Appendix A

Geotechnical Information

Appendix A – Part I

Geotechnical Investigation Report

Support of New Chalets on the Rideau Canal, Ottawa, Ontario

National Capital Commission (NCC)

Support of New Chalets on the Rideau Canal, Ottawa, Ontario

Geotechnical Investigation Report

Date: 2011-06-16
O/Ref. N°:033-P027899-0101-GE-0001-0A

National Capital Commission (NCC)

Support of New Chalets on the Rideau Canal, Ottawa, Ontario

Geotechnical Investigation Report

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Verified by :

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Project Manager

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Property and Confidentiality

If tests have been done, the results of these tests are valid only for the sample described in the present report.

Testing (either in the field or in laboratory) has been completed by sub-contractors duly qualified according to the purchasing procedure of our quality manual. For more information, please contact your project engineer.

Register of revisions and emissions

Revision No	Date	Description of the modification and/or of the emission
0A	2011-06-16	Draft Report

INTRODUCTION

National Capital Commission (NCC) awarded a contract to LVM to carry out a geotechnical investigation required to determine the soil bearing capacity at 4 existing gravel pads along the Rideau Canal in Ottawa, Ontario.

The purpose of the investigation was to determine the nature and properties of soils at the site by means of four (4) boreholes with sampling.

The investigation was performed in accordance to our proposal dated April 28th, 2011 (O/Ref.:11-0090-033).

This report contains a description of the site, the methodology used during the site investigation as well as a detailed description of the soil nature and their properties. It also contains a section where geotechnical recommendations are provided for the design of the project. The recommendations provided in this report are according to the ‘’National Building Code of Canada, 2010’’ (NBC 2010).

The specific limitations of the investigation, outlined in Appendix 1, should be read jointly with this report.

1 SITE AND PROJECT DESCRIPTION

1.1 PROJECT DESCRIPTION

Based on the information provided by the NCC, geotechnical services were required to investigate future chalet construction sites located in the Rideau Canal.

1.2 SITE DESCRIPTION

The study sites are located on the Rideau Canal in Ottawa, Ontario. It consists of four (4) gravel pads used to support chalets on the Rideau Canal Skateway (RCS) throughout the winter. Those pads are located along the canal at four (4) access points: National Art Center (NAC), Concord, Old Bronson and New Bronson.

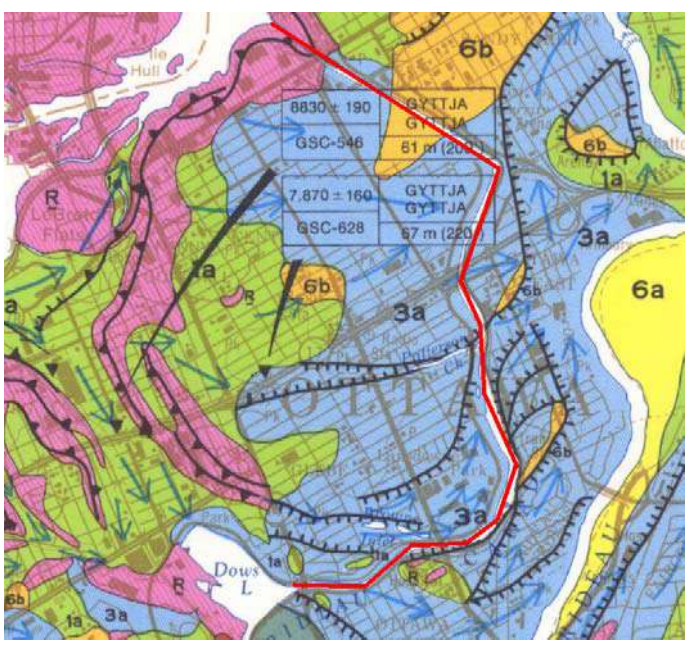
The study sites are usually underwater in the summer when the canal water level is high enough to allow sailing. Otherwise, in winter, the gravel pads are shown and support the chalets. The sites are accessible by stairs and/or ramps from the roads beside them. Figure 1 shows the chalets after the snow melt, just before being removed from the Canal.

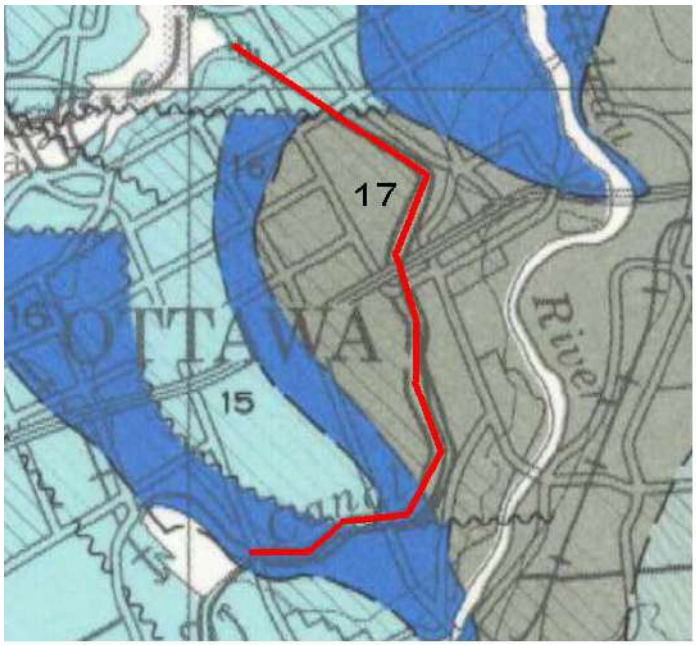
Figure 1 : Old Bronson site

1.3 LOCAL GEOLOGY

The local geology is illustrated on the geological map "Generalized Bedrock Geology'' number 1508A, and the geological map "Surficial Geology'' number 1506A Ottawa – Hull area, produced by the Geological Survey of Canada. Within the area studied, three stratigraphic units are present and consist of different granular deposits followed by rock in depth which can also be divided in three stratigraphic units. Figure 2 shows the Rideau Canal (in red) along with the stratigraphic units it crosses.

Figure 2 : Local geology





3a — Clay and silt underlying erosional terraces; upper part of marine deposits removed to variable depths by fluvial erosion so in places clay is uniform blue-grey; unit includes lenses, bars and channel fills of sand and pockets of nonmarine silt that were formed during terrace (or channel) cutting

6b — Medium grained stratified sand with some silt; in the form of fluvial terraces and channels cut in marine clay, and bars and spits within abandoned channels

PALEOZOIC

R — Limestone, dolomite, sandstone and locally shale; relatively flat lying; mainly occurring as bare, tabular outcrops; includes areas thinly veneered by unconsolidated Quaternary sediments up to 1 m (3 ft) thick

17 — BILLINGS FORMATION: black shale with some brown shale

16 — EASTVIEW FORMATION: dark grey almost black limestone

15 — OTTAWA FORMATION: limestone with some shaly partings: some sandstone in basal part

2 INVESTIGATION PROCEDURES (FIELD WORK)

2.1 LOCATION OF THE BOREHOLES

The site survey to determine the borehole locations was carried out by LVM representatives. The four (4) borehole locations are shown on the site plans included in Appendix 4.

2.2 FIELD WORK

The fieldwork was performed on April 27th to 28th, 2011. A total of four (4) borehole samples were carried out under the full time supervision of a geotechnical technician from LVM. The boreholes were identified from BH-01-11 to BH-04-11.

The four (4) boreholes with continuous sampling were conducted using a soil sampler on a tripod, under the full time supervision of a geotechnical technician of LVM. The location and the implantation of the boreholes were performed by LVM and NCC representatives and are shown on sites plans in Appendix 4. Soil sampling has been obtained by driving a 51 mm diameter split spoon sampler, in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586).

The subsoil details are presented in the individual borehole logs in Appendix 2.

2.3 LABORATORY TESTING

All recovered samples were carefully preserved and transported to LVM's laboratory for identification, laboratory testing and classification. All soil samples were examined by a geotechnical engineer and were classified in accordance with the requirements specified in ASTM D2488. Five (5) representative soil samples from the boreholes were submitted for grain size analysis. The complete laboratory test results are presented in Appendix 3 and are also included on the borehole logs in Appendix 2.

All geotechnical samples recovered from boreholes which were not consumed during laboratory analysis will be stored for a period of 6 months from the date of completion of the fieldwork; after which, they will be destroyed unless written instructions on the sample storage and/or disposition are received by LVM.

3 NATURE AND PROPERTIES OF SUBSOIL

The following paragraphs present a summary of the different soil layers encountered in the boreholes. The locations of the four (4) boreholes are presented on the plans n° 033-P027899-0101-GE-0001-00 to 033-P027899-0101-GE-0004-00 in Appendix 4. The detailed borehole logs are presented in Appendix 2.

Table 1: Borehole Summary

Borehole n°	Site	Gravel pad (m)	Natural deposit (m)	End of borehole (m)
BH-01-11	Old Bronson	0,00 - 0,91	0.91 – 2.74	2.74
BH-02-11	Concord	0,00 – 1,52	1,52 - 4.57	4.57
BH-03-11	NAC	0.00 – 0,86	**	2.74
BH-04-11	New Bronson	0.00 - 0.30	0.30-4.88	4.88
* Gravel pad directly on bedrock				

3.1 GRAVEL PAD

Directly on the surface of all the boreholes, a gravel pad was intercepted with a thickness varying between 30 mm and 1500 mm. The capacity of this gravel pad varies between loose to compact.

One (1) sieve analysis was done based on a representative samples. Table 2 shows the results of the analysis.

Table 2: Sieve Analysis of the Gravel Pad

Borehole n°	Depth (m)	Gravel > 4.75 mm (%)	Sand < 4.75 mm and > 75 µm (%)	Silt and Clay < 75 µm (%)	Classification (USCS)
BH-04-11	0.30 – 0.91	51	40	9	GW-GM

According to the grain size distribution, the tested sample is sand with gravel and some silt. According to the Unified Soil Classification System (USCS), the deposit is classified as a GW-GM.

3.2 NATURAL DEPOSIT (GRANULAR DEPOSIT)

A natural deposit of water-saturated gray silty sand with gravel was intercepted in all the boreholes immediately beneath the gravel pad at the exception of the BH-03-11 (NAC site). This deposit was intercepted on an approximate thickness of 5 m.

Four (4) sieve analyses were done based on a representative samples. Table 3 shows the results of the analysis.

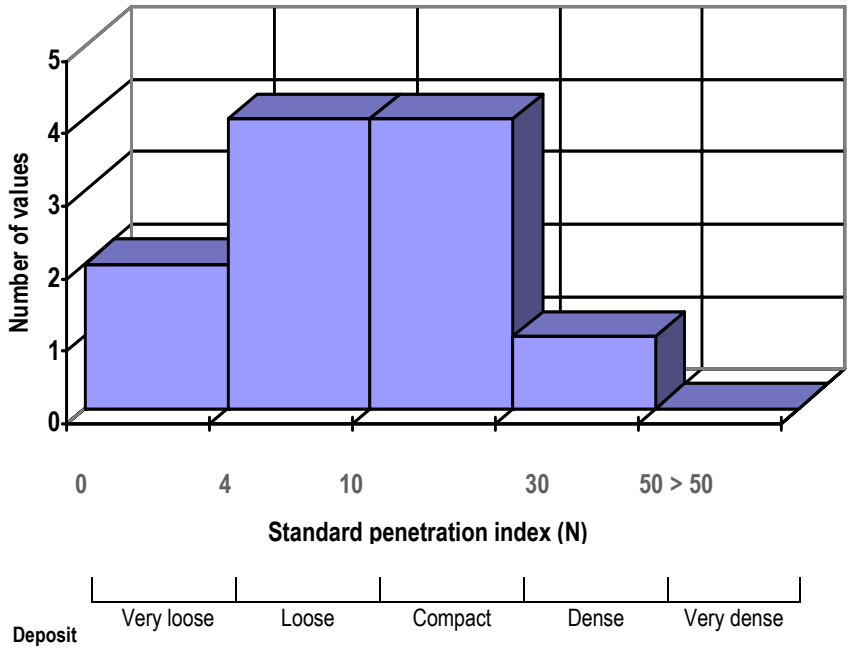
Table 3: Sieve Analysis of Natural Deposit

Borehole n°	Depth (m)	Gravel > 4.75 mm (%)	Sand < 4.75 mm and > 75 µm (%)	Silt and Clay < 75 µm (%)	Classification (USCS)
BH-01-11	1.52 – 2.13	37	46	17	SM
BH-02-11	1.52 – 2.13	24	72	4	SW
BH-02-11	2.74 – 3.35	20	60	20	SM
BH-04-11	1.83 – 2.44	9	26	65	SM

According to the grain size distribution, the tested sample is sand with traces of silt and clay. According to the USCS, the deposit is classified as a SM or SW.

Standard penetration index (N) was recorded 13 times in this layer. It generally varies from 2 to 31. The compactness of this deposit is generally qualified from very loose on surface and becomes compact at a deeper level.

Figure 3 : Site Location Distribution of Standard Penetration Index (N), Natural Deposit



(According to the Canadian foundation engineering manual - Second edition)

4 DISCUSSION AND RECOMMENDATIONS

4.1 GENERAL REMARKS

On the basis of the information gathered from the boreholes, the subsurface stratigraphy is mainly characterized by the presence of a granular pad of varying thickness depending on the site studied, followed by a natural granular deposit (Old Bronson, New Bronson and Concord site) or bedrock (NAC site). The granular deposit mainly consists of silty sand with gravel, with a compactness varying from very loose to dense.

Based on given information, the project consists of installing new chalets on the Rideau Canal during winter, which requires new footings.

According to the available data and the information carried out from the boreholes, our geotechnical commentaries and recommendations are presented in the following sections.

4.2 FOUNDATION

The following recommendations are based on the directives of the NBC 2010 which recommends the use of the limits states method for calculation of the foundations.

The limits states represent the conditions of a structure beyond of which it ceases to fulfill the function for which it was designed. In the NBC 2010, the limits states are divided into two (2) groups:

- The ultimate limit state which correspond to the mechanisms of collapse and rupture of the structures; they are notions of safety of the works. As an example, the ultimate limit state for the foundation could be a shearing failure of the soil.
- The serviceability limit state corresponds to the mechanisms which limit the proposed use of the structure. These mechanisms are usually associated with movements which stop or limit a structure to fulfill its purpose. As an example, the serviceability limit states for a foundation can be some excessive movements and settlements.

A secure foundation design has to satisfy these two (2) requirements. The ultimate limit states and serviceability limit states are presented in the next paragraphs.

4.2.1 Ultimate Limit State (ULS)

According to the site stratigraphy, previously described, the loads of the chalets will be transferred to the granular deposit (loose) encountered below the existing gravel pads, using conventional shallow footings.

$$q_{ult} = q' N_q S_q + 0.5\gamma' B N_\gamma S_\gamma + c' N_c S_c$$

The following geotechnical parameters can be used for the ultimate limit states (ULS) calculation.

Table 4: Geotechnical Parameters – Granular Deposit

PARAMETERS	GRANULAR DEPOSIT
Effective soil cohesion (c')	0 kPa
Effective angle of internal friction (φ')	30°
Wet unit weight of soil (γ)	18 kN/m³
Submerged unit weight of soil (γ')	8 kN/m³
Bearing capacity factor (N_c)	33
Bearing capacity factor (N_q)	21
Bearing capacity factor (N_γ)	19

For example, for vertical and centered loads on foundations placed on the granular deposit (loose), a geotechnical resistance of 100 kPa can be used at the ultimate limit state (ULS) for a square footings of 2.0 m width.

According to the NBC 2010, a resistance factor of 0.5 must be applied to the value of the ultimate bearing capacity in order to obtain a factored resistance.

4.2.2 Serviceability Limit State (SLS)

In the case of foundations supported by a granular deposit of loose compactness, a serviceability pressure of 40 kPa is recommended to design square footing of a maximum width of 2 m.

By not exceeding this constraint and under conventional footings, the total settlement generated by such pressure should be lower than 25 mm, and the differential settlements should be lower than 20 mm, as long as the maximum width of the footing is 2 m.

These settlement values suppose that surfaces at the level of the footing would be exempt of any mud or any remolded soil, before installing the footing.

Moreover, serviceability pressure is defined as the pressure that can be transmitted to the soil by a footing without considering the soil weight. Therefore, the weight of the soil above the footing will not be included in the calculation of the pressure transmitted by the foundation.

4.2.3 Helical Piers

An alternative to conventional foundations is the use of helical piers as the foundation support for the chalets. A 'Helical Pier Foundation System' comprises large diameter steel helices on the end of small diameter solid steel shafts. The steel helices are screwed into the ground to the level of competent bearing soil, and the foundation is constructed at the top of the shaft.

Helical piers are relatively easy to install and can be done with light equipment such as small backhoe or skid-steer. This type of foundation system is well suited to sites with limited access where soft soils overlie competent bearing soils. The bearing capacity that can be obtained by these kinds of system will be provided by the supplier.

4.3 SEISMIC GEOTECHNICAL DATA

4.3.1 Site Class

The parameters used for the calculation of earthquake load and effects have been determined using the general stratigraphy of the site. Considering the information obtained from the borehole, the site class «D» must be used for the Old Bronson, New Bronson and Concord location, and a site class «C» can be used for the NAC location.

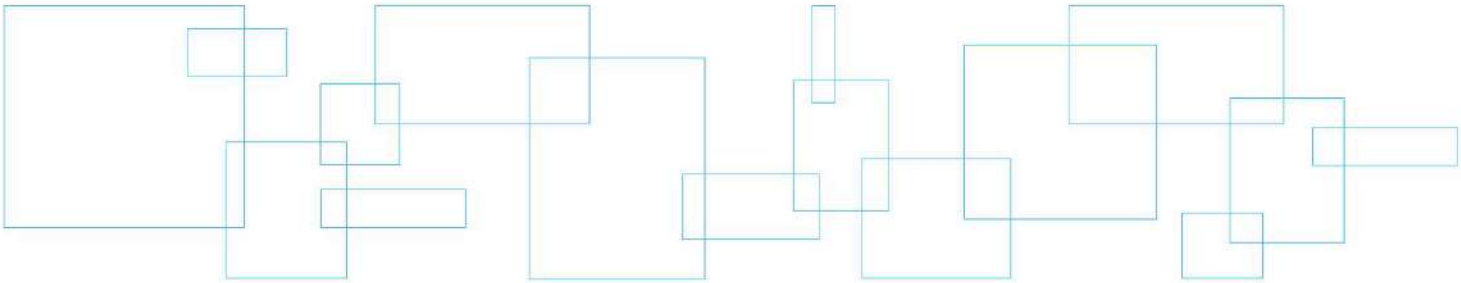
4.3.2 Spectral Response Acceleration

The values of spectral response acceleration for different periods and the values of Peak Ground Acceleration (PGA) for different municipalities are indicated in the NBC 2010. The data is presented in Table 5.

Table 5 : Spectral Acceleration and PGA

Area of the study site	SEISMIC DATA				
	Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
Ottawa	**0.66**	**0.32**	**0.13**	**0.044**	**0.42**

Appendix 1 Limitations of the Investigation



SCOPE OF THE GEOTECHNICAL STUDY

1.0 Characteristics of soil and rock

The soil and rock characteristics described in this report originate from geotechnical investigations conducted within a given period and correspond to the nature of the terrain only at the specific locations where these investigations were carried out.

Soil and rock formations have natural variations. The limits between the different formations presented in the sounding logs must therefore be considered as transitions between the formations rather than set boundaries. The precision of these limits depends on the type and number of soundings, the sounding methods used, as well as sampling frequency and methods.

The descriptions of the samples taken are based on recognized identification and classification methods used in geotechnics. They can call into play the judgement and interpretation of the personnel who carried out the examination of materials and can be presumed to be accurate and correct in keeping with current best practices in the field of geotechnics. Finally, if tests were carried out, the results of these tests apply solely to the samples tested, as described in this report.

The properties of the soil and rock can undergo significant modifications in the wake of construction activities such as excavation, blasting, pile driving or drainage activities, carried out on the site under study or an adjacent site. They can also be indirectly modified by the exposure of the soil or rock to freezing or weather stresses.

2.0 Groundwater

The groundwater conditions presented in this report apply only to the site under study. The accuracy and representation of these conditions must be interpreted based on the type of instrumentation used, as well as the period, duration, and number of observations carried out. These conditions can vary depending on precipitation, the seasons and, ultimately, the tides. They can also vary as a result of construction activities or the modification of physical elements on the site under study or in its vicinity. The problematic of ferrous ochre and its effects is not covered in this report.

3.0 Use of the report

The comments and recommendations contained in this report are intended primarily for the project's design team. The number of soundings required to identify all of the underground conditions that could impact construction costs, techniques, the choice of equipment and planning of operations could be greater than the number required for design purposes. All contractors bidding on or carrying out the work on the site under study must undertake their own interpretation of the results of the soundings and, if need be, carry out their own investigations to determine how site conditions could influence their operations or work methods.

Any modifications to the design, position and elevation of the works must be quickly communicated to LVM, allowing the validity of the recommendations presented to be verified. Complementary site or laboratory work could ultimately be required.

4.0 Project tracking

The interpretation of the on-site and laboratory results obtained, as well as the recommendations presented in this report, apply solely to the site under study and to the information available about the project at the time this report was drafted.

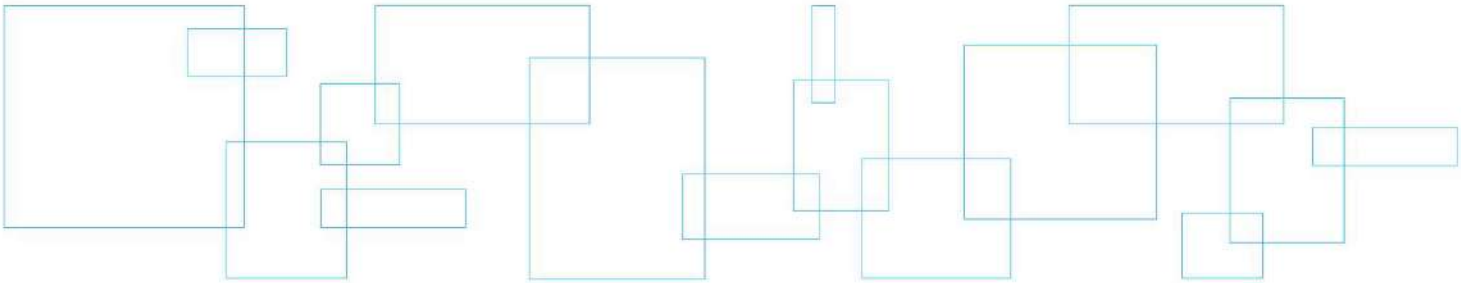
Information available concerning the site and groundwater conditions increases as construction work progresses. As site conditions were interpreted and correlated between sounding points, LVM should be allowed to verify these conditions, during site visits conducted as work progresses, in order to confirm the information provided by the drillings soundings. If it is not possible for us to conduct these verifications, LVM shall assume no responsibility for geotechnical interpretations by third parties concerning recommendations contained in this report, particularly if the design has been modified or if site conditions different from those described in this report are encountered. The identification of such changes requires experience and must be carried out by an experienced geotechnical engineer.

5.0 Environment

The information contained in this report does not cover the environmental aspects of the site conditions, as these aspects were not included in the study mandate.

Appendix 2

Explanation Notes on the Boring Log, Boring Logs



EXPLANATION NOTE ON SOUNDING LOGS

The following sounding logs summarize soils and rock geotechnical properties as well as ground water conditions, as collected during field work and/or obtained from laboratory tests. This note explains the different symbols and abbreviations used in these logs.

STRATIGRAPHIC UNITS

Elevation/Depth: Reference to the geodesic elevation of the soil or to a bench mark of arbitrary elevation, at the location of the sounding. Depth of the different geological boundaries as measured from ground surface. On the left, the scale is in meters while on the right, it is in feet.

Description of the stratigraphic units: Every geological formation is detailed.

The proportion of the different elements of the soil, defined according to the size of the particles, is given following the classification hereafter. The relative compactness of cohesionless soils is defined by the "N" index of the Standard Penetration Test. The consistency of cohesive soils is defined by their shear resistance.

Classification	Particle size (mm)
Clay	< 0.002
Clay and silt (undifferentiated)	< 0.08
Sand	0.08 to 5
Gravel	5 to 80
Cobble	80 to 300
Boulder	> 300

Descriptive terminology	Proportion (%)
"Traces" (tr.)	1 to 10
"Some" (s.)	10 to 20
Adjective (ex.: sandy, silty)	20 to 35
"And" (ex.: sand and gravel)	35 to 50

Compactness of cohesionless soils	Standard Penetration Test index ("N" value), ASTM D-1586 (blows for a 300mm penetration)
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

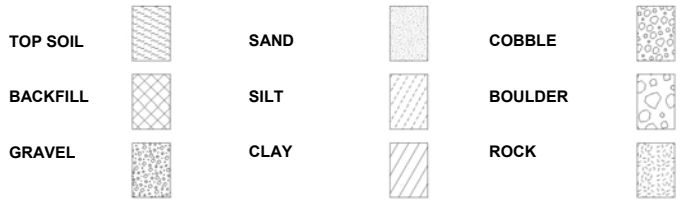
Consistency of cohesive soils	Undrained shear strength (kPa)
Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

Plasticity of cohesive soils	Liquid limit (%)
Low	< 30
Medium	30 to 50
High	> 50

Sensitivity of cohesive soils	$S_t = (C_u/C_{ur})$
Low	$S_t < 2$
Medium	$2 < S_t < 4$
High	$4 < S_t < 8$
Extra-sensitive	$8 < S_t < 16$
Quick (sensitive) clay	$S_t > 16$

Classification of rock	RQD (%)
Very poor quality	< 25
Poor quality	25 to 50
Fair quality	50 to 75
Good quality	75 to 90
Excellent quality	90 to 100

SYMBOLS



WATER LEVEL

This column shows the ground water level, as measured at a given time during the geotechnical investigation. The details of the installation (type and depth) are also illustrated in this column.

SAMPLES

Type and number: Each sample is labelled in accordance with the number of this column and the given notation refers to samples types.

Sub-sample: When a sample contains two or more different stratigraphic units, it is sometimes necessary to separate it and create sub-samples. This column allows for the identification of the latter and the association to *in situ* or laboratory measurements to these sub-samples.

Condition: The position, length and condition of each sample are shown in this column. The symbol shows the condition of the sample, following the legend given on the sounding log.

Size: This column indicates the split spoon sampler size.

"N" index The standard penetration index shown in this column is expressed with the letter "N". This index is obtained with the Standard Penetration Test. It corresponds to the number of blows required to drive the last 300mm of the split spoon, using a 622 Newton hammer falling freely from a height of 762mm (ASTM D-1586). For a 610mm long split spoon, the "N" index is obtained by adding the number of blows required for the driving of the 2nd and 3rd 150mm of the split spoon. Refusal (R) indicates a number of blows greater than 100. A set of numbers such as 28-30-50/60mm indicates that the number of blows required to drive the 1st and 2nd 150mm of the split spoon are respectively 28 and 30. Moreover, it indicates that 50 blows were necessary to get a penetration of 60mm, whereupon the test was suspended.

RQD index: Rock Quality Designation index: This index is defined as the ratio between the total length of all rock cores of 100mm and more in length over the total length of the core run. The RQD index is an indirect measurement of the number of "natural" fractures and of the amount of the alteration in a rock mass.

TESTS

Results: This column shows, for the corresponding depth, the results of tests carried out in the field or in the laboratory (shear strength, dynamic penetration, Atterberg limits with the cone, etc.). For more information, please refer to the legend in the upper part of the sounding log. However, an abbreviation indicating the type of analysis performed is shown next to the sample tested.

Graph: This graph shows the undrained shear strength resistance of cohesive soils, as measured *in situ* or in the laboratory (NQ 2501-200). It is also used to present the Dynamic Cone Penetration Test (NQ 2501-145) results.

Moreover, this graph is used for the representation of the water content and Atterberg limits test results.

