ROCK CORE
BS BLOCK SAMPLE	PH TW ADVANCED HYDRAULICALLY
CS CHUNK SAMPLE	PM TW ADVANCED MANUALLY
TW THINWALL OPEN	FS FOIL SAMPLE

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$C_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$\text{kg}/\text{m}^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{\min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$\text{KN}/\text{m}^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
$\rho_w$	$\text{kg}/\text{m}^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$\text{KN}/\text{m}^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$\text{kg}/\text{m}^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$\text{KN}/\text{m}^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$\text{kg}/\text{m}^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$\text{m}^3/\text{s}$	RATE OF DISCHARGE
$\gamma_d$	$\text{KN}/\text{m}^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{\text{sat}}$	$\text{kg}/\text{m}^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{\text{sat}}$	$\text{KN}/\text{m}^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$\text{kg}/\text{m}^3$	DENSITY OF SUBMERGED SOIL	$e_{\max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$\text{KN}/\text{m}^3$	SEEPAGE FORCE
$\gamma'$	$\text{KN}/\text{m}^3$	UNIT WEIGHT OF SUBMERGED SOIL						

# APPENDIX D

## Core Logs and Photographs

# CORE LOG

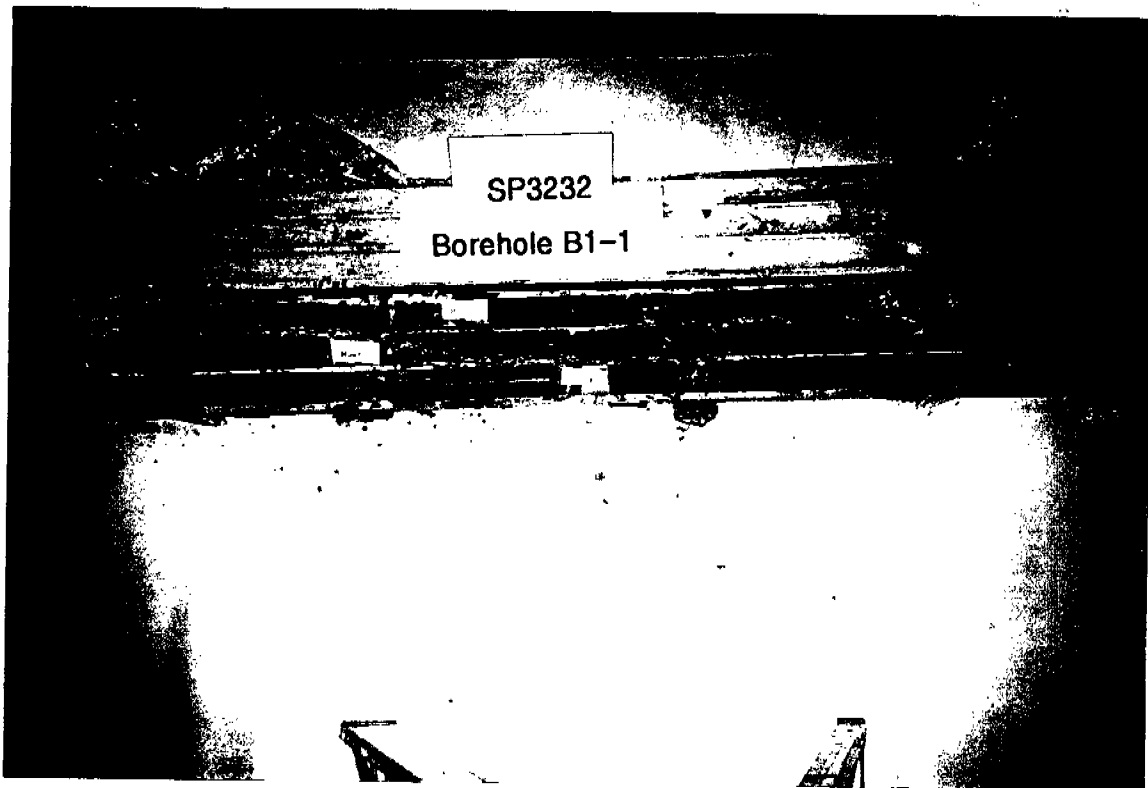
**BH NO.B1-1**

[illegible]

**S & P**

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**Consulting Geo-Environmental Engineers**

*please photocopy  
from originals*

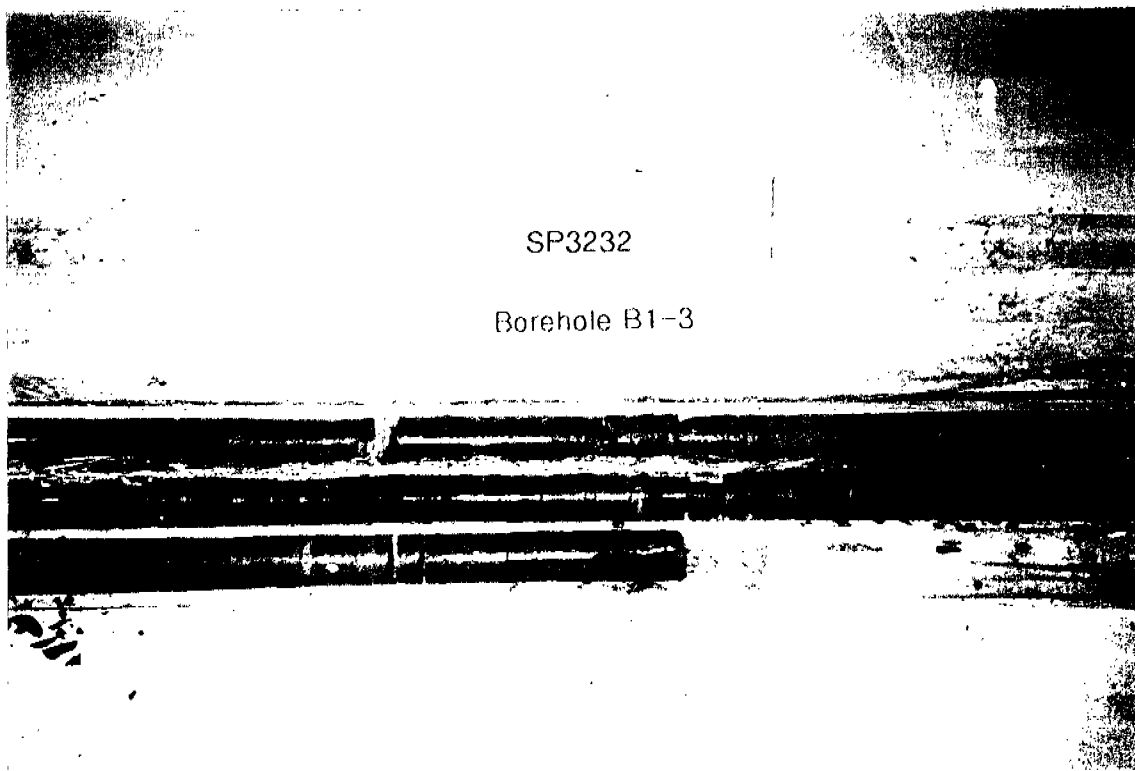


**Photograph of Core  
Borehole B1-1  
Elev. 107.4 m – 102.2 m**

CORE LOG											BH NO B1-3							
PROJECT Foundation Investigation					ORIENTATION Vertical		ELEVATION (m) 105.0		DATUM Geodetic		PROJECT NO. SP3232							
LOCATION Q.E.W./Hwy 427/Brown's Line Interchange Modification					DATE STARTED 02/15/00		COMPLETED 02/15/00		LOGGED BY E.P.		DRAWING NO.							
CLIENT					DRILLER Groundworks		DRILL TYPE CME 75		CORE BARREL NQ		SHEET 1 of 1							
ELEV. (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	JOINT CHARACTERISTICS							WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN No.	RECOVERY %	ROD	WATER RECOVERY %	WATER COLOUR
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERATURE (mm)								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
105.0			OVERBURDEN: see soils log for description															
103.6	1		<b>GEORGIAN BAY FORMATION:</b> Shale with Interbedded Limestone and Sandstone Shale (96%) thinly bedded or laminated, dark grey, slightly to moderately weathered to 2.8 m, low strength Limestone (1%) fine grained, fossiliferous, unweathered, moderate strength Sandstone and Siltstone (3%) stratified, brownish grey to medium grey, unweathered, moderate strength Discontinuities: bedding joints are at close to very close intervals, occasional vertical joints, the maximum thickness of limestone or sand/siltstone layers was about 90 mm, joint surfaces are smooth planar to rough planar Rubble seams of 5 mm noted at 2.68 m and 3.0 m Clay seam of 5 mm noted at 4.1 m End of Borehole	1	B	F	C	SP	T	0				1	100	70	100	grey
	2							VC	RP	R	5							
	3									R	5							
	4									SO	5			2	98	70	100	grey
99.4	5			C		V								3	100	93	100	grey
	6																	
	7																	
	8																	
	9																	
	10																	
	11																	
	12																	
	13																	
	14																	
	15																	
	16																	
	17																	
	18																	
	19																	

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



























Photograph of Core  
Borehole B1-3  
Elev. 103.6 m – 99.4 m

# CORE LOG

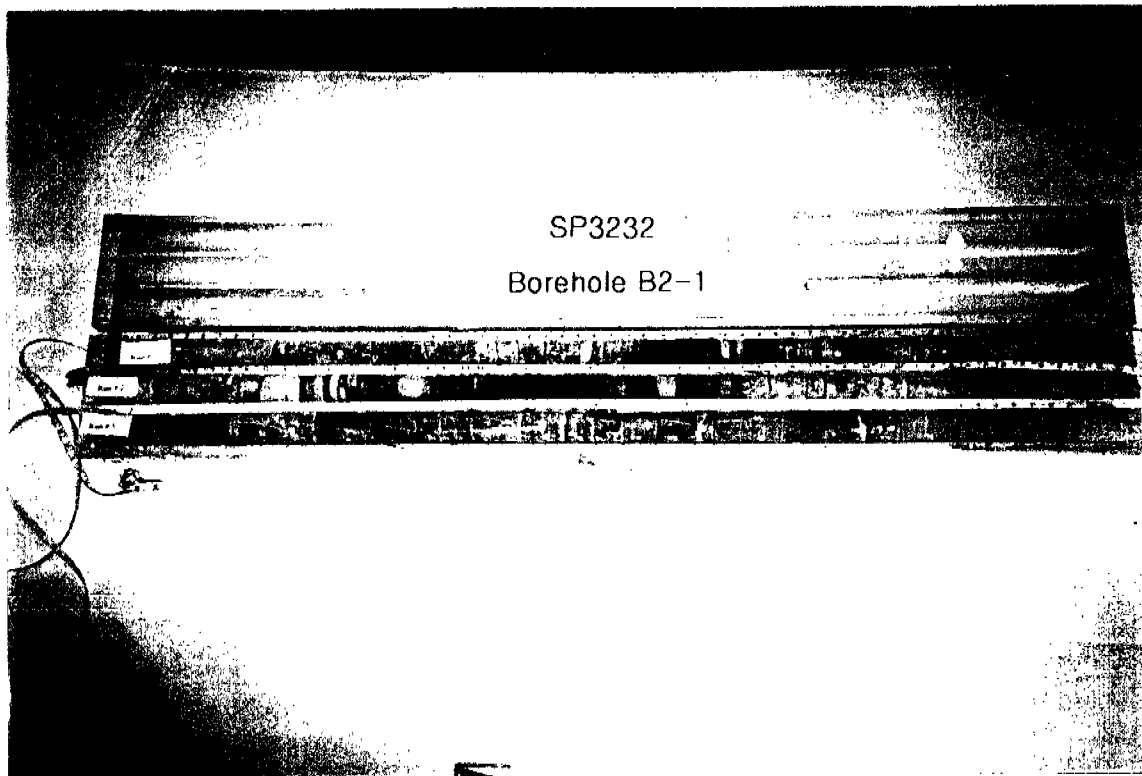
## BH NO B2-1

PROJECT Foundation Investigation	ORIENTATION Vertical	ELEVATION (m) 111.2	DATUM Geodetic	PROJECT NO. SP3232
LOCATION Q.E.W./Hwy 427/Brown's Line Interchange Modification	DATE STARTED 02/11/00	COMPLETED 02/11/00	LOGGED BY E.P.	DRAWING NO.
CLIENT	DRILLER Groundworks	DRILL TYPE CME 75	CORE BARREL NQ	SHEET 1 of 1

ELEV. (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	JOINT CHARACTERISTICS							WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN No.	RECOVERY %	ROD	WATER RECOVERY %	WATER COLOUR	
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERATURE (mm)									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
111.2			OVERBURDEN: see soils log for description																
	1																		
	2																		
108.5																			
107.9	3		SHALE: sampled with split-barrel sampler; see soils log for description																
	4		GEORGIAN BAY FORMATION: Shale with Interbedded Limestone and Sandstone	1	B	F D	C VC	SP RP	T	0									
	5		Shale (79%) thinly bedded or laminated, dark grey, slightly to moderately weathered to 4.8 m, low strength	2	B C	V									1	100	65	100	grey
	6		Limestone (9%) fine grained, fossiliferous, unweathered, moderate strength						R R	5 5					2	100	45	100	grey
	7		Sandstone and Siltstone (12%) stratified, brownish grey to medium grey, unweathered, moderate strength												3	100	75	100	grey
103.3	8		Discontinuities: bedding joints are at close to very close intervals, the maximum thickness of limestone or sand/siltstone layers was about 225 mm, occasional random vertical joints, joint surfaces are smooth planar to rough planar																
	9																		
	10		Rubble seams about 5 mm thick noted at 5.57 and 5.65 m depth.																
	11		End of Borehole																
	12																		
	13																		
	14																		
	15																		
	16																		
	17																		
	18																		
	19																		

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Photograph of Core  
Borehole B2-1  
Elev. 107.9 m – 103.3 m