Client :

National Capital Commission

BOREHOLE REPORT

File n°: **P027899-0101**
Borehole n°: **BH-01-11**
Date: **2011-04-27**

Project: **Chalets on Rideau Canal**

Location: **Ottawa, Ontario, (Bronson site)**

Coordinates (m): North 5028518.8 (Y)
East 367692.8 (X)
Elevation **0.00 (Z)**
Arbitrary Bedrock: m End depth: 2.74 m

Sample condition
Intact | Remoulded | Lost | Core

Organoleptic soil examination:
Visual aspect: Non-existent(N); Disseminated(D); Soaked(S)
Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)

Sample type

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Rock core
TA	Auger
MA	Bulk sample
PW	LVM Mega-Sampler
FG	Frozen ground

Tests

L	Consistency Limits	O.M.	Organic Matter (%)		Water Level
W_L	Liquid Limit (%)	K	Permeability (cm/s)	N	Std Penetration test (blows/300mm)
W_P	Plastic Limit (%)	UW	Unit Weight (kN/m³)	N_C	Dyn. Penetration test (blows/300mm)
I_P	Plasticity Index (%)	A	Absorption (l/min. m)	σ'_P	Preconsolidation Pressure (kPa)
I_L	Liquidity Index	U	Uniaxial Compressive strength (MPa)	SCI	Soil Corrosivity Index
W	Natural Water Content (%)	RQD	Rock Quality Designation (%)		
GS	Grain Size Analysis	AC	Chemical Analysis		Undrained shear strength (Field / Laboratory)
S	Hydrometer analysis	P_L	Limit Pressure (kPa)	C_U	Undisturbed (kPa)
R	Refusal	E_M	Pressuremeter Modulus (MPa)	C_{UR}	Remoulded (kPa)
VBS	Methylene Blue Value	E_r	Modulus of subgrade reaction (MPa)		
WR	Weight of Rods	SP_o	Segregation Potential (mm²/H °C)		

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	SAMPLES: TYPE AND NUMBER	SUB-SAMPLE	CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. Exam: Odor	Organo. Exam: Visual	RESULTS	FIELD AND LABORATORY TESTS: NATURAL WATER CONTENT AND LIMITS (%) Wp W WL (20 40 60 80 100 120) / UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION (20 40 60 80 100 120)
		0.00														
1		0.00	***Gravel pod:*** Grey gravel with sand.													
		-0.91														
3	1	0.91	***Probable natural deposit:*** Grey sand with gravel, moist.			SS-1				33	10-22 19-13	41				
		-1.52														
		1.52	saturated													
6						SS-2				83	17-15 17-48	32			GS	
		-2.13														
7		2.13	Grey silty sand with traces of gravel, saturated.			SS-3				100						
		-2.74														
9		2.74	End of borehole													
10	3															
13	4															
16	5															
19																

Vertical Scale = 1 : 50

Remarks:

Borehole type: **Auger sampler hole**

Boring equipment: **Tripod**

Prepared by: **C. Perez, B.Sc.A.**

Approved by:

2011-06-07

Page: 1 of 1

Client :

National Capital Commission

BOREHOLE REPORT

File n°: **P027899-0101**
Borehole n°: **BH-02-11**
Date: **2011-04-27**

Project: **Chalets on Rideau Canal**

Location: **Ottawa, Ontario, (Concord site)**

Coordinates (m): North 5031153.3 (Y)
East 368940.4 (X)
Elevation **0.00 (Z)**
Arbitrary Bedrock: m End depth: 4.57 m

Sample condition
Intact | Remoulded | Lost | Core

Organoleptic soil examination:
Visual aspect: Non-existent(N); Disseminated(D); Soaked(S)
Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)

Sample type

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Rock core
TA	Auger
MA	Bulk sample
PW	LVM Mega-Sampler
FG	Frozen ground

Tests

L	Consistency Limits	O.M.	Organic Matter (%)		Water Level
W_L	Liquid Limit (%)	K	Permeability (cm/s)	N	Std Penetration test (blows/300mm)
W_P	Plastic Limit (%)	UW	Unit Weight (kN/m³)	N_C	Dyn. Penetration test (blows/300mm)
I_P	Plasticity Index (%)	A	Absorption (l/min. m)	σ'_P	Preconsolidation Pressure (kPa)
I_L	Liquidity Index	U	Uniaxial Compressive strength (MPa)	SCI	Soil Corrosivity Index
W	Natural Water Content (%)	RQD	Rock Quality Designation (%)		
GS	Grain Size Analysis	AC	Chemical Analysis		Undrained shear strength (Field / Laboratory)
S	Hydrometer analysis	P_L	Limit Pressure (kPa)	C_U	Undisturbed (kPa)
R	Refusal	E_M	Pressuremeter Modulus (MPa)	C_{UR}	Remoulded (kPa)
VBS	Methylene Blue Value	E_r	Modulus of subgrade reaction (MPa)		
WR	Weight of Rods	SP_o	Segregation Potential (mm²/H °C)		

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	TYPE AND NUMBER	SUB-SAMPLE	CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. Exam: Odor	Organo. Exam: Visual	RESULTS
		0.00													
1		0.00	***Gravel Pad :*** Grey sandy gravel, moist.			SS-1				25	2-3 4-5	7			
2															
3	1					SS-2				17	2-1 2-2	3			
4		-1.52													
5		1.52	***Probable natural deposit :*** Grey gravely sand, saturated.			SS-3				25	3-6 2-1	8			GS
6															
7	2					SS-4				25	1-1 1-1	2			
8															
9						SS-5				25	1-1 2-5	3			GS
10	3														
11		-3.35													
12		3.35	Grey clayed silt, saturated.			SS-6				50	4-5 6-5	11			
13	4														
14						SS-7				75	7-5 5-5	10			
15		-4.57													
16		4.57	End of borehole												
17	5														
18															
19															

FIELD AND LABORATORY TESTS
NATURAL WATER CONTENT AND LIMITS (%) — Wp W WL — 20 40 60 80 100 120
UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION — 20 40 60 80 100 120

Vertical Scale = 1 : 50

Remarks:

Borehole type: **Auger sampler hole**

Boring equipment: **Tripod**

Prepared by: **C. Perez, B.Sc.A.**

Approved by:

2011-06-07

Page: 1 of 1

Client :

National Capital Commission

BOREHOLE REPORT

File n°: **P027899-0101**
Borehole n°: **BH-03-11**
Date: **2011-04-28**

Project: **Chalets on Rideau Canal**

Location: **Ottawa, Ontario, (NAC site)**

Coordinates (m): North 5031859.6 (Y)
East 367993.6 (X)
Arbitrary Elevation **0.00 (Z)**
Bedrock: 0.86 m End depth: 2.74 m

Sample condition
Intact | Remoulded | Lost | Core

Organoleptic soil examination:
Visual aspect: Non-existent(N); Disseminated(D); Soaked(S)
Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)

Sample type

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Rock core
TA	Auger
MA	Bulk sample
PW	LVM Mega-Sampler
FG	Frozen ground

Tests

L	Consistency Limits	O.M.	Organic Matter (%)		Water Level
W_L	Liquid Limit (%)	K	Permeability (cm/s)	N	Std Penetration test (blows/300mm)
W_P	Plastic Limit (%)	UW	Unit Weight (kN/m³)	N_C	Dyn. Penetration test (blows/300mm)
I_P	Plasticity Index (%)	A	Absorption (l/min. m)	σ'_P	Preconsolidation Pressure (kPa)
I_L	Liquidity Index	U	Uniaxial Compressive strength (MPa)	SCI	Soil Corrosivity Index
W	Natural Water Content (%)	RQD	Rock Quality Designation (%)		
GS	Grain Size Analysis	AC	Chemical Analysis		Undrained shear strength (Field / Laboratory)
S	Hydrometer analysis	P_L	Limit Pressure (kPa)	C_U	Undisturbed (kPa)
R	Refusal	E_M	Pressuremeter Modulus (MPa)	C_{UR}	Remoulded (kPa)
VBS	Methylene Blue Value	E_r	Modulus of subgrade reaction (MPa)		
WR	Weight of Rods	SP_o	Segregation Potential (mm²/H °C)		

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	SAMPLES: TYPE AND NUMBER	SUB-SAMPLE	CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. Exam: Odor	Organo. Exam: Visual	FIELD AND LABORATORY TESTS: RESULTS	NATURAL WATER CONTENT AND LIMITS (%) Wp W WL (20 40 60 80 100 120) / UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION (20 40 60 80 100 120)
		0.00														
1		0.00	***Gravel Pad :*** stone, sand and silt.													
2						RC-1				29		57				
		-0.86														
3	1	0.86	***Rock :*** Limestone													
4		-1.22														
		1.22	Limestone with carbonate.													
5																
6																
7	2					RC-2				100		70				
8																
9		-2.74														
10	3	2.74	End of borehole													
11																
12																
13	4															
14																
15																
16	5															
17																
18																
19																

Vertical Scale = 1 : 50

Remarks:

Borehole type: **Diamond Core Drill**

Boring equipment: **Tripod**

Prepared by: **S. Séguin, tech.**

Approved by:

2011-06-07

Page: 1 of 1

Client :

National Capital Commission

BOREHOLE REPORT

File n°: **P027899-0101**
Borehole n°: **BH-04-11**
Date: **2011-04-28**

Project: **Chalets on Rideau Canal**

Location: **Ottawa, Ontario, (New Bronson site)**

Coordinates (m): North 5028335.2 (Y)
East 367506.1 (X)
Elevation **0.00 (Z)**
Arbitrary Bedrock: m End depth: 4.88 m

Sample condition
Intact | Remoulded | Lost | Core

Organoleptic soil examination:
Visual aspect: Non-existent(N); Disseminated(D); Soaked(S)
Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)

Sample type

SS	Split Spoon
TM	Thin wall Tube
PS	Piston Tube
RC	Rock core
TA	Auger
MA	Bulk sample
PW	LVM Mega-Sampler
FG	Frozen ground

Tests

L	Consistency Limits	O.M.	Organic Matter (%)		Water Level
W_L	Liquid Limit (%)	K	Permeability (cm/s)	N	Std Penetration test (blows/300mm)
W_P	Plastic Limit (%)	UW	Unit Weight (kN/m³)	N_C	Dyn. Penetration test (blows/300mm)
I_P	Plasticity Index (%)	A	Absorption (l/min. m)	σ'_P	Preconsolidation Pressure (kPa)
I_L	Liquidity Index	U	Uniaxial Compressive strength (MPa)	SCI	Soil Corrosivity Index
W	Natural Water Content (%)	RQD	Rock Quality Designation (%)		
GS	Grain Size Analysis	AC	Chemical Analysis		Undrained shear strength (Field / Laboratory)
S	Hydrometer analysis	P_L	Limit Pressure (kPa)	C_U	Undisturbed (kPa)
R	Refusal	E_M	Pressuremeter Modulus (MPa)	C_{UR}	Remoulded (kPa)
VBS	Methylene Blue Value	E_r	Modulus of subgrade reaction (MPa)		
WR	Weight of Rods	SP_o	Segregation Potential (mm²/H °C)		

DEPTH - ft	DEPTH - m	ELEVATION - m / DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	SAMPLES: TYPE AND NUMBER	SUB-SAMPLE	CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. Exam: Odor	Organo. Exam: Visual	RESULTS
		0.00													
1		0.00	***Gravel Pad :*** Gravel with some sand and traces of silt, moist.			SS-1				21	5-6 11-10	17			GS
2															
3	1	-1.37													
4		1.37	Grey silt with some clay, saturated.												
5						SS-2				33	2-2 2	4			
6		-1.83													
7	2	1.83	Grey sand with some silt, some clay and traces of gravel, saturated.			SS-3				71	1-3 2-3	5			
8		-2.44													
9		2.44	Sandy silt with some clay and traces of gravel, saturated.			SS-4				58	15-4 4-11	8			
10	3														
11						SS-5				71	11-15 16-17	31			
12															
13	4					SS-6				58	7-16 11-10	27			
14															
15						SS-7				92	7-9 11-12	20			
16		-4.88													
17	5	4.88	End of borehole.												
18															
19															

FIELD AND LABORATORY TESTS
NATURAL WATER CONTENT AND LIMITS (%) — Wp W WL — 20 40 60 80 100 120
UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION — 20 40 60 80 100 120

Vertical Scale = 1 : 50

Remarks:

Borehole type: **Diamond Core Drill**

Boring equipment: **Tripod**

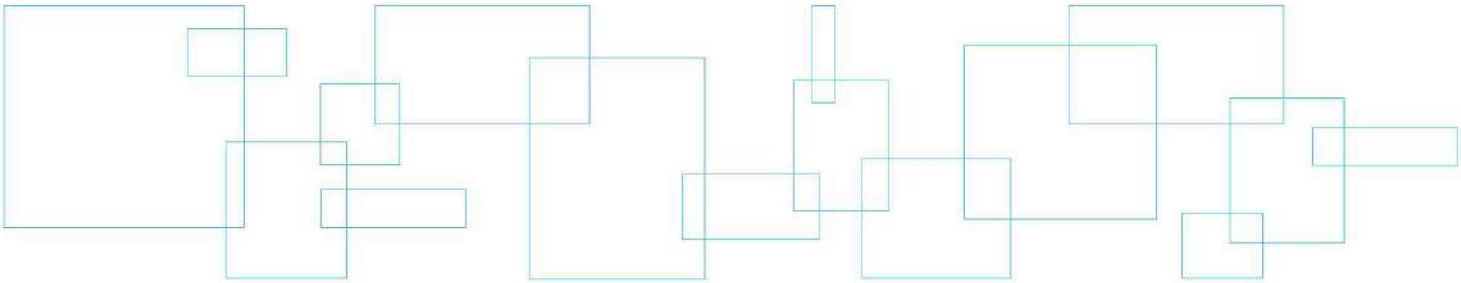
Prepared by: **S. Séguin, tech.**

Approved by: **C. Perez, Jr. Eng.**

2011-06-07

Page: 1 of 1

Appendix 3 Laboratory Tests



LVM 1961 2011
900, boul. de la Carrière, bur. 100
Gatineau, J8Y 6T5
Téléphone: (819) 778-3143

Testing on Soils, Aggregates and Other Materials

Client : National Capital Commission
Project : Geotechnical Engineering / Quality Control Testing ; Chalet on the Rideau Canal
Location : Ottawa, Ontario

Project # : P027899-0101
Client ref. :
Report # : 1 Rev. 0
Page 1 of 1

Sampling

Sampling #	:	1
Your sampling #	:	
Material	:	
Source; location	:	From borehole
Sampling location	:	BH-01-11, SS-2; 1.52 - 2.13 m

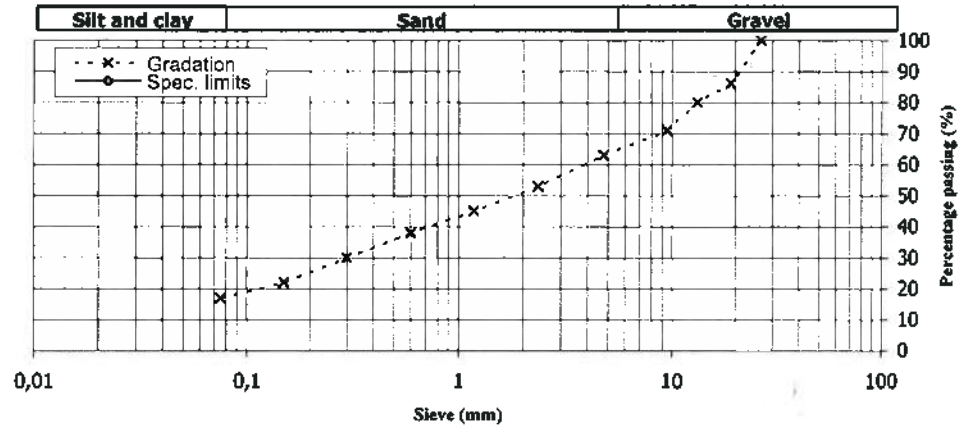
Specification # 1

Reference	:	
Use	:	
Calibre	:	
Class	:	

Sampling date	:	2011-04-28
By	:	Sylvain Séguin, tech.
Date received	:	2011-05-03

Sieve analysis (ASTM C136)

SIEVE (mm)	% PASSING REQUIREMENTS	% PASSING RESULT
106		
75		
50		
37,5		
26,5		100
19		86
13,2		80
9,5		71
4,75		63
2,36		53
1,18		45
0,600		38
0,300		30
0,150		22
0,075		17,0



Cu : Cc : FM : 2,71 | D_{10} : D_{30} : 0,302 D_{60} : 3,797

Maximum dry density kg/m³	Optimum moisture %	Retained 5 mm %

Proportions from sieve analysis (%)

Cobble :	Sand :
Gravel :	Silt and clay :

Other testing	Required	Result

Remarks

RESULTS WITH AN ASTERISK DO NOT MEET REQUIREMENTS.

Prepared by : Jean-Pierre Lavoie, chef d'équipe — **Date :** 2011-05-06

Approved by : Camilo Perez, ing. jr — **Date :** 2011-05-06

900, boul. de la Carrière, bur. 100
Gatineau, J8Y 6T5
Téléphone: (819) 778-3143

Testing on Soils, Aggregates and Other Materials

Client : National Capital Commission
Project : Geotechnical Engineering / Quality Control Testing ; Chalet on the Rideau Canal
Location : Ottawa, Ontario

Project # : P027899-0101
Client ref. :
Report # : 2 Rev. 0

Sampling

Sampling #	:	2
Your sampling #	:	
Material	:	
Source; location	:	From borehole
Sampling location	:	BH-02-11, SS-3; 1.52 - 2.13 m

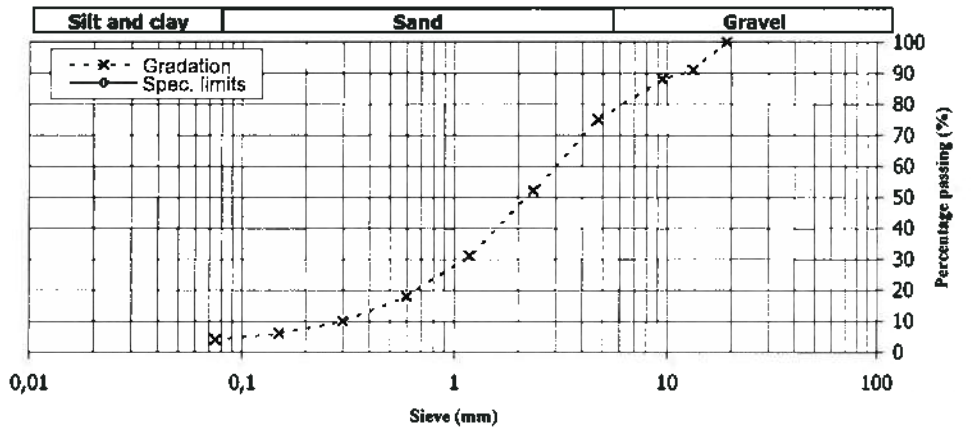
Specification # 1

Reference	:	
Use	:	
Calibre	:	
Class	:	

Sampling date	:	2011-04-28
By	:	Sylvain Séguin, tech.
Date received	:	2011-05-03

Sieve analysis (ASTM C136)

SIEVE (mm)	% PASSING REQUIREMENTS	% PASSING RESULT
106		
75		
50		
37,5		
26,5		
19		100
13,2		91
9,5		88
4,75		75
2,36		52
1,18		31
0,600		18
0,300		10
0,150		6
0,075		3,7



Cu : 10,7 Cc : 1,5 FM : 3,14 | D_{10} : 0,282 D_{30} : 1,131 D_{60} : 3,022

Maximum dry density kg/m³	Optimum moisture %	Retained 5 mm %

Proportions from sieve analysis (%)

Cobble :	Sand :
Gravel :	Silt and clay :

Other testing	Required	Result

Remarks

RESULTS WITH AN ASTERISK DO NOT MEET REQUIREMENTS.

Prepared by : Jean-Pierre Lavoie, chef d'équipe — **Date :** 2011-05-06

Approved by : Camilo Perez, ing. jr — **Date :** 2011-05-06

LVM 1961 2011

900, boul. de la Carrière, bur. 100
Gatineau, J8Y 6T5
Téléphone: (819) 778-3143

Testing on Soils, Aggregates and Other Materials

Client : National Capital Commission
Project : Geotechnical Engineering / Quality Control Testing ; Chalet on the Rideau Canal
Location : Ottawa, Ontario

Project # : P027899-0101
Client ref. :
Report # : 3 Rev. 0
Page 1 of 1

Sampling

Sampling #	:	3
Your sampling #	:	
Material	:	
Source; location	:	From borehole
Sampling location	:	BH-02-11, SS-5; 2.74 - 3.35 m

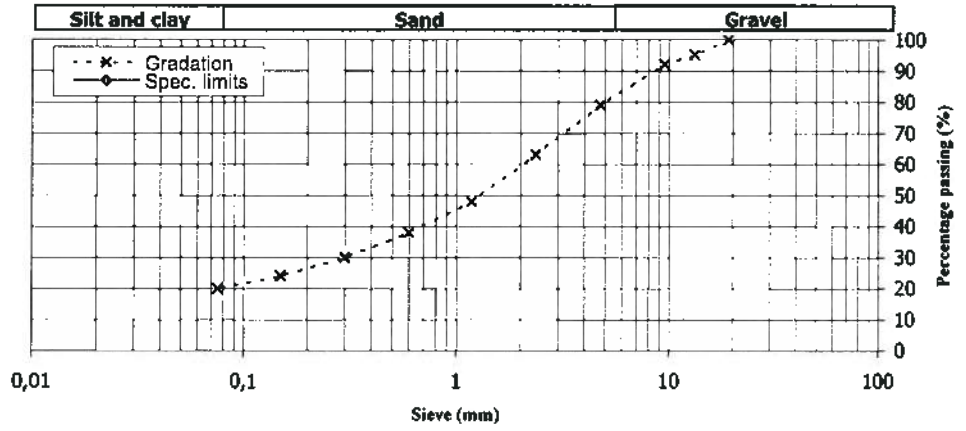
Specification # 1

Reference	:	
Use	:	
Calibre	:	
Class	:	

Sampling date	:	2011-04-28
By	:	Sylvain Séguin, tech.
Date received	:	2011-05-03

Sieve analysis (ASTM C136)

SIEVE (mm)	% PASSING REQUIREMENTS	% PASSING RESULT
106		
75		
50		
37,5		
26,5		
19		100
13,2		95
9,5		92
4,75		79
2,36		63
1,18		48
0,600		38
0,300		30
0,150		24
0,075		19,6



Cu : Cc : FM : 2,42 | D_{10} : D_{30} : 0,296 D_{60} : 2,078

Maximum dry density kg/m³	Optimum moisture %	Retained 5 mm %

Proportions from sieve analysis (%)

Cobble : Sand :
Gravel : Silt and clay :

Other testing	Required	Result

Remarks

RESULTS WITH AN ASTERISK DO NOT MEET REQUIREMENTS.

Prepared by : Jean-Pierre Lavoie, chef d'équipe **Date :** 2011-05-06

Approved by : Camilo Perez, ing. jr **Date :** 2011-05-06

LVM 1961 2011
900, boul. de la Carrière, bur. 100
Gatineau, J8Y 6T5
Téléphone: (819) 778-3143

Testing on Soils, Aggregates and Other Materials

Client : National Capital Commission
Project : Geotechnical Engineering / Quality Control Testing ; Chalet on the Rideau Canal
Location : Ottawa, Ontario

Project # : P027899-0101
Client ref. :
Report # : 4 Rev. 0
Page 1 of 1

Sampling

Sampling #	:	4
Your sampling #	:	
Material	:	
Source; location	:	From borehole
Sampling location	:	BH-04-11, SS-1; 0.30 - 0.91 m

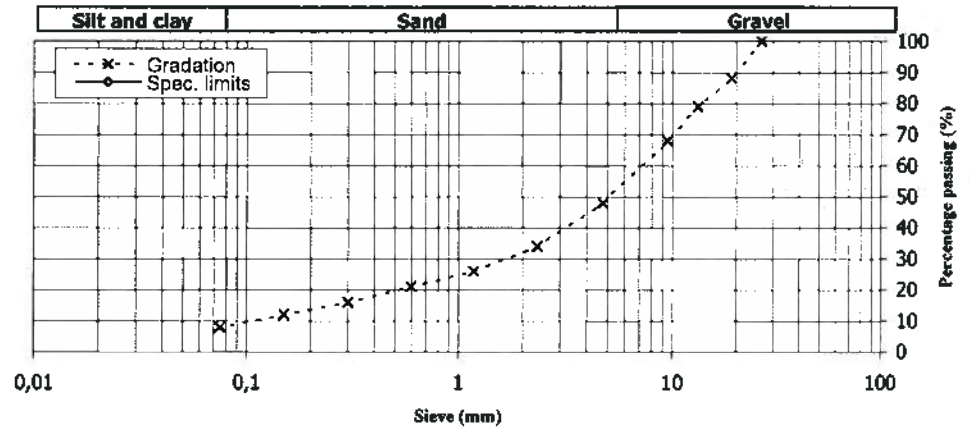
Specification # 1

Reference	:	
Use	:	
Calibre	:	
Class	:	

Sampling date	:	2011-04-28
By	:	Sylvain Séguin, tech.
Date received	:	2011-05-03

Sieve analysis (ASTM C136)

SIEVE (mm)	% PASSING REQUIREMENTS	% PASSING RESULT
106		
75		
50		
37,5		
26,5		100
19		88
13,2		79
9,5		68
4,75		48
2,36		34
1,18		26
0,600		21
0,300		16
0,150		12
0,075		8,4



Cu : 69,2 Cc : 3,6 FM : 3,55 D_{10} : 0,105 D_{30} : 1,647 D_{60} : 7,264

Maximum dry density kg/m³	Optimum moisture %	Retained 5 mm %

Proportions from sieve analysis (%)

Cobble :	Sand :
Gravel :	Silt and clay :

Other testing	Required	Result

Remarks

RESULTS WITH AN ASTERISK DO NOT MEET REQUIREMENTS.

Prepared by : Jean-Pierre Lavoie, chef d'équipe **Date :** 2011-05-06

Approved by : Camilo Perez, ing. jr **Date :** 2011-05-06

900, boul. de la Carrière, bur. 100
Gatineau, J8Y 6T5
Téléphone: (819) 778-3143

Testing on Soils, Aggregates and Other Materials

Client : National Capital Commission
Project : Geotechnical Engineering / Quality Control Testing ; Chalet on the Rideau Canal
Location : Ottawa, Ontario

Project # : P027899-0101
Client ref. :
Report # : 5 Rev. 0

Sampling

Sampling #	:	5
Your sampling #	:	
Material	:	
Source; location	:	From borehole
Sampling location	:	BH-04-11, SS-3; 1.83 -2.44 m

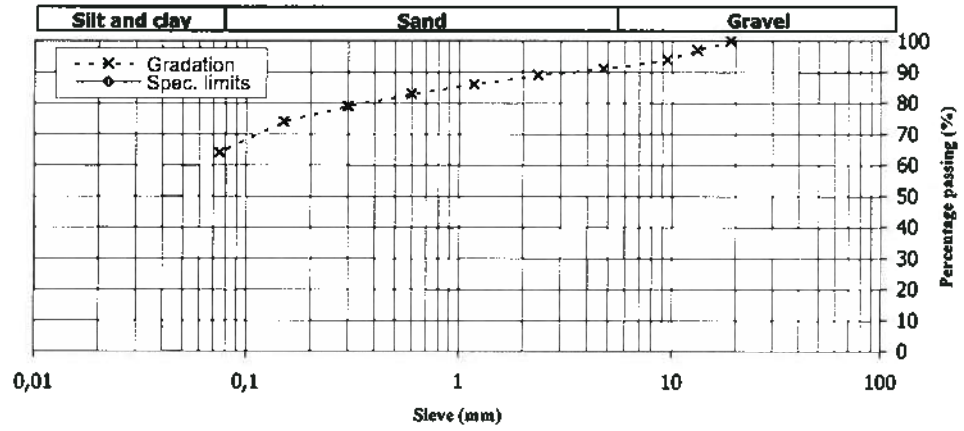
Specification # 1

Reference	:	
Use	:	
Calibre	:	
Class	:	

Sampling date	:	2011-04-28
By	:	Sylvain Séguin, tech.
Date received	:	2011-05-03

Sieve analysis (ASTM C136)

SIEVE (mm)	% PASSING REQUIREMENTS	% PASSING RESULT
106		
75		
50		
37,5		
26,5		
19		100
13,2		97
9,5		94
4,75		91
2,36		89
1,18		86
0,600		83
0,300		79
0,150		74
0,075		64,0



Cu : Cc : FM : 0,72 | D_{10} : D_{30} : D_{60} :

Maximum dry density kg/m³	Optimum moisture %	Retained 5 mm %

Proportions from sieve analysis (%)

Cobble :	Sand :
Gravel :	Silt and clay :

Other testing	Required	Result

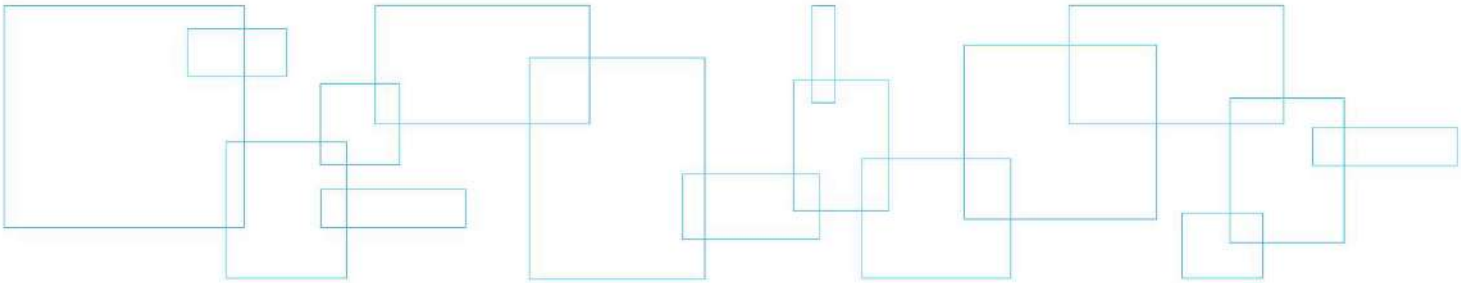
Remarks

RESULTS WITH AN ASTERISK DO NOT MEET REQUIREMENTS.

Prepared by : Jean-Pierre Lavoie, chef d'équipe — **Date :** 2011-05-06

Approved by : Camilo Perez, ing. jr — **Date :** 2011-05-06

Appendix 4 Plan of Borehole Locations



10 cm
0 1 2 3 4 5

LEGEND :

TF-NN-AA BOREHOLE-NUMBER-YEAR

COORDINATES OF SURVEYS		
BOREHOLE	NORTH (Y)	EAST (X)
BH-01-11	5028519	367693

Project

National Capital Commission
Chalet on Rideau canal
Bronson site

Ottawa, Ontario

Title

Borehole location

LVM inc.
2625, Qeensview Drive, Suite 105
Ottawa (Ontario) K2B 8K2
Telephone : 613.226.9667
Fax : 613.226.7389

Prepared	C. Perez	Discipline	GEOTECHNICAL	Project manager	C. Perez
Drawn	R. Frenette	Scale	None	Sequence no.	Rev. 00
Checked	C. Perez	Date	2011-06-07		

M. dept.	Project	Work pckg.	Sub-w.p.	Disc.	Drawing no.	Rev.
033	P027899	0101	000	GE	0001	00

G:\033\P027899\LOT 101\Z5_CAD\033-P027899-0101-GE.DWG

LEGEND :

TF-NN-AA BOREHOLE-NUMBER-YEAR

COORDINATES OF SURVEYS

BOREHOLE	NORTH (Y)	EAST (X)
BH-02-11	5031153	368940

Project

National Capital Commission
Chalet on Rideau canal
Concord site

Ottawa, Ontario

Title

Borehole location

LVM inc.
2625, Qeensview Drive, Suite 105
Ottawa (Ontario) K2B 8K2
Telephone : 613.226.9667
Fax : 613.226.7389

Prepared	C. Perez	Discipline	GEOTECHNICAL	Project manager	C. Perez
Drawn	R. Frenette	Scale	None	Sequence no.	Rev. 00
Checked	C. Perez	Date	2011-06-07		

M. dept.	Project	Work pckg.	Sub-w.p.	Disc.	Drawing no.	Rev.
033	P027899	0101	000	GE	0002	00

G:\033\P027899\LOT 101\Z5_CAD\033-P027899-0101-GE.DWG

LEGEND :

TF-NN-AA BOREHOLE-NUMBER-YEAR

COORDINATES OF SURVEYS		
BOREHOLE	NORTH (Y)	EAST (X)
BH-03-11	5031860	367994

Project

National Capital Commission
Chalet on Rideau canal
NAC site

Ottawa, Ontario

Title

Borehole location

LVM inc.
2625, Qeensview Drive, Suite 105
Ottawa (Ontario) K2B 8K2
Telephone : 613.226.9667
Fax : 613.226.7389

Prepared	C. Perez	Discipline	GEOTECHNICAL	Project manager	C. Perez
Drawn	R. Frenette	Scale	None	Sequence no.	Rev. 00
Checked	C. Perez	Date	2011-06-07		

M. dept.	Project	Work pckg.	Sub-w.p.	Disc.	Drawing no.	Rev.
033	P027899	0101	000	GE	0003	00

LEGEND :

TF-NN-AA BOREHOLE-NUMBER-YEAR

COORDINATES OF SURVEYS		
BOREHOLE	NORTH (Y)	EAST (X)
BH-04-11	5028335	367506

Project

National Capital Commission
Chalet on Rideau canal
New Bronson site

Ottawa, Ontario

Title

Borehole location

LVM inc.
2625, Qeensview Drive, Suite 105
Ottawa (Ontario) K2B 8K2
Telephone : 613.226.9667
Fax : 613.226.7389

Prepared	C. Perez	Discipline	GEOTECHNICAL	Project manager	C. Perez
Drawn	R. Frenette	Scale	None	Sequence no.	Rev. 00
Checked	C. Perez	Date	2011-06-07		

M. dept.	Project	Work pckg.	Sub-w.p.	Disc.	Drawing no.	Rev.
033	P027899	0101	000	GE	0004	00

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Appendix A – Part II

Geotechnical Study

Rideau Canal – Ottawa: Echo Drive Retaining Walls

Geotechnical Study

Rideau Canal – Ottawa

Echo Drive Retaining Walls

Final report

05-19999-5000

November 2010

Our parent company, AECOM, is evolving to better serve its global clients. As a part of this evolution, Tecsult has adopted the AECOM brand and changed its name to AECOM Tecsult Inc. AECOM provides a blend of global reach, local knowledge, innovation and technical excellence in delivering solutions that enhance and sustain the world's built, natural and social environments. Though our name is changing, our commitment to the success of your projects and organization remains strong.

This report was prepared by AECOM Tecsult Inc. with the cooperation of the professionals specifically listed below:

November 12, 2010

Bacit Mokhtari, M.A.Sc.
Geotechnics

November 12, 2010

Mostafa Tayae, Eng.
Geotechnical project engineer

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1 Introduction

The services of AECOM Tecsult Inc. (AECOM) were retained by Public Works and Government Services Canada for the geotechnical study related to the repair or replacement of canal retaining walls at Patterson Creek and Echo Drive on the Rideau Canal in Ottawa.

This report concerns the Echo Drive section and the purpose of this geotechnical study is to provide:

- Field Exploration: consisting of subsurface investigation by drilling and field testing;
- Laboratory analyses on representative soil samples collected during the subsurface exploration;
- Engineering analysis of the surface and subsurface conditions observed;
- Conclusions and recommendations for the geotechnical issues concerning Echo Drive retaining wall between station 14+50 and 19+50;
- Preparation of this report which includes the items discussed above.

The geotechnical study for the canal wall at Patterson Creek is the subject of a separate report.

2 References

The following documents have been consulted:

I. Canadian Foundation Engineering Manual (CFEM 2006);
II. Subsurface investigation, Rideau Canal (Ottawa Reach), Retaining wall at Patterson Creek section and Echo Drive Section, No SF-4636, 23 June 2000, McRosite Genest St-Louis.

3 Field investigation

The field investigation conducted specifically for this study consisted of subsurface exploration by means of drilling 5 (five) boreholes and field testing in the boreholes (standard penetration testing -SPT and Field vane test (FVT)). The purpose of the field investigation was to obtain information on the geotechnical characteristics of the soil underlying the study area in order to proceed with the geotechnical design of the new retaining wall or the stabilization of the existing retaining wall, as well as to provide recommendations regarding the fill materials behind the retaining wall.

3.1 Site reconnaissance

Reconnaissance of the site was conducted between August 12th and 17th, 2010 by a geotechnical engineer from AECOM. The purpose of the site reconnaissance was to identify backfill and foundations features which could affect the stability of the retaining wall at Echo Drive between stations 14+50 and 19+50 approximately.

3.2 Subsurface exploration

The subsurface exploration consisted in drilling and sampling of 5 (five) boreholes with field testing in the boreholes (standard penetration testing -SPT and Field vane test (FVT)). The exploration was conducted under the supervision of a geotechnical engineer from AECOM who directed the field testing, the sampling program and logged the subsurface conditions encountered. The objective of the drilling program was to provide an accurate profile of the subsurface soils and relevant information on the engineering characteristics of the fill and native soils. The boreholes were designated E-1 through E-5 and were advanced up to depth of 15,24 meters below existing grade. Drilling was conducted using a "CME 55" type drilling machine operated by "Succession Forage Downing Ltée".

Table 1 Drilled Boreholes

Borehole number	Depth of the borehole (m)	Station/ Location	Surface elevation (m)
E-1	14.02	14+70	65.03
E-2	10.80	17+40	66.36
E-3	15.24	17+65	65.73
E-4	15.24	18+45	65.22
E-5	15.24	19+35	65.18

Initially, the borehole E-2 has been planned to be drilled at station 16+50. Difficulties to access to that location and to reroute safely pedestrian traffic forced its relocation.
Samples were obtained at 0,61 m or 1,6 m intervals using a split spoon sampler. The split spoon was used to carry out the standard penetration tests (SPT) and was driven into the soil using an automatic hammer. The number of hammer blows to advance the sampler for each 15 cm drive was noted and used to determine the standard penetration resistance (SPT or N value) of the soil at that given location and depth. The Field vane test (FVT) was used to determine the undrained shear strength.

Samples retrieved during drilling were visually classified in the field, labelled, sealed in plastic containers, and taken to laboratory for testing.

The location of the boreholes is shown on the location plan presented in Appendix 1. Detailed logs of the boreholes are presented in Appendix 2. All of the boreholes were backfilled manually with auger cuttings following the completion of the drilling.

4 Geotechnical Conditions

4.1 Stratigraphy

4.1.1 Fill Material

The study area is underlain by a layer of heterogeneous fill that is up to 5,49 meters thick. The fill materials consist of a heterogeneous mixture of silty gravely sand with other man-made materials (some wood) mixed in. Some clayey beds could be encountered.

In borehole E-2, E-3 and E-4, boulders have been encountered starting from depth 0,61 m approximately to 3,05 m. The progression of the augers during drilling has been very difficult because of these boulders.

The standard penetration resistance (N value) has been measured fifteen (15) times in the fill materials. The N values vary between 2 and 15. Some refusals have been noted because of the wood, gravels or boulders presence in the fill materials. The density was qualified as loose.

Table 2 contains the thickness of the fill at the location of the completed boreholes of this study.

Table 2 Thickness of Fill

Borehole number	Thickness of fill (m)
E-1	5,49
E-2	5,49
E-3	4,57
E-4	4,27
E-5	3,96

Six (6) grain size tests (NQ 2501-025) were carried out on representative samples for the fill material respectively. All samples have been taken at 0.00 m except CF-3 in borehole E-2 which has been sampled at 3,66 m. Table 3 presents the grain size results and the classification of soils. The complete laboratory test results are presented in Appendix 3.

Table 3 Grain Size Properties of the Fill Material

Soil sample	Gravel % (5-80 mm)	Sand % (0.08-5 mm)	Silt % (0.08-0.002 mm)	Clay % (< 0.002 mm)	Classification USCS
E-1: CF-1	8,4	49,1	27,5		SM
E-2: CF-1	34,0	54,8	11,2		SP-SM
E-2: CF-3	8,3	55,6	28,8	7,3	SM
E-3: CF-1	28,4	59,6	12,0		SM
E-4: CF-1	18,0	60,8	21,2		SM
E-5: CF-1	31,2	42,4	18,4	8,0	SM

Water content tests and the Atterberg limits tests were conducted on samples E-1: CF-1, E-2: CF-3, E-3: CF-1 and E-5: CF-1. These results are presented in table 4.

Table 4 Water Content and Atterberg Limits for the Fill Material

Soil Sample	Water Content (%)	Liquid Limit (WL) (%)	Plastic Limit (WP) (%)	Plasticity Index (Ip)	Liquidity Index (I_L)	Classification USCS
E-1: CF-1	7,7	21,0	16,8	4,2	-2,15	SM
E-2: CF-3	43,3	38,3	29,9	8,4	1,59	SM
E-3: CF-1	2,6	17,0	14,9	2,2	-5,68	SM
E-5: CF-1	4,8	20,0	13,4	6,6	-1,31	SM

The results show that generally the soils are classified as SM (silty sands, sand-silt mixtures) according to the USCS. The liquid limits are between 17,0% and 38,3% and the plastic limits are varying between 13,4% and 29,9%. The water content values vary between 2,6% and 43,3%. The highest value of the water content corresponds to the bottom of the backfill layer where more fine particles constitute soils. The plasticity index varies between 2,2 and 8,4 confirming that soils are not or very lightly plastic.

4.1.2 Native Soils

Native soils are encountered under the backfill layer. It consists of a greenish silty clay or mixture of clay and silt with traces of sand. It is generally stiff, lightly moist and fissured (it is commonly called crust). The thicknesses of this greenish clay are 1,52 m at the borehole E-1, 1,83 m at the borehole E-3, 1,58 m at the borehole E-4 and 1,91 at the borehole E-5. This crust has not been detected at the borehole E-2. Bellow this layer, the gray silty clay or mixture of clay and silt, moist to very moist and plastic to very plastic is found down to 15,24 m depth approximately. At the bottom of the boreholes E-1, E-3 and E-4, this clay is becoming consolidated as shown and described in the boreholes logs.

The native soils extend to the depth of exploration in all of the boreholes. Bedrock was not reached in any of the boreholes completed for this study even if refusal has been noted in the borehole E-1 at depth 14,02 m.

The standard penetration resistance (N value) has been measured twenty one (21) times in the native soils. The N values were between 1 and 10. The highest values coincide with the crust. The lowest values correspond to the soft, plastic and gray clay.

Three (3) grain size tests (NQ 2501-025) were carried out on representative samples for the native soils at respectively 5,49 m, 4,57 m and 4,27 m depth (respectively E-1: CF-4, E-3: CF-3 and E-4: CF-4). The results and the soils classification are given in table 5. The complete laboratory test results are presented in Appendix 3.

Table 5 Grain Size Properties of the Native Soils

Soil sample	Gravel % (5-80 mm)	Sand % (0.08-5 mm)	Silt % (0.08-0.002 mm)	Clay % (< 0.002 mm)	Classification USCS
E-1: CF-4	0,0	3,9	35,9	60,2	CL-CH
E-3: CF-3	0,0	9,6	38,9	51,5	CL-CH
E-4: CF-4	0,0	3,5	37,6	58,9	CL-CH

The water content and the Atterberg limits were conducted on the same samples. The results are presented in table 6.

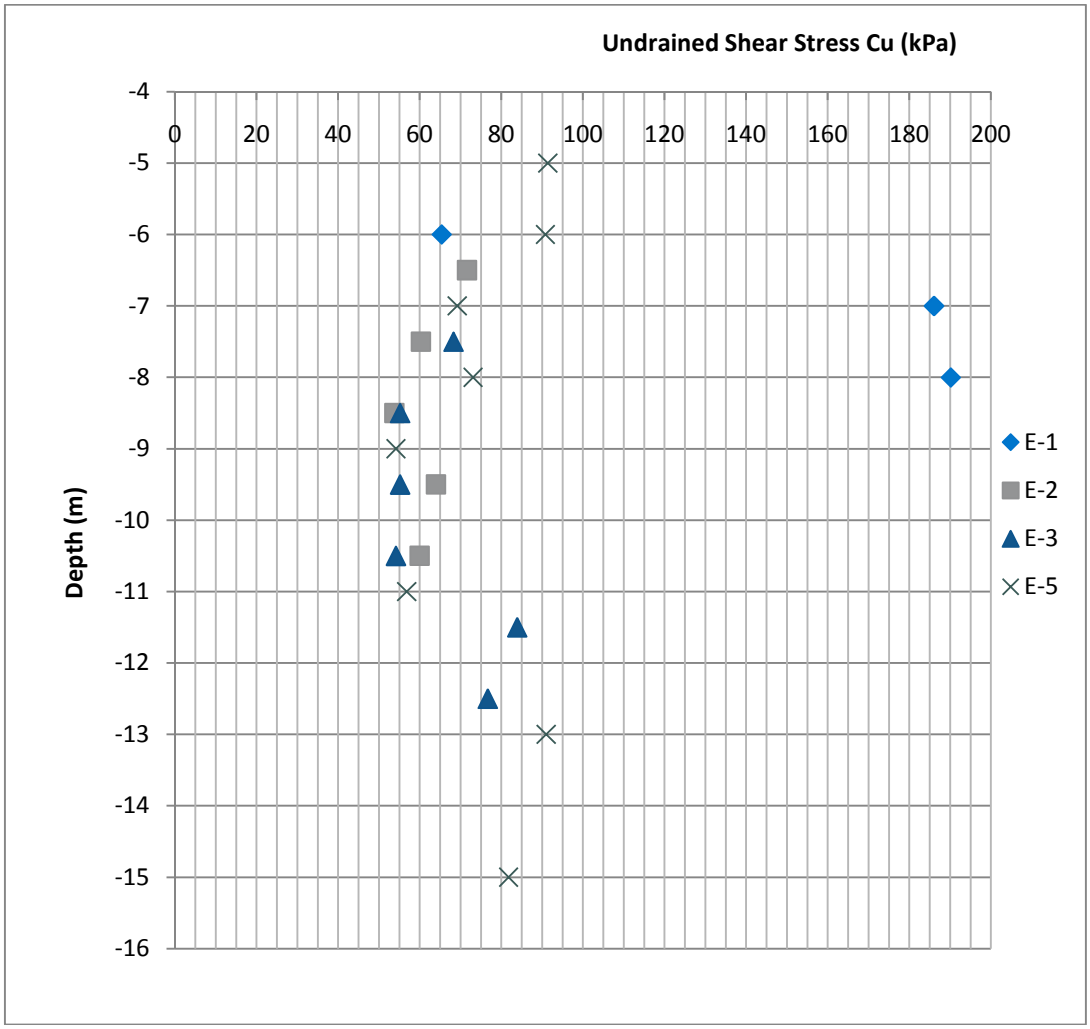
Table 6 Water Content and Atterberg Limits for the Native Soils

Soil Sample	Water Content (%)	Liquid Limit (WL) (%)	Plastic Limit (WP) (%)	Plasticity Index (Ip)	Liquidity Index (I_L)
E-1: CF-4	46,6	68,1	30,4	37,8	0,43
E-3: CF-3	39,5	58,5	26,3	32,2	0,41
E-4: CF-4	48,0	64,2	24,8	39,4	0,59

The water content is varying from 39,5% to 48,0%. The plasticity index is varying from 32,2% to 39,4% which means that this clayey layer is plastic to very plastic. Based on the USCS, the soils are classified as CL-CH (inorganic clay with medium to high plasticity).

Four field vane tests (FVT) were carried out in the boreholes each of boreholes E-1, E-2, E-3 and E-5 in order to determine the undrained shear strength profile. The results are presented in figure 1.

Figure 1 Undrained shear strength profile



4.2 Hydrogeologic conditions

The borehole E-4 has been equipped with a piezometer in order to read the water table elevation. The screen is installed at the bottom of the borehole (see the log in appendix 2). On August 17th, the water table elevation in that borehole was at 4,05 m depth from the ground elevation.

At the end of drilling operations in the boreholes E-1, E-2, E-3 and E-5, the water table stabilised between 1,0 m and 1,5 depths from the ground elevation. However, the dissipation was probably not completed.

5 Geotechnical Recommendations

5.1 Bearing capacity for shallow foundations

The foundations of the new wall should set on the same horizon than the existing one which coincides with the top of the stiff clay (crust). In order to allow for the removal of any disturbed clay soils during the process of demolition, these elevations could be slightly deeper. Therefore, the bottom of the foundations should be at the elevations varying between 59,54 m (5,49 m depth) and 61,22 m (3,96 m depth) according to the boreholes E-1, E-3, E-4 and E-5.

The ultimate bearing capacity (q_u) can be calculated by the following equations given in the Canadian Foundation Engineering Manual, section 10.2.

$$q_U = C\ N_c\ S_c + \ q_s\ N_q\ S_{q+}\frac{1}{2}\gamma.B.N\gamma$$

- q_u: ultimate bearing capacity;
- C : Soil cohesion = Cu undrained shear strength of the clay (kPa) (value is measured within a depth corresponding to D+2B);
- B : width of foundation (m) ;
- D : depth of the foundation in reference to the initial natural ground level (m) ;
- q_s : vertical stress acting at the elevation of the base of foundation (kPa);
- N_γ, N_c, N_q bearing capacity factors; (N_c = 2+π, N_γ= 0 et N_q= 1) ;
- γ: soil unit weight;
- S_c, S_q, S_γ : factors for foundation shape, (S_q = S_c = S_γ=1 for continuous footing).
- D = approximately 4.3 m;
- Existing ground surface elevation between 65.0 m and 66.3 m.
- C_u=55 kPa;
- qa: allowable bearing capacity, $qa = \frac{\mathrm{qu}}{\mathrm{FS}}$
- FS: Factor of safety, FS=2, reference table 8.3 of Canadian Foundation Engineering Manual, section 8.

For foundation widths varying from 3,0 m to 5,0 m, the influence zone of foundation (solicited soils) will reach respectively 9,5 m to 13,5 m. The minimum undrained shear strength measured in that horizon is about C_u = 55 kPa as shown in figure 1. Therefore, the ultimate bearing capacity will be:

q_u = 5.14 x C_u + q_s;
q_s = 4.3 x γ_h;
γ_h = 17.5 kN/m^3 since average w_n is around 45%;

Then
$q_s \approx 75$ kPa;
$q_u \approx 360$ kPa

The allowable bearing capacity is finally:

q_a = 180 kPa.

5.2 Deep foundations

If it is decided to proceed with deep foundations, the most suitable ones are the steel and driven H-piles. If the piles are driven until refusal into the dense till or the rock, which correspond to 15 m to 20 m depths, the geotechnical capacity of these piles will be equal to the their structural capacity.

5.3 Earth anchors

One of the proposed solutions is to stabilize the wall using the earth anchors in clay. The bond capacity in this case is calculated as follow:

$$\text{Bond Capacity} = \alpha_c \times C_u / SF$$

α_c is empirical coefficient which is equal to 0,4 in this case;
C_u is the undrained shear stress of the clay in the concerned horizon. A value of 65 kPa is taken according to the vane tests;
SF is the safety factor, equal to 2,5 according to the Canadian Manual of Foundations
Therefore,

Bond Capacity ≈ 10 kPa

5.4 Soil susceptible to frost action

The encountered subgrade fills and native soils in all boreholes are frost susceptible. Some frost action can be expected. To prevent any frost action behind the new wall, the soil behind the retaining wall should be excavated and replaced by non-frost susceptible compacted granular fill materials.

The foundation footings should be insulated to be protected against frost action.

5.5 Excavation during rehabilitation

During the works, the slopes of the excavations should be safe: 1,5H:1V minimum. The bottom of the excavations and the slopes should be dewatered by building a coffer dam in the river side, and by excavating trenches and pumping continuously in the other side. The pumped water should be discharged away enough from the work site to not feed again the pumped water table.

5.6 Geotechnical parameters for the earth pressure on the wall

The geotechnical parameters to be considered for the soil placed behind the wall are given in the table 7:

Table 7 Geotechnical parameters for the calculation of the active and passive earth pressure on the walls

Parameters		Values
Internal friction angle, Φ (°)		30
Cohesion, c' (kPa)		0
Bulk unit weight, γ (kN/m³)		21
Friction angle at the interference wall- soil, δ_s (°)		15
Friction coefficient for sliding resistance		0,5
Static condition	At rest earth pressure coefficient, K_0	0,5
	active earth pressure coefficient, K_a	(1)*
	passive earth pressure coefficient, K_p	(2)*
In case of earthquakes	active earth dynamic pressure coefficient, K_{ae}	(3)*
	active earth dynamic pressure coefficient, K_{pe}	(4)*

*See sections below

$$(\mathbf{1})\ K_a = \frac{cos^2\,(\Phi - \theta)}{\cos(\theta)^2 \cos(\delta_s + \theta)\,(1 + \sqrt{\frac{\sin(\delta_s + \Phi)\sin(\Phi - \beta)}{\cos(\delta_s + \theta)\cos(\beta - \theta)}})^2}$$

With the values listed in the table above, **Ka = 0,48.**

(2) The K_p value has been determined based on the following figure. For example, for ϕ = 25, β/ϕ = -0,2 and δ/ϕ = -0,3, K_p = R (K_p pour δ/ϕ = -1) with R a reduction factor presented in the table on the up left side from the figure. In this example, R = 0,711 and (Kp pour δ/ϕ = -1) = 3,62. Finally, Kp = 0,711 x 3,62 or **kp = 2,58.**

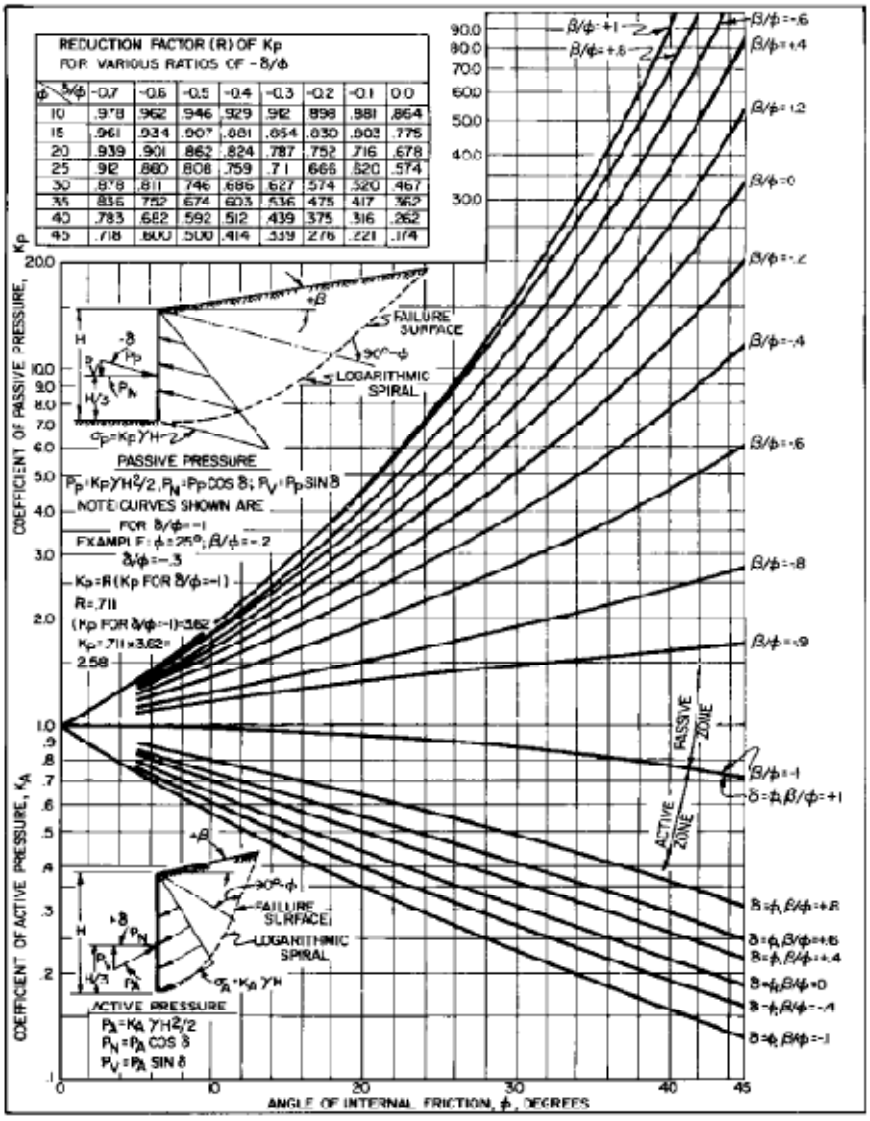


Figure 2 Figure extrait from NAVFAC (7.2-67)

$$(\mathbf{3})\ K_{ae} = \frac{cos^2\,(\Phi - \theta - \psi)}{\cos(\psi)\cos^2(\theta)\ \cos(\delta_s + \theta + \psi)\,(1 + \sqrt{\frac{\sin(\delta_s + \Phi)\sin(\Phi - \beta - \psi)}{\cos(\delta_s + \theta + \psi)\cos(\beta - \theta)}})^2}$$

$$(\mathbf{4})K_{pe} = \frac{cos^2\,(\Phi + \theta - \psi)}{\cos(\psi)\cos^2(\theta)\ \cos(\delta_s - \theta + \psi)\,(1 - \sqrt{\frac{\sin(\delta_s + \Phi)\sin(\Phi + \beta - \psi)}{\cos(\delta_s - \theta + \psi)\cos(\beta - \theta)}})^2}$$

- β : slope embankment to the horizontal plane (°) ;
- θ slope of the wall (°) ;
- ψ seismic corposant :

$$\psi = \text{atan}\ (\frac{k_h}{1 - k_v})$$

- k_h and k_v are the respective horizontal and vertical acceleration coefficients.