# CORE LOG

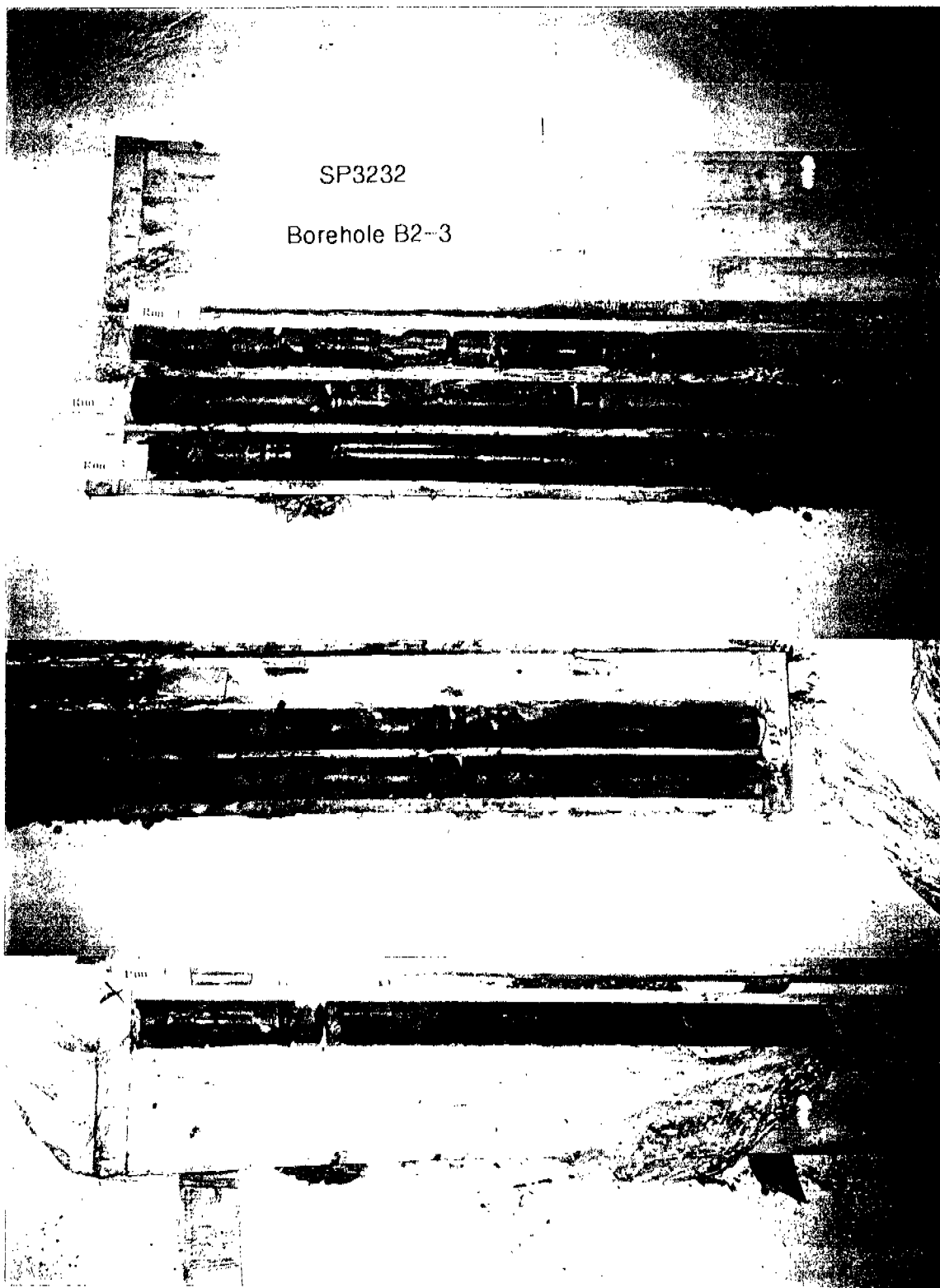
## BH NO B2-3

PROJECT Foundation Investigation	ORIENTATION Vertical	ELEVATION (m) 104.1	DATUM Geodetic	PROJECT NO. SP3232
LOCATION Q.E.W./Hwy 427/Brown's Line Interchange Modification	DATE STARTED 02/25/00	COMPLETED 02/25/00	LOGGED BY E.P.	DRAWING NO.
CLIENT	DRILLER Groundworks	DRILL TYPE CME 75	CORE BARREL NQ	SHEET 1 of 1

ELEV. (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	JOINT CHARACTERISTICS							WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN No.	RECOVERY %	ROQ	WATER RECOVERY %	WATER COLOUR
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERATURE (mm)								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
104.1			OVERBURDEN: see soils log for description															
103.0	1		SHALE: sampled with split-barrel sampler; see soils log for description															
	2																	
	3																	
	4																	
98.8	5		GEORGIAN BAY FORMATION:	1	B	F	C	SP	T	0				1	100	32	100	grey
	6		Shale with Interbedded Limestone and Sandstone				VC	RP										
	7		Shale (76%) thinly bedded or laminated, dark grey, slightly to moderately weathered to 6.0 m, low strength											2	100	92	100	grey
	8		Limestone (11%) fine grained, fossiliferous, unweathered, moderate strength						SO	5								
	9		Sandstone and Siltstone (13%) stratified, brownish grey to medium grey, unweathered, moderate strength						SO	50				3	100	75	100	grey
	10		Discontinuities: bedding joints are at close to very close intervals, the maximum thickness of limestone or sand/siltstone layers was about 280 mm, occasional random vertical joints, joint surfaces are smooth planar to rough planar						SO	5				4	100	93	100	grey
94.0	11		Clay seams of 5 mm noted at 7.82 m and 8.71 m, and 50 mm at 8.62 m															
	12		End of Borehole															
	13																	
	14																	
	15																	
	16																	
	17																	
	18																	
	19																	

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Photograph of Core  
Borehole B2-3  
Elev. 98.8 m – 94.0 m

# EXPLANATORY SHEET TO CORE LOG

Column No.	Description
1	Elevation of geotechnical boundary.
2	Depth of geotechnical boundary in borehole.
3	Geological symbol for rock or soil material.
4	General description of geotechnical unit - qualitative description including rock type(s), percentage rock types, frequency and sizes of interbeds, colour, texture, weathering, strength, general joint spacing.
5-11	Joint (discontinuity) characteristics
5	Number of joint sets: a rock mass can be intersected by a number of joint sets of varying orientations.
6	Joint type: B = Bedding Joint F = Fault C = Cross Joint S = Shear Plane
7	Orientation: only variations in dip can be identified in core; dip direction is obtained from field mapping or oriented core. F = Flat = 0 - 20° D = Dipping = 20 - 50° V = Vertical = 50 - 90°
8	Joint spacing: this is an approximate measure of spacing between joints in specific joint sets VW = Very Wide = 3 m W = Wide = 1 - 3 m M = Moderate = 30 cm - 1 m C = Close = 5 - 30 cm VC = Very Close = 5 cm
9	Roughness: RU = Rough Undulating RP = Rough Planar SU = Smooth Undulating SP = Smooth Planar LU = Slickensided Undulating LP = Slickensided Planar
10	Fillings: Approx. % T = Tight, hard, non-softening - O = Oxidation surface staining only 25 - 35 SA = Slightly altered; clay-free 25 - 30 S = Sandy particles; clay-free 25 - 30 Si = Sandy and silty, minor clay 20 - 25 NC = Non softening clays ( 5 mm) 16 - 24 SO = Softening clays ( 5 mm) 12 - 16 SC = Swelling clay fillings ( 5 mm) 6 - 12
11	Apertures: estimated sizes of joint opening
12	Degree of weathering of rock material: Unweathered = no signs of discolouration or oxidation Slightly weathered = partial discolouration; fractures (joints) typically oxidized Moderately weathered = total discolouration Highly weathered = total discolouration; typically friable & pitted Completely weathered = resembles a soil; rock structure usually preserved

Column No.	Description	Approx. Uniaxial Compressive Strength
13	Strength of rock material: Very high strength = specimen can only be chipped by geological hammer High strength = specimen requires a number of blows of geological hammer to fracture it; cannot be scraped with pocket knife Medium strength = specimen can be fractured by single firm blow of geological hammer; can be scraped with pocket knife, not peeled Low strength = shallow indentations made by firm blow with point of geological hammer; can be peeled by pocket knife with difficulty Very low strength = crumbles under firm blow with point of geological hammer; can be peeled by pocket knife	200 MPa 50 - 200 MPa 15 - 50 MPa 4 - 15 MPa 1 - 4 MPa
14	Fracture Frequency: Number of natural joints occurring over a metre length of core. All natural joints are counted irrespective of the number of joint sets.	
	Fracture frequency 0.3/m 0.3 - 1/m 1 - 3/m 3 - 20/m 20/m	Joint spacing Very wide = 3 m Wide = 1 - 3 m Moderate = 30 cm - 1 m Close = 5 - 30 cm Very close = 5 cm
15	Run Number and Core Recovery: (i) Drill run number; (ii) Core Recovery is the total length of core pieces, irrespective of their individual lengths, obtained in a core run and expressed as a percentage of the length of that core run.	
16	Rock Quality Designation (RQD): The total length of those pieces of sound core which are 10 cm or greater in length in a core run expressed as a percentage of the total length of that core run. Sound pieces of rock are those pieces separated by natural breaks and not machine breaks or subsequent artificial breaks.	
	RQD 0 - 25 % 25 - 50 % 50 - 75 % 75 - 90 % 90 - 100 %	Rock Mass Classification (After Deere) very poor poor fair good excellent
17	Core and Casing Sizes: changes of core and casing sizes are indicated.	
18	Water recovery, level and tests.	

## APPENDIX E

### Logs of Boreholes Drilled in 1960's

# GEOTECHNICAL DATA SHEET FOR BOREHOLE . . . 89 . . .

OUR REFERENCE NO. 6-6-18

CLIENT: D.H.O.  
 PROJECT: BRIDGE No. 5. Q.E.W. & HWY. 27.  
 LOCATION: 178,446 N ; 209,348 E  
 DATUM ELEVATION: G.S.C.

METHOD OF BORING: WASHBORING  
 DIAMETER OF BOREHOLE: 2 3/8"  
 DATE: JUNE 30. 1966.  
 W.P. 238-61-4

ENCLOSURE NO.

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE		CONSISTENCY		REMARKS
				NUMBER	TYPE	Advancement of Sample	blows per foot	SHEAR STRENGTH	water content %	Pl W LI	
368.9	0	GROUND SURFACE									
		Brown SAND (FILL)									
347.4	1.5	Dark Brown CLAYEY SILT with a trace of SAND and GRAVEL (FILL)									
365.0	5	Organic TOPSOIL		1 A	SS	SS					
363.9	5.9	Dense FINE SAND with some SILT		B							
361.4	7.5	Very Dense Grey SAND and SILT with numerous SHALE fragment and a trace of embedded fine GRAVEL (GLACIAL TILL)		2	SS	50/4"					
360.0	10			3	SS	65/4"					
				4	SS	100/4"					
355.0	15			5	SS	100/4"					
353.9		Grey SHALE BEDROCK		6	RC	89 %					
350.0	20										
348.5		END OF BOREHOLE									

W.L. 364.6 Ft.  
 JULY 6, 1966.  
 Sa - 83% ; Si - 17 %  
 So - 56% , Si - 44 %

# GEOTECHNICAL DATA SHEET FOR BOREHOLE . . 90 . .

OUR REFERENCE NO. 6-6-14

CLIENT: D.H.O.  
PROJECT: BRIDGE No. 3, O.E.W. & HWY. 27.  
LOCATION: 178,590 N 1 209,358 E  
DATUM ELEVATION: O.S.C.

METHOD OF BORING: AUGERING  
DIAMETER OF BOREHOLE: 4"  
DATE: JUNE 30, 1966.  
W.P. 238-61-2

ENCLOSURE NO.

ELEVATION F.	DEPTH F.	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE		CONSISTENCY		REMARKS
				NUMBER	TYPE	Advisory No. Sample	blows per foot	lb./sq. ft.	water content %	PL W LI	
349.7	0	GROUND SURFACE									
		Compact to Dense Brown SILTY FINE SAND with a trace of CLAY		1	AS						Sc. 67 % Sl. 30 % ; Cl. - 3 % W.L. 365.2 Ft. JULY 6, 1966.
365.0	5			2	SS	39					
348.7	6.0	Very Dense Grey SILTY SAND with a trace of GRAVEL and CLAY		3	SS	71/5					Gr. 8 % ; Sc. 59 % Sl. 25 % ; Cl. 8 %
340.0	10			4	SS	75/5					
347.8	12.0	Grey SHALE with intermittent layers of LIMESTONE BEDROCK		5	RC	86 %					
339.0	15			6	RC	66 %					
330.0	20			7	RC	16 %					
348.0	23			8	RC	78 %					
340.0	30	END OF BOREHOLE									
335.0	35										

VERTICAL SCALE: 1 IN TO 5 FT

DOMINION SOIL INVESTIGATION LIMITED

MADE: V.G.H. CHD.

# GEOTECHNICAL DATA SHEET FOR BOREHOLE . . . 115.

OUR REFERENCE NO 6-6-13

CLIENT: D.H.O.

PROJCT: G.E.W. & HWY. No. 27 INTERCHANGE, BRIDGE No 2

LOCATION 178,488 N 209,454 E

DATUM ELEVATION: G.S.C.

METHOD OF BORING: WASHBORING.

DIAMETER OF BOREHOLE: 3 1/2"

DATE: JUNE 30 - JULY 8, 1966

W.P. 238-61-1

ENCLOSURE NO.

ELEVATION ±	DEPTH ±	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE blows per foot					CONSISTENCY water content %		REMARKS
				NUMBER	TYPE	TEST	20	40	60	80	100	PI	W	
367.5	0	GROUND SURFACE												
		6" TOPSOIL												
365.0		SANDY, CLAYEY SILT (FILL)												
363.8	4.0	Dense, Brown FINE SAND		1	SS	60								
362.0	5.8	Dense, Grey SANDY SILT with some gravel (GLACIAL TILL)												
360.0														
357.5	10													
355.0		Grey EXTREMELY WEATHERED SHALE		3	R.C.	80 %								
350.0	12			5	R.C.	80 %								
	20	BEDROCK		6	R.C.	10 %								
345.0				7	R.C.	10 %								
	25			8	R.C.	0 %								
340.0		Sound		9	R.C.	80 %								
335.0	30													
	32													

W.L. El. 364.2 ft.  
July 6, 1966

VERTICAL SCALE 1 IN TO 5 FT

DOMINION SOIL INVESTIGATION LIMITED

MADE: C.K. CHD

# GEOTECHNICAL DATA SHEET FOR BOREHOLE . . 119.

OUR REFERENCE NO 6-6-13

CLIENT: D.H.O.