Appendix 1

Borehole Location Plan

Appendix 2

Borehole Logs

Appendix 3

Geotechnical Laboratory Test Results

Appendix 4

Photos

Drilling the borehole E-2

Tpical sample of the backfill material (From borehole E-1)

Typical sample of greenish clay (crust, from borehole E-5)

Typical sample of gray and plastic silty clay (from borehole E-4)

Piezometer cover, backfilling and asphalting the hole after drilling (borehole E-4)

Appendix A – Part III

Report on subsurface Investigation Rideau Canal (Ottawa Reach)
Retaining Wall at Patterson Creek Section and Echo Drive

Heritage Canals

REPORT ON

SUBSURFACE INVESTIGATION

RIDEAU CANAL (OTTAWA REACH)

RETAINING WALL

AT

PATTERSON CREEK SECTION

AND

ECHO DRIVE SECTION

TO

PUBLIC WORKS AND GOVERNMENT

SERVICES CANADA

Report No. SF-4636
June 23, 2000

McROSTIE GENEST ST-LOUIS

& ASSOCIATES LTD. - CONSULTING ENGINEERS
& ASSOCIÉS LTÉE - INGÉNIEURS CONSEILS
OTTAWA CANADA

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1. TERMS OF REFERENCE

We were requested and authorized by Mr. Jim Richardson,P.Eng. of Public Works and Government Services Canada, to carry out a subsurface investigation in Ottawa along the Rideau Canal, focused on the Patterson Creek and Echo Drive sections of the canal retaining wall.

The investigation was to be carried out in accordance with our work and cost proposal dated March 9, 2000, and the scope of work prepared by PWGSC. On March 2nd, 2000, we had visited both sites with Mr. Eric Sunstrum,P.Eng. and Mr. Luc Bériault,P.Eng., both of PWGSC, to review the locations to be tested, discuss the terms of reference and agree on the scope of work.

The field and geotechnical investigations of wall sections at Patterson's Creek and Echo Drive were to provide the necessary date, information and recommendations needed to carry out the design for repairing the walls.

The number, depth and location of the boreholes were determined by Heritage Canals but needed to be modified due to the findings.

Environmental concerns are beyond the scope of this geotechnical study.

2. BRIEF SITE DESCRIPTIONS

The Patterson Creek site is on the west side of the canal and comprises approximately 152 metres of retaining wall. It is more precisely located along the Queen Elizabeth Driveway and starts 22 metres south of Patterson Bridge going south.

The Echo Drive site is on the east side of the canal over a distance of approximately 158 metres. This section of wall is located at about 390 metres south of the University of Ottawa Nicholas Street pedestrian underpass tunnel.

The canal walls are gravity retaining walls dating back to the early 1930's. Typical wall sections provided to us by PWGSC are included in Appendix 'C' for completeness.

We understand that patching of the walls has been done on a semi-regular basis in the past, but the deterioration of the walls and coping is accelerating. Several wall sections have been previously refaced, replaced or rebuilt.

3. CONCLUSIONS AND RECOMMENDATIONS (PATTERSON CREEK SECTION)

3.1 Generalized Subsurface Conditions

At the Patterson Creek site, subsurface conditions can be generalized as consisting of a thick layer of unselected fill, topsoil and organic silt behind the existing retaining wall founded on a hard to very stiff fissured brownish gray clay crust. Below the desiccated crust, the clay becomes stiff and changes in colour to gray. At a depth of fifteen (15) metres, silt containing some sand layers was encountered. Based on borehole information from the area, normally the silt layer is underlain by glacial till (mixture of clay, silt, sand, gravel, cobbles, boulders and rock blocks) in turn underlain by bedrock. As inferred from the probing or dynamic cone testing, the till would start at a depth of approximately twenty-five (25) metres. Based on geological mapping, the bedrock below the site would consist of a black shale of the Billings Formation at a depth of at least twenty-eight (28) metres from the ground surface according to the results of the probing information.

Details of soil and groundwater conditions encountered at the site are shown on accompanying Plates.

3.2 Condition of Existing Wall

As shown on the photographs, included in Appendix 'A' of this report, the very upper part of the wall in this section is in relatively good condition. Deterioration and delamination of concrete can however be observed at the summer water level, approximately 200mm in dimension, where the surface

of the concrete can also be seen to be darker in colour. The lower portion of the wall seems to be generally in good condition.

It should be pointed out that this wall leans outwards, likely responsible for the visible longitudinal cracking in the asphalt pavement along the bicycle path. The rebars are visible at one location where the coping shows signs of spalling. There are signs of staining on the wall up to the summer water levels.

3.3 Quality of Concrete

We were requested to carry out a cursory study of the concrete characteristics as they relate to air content, alkali-aggregate potential reactivity and compressive strength.

The cores were examined, logged and photographed with the results shown in Appendix 'B'. The concrete can generally be described as well consolidate with large limestone and granitic aggregate. We would not expect any entrained air in concrete of this vintage.

The cores were cut and prepared for compressive strength testing. The intact concrete gave results ranging between 34.6MPa and 59.6MPa at this site with an average of 43.2MPa. Details are included in Appendix 'D'.

Samples were also forwarded to Montreal for specialized petrographic analysis, arranged through a local testing agency, Les Laboratoires Outaouais Inc.

We visited the site with a concrete engineer from the same firm that carried out the petrographic analysis in order to get an overall appreciation of the condition of the concrete in the field. Based on the observations made during the site visit, the exposed concrete surfaces do not show any evidence of alkali-aggregate reaction.

The coarse aggregate in the concrete is essentially composed of granitic and limestone rocks. The fine aggregate is mostly composed of feldspars, quartz and rock fragments.

As part of the petrographic analysis, a visual examination of the cores was performed, on concrete samples from boreholes Nº 00-2H and 00-4H with no apparent signs of alkali-aggregate reaction detected. We were informed, however, that there were signs of secondary reaction products that could be identified by a scanning electron microscope or by X-ray diffraction analysis, if required.

As indicated on the petrographic analysis record in Appendix 'D', both the coarse and fine aggregate have a low alkali-aggregate reactivity potential.

Based on the limited amount of testing on the concrete cores to evaluate the potential for alkali-aggregate reaction to occur and assuming that the tests were performed on samples representative of the entire site, the overall potential for such occurrence is considered low.

3.4 Remedial Work Requirements

At the Patterson Creek site, the existing retaining wall is leaning towards the Rideau Canal and a crack has developed in the asphalt bicycle path behind the

wall. Since the backfill behind the wall is unselected and has poor drainage characteristics as well as being frost acting, the most probable causes for the distress, would be a combination of differential groundwater pressures versus canal water levels and horizontal frost pressures from within the backfill.

Replacing the old wall with a new wall supported on the natural clay soils including removal of the unselected fill behind the wall is recommended.

The new wall should be made to bear on the clay crust at the same elevation as the old wall or just slightly deeper, in order to allow for the removal of any disturbed clay soils by the process of demolition. Furthermore, since the natural clay becomes softer with depth, it is important to take advantage of the presence of even a small portion of the clay crust.

The new backfill behind the wall needs to be free-draining and weep holes should be placed through the new wall. A material meeting the gradation characteristics of OPSS Granular 'B' (Type I) would be acceptable.

The designers will no doubt take into consideration the high levels of chlorides found in the groundwater in their design. These concentrations are likely attributable to de-icing chemicals being used during the winter months. Detailed results are given in Appendix 'D'.

The following soil parameters can be used for the design of the new retaining wall.

- soil density 21.0kN/m^3
- active earth pressure coefficient Ka = 0.35
- triangular distribution
- allowance for surcharge
- relief of hydrostatic pressure by drainage

A small batter should be placed on the face of the new retaining wall in order to reduce the effect or appearance caused by any lateral movement that will occur.

The allowable bearing pressure under a retaining wall or any other foundation system is dependent on the width of the loaded area and the variation in undrained shear strength in the clay below the footing.

Based on a few assumptions including founding the new wall just slightly deeper than the existing foundations, a maximum allowable bearing value of 200kPa can be used for design for a wall base in the range of 1.8m to 2.4m. For a wider base, this value would need to be reduced.

The above value of bearing pressure is based on a statistical analysis of vane shear strength versus geodetic elevation which can be found in Appendix 'E' of this report.

Pile type foundations for a new wall would also be an alternative but not considered economical and thus not recommended.

The toe of the existing retaining wall at this site does not have sufficient soil cover for frost protection. We recommend that suitable polystyrene insulation be placed beneath the new wall and extended into the canal over a short distance in order to provide frost protection equivalent to 1.8m of soil cover. Presently the soil cover is slightly greater than one metre.

Another alternative that might be considered, but only if the canal width can be narrowed somewhat, would be the placing of a new wall attached to the face of the existing wall after the removal of all loose concrete.

This alternative would, however, require the removal of the unselected fill behind the wall or else, the same condition would likely repeat itself after only a few years.

Also, before considering this alternative as an option, it would be necessary to study in greater detail the potential alkali-aggregate reactivity since the financial consequences would be enormous should there be even small reactions between new concrete and the existing wall. The variability in the aggregate used can be seen on the core photographs in Appendix 'B', thus reinforcing the need for further testing if this option is even considered.

3.5 Details of the Investigation

Six (6) vertical boreholes were put down at the site, two (2) of which were drilled through the wall coping and four (4) of which were put down 1200mm behind the back of the retaining wall. Two (2) horizontal holes were also drilled in order to determine the thickness of the wall at a given geodetic elevation. The location of the boreholes is shown on Plate Nº 2 of this report.

All of the field work was carried out by specialized drilling contractors under continuous technical supervision by our technical staff.

At the location of the vertical boreholes down through the wall, the existing hand rail was cut to accommodate the drilling equipment and reinstated to its existing condition by welding followed by painting. All borings through the wall, vertical and horizontal, were reinstated by filling with non-shrink grout.

During the field work, barricades, flashers and all necessary safety equipment were in place to protect pedestrians. The Rideau Canal office in Smiths Falls

and the National Capital Commission in Ottawa had been notified prior to the commencement of the field work.

All of the vertical boreholes at this site were put down by Marathon Drilling using a track-mounted CME-55 drill rig equipped with hollow stem augers and a special platform. The horizontal boreholes were performed by Capital Cutting and Coring using portable electric drilling equipment.

Standard penetration resistance tests were performed simultaneously with all split barrel sampling. The undrained shear strength of the underlying clay was measured by means of a field vane. Pocket penetrometer tests were also performed at the end of the split barrel upon retrieval. The walls were cored in NQ-size using diamond bits in the case of the vertical holes. The horizontal holes were cored using 75mm ø equipment.

Perforated pipes were placed in all the boreholes behind the wall for groundwater monitoring purposes. Once groundwater levels and samples had been taken, the asphalt was neatly cut at the borehole locations, crushed stone was added and compacted, followed by hot mix paving.

All soil samples and concrete cores were brought to our laboratory to be examined and tested. Moisture content determinations and visual classifications were made on all retrieved soil samples. The concrete cores were examined by an engineer and some samples were tested in our laboratory. Special testing was also performed by a specialized laboratory. Routine chemical test were performed on groundwater samples.

4. CONCLUSIONS AND RECOMMENDATIONS (ECHO DRIVE SECTION)

4.1 Generalized Subsurface Conditions

At the Echo Drive site, subsurface conditions can be generalized as consisting of sand and gravel as well as clay and wood behind the existing retaining wall founded on a hard to very stiff brownish gray clay crust or on a fine sand layer just above the clay. Behind the existing wall, during the drilling work, obstructions were encountered, including wood; possibly an old timber crib filled with unselected fill consisting of sand, gravel and clay. Below the desiccated crust, the clay becomes stiff and changes in colour to gray. At a depth of between sixteen (16) and seventeen (17) metres, silt was encountered. The silt layer is generally underlain by glacial till (mixture of clay, silt, sand, gravel, cobbles, boulders and rock blocks) that veneers bedrock. As inferred from the probing or dynamic cone testing, the till layer would be relatively thin at this site unless a large boulder was encountered at the bottom of the borehole. Based on geological mapping, the bedrock below the site would consist of a black shale of the Billings Formation at a depth of at least twenty-one (21) metres from the ground surface according to the results of the probing information.

Details of the soil and groundwater conditions encountered at the site are shown on accompanying Plates.

4.2 Condition of Existing Wall

A visual inspection of this section shows that for some portion of the studied area, degradation of the concrete can be observed in the first 650mm (approximately) from the top of the wall. As shown on our photographs in

Appendix 'A', the deteriorated concrete alternates with portions where concrete is found to be in good condition. Also, at each vertical joint, severe cracking and/or deterioration of the concrete can be observed. The reinforcing steel in the wall can be seen at several locations where the concrete is badly deteriorated. There are signs of staining on the wall up to the summer water levels.

4.3 Quality of Concrete

We were requested to carry out a cursory study of the concrete characteristics as they relate to air content, alkali-aggregate potential reactivity and compressive strength.

The cores were examined, logged and photographed with the results shown in Appendix 'B'. The concrete can generally be described as well consolidated with large granitic and limestone aggregate as well as other sedimentary rock aggregates.

The cores were cut and prepared for compressive strength testing. The intact concrete gave results ranging between 35.2MPa and 63.9MPa at this site with an average of 44.9MPa. Details are included in Appendix 'D'.

Samples were also forwarded to Montreal for specialized petrographic analysis and air content testing, arranged through a local testing agency, Les Laboratoires Outaouais Inc.

We visited the site with a concrete engineer from the firm that carried out the petrographic analysis in order to get an overall appreciation of the condition of the concrete in the field. Based on the observations made during the site

visit, the exposed concrete surfaces do not show any evidence of alkali-aggregate reaction.

The coarse aggregate in the concrete is essentially composed of sedimentary rocks like shale, siltstone and limestone as well as some granitic rocks. The fine aggregate is mostly composed of feldspars, quartz, rock fragments and limestone particles.

As part of the petrographic analysis, a visual examination of the cores was performed on a concrete sample from borehole Nº 00-102H with only minute signs of alkali-aggregate reaction detected. We were also informed that the amount and severity of the reaction was low and that there were also secondary reaction products found that could be identified by a scanning electron microscope or by X-ray diffraction analysis, if required.

As indicated on the petrographic analysis record in Appendix 'D', the coarse aggregate has a medium to high alkali-aggregate reactivity potential.

A sample from this site was also tested for microscopical determination of air content with a result showing 4.0% but with a high spacing factor indicating the presence of entrapped air rather than entrained air.

Based on the limited amount of testing on concrete cores from this site in order to evaluate the potential for alkali-aggregate reactions to occur and assuming that the tests were performed on representative samples, the overall potential for such occurrences is considered medium to high. However, it must be noted that the amount and severity of any alkali-aggregate reaction to date is low given consideration to the age of the concrete.

4.4 Remedial Work Requirements

At the Echo Drive site, the existing retaining wall is badly deteriorated over the entire study area. The backfill behind the wall is variable and likely not very efficient with respect to drainage.

Replacing the old wall with a new wall supported on the natural clay soils including removal of the unselected fill and timber cribs likely in place behind the wall is recommended.

The new wall should be made to bear on the clay crust at the same elevation as the old wall or just slightly deeper, in order to allow for the removal of any disturbed clay soils by the process of demolition. Furthermore, since the natural clay becomes softer with depth, it is important to take advantage of the presence of even a small portion of the clay crust.

The new backfill behind the wall needs to be free draining and weep holes should be placed through the new wall. A material meeting the gradation characteristics of OPSS Granular 'B' (Type I) would be acceptable.

The designers will no doubt take into consideration the high levels of chlorides found in the groundwater in their design. These concentrations are likely attributable to de-icing chemicals being used during the winter months. Detailed results are given in Appendix 'D'.

At the Echo Drive site, it would be useful to research any available archive information in an attempt to discover how the wall was built, including the probable presence of a timber crib since we had serious difficulties in getting some of the boreholes down through the fill behind the retaining wall.

The allowable bearing pressure under a retaining wall or any other foundation system is dependent on the width of the loaded area and the variation in undrained shear strength in the clay below the footing.

Based on a few assumptions including founding the new wall just slightly deeper than the existing foundations, a maximum allowable bearing value of 200kPa can be used for design for a wall base in the range of 1.8m to 2.4m. For a wider base, this value would need to be reduced.

The above value of bearing pressure is based on a statistical analysis of vane shear strength versus geodetic elevation which can be found in Appendix 'E' of this report. IS THIS A CORRECT ASSUMPTION?

Pile type foundations for a new wall would also be an alternative but not considered economical and thus not recommended.

The toe of the existing retaining wall at this site does not have sufficient soil cover for frost protection. We recommend that suitable polystyrene insulation be placed beneath the new wall and extended into the canal over a short distance in order to provide frost protection equivalent to 1.8m of soil cover. Presently the soil cover is slightly greater than one metre.

4.5 Details of the Investigation

Nine (9) vertical holes were put down at the site, one (1) of which was drilled through the wall coping down into the underlying soil. In the vertical boreholes placed at various distances behind the wall, five (5) additional attempts were needed to deepen the holes, due to obstructions being encountered at shallow depths. One (1) horizontal hole was also drilled in

order to determine the thickness of the wall at a given geodetic elevation. The location of the boreholes is shown on Plate Nº 3 of this report.

All of the field work was carried out by specialized drilling contractors under continuous technical supervision by our technical staff.

At the location of the vertical boreholes, down through the wall, the existing hand rail was cut to allow access for the drilling equipment. After completion of the drilling the concrete wall was filled with non-shrink grout. The hand rail was welded back into position and painted. The horizontal holes through the wall were also filled with non-shrink grout.

During the field work, barricades, flashers and all necessary protection for pedestrians were in place. The National Capital Commission and the Rideau Canal office were made aware of our activities.

All of the vertical holes at this site were put down by Marathon Drilling using a track-mounted CME-55 drill rig equipped with hollow stem augers and a special platform except borehole Nº 00-102 which was done by Capital Cutting and Coring because of access difficulties with the CME-55 equipment. The horizontal boreholes were also performed by Capital Cutting and Coring using portable electric drilling equipment.

Standard penetration resistance tests were performed simultaneously with all split barrel sampling. The undrained shear strength of the underlying clay was measured by means of a field vane. Pocket penetrometer tests were also carried out at the end of the split barrel in the field.

One (1) vertical hole through the wall was diamond core drilled in NQ-size, and the other was drilled using 75mm ⌀ electric equipment as were both horizontal holes. In one (1) vertical borehole behind the wall, it was necessary to drill casing with a diamond shoe in order to advance the borehole down through the unselected fill layers and wood.

Perforated pipes were placed in all the vertical holes behind the wall in which advancement was possible. Groundwater levels and samples were taken, the asphalt was neatly cut at the borehole locations, crushed stone was added and compacted followed by hot mix paving.

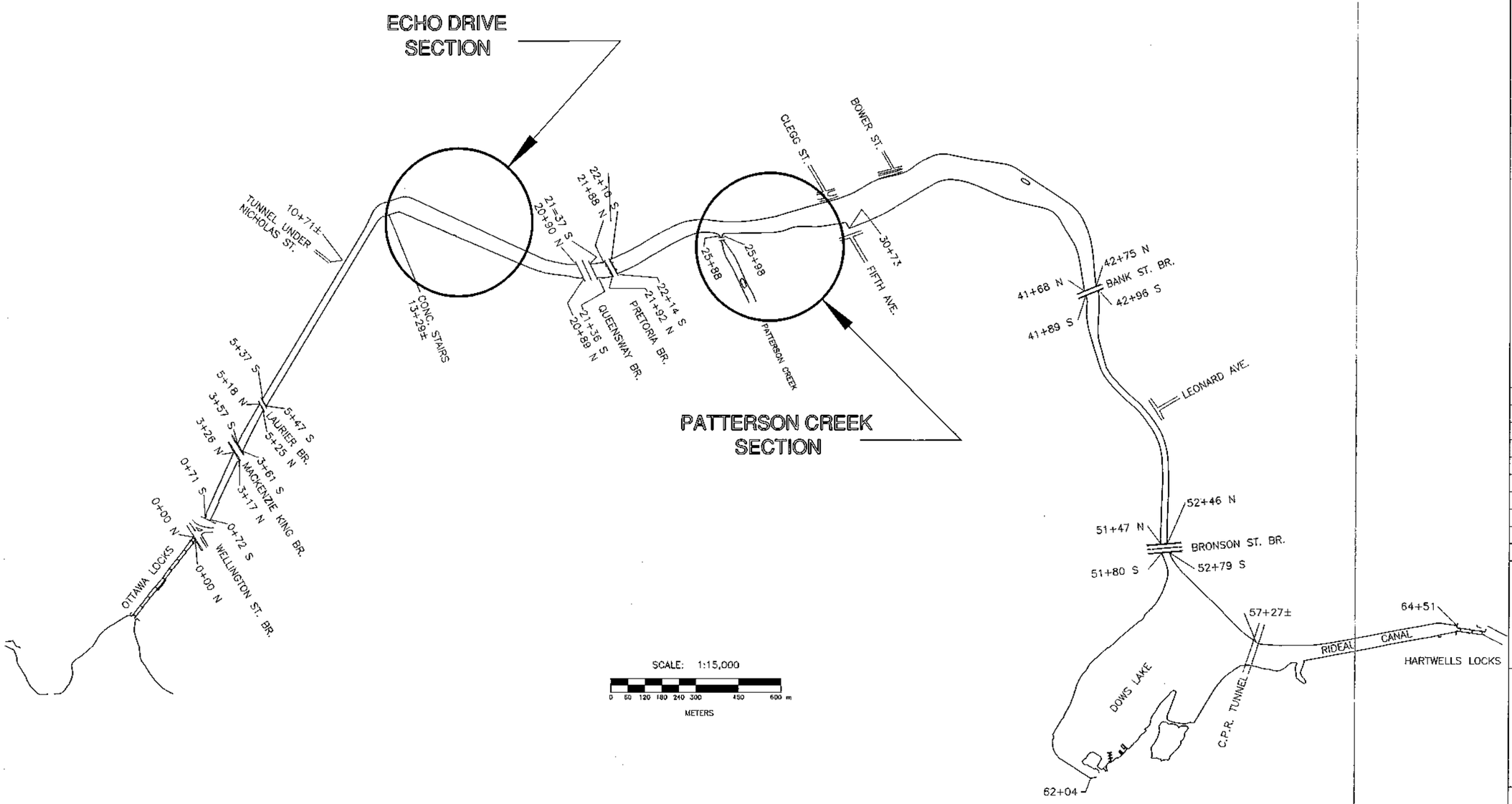
All soil samples and concrete cores were brought to our laboratory to be examined and tested. Moisture content determinations and visual classifications were made on all retrieved soil samples. The concrete cores were examined by an engineer and some samples were tested in our laboratory. Special testing was also performed by a specialized laboratory. Routine chemical tests were performed on groundwater samples.

5. STATEMENT OF LIMITATIONS

The 'Statement of Limitations' in Appendix 'F' forms an integral part of this report.

This report prepared by:—

Michel W. St-Louis,P.Eng.
McRostie Genest St-Louis
& Associates Ltd.



NOTES:

NO.	REVISION	DATE	
9			
8			
7			
6			
5			
4			
3			
2			
1			

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CONSULTING ENGINEERS INGÉNIEURS CONSEILS
OTTAWA CANADA

CLIENT :

Heritage Canals and Engineering Works National Centre of Expertise

Canaux historiques et travaux d'ingénierie Centre d'expertise national

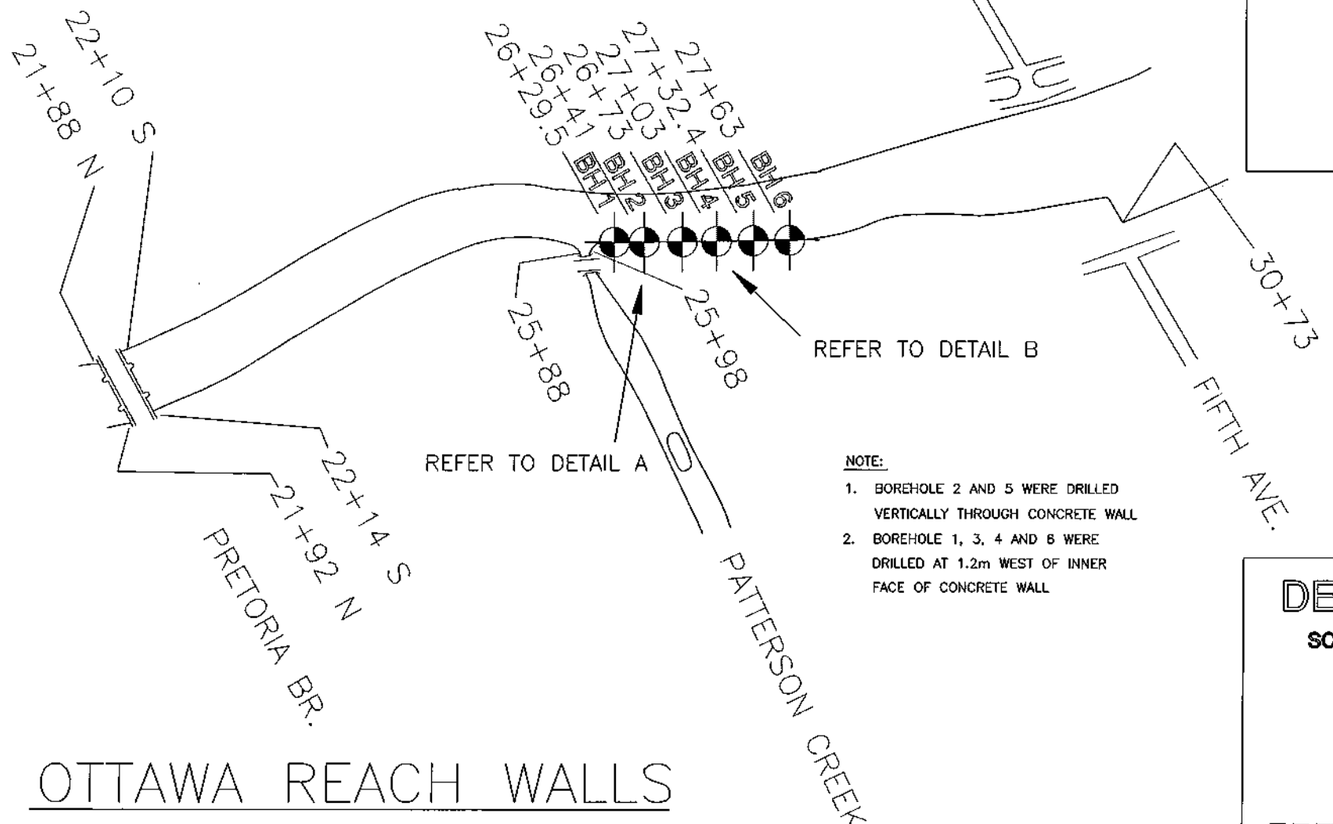
TITLE:

RIDEAU CANAL WALLS

SITE PLAN

DRAWN BY:	GIAMBERARDINO, V.N.
CHECKED BY:	ST. LOUIS, M
DATE:	JUNE 5, 2000
JOB NUMBER:	E-7928
DRAWING NO.:	PLATE No. 1
REV.:	0

PATTERSON CREEK SECTION



OTTAWA REACH WALLS

SCALE: 1:5,000

0 50 100 150 m

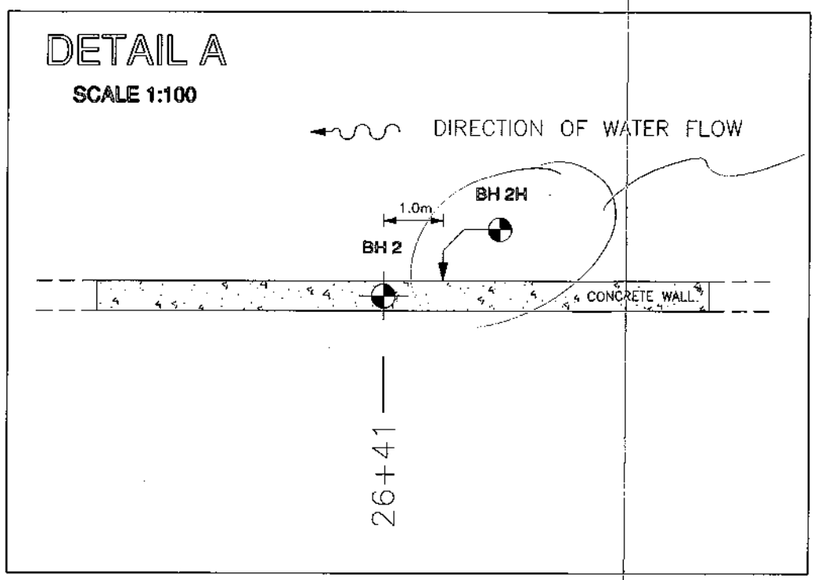
METERS

NOTE:

1. BOREHOLE 2 AND 5 WERE DRILLED VERTICALLY THROUGH CONCRETE WALL
2. BOREHOLE 1, 3, 4 AND 6 WERE DRILLED AT 1.2m WEST OF INNER FACE OF CONCRETE WALL

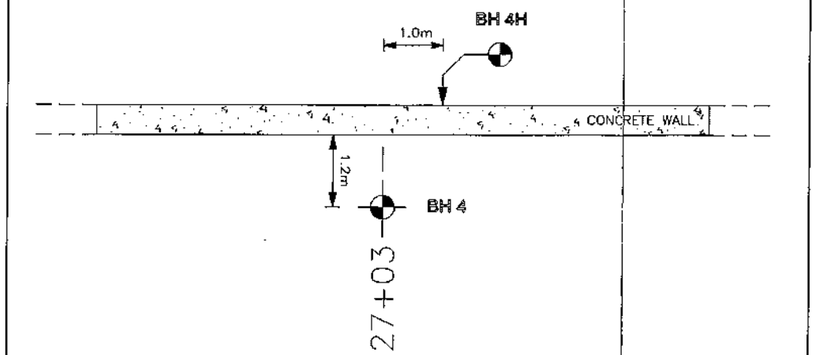
DETAIL A

SCALE 1:100



DETAIL B

SCALE 1:100



NOTES:

What Depth
where bedrock
was
?