PROJECT: Q.E.W. & HWY. No. 27 INTERCHANGE, BRIDGE No 2

METHOD OF BORING: WASHBORING.

ENCLOSURE NO

LOCATION: 178,360N 209,326E

DATE: JULY 6, 1966

DATUM ELEVATION: G.S.C.

W.P. 238-61-1

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE blows per foot					CONSISTENCY water content %		REMARKS
				NUMBER	TYPE	N- Advancement of Sample	2.0	4.0	6.0	8.0	10.0	FL	W	
368.0	0	GROUND SURFACE												
363.0		1" ASPHALT SILTY SAND with some gravel FILL												
364.0	4.0	SILTY FINE SAND												
363.0	5	Hal, Grey CLAYEY SILT to SANDY SILT with some gravel and shale fragments (GLACIAL TILL)		1	SS	35								
360.0	10			2	SS	100/4								
355.0				3	SS	100/2								
353.2	14.8			4	WS	-								
350.0	20	Grey SHALE with layers of - limestone		5	R.C.	77%								
345.0	25	BEDROCK		6	R.C.	80%								
		END OF BOREHOLE												

W.L. El. 362.8 ft.  
July 6, 1966

**FOUNDATION DESIGN REPORT  
PROPOSED RETAINING STRUCTURE  
ALONG THE WEST SIDE OF BROWN'S LINE AT Q.E.W. INTERCHANGE  
TORONTO, ONTARIO  
W.P. 176-00-01**

**Prepared For:**

**DS-LEA ASSOCIATES LIMITED  
251 Consumers Road, Suite 1200  
North York, Ontario  
M2J 4R3**

**Prepared by:**

**SHAHEEN & PEAKER LIMITED**

**Project: SP3232L  
July 5, 2000**

**250 Galaxy Boulevard  
Etobicoke, Ontario  
M9W 5R8  
Tel: (416) 213-1255  
Fax: (416) 213-1260**

## Table of Contents

### FOUNDATION DESIGN REPORT

5.	DISCUSSION AND RECOMMENDATIONS	9
6.	CLOSURE	14

### APPENDICES

Sketches of Details of Proposed Retaining Works

Appendix F

Limitations of Report

Appendix G

**FOUNDATION DESIGN REPORT  
PROPOSED RETAINING STRUCTURE  
ALONG THE WEST SIDE OF BROWN'S LINE AT Q.E.W. INTERCHANGE  
TORONTO, ONTARIO  
W.P. 176-00-01**

**5. DISCUSSION AND RECOMMENDATIONS**

The existing Brown's Line SBL will be shifted towards the west and the excavation will approach the existing and the proposed bridge foundations. In order to prevent the undermining and/or causing unacceptable settlements of the existing and the proposed spread footing foundations, a rigid retaining structure is planned to be constructed in front of the west abutment footings of the following bridges:

- Existing Bridge No. 2
- Existing Bridge No. 3
- Proposed Ramp E-Sherway Gardens Road Bridge

The extent of the proposed retaining structure is shown on the sketch presented in Appendix F. As shown on sketches that were provided to us and appended to this report (Appendix F), in essence the proposed retaining structure consists of a contiguous caisson wall which will incorporate permanent tieback (rock anchors) and concrete facing. The most critical section is anticipated to be the southwest corner of the existing footing for Bridge No. 3 (as illustrated on the sketches provided in Appendix F), as the proposed excavation comes very close to the corner of the abutment footing.

Boreholes B1-1, B1-2, B2-1 and B2-2 drilled in the general area for the proposed bridge structures show, in general, below some fill, the presence of clayey silt till, underlain by a till/shale complex which is a transition zone into the underlying shale bedrock. The surface of the bedrock at the borehole locations was recorded at approximate elevation ranging from 108.8 to 108.5 m. In the boreholes drilled in 1960's for MTO (before the area was developed) in the general area, the

surface of the bedrock was encountered at elevations ranging from 109.0 and 107.6 m (Borehole Log Sheets presented in Appendix E).

The sketch provided (Appendix F) shows that the footing for existing Bridge No. 3 is founded on bedrock at about Elevation 105.4 m and the excavation level in front will be  $104.0 \pm$  m, that is about 1.4 m below the bottom of the existing footing. We understand that this is typical of the entire retained length along the proposed retaining structure.

In our opinion, with the prevailing subsurface conditions, the proposed scheme is a suitable solution. The following values can be used for the design of the caissons.

$K_o$	=	0.45 all soils, do not use $K_a$
$K$	=	1.0 when retaining horizontal loads from adjacent footings, piles, etc.
$K$	=	0.15 in the shale bedrock
$\gamma$	=	21 kN/m <sup>3</sup> all soils above watertable
$\gamma$	=	23 kN/m <sup>3</sup> shale bedrock
$Q$	=	surcharge loads as required

Note that  $K$  values assume a horizontal backfill. If the backfill is inclined  $K_o$  will increase. Where footings or pile tips are within a 45° line drawn from the edge of the footing or pile tip and this line intersects the wall, the effect of this load must be incorporated into the wall design. In this case,  $K=1$  is applicable to this portion of the load on the wall.

The following unfactored values can be used for the calculation of passive earth pressure in front of the caisson wall.

$K_p$	=	4.0 for clayey silt till and till/shale complex
$K_p$	=	4.5 for shale bedrock

Passive resistance developed within 1.2 m of the ground surface (i.e. within the frost zone) should be ignored.

Coefficient of horizontal subgrade reaction (force per volume) can be calculated from the following expression:

$$k_s = \frac{67}{d} c_u$$

where

$k_s$  = coefficient of subgrade reaction

$c_u$  = undrained shear strength of the material

$d$  = pile diameter

The unfactored  $c_u$  (i.e. undrained shear strength) for the shale bedrock can be taken as 1200 kPa.

The expression and the value given above are applicable to single caisson units only.

For the calculation of vertical loads to be resisted by caissons, a rock resistance value of up to 1200 kPa can be used at U.L.S. for caisson lengths of between 2.3 and 3.0 m below the finished road surface in front of the wall. This value can be increased to 1700 kPa for caisson lengths of between 3.0 and 4.0 m below the ground surface and up to 2200 kPa for caissons extending more than 4.0 m below the ground surface, S.L.S. will not govern.

Some general comments for the design and construction are as follows:

- (a) Use double corrosion protection on the tiebacks;
- (b) Test all tiebacks to a proof load of 133% of design load, but load test two tiebacks to 200% of design;
- (c) Monitor all tieback installations;
- (d) Do not load the tieback so that movement during stressing (into the soil) exceeds 4 mm;
- (e) Keep the free (unloaded) zone in the area defined by a 45° line drawn up from the toe of the pile, but the minimum free (i.e. unbonded) length

should be 6 m. For the calculation of anchor resistance for tie back design, the bond resistance at U.L.S. can be taken as 500 kPa (incorporating a safety factor of 2 against an ultimate failure condition) in the bedrock and S.L.S. will not govern. The minimum bond length should be 5 m.

- (f) The unbonded length must continue beneath all adjacent footings;
- (g) The walers will be welded to the H piles in the caissons and the face of all caissons will be cut back to the face of the H piles. Concrete strength and/or timing may need to take this aspect into consideration in planning.
- (h) Proper drainage should be provided to prevent the accumulation of water behind the retaining wall structure.
- (i) High strength, high density rigid insulation should be used; the insulation should be extended horizontally to cover the horizontal surface of the footing and vertically (upward) by about 0.5 m on the west face of the abutment (foundation) wall.
- (j) We recommend that the existing bridge foundation be monitored during the construction, especially during and immediately after tieback installation.

The limited headroom available when working underneath the existing bridge decks will require special consideration. In particular, the hard shale, siltstone, sandstone and particularly limestone seams and layers, which are known to be present in the shale bedrock, may be difficult to penetrate during the caisson excavations, especially if small equipment is to be used for this purpose, due to limited headroom.

Design frost penetration for the general area is 1.2 m. Therefore, a permanent soil cover of 1.2 m or its thermal equivalent is required for frost protection, including the shale bedrock.

As an alternative to the presently proposed system of a tied back contiguous caisson wall, the use of conventional 'soldier pile and lagging' (with

tiebacks) type of shoring can also be considered but, based on our experience, in general a rigid, non-yielding support structure is needed when an excavation extends close to existing significant structures, such as existing buildings and bridges. In such cases, the permanent retaining structure must be designed to resist the horizontal and vertical pressures applied by these foundations. Traditionally, in the Toronto area, contiguous caisson type rigid structures (as proposed in this case) have been utilized when excavating immediately adjacent to existing buildings, etc., in order to minimize lateral yield and surface settlements. It is, therefore, our opinion that conventional 'soldier pile and lagging' is not a suitable alternative.

Other types of support such as 'nailing' have been considered but these are not believed to be sufficiently rigid for the intended use.

A structural diaphragm (slurry) wall can be considered. Because of limited space available, only a narrow wall can likely be constructed and therefore, in this case, anchoring (i.e. tie backs) will be necessary. In addition, from a stability point of view, opening a continuous trench in front of slopes and existing foundations may endanger the stability and, therefore, it must be constructed with this aspect in mind (i.e. constructed in short sections). In this respect, a contiguous caisson wall is a safer approach. In addition, the subsurface conditions are not well suited for the use of a slurry wall (i.e. bedrock at shallow depth) as the availability of equipment capable of operating in a restricted area, especially due to low overhead, may present problems. Another disadvantage of this type of support is that its future performance is highly dependent on workmanship.

## 6. CLOSURE

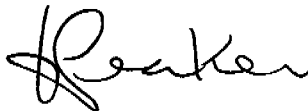
We recommend that once the details of the structure are finalized, our recommendations be reviewed for their specific applicability.

The Limitations of Report, as quoted in Appendix G, are an integral part of this report.

### **Shaheen & Peaker Limited**



Zuhtu Ozden, P.Eng.