LEGEND:

BH 101 — BOREHOLE LOCATION

DIRECTION OF WATER FLOW

NO.	REVISION	DATE	
9			
8			
7			
6			
5			
4			
3			
2			
1			

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Heritage Canals and Engineering Works National Centre of Expertise

Canaux historiques et travaux d'ingénierie Centre d'expertise national

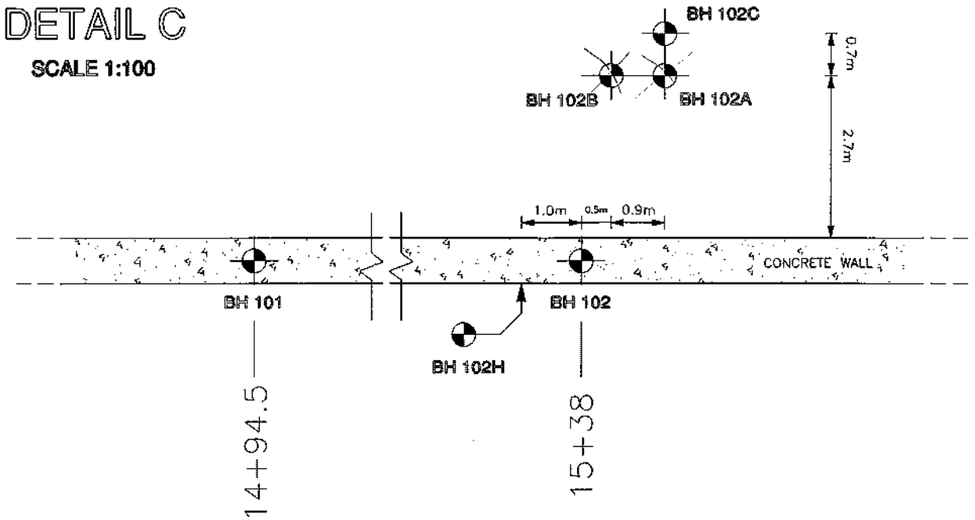
TITLE:

RIDEAU CANAL WALLS
PATTERSON CREEK SECTION

DRAWN BY:	GIAMBERARDINO, V.N.
CHECKED BY:	ST. LOUIS, M
DATE:	JUNE 5, 2000
JOB NUMBER:	E-7928
DRAWING NO.:	PLATE No. 2
REV.:	0

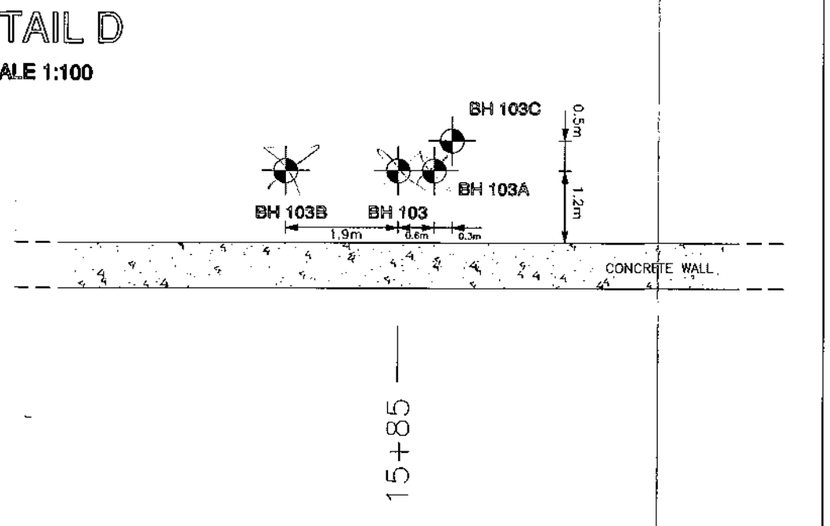
DETAIL C

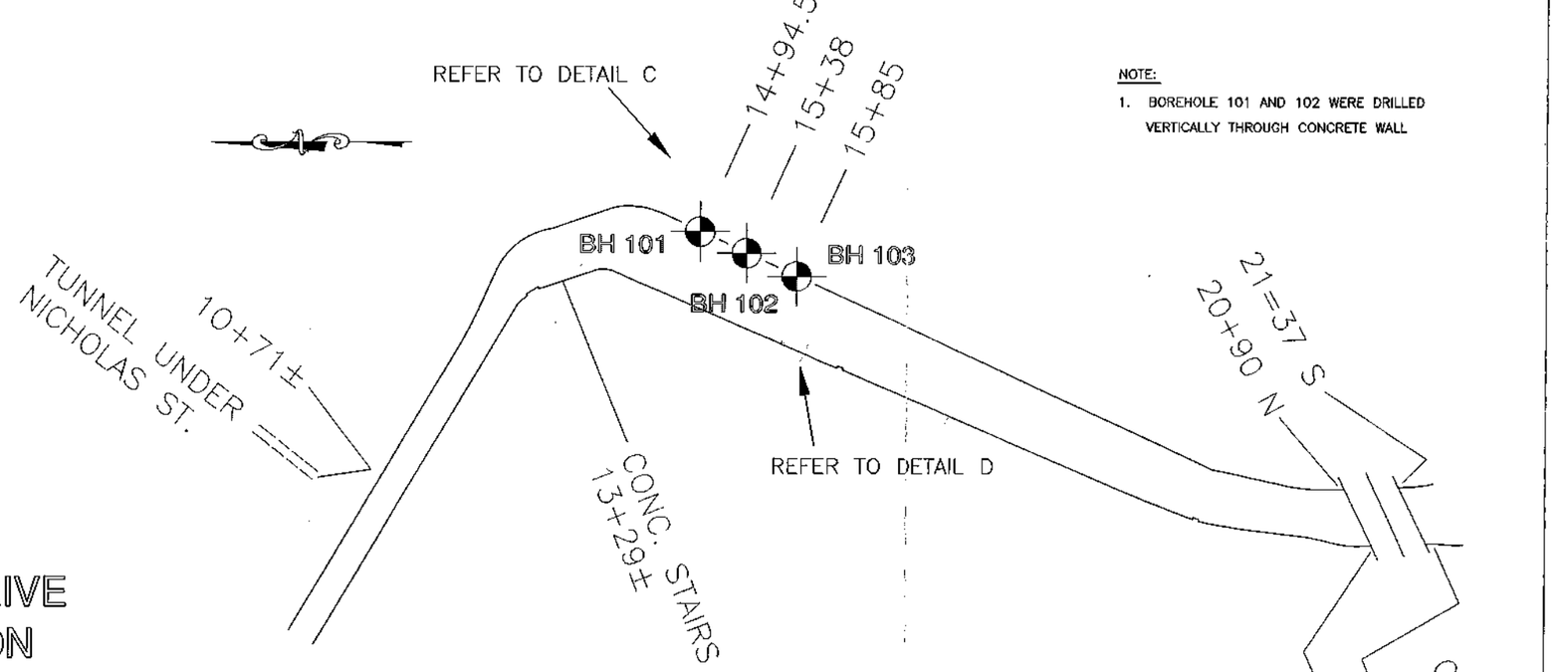
SCALE 1:100



DETAIL D

SCALE 1:100





NOTE:

1. BOREHOLE 101 AND 102 WERE DRILLED VERTICALLY THROUGH CONCRETE WALL

SCALE: 1:5,000

0 50 100 150 m

METERS

ECHO DRIVE SECTION

OTTAWA REACH WALLS

NOTES:

LEGEND:

BH 101 — BOREHOLE LOCATION

DIRECTION OF WATER FLOW

NO.	REVISION	DATE	
9			
8			
7			
6			
5			
4			
3			
2			
1			

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CLIENT :

Heritage Canals and Engineering Works National Centre of Expertise

Canaux historiques et travaux d'ingénierie Centre d'expertise national

TITLE:

RIDEAU CANAL WALLS

ECHO DRIVE SECTION

DRAWN BY:	GIAMBERARDINO, V.N.
CHECKED BY:	ST. LOUIS, M
DATE:	JUNE 5, 2000
JOB NUMBER:	E-7928
DRAWING NO.:	PLATE No. 3
REV.:	0

BOREHOLES

PATTERSON CREEK SECTION

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-1
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/01		ELEVATION: 64.97 m

SAMPLE TYPE: REMOULDED | SHELBY TUBE | SPLIT-SPOON | PROBING | NO RECOVERY | CORE

VANE Cu (kPa): 80 160 240 320
▲ VANE Cu REMOULDED (kPa) ▲: 80 160 240 320
PLASTIC M.C. LIQUID: 20 40 60 80

DEPTH(m)	SMALL PEN. SPT (kPa)	(N)	SAMPLE TYPE	SAMPLE NO	SOIL DESCRIPTION	ELEVATION(m)
0.0		2			FILL – topsoil	
		2		1		
					64.67	
1.0	WL	2			Water level May 9/00 elev 63.96m	64
		16		2		
					FILL	
		10			sandy topsoil with some sand, wood,	
		18		3	and traces of gravel	248
2.0						63.0
		7				
		8		4		
3.0	305,270,270	7				62.0
		8		5		
					61.87	
4.0						61.0
					hard	
	60,60,60	4			brownish gray CLAY	
		4		6		
5.0						60.0
6.0		2/60cm				59.0
				7		
					58.97	
7.0					stiff	58.0
					silty gray CLAY	
	20,20,20	2/60cm		8		
8.0					Borehole continued 56.97	57.0

McROSTIE GENEST ST-LOUIS Ottawa, Canada	LOGGED BY: JML REVIEWED BY: E.S. Fig. No: 4	COMPLETION DEPTH: 8.7 m COMPLETE: 00/05/01 Page 1 of 2

00/06/11 12:07PM (STANDARD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-1
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/01		ELEVATION: 64.97 m

SAMPLE TYPE: REMOULDED | SHELBY TUBE | SPLIT-SPOON | PROBING | NO RECOVERY | CORE

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	SOIL DESCRIPTION	VANE Cu (kPa) 80 160 240 320 / VANE Cu REMOULDED (kPa) 80 160 240 320 / PLASTIC M.C. LIQUID 20 40 60 80	ELEVATION(m)
8.0		⊠	8	stiff silty gray CLAY		56.0
				Bottom of hole 56.27		
9.0						55.0
10.0						
11.0						54.0
12.0						53.0
13.0						52.0
14.0						51.0
15.0						50.0
16.0						49.0

McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 8.7 m
REVIEWED BY: E.S.	COMPLETE: 00/05/01
Fig. No: 5.	Page 2 of 2

00/06/11 12:07PM (STANDARD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-2
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/03		ELEVATION: 64.73 m

SAMPLE TYPE: REMOULDED-AUGER / SHELBY TUBE / SPLIT-SPOON / NW-CASING / NO RECOVERY / NQ CORE

VANE Cu (kPa) 80 160 240 320

VANE Cu REMOULDED (kPa) 80 160 240 320

PLASTIC M.C. LIQUID 20 40 60 80

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	ELEVATION(m)
0.0					64.73	
	all water lost at el 64.13m			99	CONCRETE	
1.0					3.2m	64.0
					63.27	
2.0				100	CONCRETE	63.0
3.0				100	CONCRETE 61.81	62.0
					61.53	
	290,335,290 7 13		1			61.0
4.0					hard to very stiff fissured brownish gray CLAY	
5.0						60.0
						59.0
6.0						
	5 3		2		58.63	58.0
7.0					medium soft to soft silty gray CLAY	
	3 4		3			57.0
8.0					Borehole continued 56.73	

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LOGGED BY: JML	COMPLETION DEPTH: 8.1 m
REVIEWED BY: E.S.	COMPLETE: 00/05/03
Fig. No: 6.	Page 1 of 2

00/06/13 12:11PM (NQ-STD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-2
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/03		ELEVATION: 64.73 m

SAMPLE TYPE: REMOULDED-AUGER | SHELBY TUBE | SPLIT-SPOON | NW-CASING | NO RECOVERY | NQ CORE

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	VANE Cu (kPa) 80 160 240 320 / VANE Cu REMOULDED (kPa) 80 160 240 320 / PLASTIC M.C. LIQUID 20 40 60 80	ELEVATION(m)
8.0		⊠	3		medium soft to soft silty gray CLAY		56.0
9.0					Bottom of hole 56.63		55.0
10.0							54.0
11.0							53.0
12.0							52.0
13.0							51.0
14.0							50.0
15.0							49.0
16.0							

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Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 8.1 m
REVIEWED BY: E.S.	COMPLETE: 00/05/03
Fig. No: 7	Page 2 of 2

00/06/12 09:48AM (NQ-STD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-3
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/02		ELEVATION: 64.72 m

SAMPLE TYPE: REMOULDED | SHELBY TUBE | SPLIT-SPOON | PROBING | NO RECOVERY | CORE

VANE Cu (kPa) 80 160 240 320
▲ VANE Cu REMOULDED (kPa) ▲ 80 160 240 320
PLASTIC M.C. LIQUID 20 40 60 80

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	SOIL DESCRIPTION	ELEVATION(m)
0.0				ASPHALT	
				FILL – crushed stone 64.67	
	10 5		1	64.42	64.0
1.0	6 3/15cm 12/15cm		2		
	9 7		3	FILL crushed stone with some topsoil, clay, sand, gravel, wood, and pieces of concrete	63.0
2.0	8 5/15cm 43/8cm		4		62.0
	split barrel refusal				
3.0	25/8cm		5		61.0
				60.97	
4.0	145,125,145 4 5		6	stiff fissured brownish gray clay	60.0
				60.22	
	50,40,60 2 2		7		
5.0	WL			Water level May 9/00 elev 59.72m	59.0
6.0	1/60cm		8	stiff silty gray CLAY	58.0
7.0					57.0
	10,10,10 wt of hammer /60cm		9	Borehole continued 56.72	
8.0					

McROSTIE GENEST ST-LOUIS
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LOGGED BY: JML	COMPLETION DEPTH: 28.2 m
REVIEWED BY: E.S.	COMPLETE: 00/05/02
Fig. No: 8.	Page 1 of 4

00/06/11 12:12PM (STANDARD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-3
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/02		ELEVATION: 64.72 m

SAMPLE TYPE: REMOULDED | SHELBY TUBE | SPLIT-SPOON | PROBING | NO RECOVERY | CORE

VANE Cu (kPa) 80 160 240 320
VANE Cu REMOULDED (kPa) 80 160 240 320
PLASTIC M.C. LIQUID 20 40 60 80

DEPTH(m)	SMALL PEN. (kPa)	SPT (N)	SAMPLE TYPE	SAMPLE NO	SOIL DESCRIPTION	ELEVATION(m)
8.0				9		
9.0	20,10,20	2/60cm		10		56.0
10.0						55.0
	40,20,40	2 2		11	stiff silty gray CLAY	54.0
11.0						
12.0	50,50,50	2 2		12		53.0
13.0						52.0
		2 4		13	51.22 stiff silty gray CLAY with some silt layers and pockets	51.0
14.0						50.0
15.0		8 8		14	49.72 medium dense SILT Borehole continued 48.72	49.0
16.0						

McROSTIE GENEST ST-LOUIS Ottawa, Canada	LOGGED BY: JML	COMPLETION DEPTH: 28.2 m
	REVIEWED BY: E.S.	COMPLETE: 00/05/02
	Fig. No: 9.	Page 2 of 4

00/06/11 12:12PM (STANDARD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-3
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/02		ELEVATION: 64.72 m

SAMPLE TYPE: REMOULDED | SHELBY TUBE | SPLIT-SPOON | PROBING | NO RECOVERY | CORE

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	SOIL DESCRIPTION	ELEVATION(m)
16.0				medium dense SILT	
	3 5		15	medium dense silty fine SAND	48.22
17.0					47.62
18.0	7 9		16	medium dense SILT	
19.0					
				PROBING	45.22
20.0					
21.0				SOIL with medium resistance to penetration	
22.0					
23.0					
				Borehole continued	40.72
24.0					

VANE Cu (kPa) ■ 80 160 240 320

▲ VANE Cu REMOULDED (kPa) ▲ 80 160 240 320

PLASTIC M.C. LIQUID 20 40 60 80

◆ PROBING (Blows/30cm) ◆ 20 40 60 80

48.0 47.0 46.0 45.0 44.0 43.0 42.0 41.0

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Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 28.2 m
REVIEWED BY: E.S.	COMPLETE: 00/05/02
Fig. No: 10.	Page 3 of 4

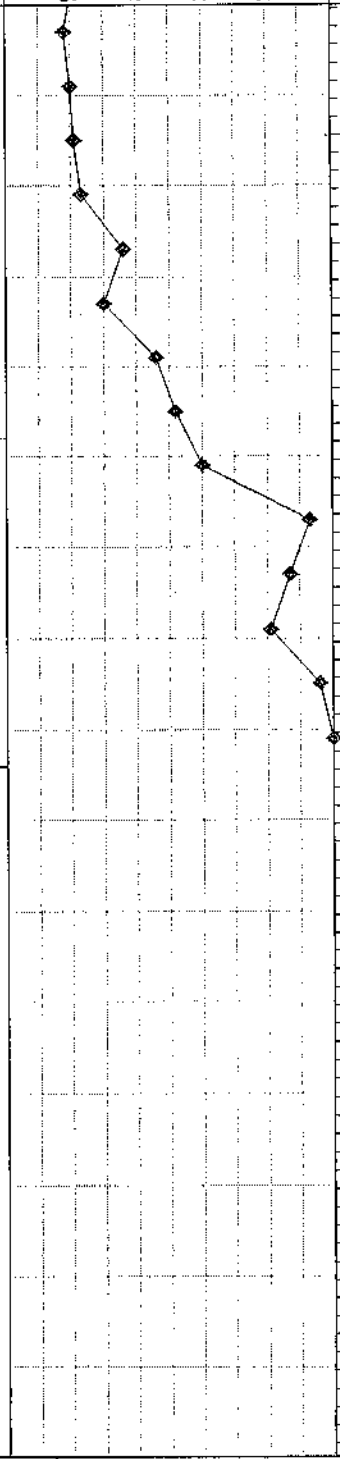
00/06/11 12:12PM (STANDARD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	TEST HOLE NO: 00-3
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/02		ELEVATION: 64.72 m

SAMPLE TYPE: REMOULDED-AUGER | SHELBY TUBE | SPLIT-SPOON | PROBING | NO RECOVERY | CORE

DEPTH(m)	COMMENTS	SAMPLE TYPE	SAMPLE NO	SOIL DESCRIPTION	ELEVATION(m)
24.0					40.0
25.0				SOIL with medium resistance to penetration	
26.0					39.0
				38.32	
27.0				SOIL with high resistance to penetration	38.0
28.0				Bottom of hole 36.52 Probing refusal	37.0
29.0					36.0
30.0					35.0
31.0					34.0
32.0					33.0

PROBING (Blows/30cm) 20 40 60 80



McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 28.2 m
REVIEWED BY: E.S.	COMPLETE: 00/05/02
Fig. No: 11.	Page 4 of 4

00/06/11 12:40PM (PROB-STD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-4
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/01		ELEVATION: 64.71 m

SAMPLE TYPE: REMOULDED | SHELBY TUBE | SPLIT-SPOON | PROBING | NO RECOVERY | CORE

DEPTH(m)	SMALL PEN. SPT (kPa)	(N)	SAMPLE TYPE	SAMPLE NO	SOIL DESCRIPTION	ELEVATION(m)
0.0					ASPHALT	
					FILL – crushed limestone 64.66	
		6			FILL 64.41	
	WL	2		1	crushed stone with some sand and traces of wood	64.0
1.0		4			63.81	
		6		2	Water level May 9/00 elev 64.11m	
		3				
		6		3	FILL	63.0
2.0					coarse sand and gravel with some wood and clay	
		5				
		22		4		62.0
3.0	315,290,315	5/15cm				
		6		5	61.56	61.0
		4/15cm			very stiff fissured brownish gray CLAY	
4.0						
	50,50,50	2			60.21	
		3		6		60.0
5.0						
						59.0
6.0	10,10,10	2			stiff silty gray CLAY	
		2		7		58.0
7.0						
	20,10,20	2/60cm		8	Borehole continued 56.71	57.0
8.0						

VANE Cu (kPa) 80 160 240 320
VANE Cu REMOULDED (kPa) 80 160 240 320
PLASTIC M.C. LIQUID
20 40 60 80

McROSTIE GENEST ST-LOUIS Ottawa, Canada	LOGGED BY: JML	COMPLETION DEPTH: 8.7 m
	REVIEWED BY: E.S.	COMPLETE: 00/05/01
	Fig. No: 12.	Page 1 of 2

00/06/11 12:13PM (STANDARD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-4
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/01		ELEVATION: 64.71 m

SAMPLE TYPE ■ REMOULDED ⟋ SHELBY TUBE ☒ SPLIT-SPOON ▤ PROBING ▯▯ NO RECOVERY ▮ CORE

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	SOIL DESCRIPTION	■ VANE Cu (kPa) ■ 80 160 240 320 ▲ VANE Cu REMOULDED (kPa) ▲ 80 160 240 320 PLASTIC M.C. LIQUID 20 40 60 80	ELEVATION(m)
8.0		☒	8	stiff silty gray CLAY		56.0
9.0				Bottom of hole 56.01		55.0
10.0						54.0
11.0						53.0
12.0						52.0
13.0						51.0
14.0						50.0
15.0						49.0
16.0						

McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 8.7 m
REVIEWED BY: E.S.	COMPLETE: 00/05/01
Fig. No: 13.	Page 2 of 2

00/06/11 12:13PM (STANDARD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-5
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/04		ELEVATION: 64.62 m

SAMPLE TYPE: REMOULDED-AUGER / SHELBY TUBE / SPLIT-SPOON / NW-CASING / NO RECOVERY / NQ CORE

VANE Cu (kPa) 80 160 240 320
VANE Cu REMOULDED (kPa) 80 160 240 320
PLASTIC M.C. LIQUID 20 40 60 80

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	ELEVATION(m)
0.0					64.62	64.0
				97	CONCRETE	
1.0					3.3m	
					63.12	63.0
				81	CONCRETE	
2.0	all water lost at el 62.72m				CONCRETE 62.60	
					62.33	62.0
				58	CONCRETE	
3.0						
	210,190,190 12 12		1		61.32	61.0
4.0					very stiff to hard fissured brownish gray CLAY	
5.0						60.0
						59.0
6.0	2 2		2		58.57	
					stiff silty gray CLAY	58.0
7.0	20,20,20 2 2		3			
					Borehole continued 56.62	57.0
8.0						

McROSTIE GENEST ST-LOUIS Ottawa, Canada	LOGGED BY: JML	COMPLETION DEPTH: 8.9 m
	REVIEWED BY: E.S	COMPLETE: 00/05/04
	Fig. No: 14.	Page 1 of 2

00/06/13 12:11PM (NQ-STD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-5
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/04		ELEVATION: 64.62 m

SAMPLE TYPE: REMOULDED-AUGER | SHELBY TUBE | SPLIT-SPOON | NW-CASING | NO RECOVERY | NQ CORE

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	VANE Cu (kPa) 80 160 240 320 / VANE Cu REMOULDED (kPa) 80 160 240 320 / PLASTIC M.C. LIQUID 20 40 60 80	ELEVATION(m)
8.0					stiff silty gray CLAY		56.0
9.0					Bottom of hole 55.72		55.0
10.0							54.0
11.0							53.0
12.0							52.0
13.0							51.0
14.0							50.0
15.0							49.0
16.0							

McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 8.9 m
REVIEWED BY: E.S.	COMPLETE: 00/05/04
Fig. No: 15.	Page 2 of 2

00/06/11 12:14PM (NQ-STD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-6
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/01		ELEVATION: 64.65 m

SAMPLE TYPE: REMOULDED | SHELBY TUBE | SPLIT-SPOON | PROBING | NO RECOVERY | CORE

DEPTH(m)	SMALL PEN. SPT (kPa)	(N)	SAMPLE TYPE	SAMPLE NO	SOIL DESCRIPTION	ELEVATION(m)
0.0					ASPHALT	
					64.57	
		12				
		2		1	FILL	
	WL				crushed limestone with some topsoil	
					Water level May 9/00 elev 64.11m	
1.0		4		2		
		6				
				2A	clayey TOPSOIL 63.45	
					63.15	
		2				
		8		3		
2.0					organic SILT	
		3		4		
		19				
				4A	medium dense 62.10	
					coarse SAND and GRAVEL	
3.0	365,385,365	5			61.65	
		7		5		
					hard	
					fissured brownish gray CLAY	
4.0						
					60.15	
	50,40,50	2				
		2		6		
5.0						
6.0	10,20,20	2			stiff	
		2		7	silty gray CLAY	
7.0						
	20,20,20	2/60cm		8		
8.0					Borehole continued 56.65	

VANE Cu (kPa) 80 160 240 320
VANE Cu REMOULDED (kPa) 80 160 240 320
PLASTIC M.C. LIQUID
20 40 60 80

McROSTIE GENEST ST-LOUIS Ottawa, Canada	LOGGED BY: JML	COMPLETION DEPTH: 8.7 m
	REVIEWED BY: E.S	COMPLETE: 00/05/01
	Fig. No: 16.	Page 1 of 2

00/06/11 12:14PM (STANDARD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-6
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/05/01		ELEVATION: 64.65 m

SAMPLE TYPE: REMOULDED | SHELBY TUBE | SPLIT-SPOON | PROBING | NO RECOVERY | CORE

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	SOIL DESCRIPTION	VANE Cu (kPa) 80 160 240 320 / VANE Cu REMOULDED (kPa) 80 160 240 320 / PLASTIC M.C. LIQUID 20 40 60 80	ELEVATION(m)
8.0		⊠	8	stiff silty gray CLAY		56.0
				Bottom of hole 55.95		
9.0						55.0
10.0						54.0
11.0						53.0
12.0						52.0
13.0						51.0
14.0						50.0
15.0						49.0
16.0						

McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 8.7 m
REVIEWED BY: E.S.	COMPLETE: 00/05/01
Fig. No: 17.	Page 2 of 2

00/06/11 12:14PM (STANDARD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-2H
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/04/19		ELEVATION:

SAMPLE TYPE: REMOULDED-AUGER | SHELBY TUBE | SPLIT-SPOON | NW-CASING | NO RECOVERY | NQ CORE

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	VANE Cu (kPa) 80 160 240 320 / VANE Cu REMOULDED (kPa) 80 160 240 320 / PLASTIC M.C. LIQUID 20 40 60 80	ELEVATION(m)
0.0					CONCRETE		0.0
1.0					SOIL 1.17		-1.0
					End of hole 1.30		
2.0							-2.0
3.0							-3.0
4.0							-4.0
5.0							-5.0
6.0							-6.0
7.0							-7.0
8.0							-8.0

McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: *.*
REVIEWED BY: E.S.	COMPLETE: 00/04/19
Fig. No: 18.	Page 1 of 1

00/06/11 12:07PM (NQ-STD)

RIDEAU CANAL WALL, PATTERSON CREEK AREA	B.M.(ELEV 66.55m)geodetic: Tablet No.	BOREHOLE NO: 00-4H
	3616 in canal wall at sta. 2598.	PROJECT NO: E-7928
START DATE: 00/04/19		ELEVATION:

SAMPLE TYPE ■ REMOULDED-AUGER ⁄ SHELBY TUBE ☒ SPLIT-SPOON ▤ NW-CASING ▯▯ NO RECOVERY ▮▯ NQ CORE

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	ELEVATION(m)
0.0					CONCRETE	0.0
1.0					SOIL 1.17	-1.0
					End of hole 1.32	
2.0						-2.0
3.0						-3.0
4.0						-4.0
5.0						-5.0
6.0						-6.0
7.0						-7.0
8.0						-8.0