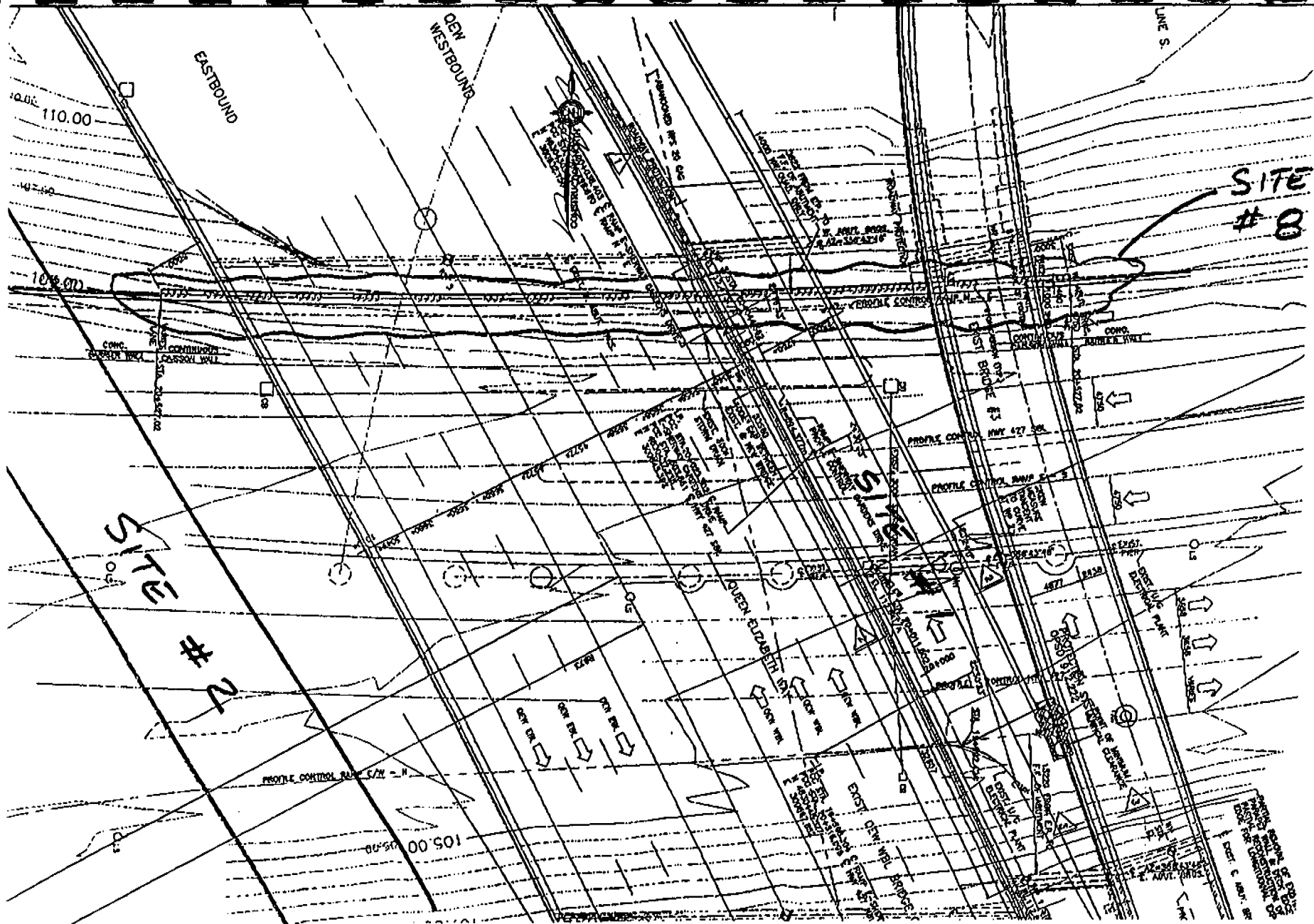


K. R. Peaker, Ph.D., P. Eng.

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## APPENDIX F

### Sketches of Details of Proposed Retaining Works



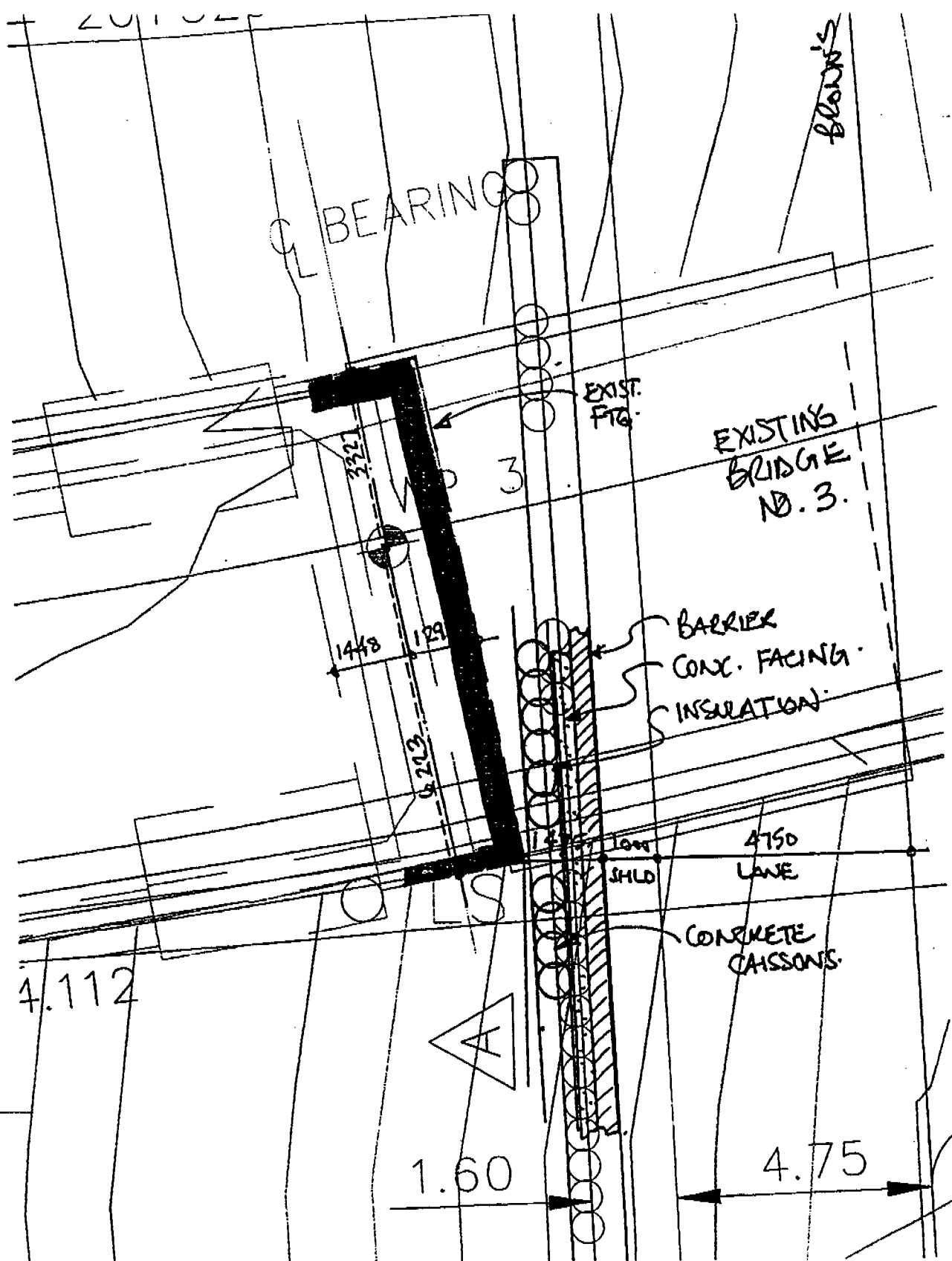
## CAISSON RETAINING WALL

**DS-Lea Associates Ltd.**

251 Consumers Road, Suite 1200  
Toronto, Canada  
Tel: (416) 490-8887, Fax: (416) 490-8378



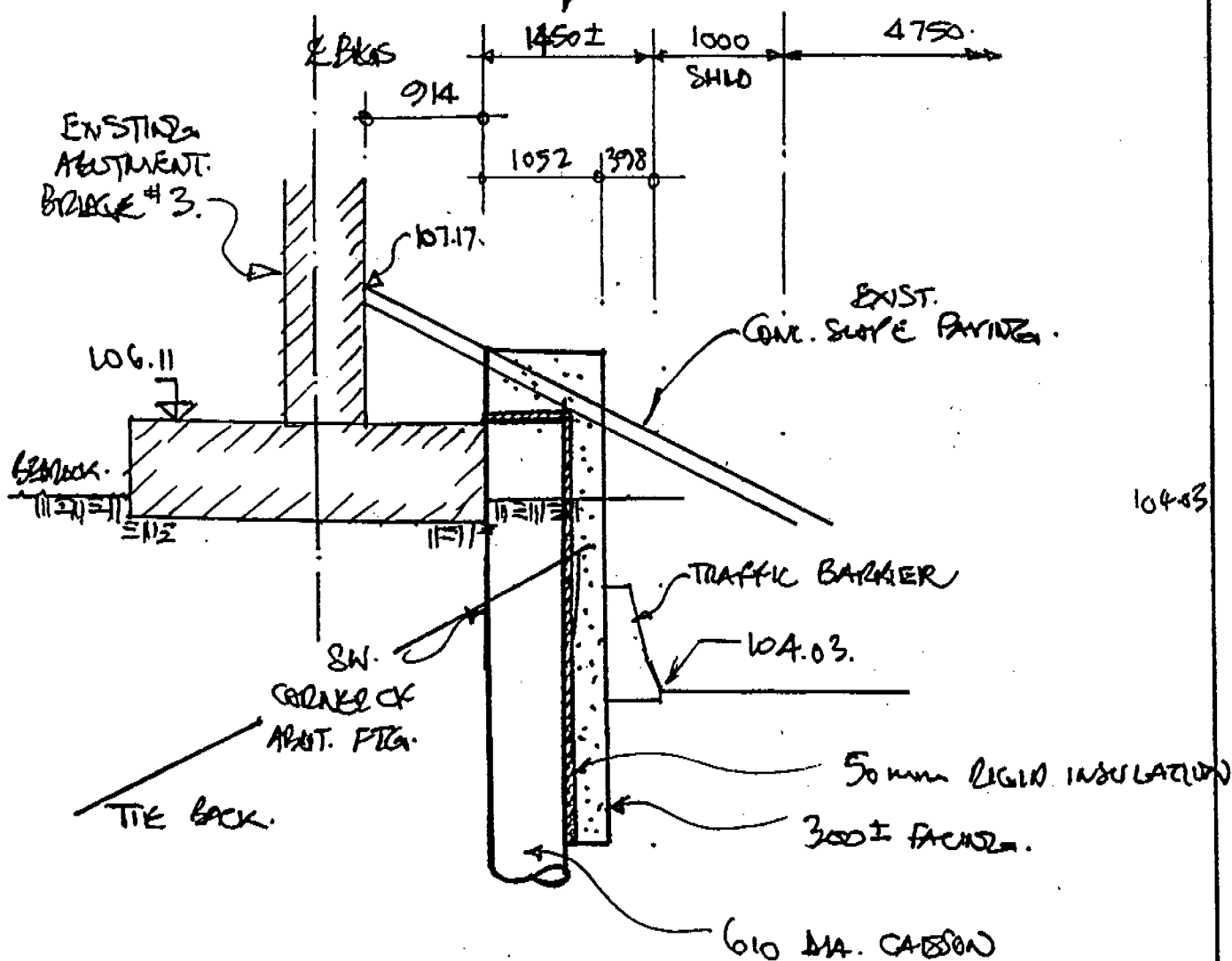
RAMP E-SHERWAY GARDENS DRIVE  
RAMP N - E