■ VANE Cu (kPa) ■
80 160 240 320
▲ VANE Cu REMOULDED (kPa) ▲
80 160 240 320
PLASTIC M.C. LIQUID
20 40 60 80

McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: *.*
REVIEWED BY: E.S.	COMPLETE: 00/04/19
Fig. No: 19.	Page 1 of 1

00/06/11 12:07PM (HQ-STD)

BOREHOLES

ECHO DRIVE SECTION

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-101
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/05/04	COR. OF HAWTHORNE & MAIN.	ELEVATION: 64.97 m

SAMPLE TYPE: REMOULDED-AUGER | SHELBY TUBE | SPLIT-SPOON | NW-CASING | NO RECOVERY | NQ CORE

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	ELEVATION(m)
0.0					64.97	
				98	CONCRETE	
1.0						64.0
					63.45	
2.0				98	CONCRETE	63.0
	4.26m					
3.0					61.95	62.0
				89	CONCRETE	
4.0						61.0
	8		1		medium dense 60.71	
	290,290,295 11		1A		silty fine SAND	
5.0					-4.6m 60.37	60.0
					hard fissured brownish gray CLAY	
6.0						59.0
7.0	20,20,20 4 3		2		58.07 very stiff silty gray CLAY	58.0
8.0					Borehole continued 56.97	57.0

VANE Cu (kPa) 80 160 240 320
▲ VANE Cu REMOULDED (kPa) ▲ 80 160 240 320
PLASTIC M.C. LIQUID 20 40 60 80

McROSTIE GENEST ST-LOUIS Ottawa, Canada	LOGGED BY: JML	COMPLETION DEPTH: 10.1 m
	REVIEWED BY: E.S.	COMPLETE: 00/05/04
	Fig. No: 20.	Page 1 of 2

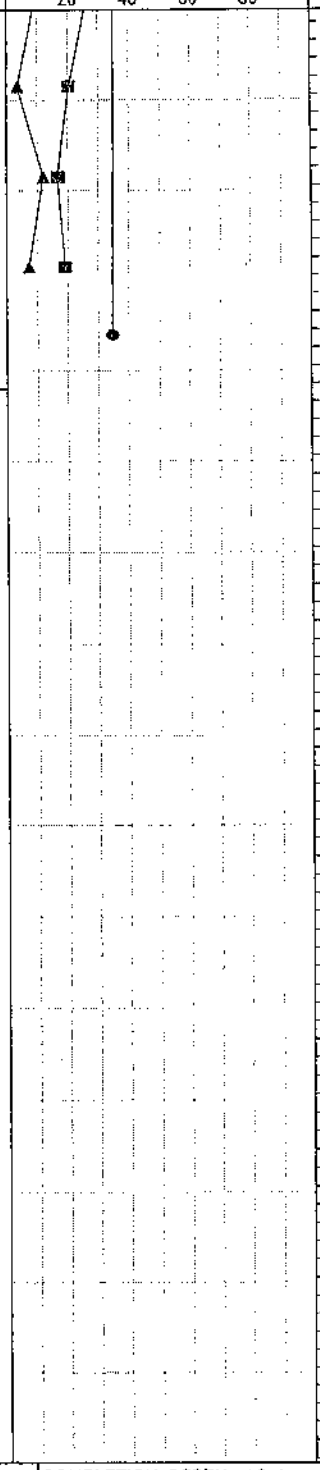
00/06/14 09:08PM (NQ-STD)

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-101
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/05/04	COR. OF HAWTHORNE & MAIN.	ELEVATION: 64.97 m

SAMPLE TYPE: REMOULDED-AUGER | SHELBY TUBE | SPLIT-SPOON | NW-CASING | NO RECOVERY | NQ CORE

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	ELEVATION(m)
8.0						
9.0					stiff silty gray CLAY	56.0
	10,10,20 2 2		3			
10.0					Bottom of hole 54.87	55.0
11.0						54.0
12.0						53.0
13.0						52.0
14.0						51.0
15.0						50.0
16.0						49.0

VANE Cu (kPa) 80 160 240 320
▲ VANE Cu REMOULDED (kPa) ▲ 80 160 240 320
PLASTIC M.C. LIQUID
20 40 60 80



McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 10.1 m
REVIEWED BY: E.S.	COMPLETE: 00/05/04
Fig. No: 21.	Page 2 of 2

00/06/14 09:08PM (NQ-STD)

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-102
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/05/09	COR. OF HAWTHORNE & MAIN.	ELEVATION: 64.98 m

SAMPLE TYPE: REMOULDED-AUGER | SHELBY TUBE | SPLIT-SPOON | NW-CASING | NO RECOVERY | NQ CORE

DEPTH(m)	SMALL PEN. SPT (kPa) / (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	ELEVATION(m)
0.0	Top of wall				64.98	
				99	CONCRETE	
1.0					64.29	64.0
				100	CONCRETE	
				97	CONCRETE 63.33	
2.0	4.06m				62.97	63.0
				96	CONCRETE	
3.0					61.96	62.0
				100	CONCRETE	
4.0					Bottom of hole 60.92	61.0
5.0						60.0
6.0						59.0
7.0						58.0
8.0						57.0

VANE Cu (kPa) 80 160 240 320

▲ VANE Cu REMOULDED (kPa) ▲ 80 160 240 320

PLASTIC M.C. LIQUID 20 40 60 80

McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 4.06 m
REVIEWED BY: E.S.	COMPLETE: 00/05/09
Fig. No: 22.	Page 1 of 1

00/06/14 09:08PM (NQ-STD)

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-102A
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/05/09	COR. OF HAWTHORNE & MAIN.	ELEVATION: 65.08 m

SAMPLE TYPE: REMOULDED-AUGER | SHELBY TUBE | SPLIT-SPOON | NW-CASING | NO RECOVERY | NQ CORE

DEPTH(m)	SMALL PEN. SPT (kPa) / (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	ELEVATION(m)
0.0					ASPHALT	65.0
					FILL - crushed limestone 65.03	
	20/15cm 6 5/15cm		1		FILL 64.78 sand and gravel	
1.0					Bottom of hole 64.16 Power auger refusal	64.0
2.0						63.0
3.0						62.0
4.0						61.0
5.0						60.0
6.0						59.0
7.0						58.0
8.0						

VANE Cu (kPa) 80 160 240 320

▲ VANE Cu REMOULDED (kPa) ▲ 80 160 240 320

PLASTIC M.C. LIQUID 20 40 60 80

McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 0.92 m
REVIEWED BY: E.S.	COMPLETE: 00/05/09
Fig. No: 23.	Page 1 of 1

00/06/14 09:08PM (NQ-STD)

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-102B
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/05/09	COR. OF HAWTHORNE & MAIN.	ELEVATION: 65.08 m

SAMPLE TYPE: REMOULDED-AUGER / SHELBY TUBE / SPLIT-SPOON / NW-CASING / NO RECOVERY / NQ CORE

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	VANE Cu (kPa) 80 160 240 320 / VANE Cu REMOULDED (kPa) 80 160 240 320 / PLASTIC M.C. LIQUID 20 40 60 80	ELEVATION(m)
0.0					SOIL SEE. B.H. No. 00-102A		65.0
1.0							64.0
2.0							63.0
3.0							62.0
4.0							61.0
5.0							60.0
6.0							59.0
7.0							58.0
8.0					Bottom of hole 63.78 Power auger refusal		

McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 1.3 m
REVIEWED BY: E.S.	COMPLETE: 00/05/09
Fig. No: 24.	Page 1 of 1

00/05/14 09:08PM (NQ-STD)

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-102C
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/05/09	COR. OF HAWTHORNE & MAIN.	ELEVATION: 65.08 m

SAMPLE TYPE: REMOULDED-AUGER / SHELBY TUBE / SPLIT-SPOON / NW-CASING / NO RECOVERY / NQ CORE

VANE Cu (kPa) 80 160 240 320
VANE Cu REMOULDED (kPa) 80 160 240 320
PLASTIC M.C. LIQUID 20 40 60 80

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	ELEVATION(m)
0.0					SOIL see B.H. No. 00-102A	65.0
1.0						64.0
2.0						63.0
3.0	3 8				62.08	62.0
	sample lost drove S.B. to 3.90m 5		1		medium dense silty fine SAND	
4.0	290,270,270 4 5		2		61.18 -3.9m	61.0
	5 6		3			
5.0	135,125,125 12 10		4		very stiff to stiff fissured brownish gray CLAY 3.15m	60.0
6.0						59.0
7.0					58.03	58.0
	10,10,10 2/60cm		5		stiff silty gray CLAY Borehole continued 57.08	
8.0						

McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML
REVIEWED BY: E.S.
Fig. No: 25.

COMPLETION DEPTH: 8.8 m
COMPLETE: 00/05/09

06/06/14 09:08PM (NQ-STD)

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-102C
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/05/09	COR. OF HAWTHORNE & MAIN.	ELEVATION: 65.08 m

SAMPLE TYPE: REMOULDED-AUGER / SHELBY TUBE / SPLIT-SPOON / NW-CASING / NO RECOVERY / NQ CORE

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	VANE Cu (kPa) 80 160 240 320 / ▲ VANE Cu REMOULDED (kPa) ▲ 80 160 240 320 / PLASTIC M.C. LIQUID 20 40 60 80	ELEVATION(m)
8.0		X	5		stiff silty gray CLAY		57.0
9.0					Bottom of hole 56.28		56.0
10.0							55.0
11.0							54.0
12.0							53.0
13.0							52.0
14.0							51.0
15.0							50.0
16.0							

McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 8.8 m
REVIEWED BY: E.S.	COMPLETE: 00/05/09
Fig. No: 26.	Page 2 of 2

00/06/14 09:09PM (NQ-STD)

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-103
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/05/08	COR. OF HAWTHORNE & MAIN.	ELEVATION: 65.01 m

SAMPLE TYPE: REMOULDED-AUGER | SHELBY TUBE | SPLIT-SPOON | NW-CASING | NO RECOVERY | NQ CORE

VANE Cu (kPa) 80 160 240 320
▲ VANE Cu REMOULDED (kPa) ▲ 80 160 240 320
PLASTIC M.C. LIQUID 20 40 60 80

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	ELEVATION(m)
0.0					ASPHALT	65.0
					FILL – crushed limestone 64.95	
	7 7		1		FILL 64.71 sand and gravel with pieces of crushed stone	
1.0	16/15cm 50/10cm		2			64.0
	split barrel refusal				Bottom of hole 63.86 Power auger refusal	
2.0						63.0
3.0						62.0
4.0						61.0
5.0						60.0
6.0						59.0
7.0						58.0
8.0						

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Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 1.15 m
REVIEWED BY: E.S.	COMPLETE: 00/05/08
Fig. No: 27.	Page 1 of 1

00/06/14 09:09PM (NQ-STD)

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-103A
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/05/08	COR. OF HAWTHORNE & MAIN.	ELEVATION: 65.01 m

SAMPLE TYPE: REMOULDED-AUGER | SHELBY TUBE | SPLIT-SPOON | NW-CASING | NO RECOVERY | NO CORE

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	VANE Cu (kPa) 80 160 240 320 / VANE Cu REMOULDED (kPa) 80 160 240 320 / PLASTIC M.C. LIQUID 20 40 60 80	ELEVATION(m)
0.0					UNABLE TO AUGER STRAIGHT BOREHOLE MOVED		65.0
1.0							64.0
2.0							63.0
3.0							62.0
4.0							61.0
5.0							60.0
6.0							59.0
7.0							58.0
8.0							

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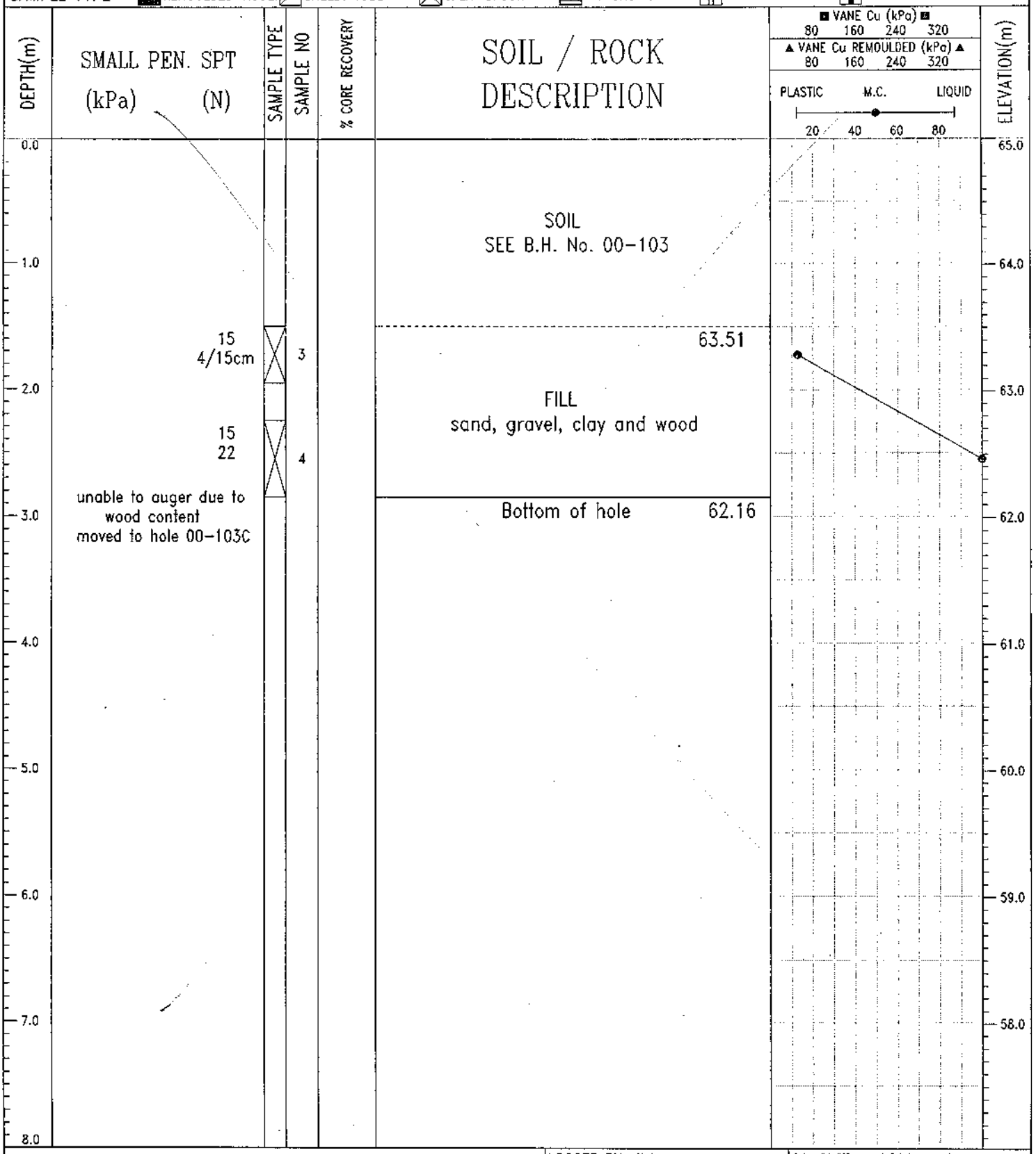
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: *.*
REVIEWED BY: E.S.	COMPLETE: 00/05/08
Fig. No: 28.	Page 1 of 1

00/06/14 09:09PM (NQ-STD)

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-103B
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/05/08	COR. OF HAWTHORNE & MAIN.	ELEVATION: 65.01 m

SAMPLE TYPE: REMOULDED-AUGER / SHELBY TUBE / SPLIT-SPOON / NW-CASING / NO RECOVERY / NQ CORE



McROSTIE GENEST ST-LOUIS Ottawa, Canada	LOGGED BY: JML REVIEWED BY: E.S Fig. No: 29.	COMPLETION DEPTH: 2.85 m COMPLETE: 00/05/08 Page 1 of 1

00/06/14 09:09PM (NO-STD)

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-103C
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/05/08	COR. OF HAWTHORNE & MAIN.	ELEVATION: 65.01 m

SAMPLE TYPE: REMOULDED-AUGER / SHELBY TUBE / SPLIT-SPOON / NW-CASING / NO RECOVERY / NQ CORE

VANE Cu (kPa) 80 160 240 320
▲ VANE Cu REMOULDED (kPa) ▲ 80 160 240 320
PLASTIC M.C. LIQUID 20 40 60 80

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	ELEVATION(m)
0.0	Reamed NW casing to 2.85m				NOTICE THAT AT THIS LOCATION THERE IS NO LAYER OF CRUST CLAY TO BE FOUND UNDER THE EXISTING WALL STIFF CLAY FOUND 9.0m BELOW. SOIL SEE B.H. No. 00-103 & 00-103B FILL SAND AND GRAVEL W/ PIECES OF CRUSHED STONE	65.0
1.0						64.0
2.0						63.0
3.0	8 4	X	5		62.16	62.0
	Reamed NW casing to 3.80m					
4.0	4 6	X	6		FILL sand, gravel, clay with some wood	61.0
	WL Reamed NW casing to 4.55m				Water level May 13/00 elev 60.63m	
5.0	6 6	X	7			60.0
	7 8 3/15cm	X	8			
6.0	Reamed NW casing to 6.0m 20,20,20 2 2	X	9		59.01 medium soft silty gray CLAY	59.0
7.0	Reamed NW casing to 7.60m					58.0
	20,20,20 1/60cm	X	10		Borehole continued 57.01	
8.0						

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Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 20.95 m
REVIEWED BY: E.S.	COMPLETE: 00/05/08
Fig. No: 30.	Page 1 of 3

00/06/21 07:22PM (NQ-STD)

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-103C
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/05/08	COR. OF HAWTHORNE & MAIN.	ELEVATION: 65.01 m

SAMPLE TYPE: REMOULDED-AUGER / SHELBY TUBE / SPLIT-SPOON / NW-CASING / NO RECOVERY / NQ CORE

VANE Cu (kPa) 80 160 240 320
▲ VANE Cu REMOULDED (kPa) ▲ 80 160 240 320
PLASTIC M.C. LIQUID 20 40 60 80

DEPTH(m)	SMALL PEN. SPT (kPa) (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	ELEVATION(m)
8.0			10			57.0
	Reamed NW casing to 9.0m				medium soft silty gray CLAY	
9.0	30,30,30 2/60cm		11		56.01	56.0
10.0	Reamed NW casing to 10.40m					55.0
	30,30,30 1/60cm		12			
11.0						54.0
	Reamed NW casing to 12.00m					
12.0	20,20,20 1/60cm		13		stiff to very stiff silty gray CLAY	53.0
13.0	Reamed NW casing to 13.50m					52.0
	30,30,30 1/60cm		14			
14.0						51.0
	Reamed NW casing to 15.00m					
15.0	40,40,40 7 2		15			50.0
16.0					Borehole continued 49.01	

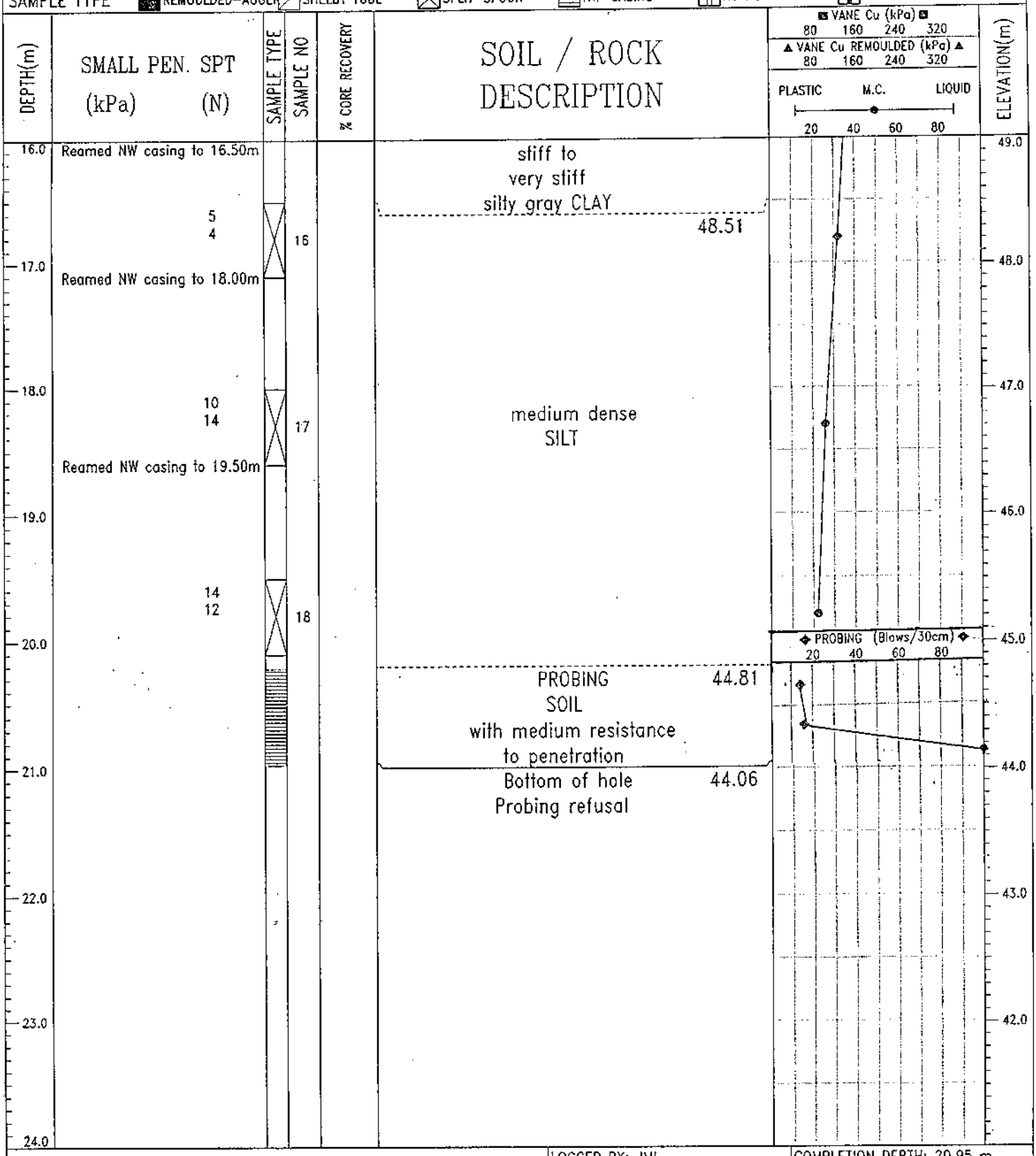
McROSTIE GENEST ST-LOUIS
Ottawa, Canada

LOGGED BY: JML	COMPLETION DEPTH: 20.95 m
REVIEWED BY: E.S.	COMPLETE: 00/05/08
Fig. No: 31.	Page 2 of 3

00/06/21 07:22PM (NQ-STD)

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-103C
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/05/08	COR. OF HAWTHORNE & MAIN.	ELEVATION: 65.01 m

SAMPLE TYPE: REMOULDED-AUGER | SHELBY TUBE | SPLIT-SPOON | NW-CASING | NO RECOVERY | NQ CORE



McROSTIE GENEST ST-LOUIS Ottawa, Canada	LOGGED BY: JML	COMPLETION DEPTH: 20.95 m
	REVIEWED BY: E.S.	COMPLETE: 00/05/08
	Fig. No: 32.	Page 3 of 3

00/06/21 07:23PM (NQ-STD)

RIDEAU CANAL WALL, ECHO DRIVE AREA	B.M.(ELEV 69.61m)geod.: CITY OF OTTAWA	BOREHOLE NO: 00-102H
	PLATE No.25 ON S.W. COR.OF BLDG.AT N.E.	PROJECT NO: E-7928
START DATE: 00/04/19	COR. OF HAWTHORNE & MAIN.	ELEVATION:

SAMPLE TYPE: REMOULDED-AUGER, SHELBY TUBE, SPLIT-SPOON, NW-CASING, NO RECOVERY, NQ CORE

DEPTH(m)	SMALL PEN. (kPa) / SPT (N)	SAMPLE TYPE	SAMPLE NO	% CORE RECOVERY	SOIL / ROCK DESCRIPTION	VANE Cu (kPa) 80 160 240 320 / VANE Cu REMOULDED (kPa) 80 160 240 320 / PLASTIC M.C. LIQUID 20 40 60 80	ELEVATION(m)
0.0					CONCRETE		0.0
1.0							-1.0
					SOIL 1.48		
					End of hole 1.60		
2.0							-2.0
3.0							-3.0
4.0							-4.0
5.0							-5.0
6.0							-6.0
7.0							-7.0
8.0							-8.0

What elevation? assumed above canal [illegible] near top of wall

Top of wall 64.98 m
Top of hole 62.44 m
Hole drilled 2,54m from top of wall

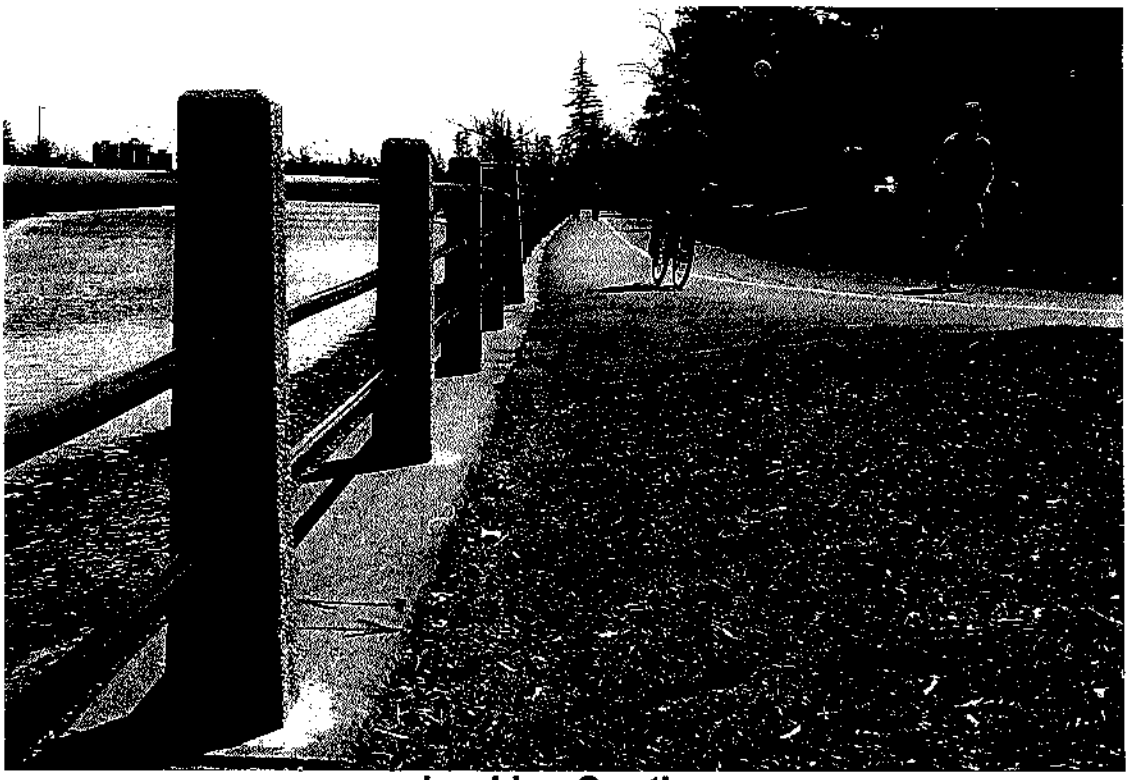
McROSTIE GENEST ST-LOUIS Ottawa, Canada	LOGGED BY: JML REVIEWED BY: E.S. Fig. No: 33.	COMPLETION DEPTH: *.* COMPLETE: 00/04/19 Page 1 of 1

00/06/14 09:09PM (NQ-STD)