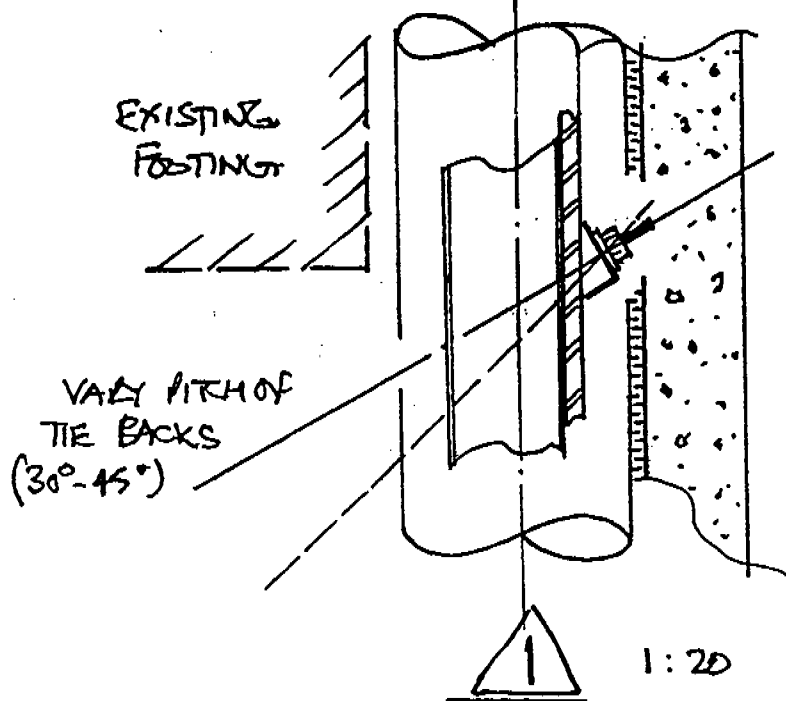
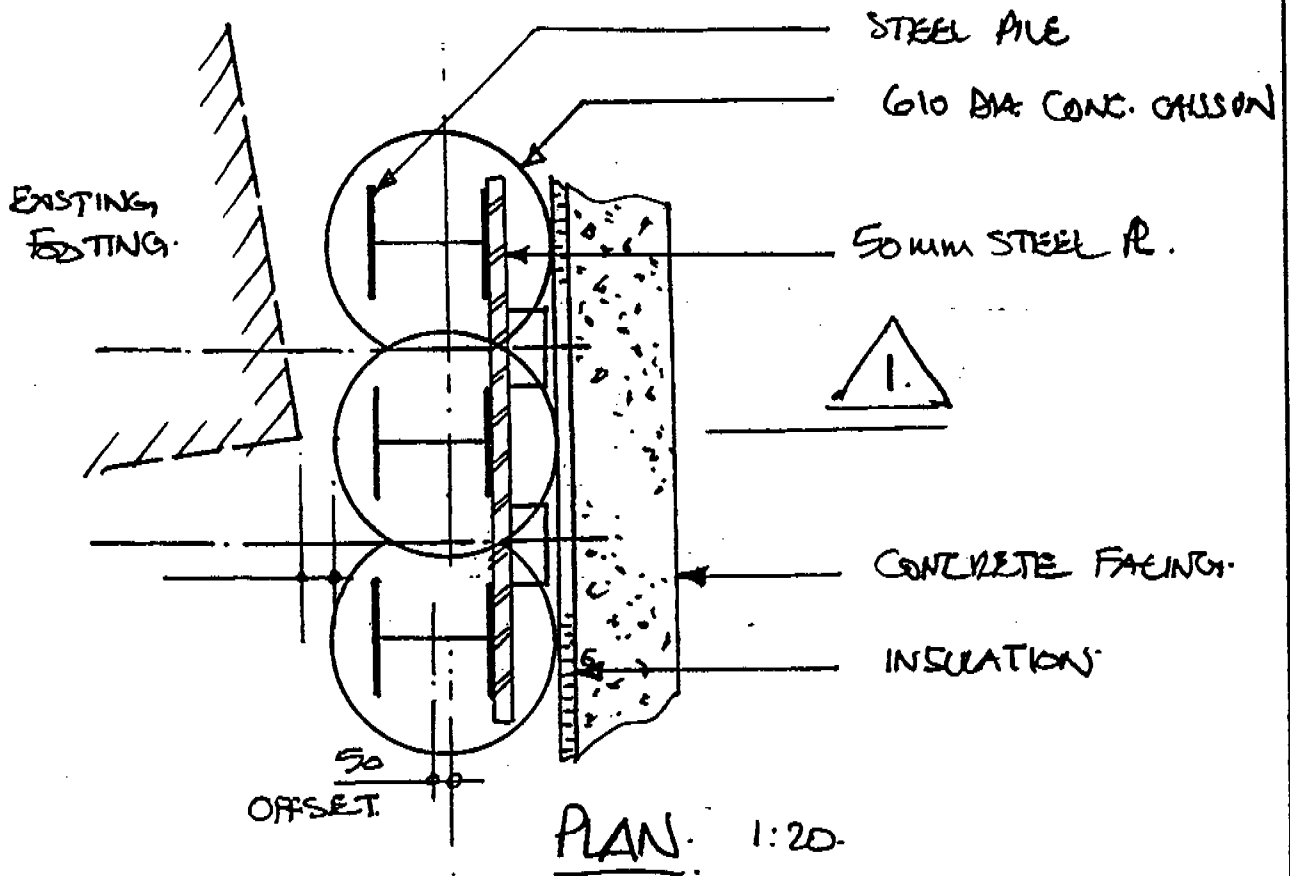


PLAN. - SITE 8 (RET. WALL - BROWN'S LINE)

CRITICAL SECTION AT  
CORNER OF EXIST. FTG.

CHECK ON COMPUTER PRIN-  
 (1475).





PROPOSED  
DETAIL  
AT S.W.  
CORNER OF  
EXIST. FTG.

# APPENDIX G

## Limitations of Report

## LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Shaheen & Peaker Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.