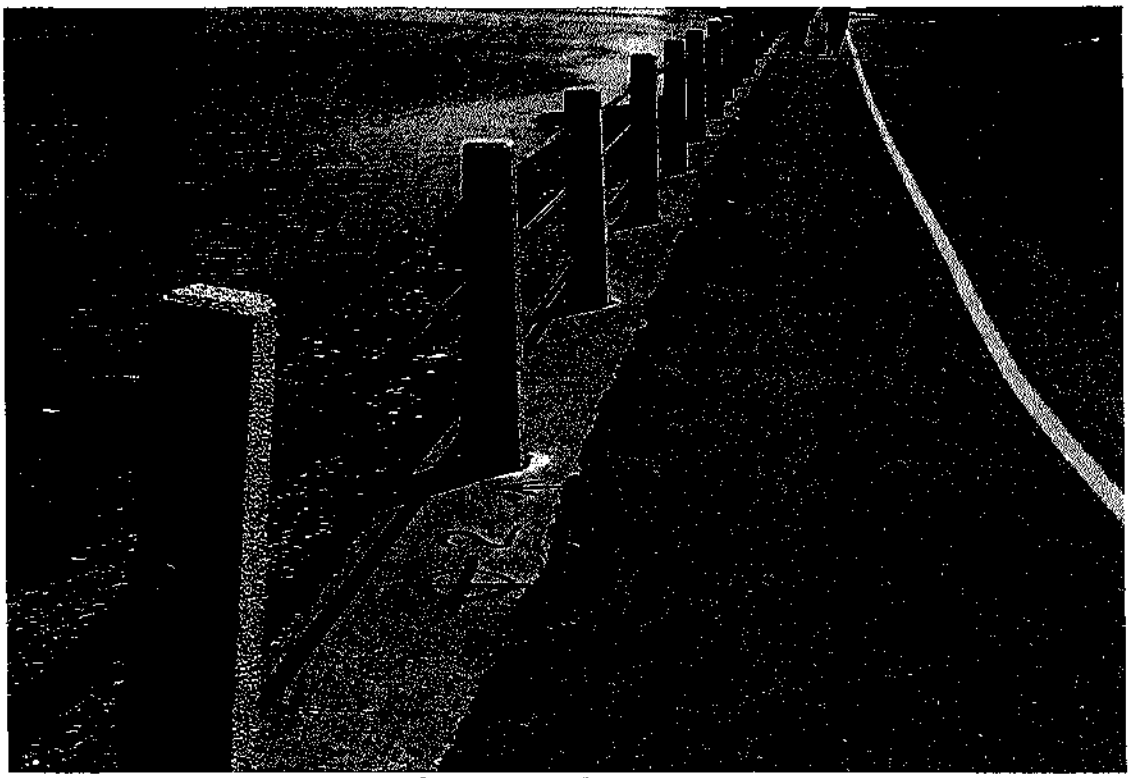
APPENDIX 'A'

SITE PHOTOGRAPHS

Rideau Canal Walls
Patterson Creek Area



Looking South
from B.H. 1



Looking South
from B.H. 2

Rideau Canal Walls
Patterson Creek Area

Looking South
from B.H. 4

Typical face of wall
at B.H. 4

Rideau Canal Walls
Echo Drive Area

Typical deterioration at top of wall, looking at North end of studied area

Typical deterioration at top of wall, looking South from B.H. 102

Rideau Canal Walls
Echo Drive Area

**Typical deterioration at joint,
close to B.H. 103**

**Typical deterioration at joint,
looking South from B.H. 103**

APPENDIX 'B'

CORE PHOTOGRAPHS

Rideau Canal Walls

Patterson Creek Area

Vertical Hole

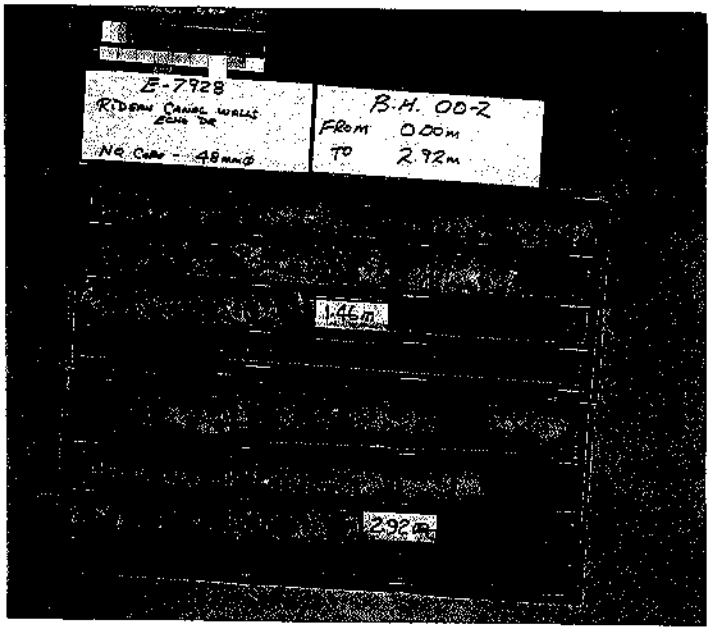
HOLE : 2 ***at geodetic elevation 64.73m***

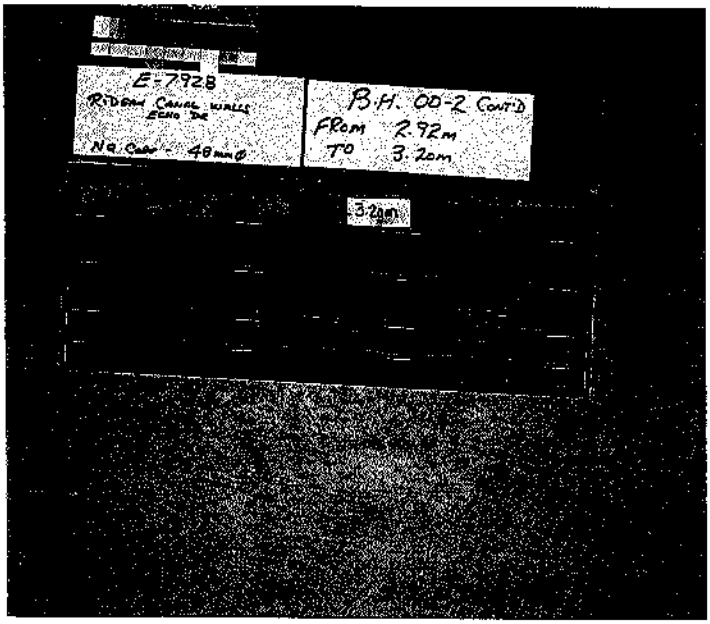
Top of wall at geodetic elevation 64.73m
Vertical hole drilled through wall

Depth	*Core Recovery*
0.00m - 1.46m	99%
1.46m - 2.92m	100%
2.92m - 3.20m	100%

Well consolidated concrete. Typical 20mm to 50mm nominal granitic and limestone coarse aggregate with a few 75mm large limestone aggregate.

Compressive strength on concrete between 2.65m and 2.74m : 39.8MPa





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OTTAWA CANADA

Rideau Canal Walls

Patterson Creek Area

Vertical Hole

HOLE : 5 ***at geodetic elevation 64.62m***

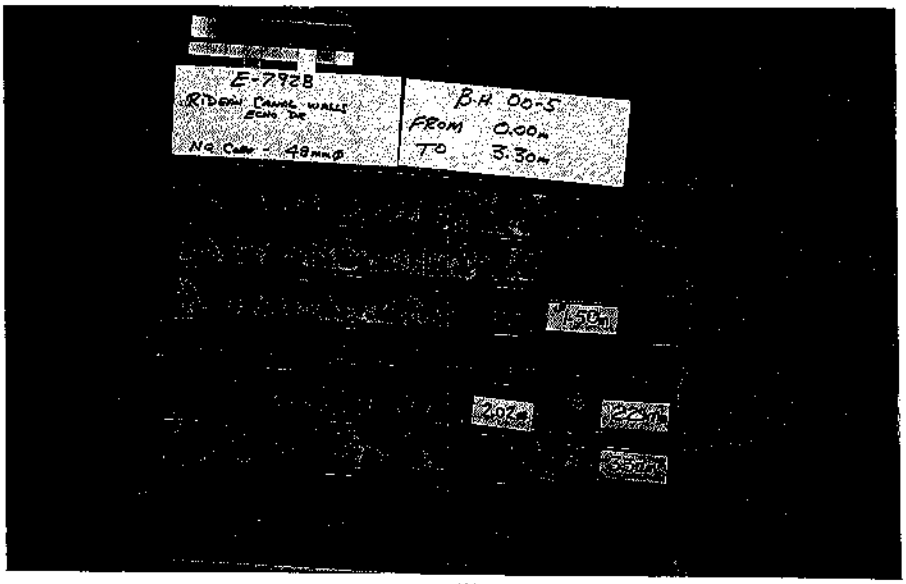
Top of wall at geodetic elevation 64.62m
Vertical hole drilled through wall

Depth	*Core Recovery*
0.00m - 1.50m	97%
1.50m - 2.02m	81%
2.29m - 3.30m	58%

Well consolidated concrete.

- From 0.00m to 0.30m : 20mm nominal limestone coarse aggregate.
- From 0.30m to 3.30m : Typical 20mm to 50mm nominal limestone and granitic coarse aggregate with a few 100mm large limestone aggregate. Highly fractured zone between 0.30m and 1.00m, and between 2.02m and 3.30m.

Compressive strength on concrete between 1.71m and 1.80m : 59.6MPa



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Rideau Canal Walls

Patterson Creek Area

Horizontal Hole

HOLE : 2H ***at geodetic elevation 63.33m***

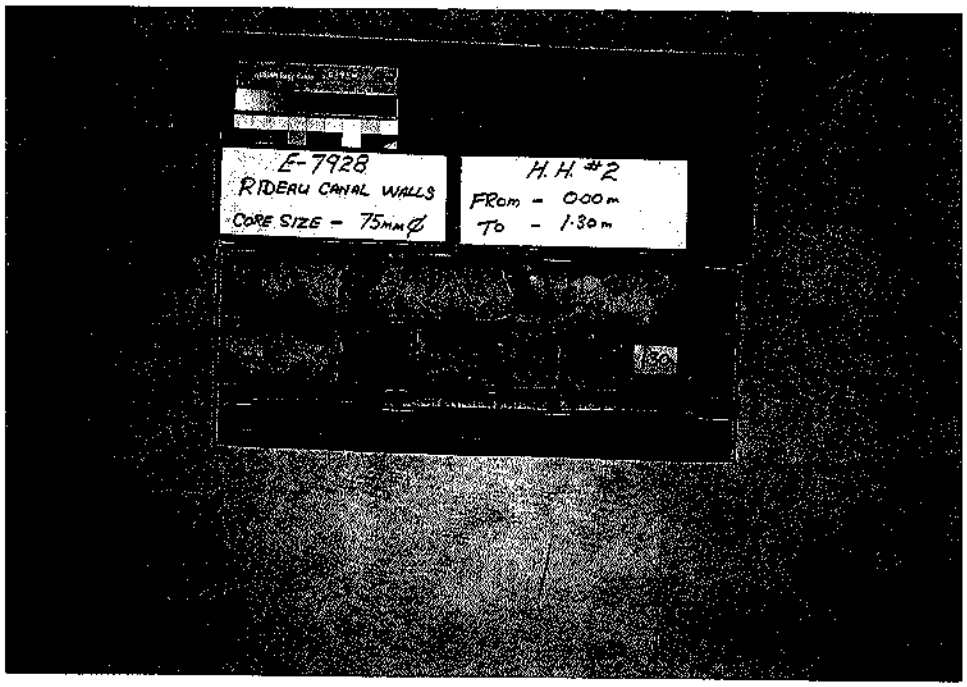
Top of wall at geodetic elevation 64.73m
Horizontal hole drilled at 1.40m from top of wall

Drilled length: 1.30m

Concrete from 0m to 1.17m. Recovery 79%. Well consolidated concrete. Typical 50mm nominal granitic coarse aggregate. Near horizontal soil infilled fracture between 0.83m and 1.17m.

Compressive strength on concrete between 0.18m and 0.29m : 34.6MPa

Soil from 1.17m to 1.30m. Recovery 0%.



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Rideau Canal Walls

Patterson Creek Area

Horizontal Hole

HOLE : 4H ***at geodetic elevation 62.86m***

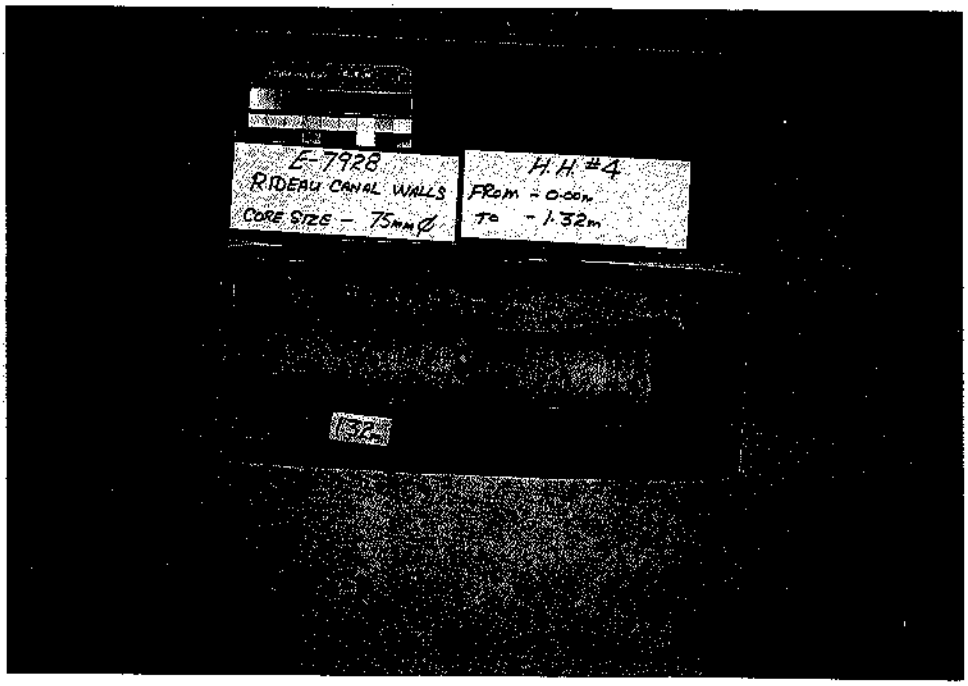
Top of wall at geodetic elevation 64.66m
Horizontal hole drilled at 1.80m from top of wall

Drilled length: 1.32m

Concrete from 0m to 1.17m. Recovery 100%. Well consolidated concrete. Typical 50mm nominal granitic coarse aggregate with some 100mm large aggregate.

Compressive strength on concrete between 0.91m and 1.06m : 38.8MPa

Soil from 1.17m to 1.32m. Recovery 0%.



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OTTAWA CANADA

Rideau Canal Walls

Echo Drive Area

Vertical Hole

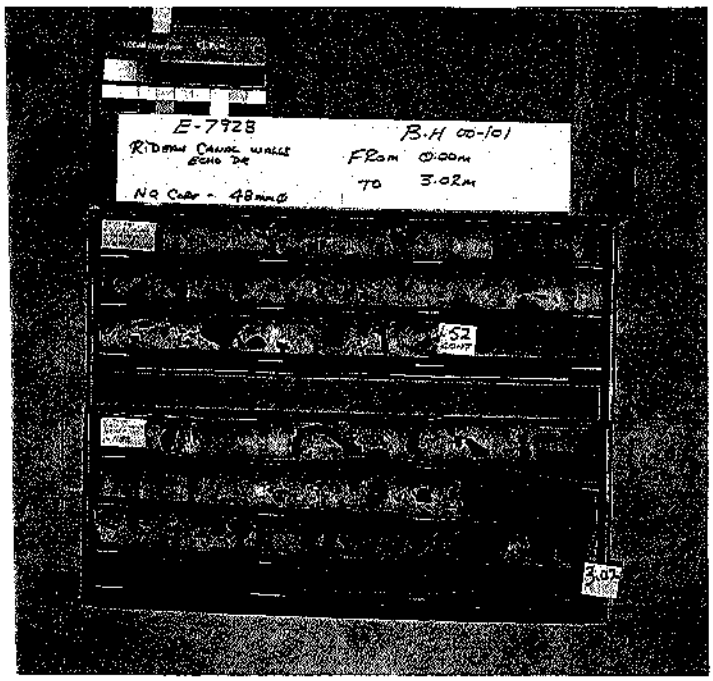
HOLE : 101 ***at geodetic elevation 64.97m***

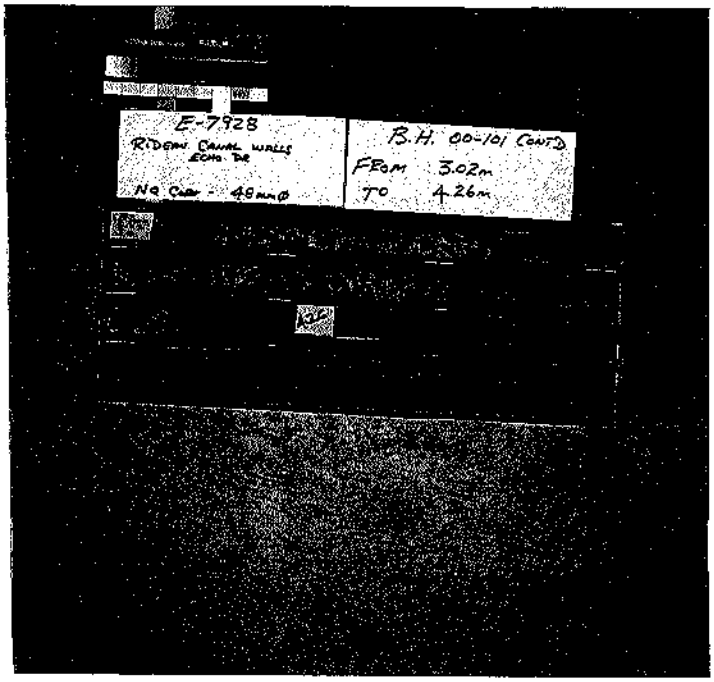
Top of wall at geodetic elevation 64.97m
Vertical hole drilled through wall

Depth	*Core Recovery*
0.00m - 1.52m	98%
1.52m - 3.02m	98%
3.02m - 4.26m	89%

Weil consolidated concrete. Typical 25mm to 50mm granitic and limestone coarse aggregate with several 100mm to 200mm large limestone aggregate. Piece of wood at end of concrete core, ±0.10m in length.

Compressive strength on concrete between 0.74m and 0.83m : 63.9MPa





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Rideau Canal Walls

Echo Drive Area

Vertical Hole

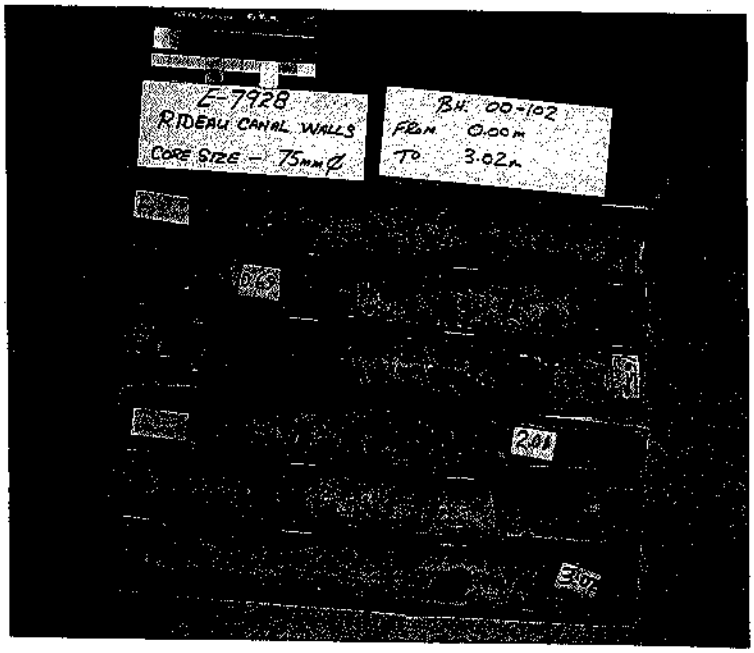
HOLE : 102 ***at geodetic elevation 64.98m***

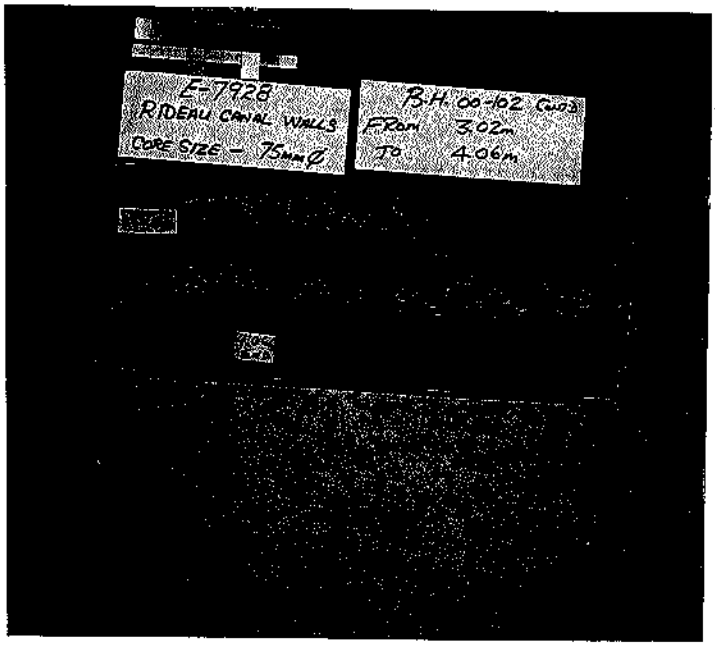
Top of wall at geodetic elevation 64.98m
Vertical hole drilled through wall

Depth	*Core Recovery*
0.00m – 0.69m	99%
0.69m – 1.65m	100%
1.65m – 2.01m	97%
2.01m – 3.02m	96%
3.02m – 4.06m	100%

Well consolidated concrete. Typical 25mm to 50mm granitic and limestone coarse aggregate with several 100mm to 200mm large limestone aggregate.

Compressive strength on concrete between 0.16m and 0.27m : 43.2MPa
Compressive strength on concrete between 3.12m and 3.25m : 35.2MPa





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OTTAWA CANADA

Rideau Canal Walls

Echo Drive Area

Horizontal Hole

HOLE : 102H ***at geodetic elevation 62.44m***

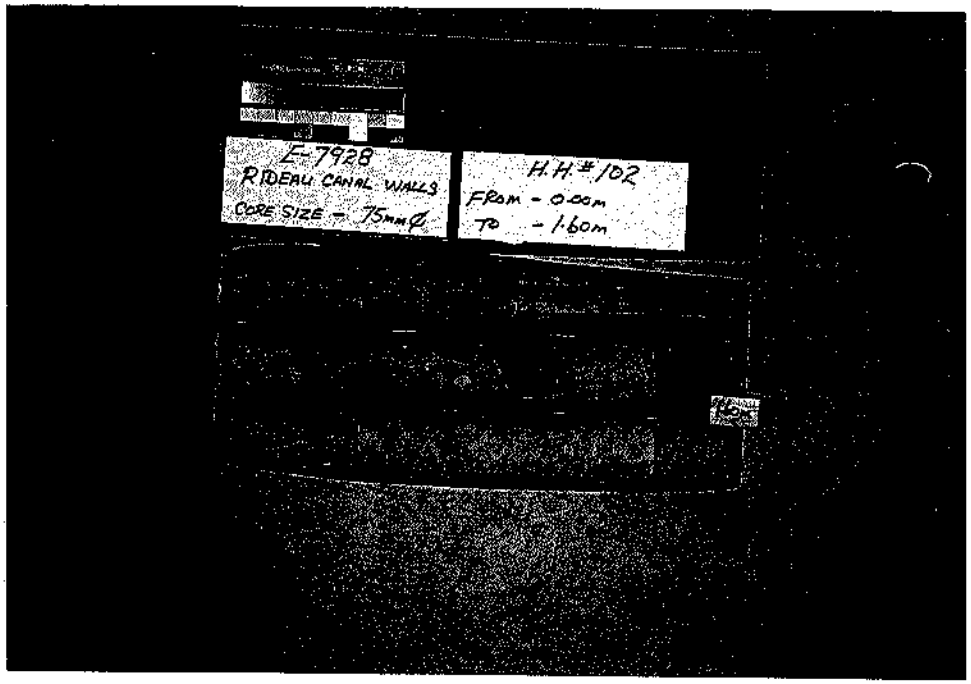
Top of wall at geodetic elevation 64.98m
Horizontal hole drilled at 2.54m from top of wall

Drilled length: 1.60m

Concrete from 0m to 1.48m. Recovery 100%. Well consolidated concrete. Typical 50mm nominal granitic and limestone coarse aggregate with a few 120mm large aggregate.

Compressive strength on concrete between 0.35m and 0.49m : 37.2MPa

Soil from 1.48m to 1.60m. Recovery 0%.



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OTTAWA CANADA

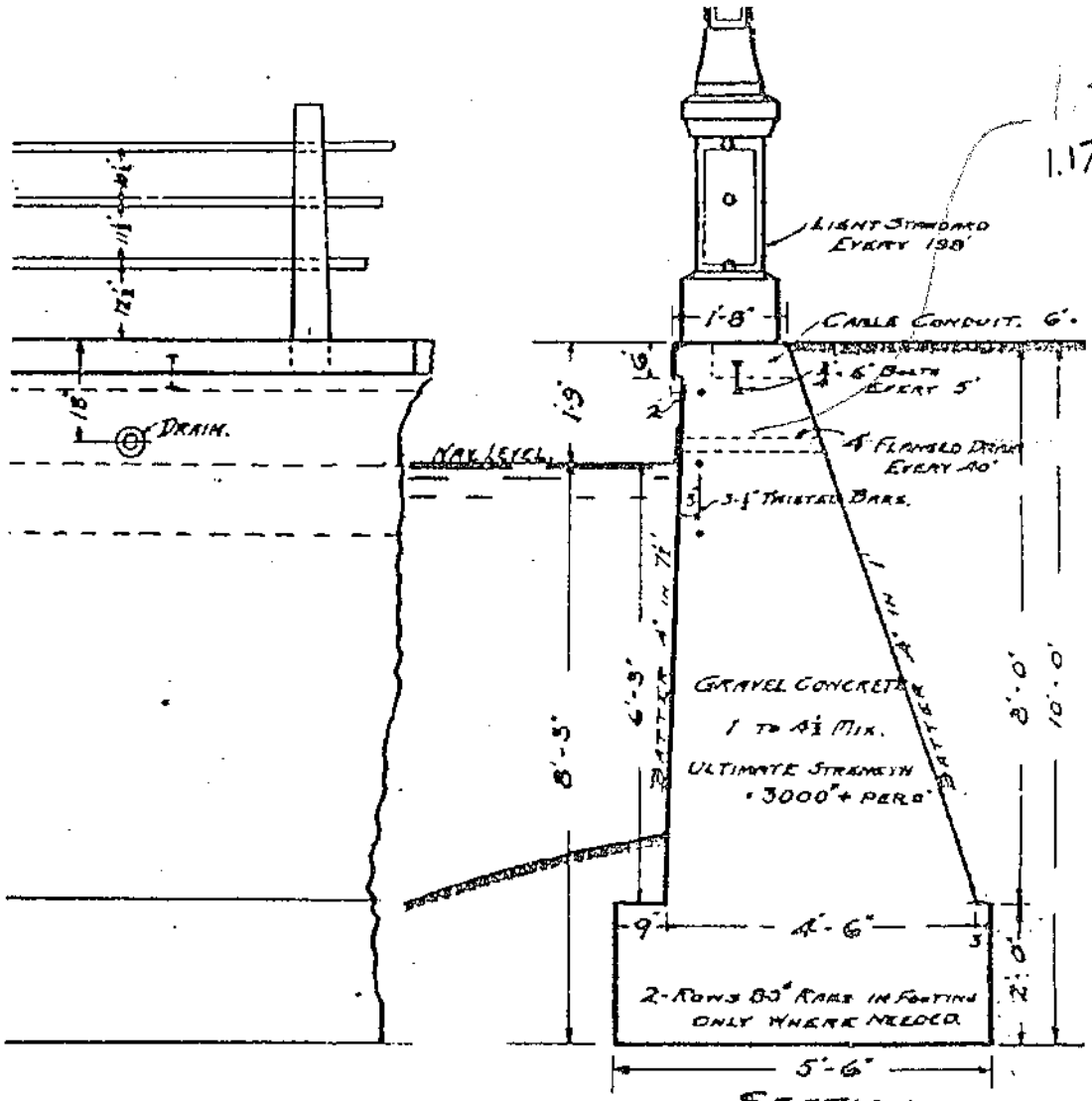
APPENDIX 'C'

TYPICAL WALL SECTIONS

Rideau Canal Walls

Patterson Creek Area

Typical Section



RIDEAU CANAL OFFICE,
OTTAWA JULY 24, 1928.

SUPTG. ENGINEER.

McROSTIE GENEST ST-LOUIS
& ASSOCIATES LTD. & ASSOCIÉS LTÉE.
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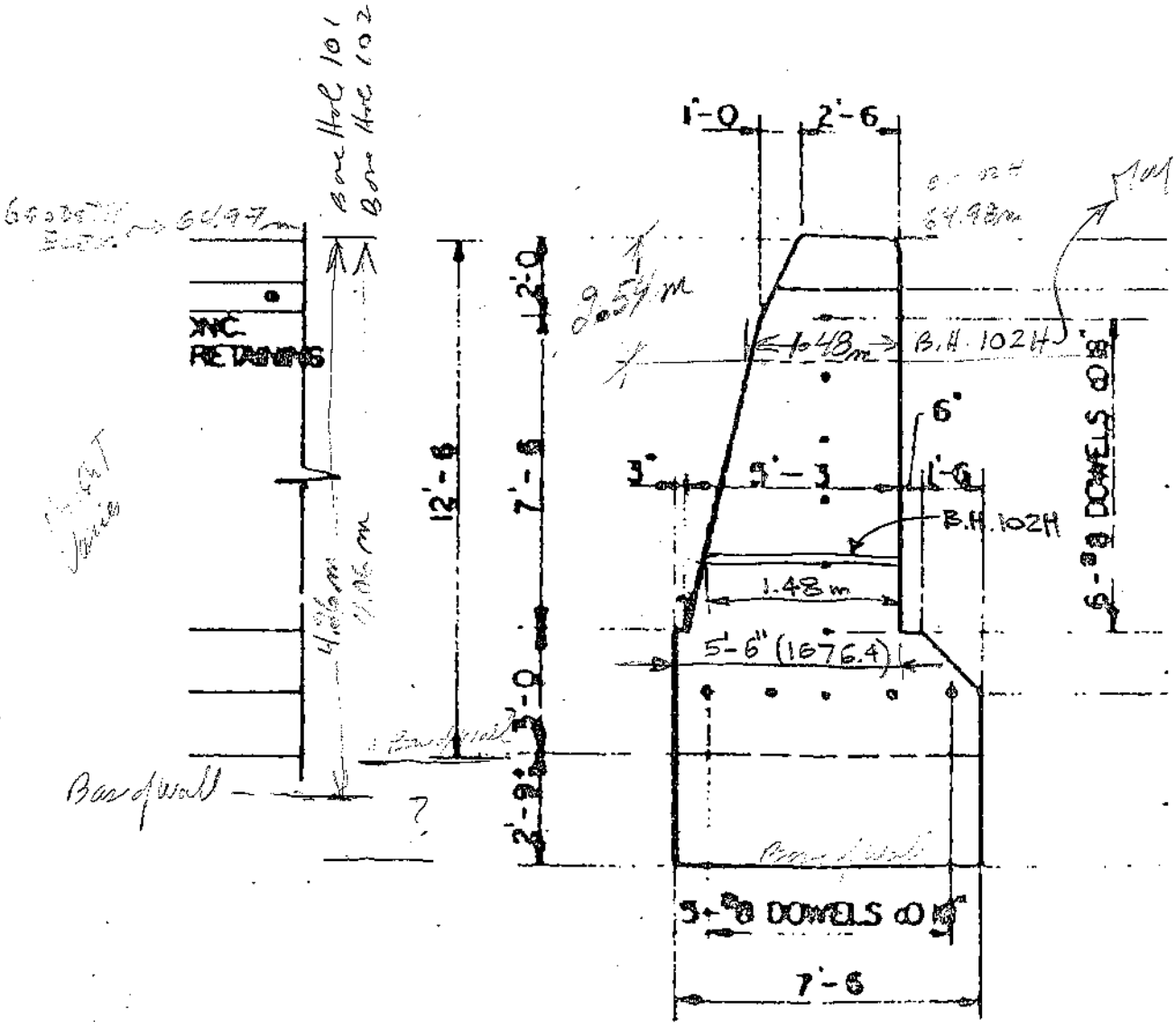
OTTAWA CANADA

Plate No.

Rideau Canal Walls

Echo Drive Area

Typical Section



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OTTAWA CANADA

Plate No.

APPENDIX 'D'

LABORATORY TEST RESULTS

COMPRESSION TESTING

of drilled concrete cores

(CAN/CSA A23.2-14C)

McROSTIE GENEST ST-LOUIS

& ASSOCIATES LTD & ASSOCIÉS LTÉE

CONSULTING ENGINEERS INGÉNIEURS CONSEILS

OTTAWA - ONTARIO - CANADA

DATE : June 15, 2000

CLIENT : RIDEAU CANAL

PROJECT : RIDEAU CANAL WALLS
PROJECT No. : E - 7928

DATE CAST:
SPECIFIED STRENGTH AT
28 DAYS : _____ **MPa**

DATE CORED : May 03 to 09, 2000
DATE REC'D :

MOISTURE CONDITION : **MOIST** ☐ **DRY** ☐ **AS RECEIVED** ☑

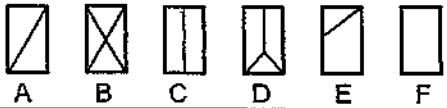
MAXIMUM AGGREGATE : __ mm

CORE No.	DIAM. (mm)	L / ϕ	CORR. FACTOR	COMPRESSIVE STRENGTH	@ AGE	FAILURE MODE	TESTED BY	CHECKED BY
2	47.0	2.045	1.000	39.8 MPa	----	----		
5	46.5	2.087	1.000	59.6 MPa	----	----		
101	46.6	2.017	1.000	63.9 MPa	----	----		
102 - A	68.2	1.716	0.978	43.2 MPa	----	----		
102 - B	69.0	2.001	1.000	35.2 MPa	----	----		

CORE No.	USE OF CONCRETE / CORE LOCATION	COMMENTS
2	Depth = 2.65 to 2.74m	Patterson Creek
5	Depth = 1.71 to 1.80m	Patterson Creek
101	Depth = 0.74 to 0.83m	Echo Drive
102 - A	Depth = 0.16 to 0.27m	Echo Drive
102 - B	Depth = 3.12 to 3.25m	Echo Drive

REMARKS:

FAILURE MODES



COMPRESSION TESTING

of drilled concrete cores

(CAN/CSA A23.2-14C)

McROSTIE GENEST ST-LOUIS

& ASSOCIATES LTD & ASSOCIÉS LTÉE

CONSULTING ENGINEERS INGÉNIEURS CONSEILS

OTTAWA - ONTARIO - CANADA

DATE : April 26, 2000

CLIENT : RIDEAU CANAL

PROJECT : RIDEAU CANAL WALLS
PROJECT No. : E - 7928

DATE CAST:
SPECIFIED STRENGTH AT
28 DAYS : _____ MPa

DATE CORED : April 19, 2000
DATE REC'D : April 19, 2000

MOISTURE CONDITION : **MOIST** ☐ **DRY** ☐ **AS RECEIVED** ☑

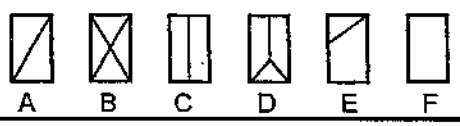
MAXIMUM AGGREGATE : __ mm

CORE No.	DIAM. (mm)	L / ϕ	CORR. FACTOR	COMPRESSIVE STRENGTH	@ AGE	FAILURE MODE	TESTED BY	CHECKED BY
2 - H	71.5	1.679	0.974	34.6 MPa	----	----		
4 - H	71.1	2.027	1.000	38.8 MPa	----	----		
102 - H	71.5	2.071	1.000	37.2 MPa	----	----		

CORE No.	USE OF CONCRETE / CORE LOCATION	COMMENTS
2 - H	Depth = 0.18 to 0.29m	Patterson Creek
4 - H	Depth = 0.91 to 1.06m	Patterson Creek
102 - H	Depth = 0.35 to 0.49m	Echo Drive

REMARKS:

FAILURE MODES



COARSE AGGREGATES

Borehole n°. : 2H
Depth : Mid section of core

Thin sections identification : 202 A and B

Macroscopic identification : Granitic rocks, rarely limestone

Description : Represents 90 % to 95 % of all coarse aggregates. Colour pink to light grey, generally massive structure with medium to coarse grain size, granular texture.

Microscopic description :

MINERALOGY	FORM	DIMENSION (mm)	PERCENTAGE (%)
Plagioclase	Irregular shape Sometimes with alteration	1,0 to 4,0	20-30
K-Feldspars	Irregular shape, usually microcline and rarely perthite	0,5 to 3,0	25-30
Quartz	Undulatory extinction Subrounded to irregular	0,5 to 5,0	30-40
Microcristalline quartz	Rounded	< 0,1	0-2
Biotite or hornblende	Elongated	0,5 to 2,0	2-5

Petrographic alkali-aggregate reactivity potential

- Potentially reactive phase: Microcristalline quartz and quartz with undulatory extinction.
- Reactivity potential: Low

FINE AGGREGATES

Borehole n°. : 2H
Depth : Mid section of core

Thin sections identification : 202 A and B

Macroscopic identification : Granitic sand

Microscopic description :

MINERALOGY	FORM	DIMENSION (mm)	PERCENTAGE (%)
Feldspars (including plagioclase)	Subangular	0,5 to 3,0	35-40
Rock fragments (usually same nature as coarse aggregates)	Subangular to subrounded Limestone and rare quartzite particles	2,0 to 5,0	25-30
Quartz	Undulatory extinction Subangular	0,5 to 2,0	25-30
Mafic minerals (biotite, amphibole and pyroxene)	Usually elongated	0,5 à 2,0	5-10

Petrographic alkali-aggregate reactivity potential

- Potentially reactive phase: Microcristalline quartz (mostly in rock fragments)
- Reactivity potential: Low

COARSE AGGREGATES

Borehole n°. : 102H
Depth : Mid section of core

Thin sections identification : 201 A and B

Macroscopic identification : Mostly sedimentary rock fragments

Description : Sedimentary rocks, colour light to dark brown, no evidence of stratification, small grain size.

Microscopic description :

MINERALOGY	FORM	DIMENSION (mm)	PERCENTAGE (%)
Shale, argillite or siltstone	Rounded to subrounded	5-15	50-55
Limestone	Rounded to subrounded	5-15	30-35
Quartzite	Rounded to subrounded	5-10	5-10
Others	Rounded to subrounded Sandstone and granitic rock fragments	5-10	5-10

Petrographic alkali-aggregate reactivity potential

- Potentially reactive phase: Microcristalline quartz abundant in argillite and siltstone.
- Reactivity potential: Medium to high

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MICROSCOPICAL DETERMINATION OF PARAMETERS OF THE AIR-VOID SYSTEM IN HARDENED CONCRETE

ASTM C 457 STANDARD, PROCEDURE B

File n°:	B5523-004	**Client:**	Les Laboratoires Outaouais inc.
Project:	D-00104	**Supplier:**	
Sampling date:		**Formula:**	
Date received :	2000-05-10	**Sample. n°:**	102H
Test date:	2000-05-19	**LBL n°:**	00-PB-203
Concrete specimen:	☐ cylinder ☑ core	**Specimen orientation:**	☐ horizontal ☑ vertical
		Surface de la plaque (cm^2):	95

TEST RESULTS

Total stops	Paste stop	Void intersected	Void stops	Number of traverse
1500	405	134	60	19

(1,5875 mm per stop, microscope magnification 110X)

AIR-VOID PARAMETERS

Air content (%)		Paste content (%)	
fresh conc.	hard. conc.	theorical	hard. conc.
	4,0		27,0

Spacing factor (μm)	Specific surf. (mm^{-1})	Chord avg. (μm)	Ratio P/A	Length of trav. (mm)	number of voids/mm
944	5,6	711	6,750	2381	0,06

Parameters	Results	Specifications	Standard
Observed surface (cm^2)	95	71	ASTM C 457
Total length of traverse (mm)	2381	2286	ASTM C 457
Total stops	1500	1350	ASTM C 457
Spacing factor, $\bar{L}$ (μm)	944	260 max	CSA-A23.1

Test executed by: Suzy Bernier, EIT. M.Sc.A.

Verified by : Dominique Chouinard, Eng. M.Sc.

3420 East, St-Joseph blvd., Montreal (Quebec) H1X 1W6 Telephone : (514) 255-0613 Fax :: (514) 252-0071

WATER ANALYSIS

JOB NO: E-7928

JOB NAME: RIDEAU CANAL WALLS

BOREHOLE NO.	WATER LEVEL	DATE SAMPLED	DATE TESTED	CONDUCTIVITY MICROMHOS/CM	SOLUBLE SULPHATE CONTENT (SO4) P.P.M.	SOLUBLE CHLORIDES CONTENT (CL) P.P.M.	pH.
00-1	1.01m	May 9 2000	May 26 2000	1100	80+/-10%	606+/-10%	7.8
00-3	5.00m	May 9 2000	May 26 2000	950	75+/-25%	454+/-10%	8.2
00-4	0.60m	May 9 2000	May 26 2000	900	100+/-10%	450+/-10%	8.0
00-6	0.54m	May 9 2000	May 26 2000	900	80+/-10%	303+/-10%	7.9
00-103	4.38m	May 9 2000	May 26 2000	850	90+/-10%	262+/-10%	8.1

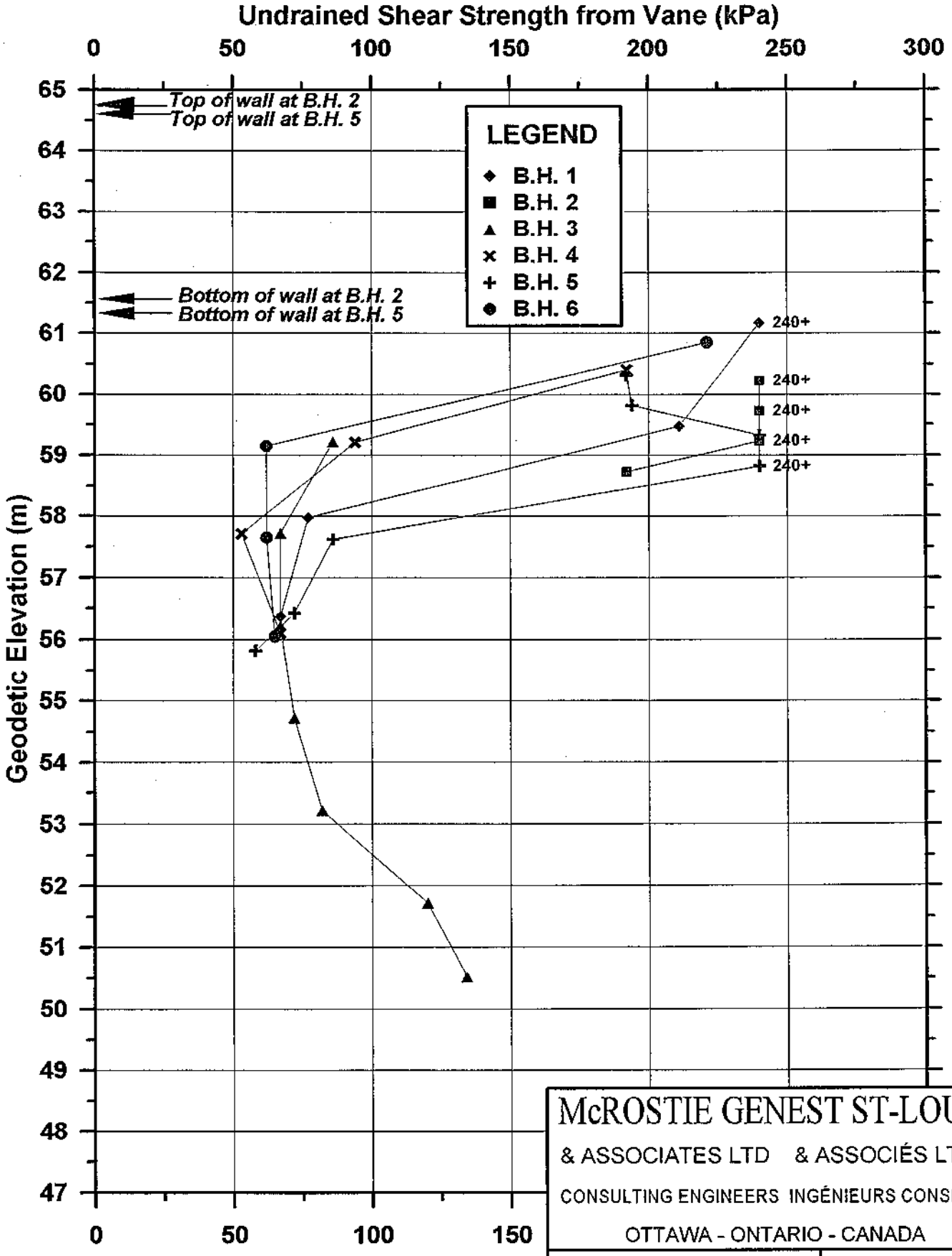
PLATE NO.:

MCROSTIE GENEST ST-LOUIS
& ASSOCIATES LTD
CONSULTING ENGINEERS
OTTAWA, CANADA

APPENDIX 'E'

UNDRAINED SHEAR STRENGTH WITH DEPTH

Patterson Creek Section



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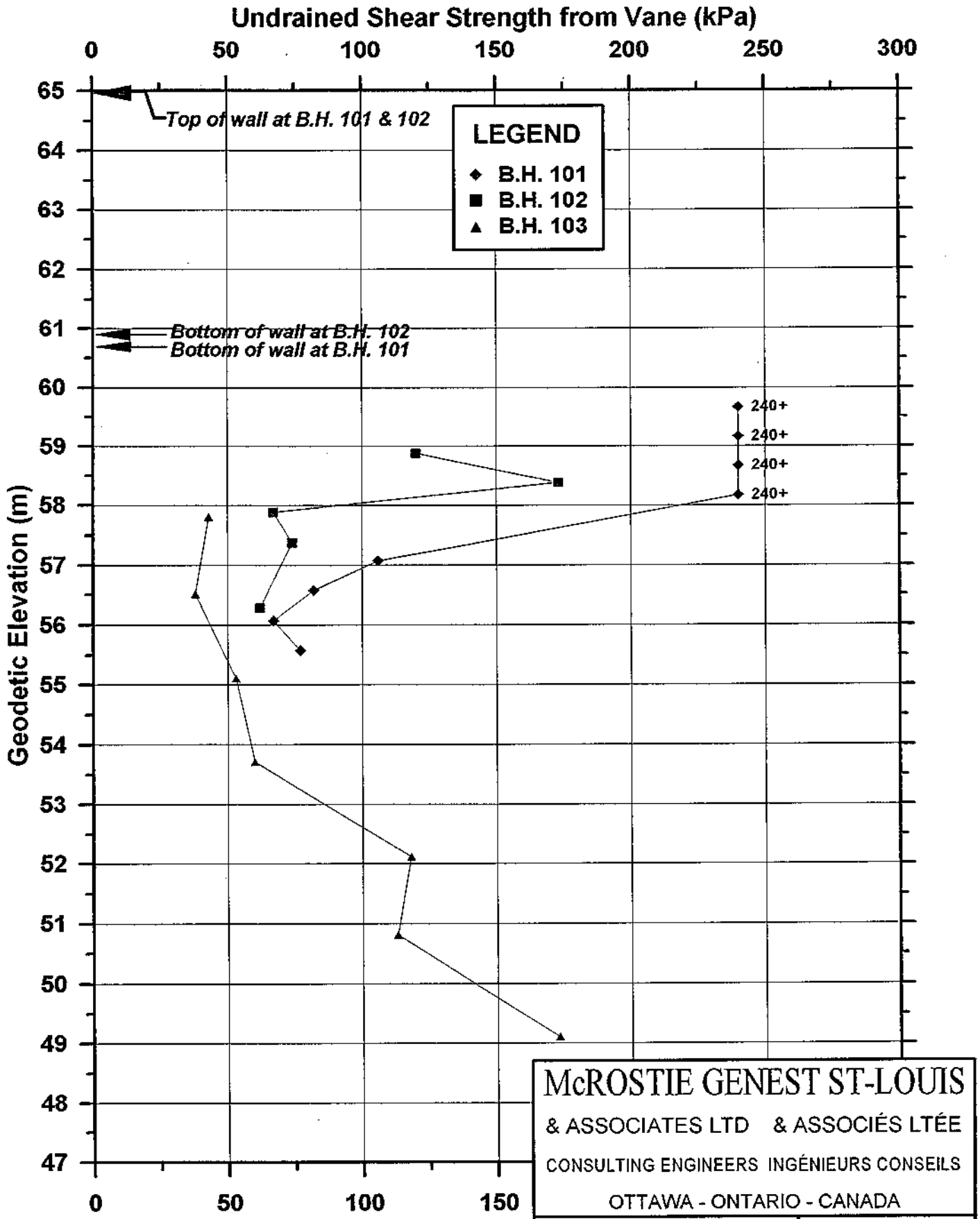
& ASSOCIATES LTD & ASSOCIÉS LTÉE
CONSULTING ENGINEERS INGÉNIEURS CONSEILS
OTTAWA - ONTARIO - CANADA

Undrained Shear Strength vs. Elevation	Plate No.

Echo Drive Section



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Undrained Shear Strength vs. Elevation	Plate No.

APPENDIX 'F'

STATEMENT OF LIMITATIONS

STATEMENT OF LIMITATIONS

Conclusions and recommendations contained in this report are based on factual information obtained at specific borehole, auger hole or test pit locations. Variations in subsurface conditions (soil and groundwater) between and beyond locations tested may be found at the time of construction.

Our report contains engineering recommendations on geotechnical aspects of the project based on our interpretation of subsurface information obtained and present project requirements in accordance with locations, elevations and alignments stated in our report. Since all details of design may not have been known to us, certain assumptions may have been necessary for analysis purposes during the preparation of this report. The actual conditions may, however, vary from those assumed, in which case specific changes and modifications may be required to our recommendations.

We recommend, therefore, that we be retained during the final design stage to review the design drawings and to verify that they are consistent with our recommendations or the assumptions made in our analysis. We also recommend that we be retained during construction to confirm that subsurface conditions over the site do not differ significantly from those encountered at tested locations. In cases where our recommendations are not followed, our company's responsibility is limited to properly interpreting subsurface details at test locations.

It must be recorded that all recommendations contained in this report are provided for the guidance of the design engineers as they pertain to this particular project. Contractors bidding on, or undertaking any work on this project, should examine the factual results of the investigation, satisfy themselves as to the adequacy of this information for construction and make their own interpretation of the factual data as it affects their proposed construction techniques, safety, schedule and equipment capabilities.

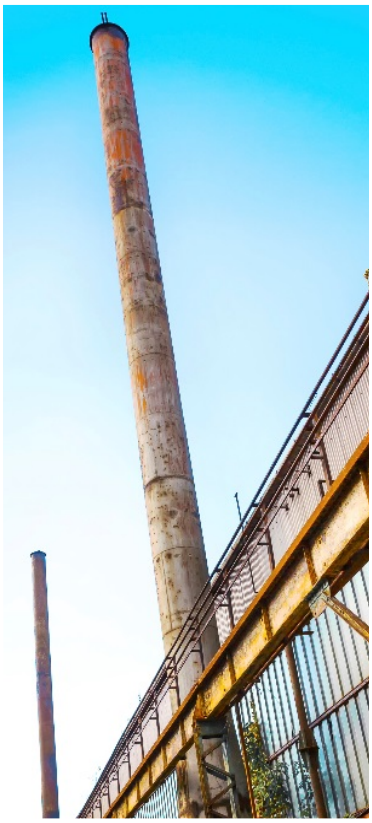
Appendix A – Part 4

Echo Drive Geotechnical Data Report for the Ottawa Walls Project

Echo Drive Geotechnical Data Report for the Ottawa Walls Project

Colonel By Drive near Echo Drive
And Concord Street Ottawa Ontario

AECOM Consultants Inc.



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1. Introduction

GHD was retained by AECOM Consultants Inc. (Client) to undertake a Geotechnical Field Investigation for the proposed rehabilitation of the Ottawa Walls (Project) to be located along Colonel By Drive, near Echo Drive and Concord Street in Ottawa, Ontario (Site).

The purpose of the investigation was to complete a geotechnical field investigation at the Site in order to summarize the subsurface conditions found at the four borehole locations specified by the Client. This report has been prepared with the understanding that GHD is not the geotechnical engineer for the project and the report is a presentation of the data derived from the field investigation and results of the Client approved Laboratory Testing Program.

The scope of work for this investigation was agreed to, as outlined in our Subconsultant Agreement for Professional Services dated October 30, 2017 and was amended to include the additional work at Echo Drive as per our proposal (Ref No: 11149792Dumas-3). In general, the scope of work for GHD consisted of the following activities:

- Underground Utility Clearances | For BH13, BH18 and BH19, GHD obtained clearance of both public and privately owned services on the Site. For BH14, a private utility locating subcontractor was contracted to provide the clearance of both public and privately owned services on the Site.
- Geotechnical Drilling | GHD retained a drilling subcontractor to drill four boreholes to varying depths across the Site. Two of the boreholes were drilled to approximately 20 meters below the existing ground surface (mbgs), one of which was advanced in the shoulder of the road, and the other in the Rideau Canal Eastern Pathway. Two boreholes were drilled in the Rideau Canal, one was advanced to a depth of approximately 7.5 mbgs and the other to 10 mbgs.
- Fieldwork Supervision | GHD field staff logged the soil at the four borehole locations based on the soil samples that were recovered.
- Laboratory Testing | GHD performed five grain size analyses and six Atterberg limits tests in our geotechnical laboratory.
- Reporting | GHD prepared this Geotechnical Data Report based on the results of the fieldwork and laboratory testing.

Geotechnical recommendations, hydrogeological investigation, Permit to Take Water (PTTW), or submittals for an Environmental Activity and Sector Registry (EASR) were not part of GHD's scope of work for this Geotechnical Field Investigation. Assessments of the environmental quality of the soils were not part of the scope of work for this Geotechnical Investigation.

2. Site and Project Description

The Site is located between Concord Street North and Main Street in Ottawa, Ontario. A civic address for the Site was not provided by the Client. The location of the Site is shown on the Site Location Map as Figure 1 at the end of this report. The nearby boroughs are known as Sandy Hill and Old Ottawa East.

The Site consists of three staggered elevations, one being Colonel By Drive with an approximate elevation of 66.31 masl as surveyed at BH18, the second being the Rideau Canal Eastern Pathway which is approximately 1.3 m lower in elevation than Colonel By Drive with an approximate elevation of 65.04 masl as surveyed at BH19 and third, the Rideau Canal bed which is approximately three to five meters lower in elevation than the pathway with elevations of 61.73 and 60.47 in boreholes BH13 and BH14 respectively. It is bound to the north and west sides by the Rideau Canal, followed by single-family residential dwellings. It is bound to the east and south by Colonel By Drive, followed by low-rise apartment buildings.

The Site includes the eastern part of the Rideau Canal and the area between the canal and Colonel By Drive including a primary concrete retaining wall at the edge of the canal, followed by the Rideau Canal Eastern Pathway, followed by a secondary retaining wall which is approximately one meter in height, this is followed by a grassed strip leading to the metal guardrail which lies between the road and the pathway, followed by Colonel By Drive.

The project was undertaken to provide the field observations and laboratory data to the Client.

3. Field Investigation

3.1 Geotechnical Drilling

The fieldwork component of this Geotechnical Investigation consisted of the advancement of a total of four boreholes, labelled as boreholes BH13, BH14, BH18 and BH19. Boreholes BH13 and BH14 were advanced to approximately 10 and 7.5 meters below the water-sediment interface respectively. Boreholes BH18 and BH19 were advanced to approximately 20 mbgs. The preliminary locations of the boreholes were provided by the Client and adjusted based on underground service locates and field conditions. These locations are shown on the Borehole Location Plan, as Figure 2 at the end of this report.

The borehole drilling for this investigation was done over four days, with various equipment and over an extended duration based on site conditions, access and permits. BH13 was advanced on May 9, 2018 with a track mounted drill rig adapted for geotechnical sampling, which was mounted on a barge. This borehole was advanced into the overburden using wash-boring equipment. BH14 was advanced from the ice surface on February 14, 2018 with portable Cathead equipment adapted for geotechnical sampling. Borehole BH14 was advanced into the overburden by first imbedding an outer casing into the soft surficial material. Below this, sampling took place within the open hole. BH18 was advanced on April 20, 2018 with a truck mounted drill rig, adapted for geotechnical sampling. This borehole was advanced into the overburden using hollow-stem continuous-flight auger equipment. BH19 was advanced on April 16, 2018 with a geoprobe adapted for geotechnical sampling. This borehole was advanced into the overburden using direct push casing.

Standard Penetration Tests (SPTs) were performed at regular intervals using a 50 mm diameter split-spoon sampler and a 63.5 kg hammer free falling from a distance of 760 mm, to collect soil samples. The number of drops required to drive the sampler 0.3 m is recorded on the borehole logs as "N" value. Field Vane Tests (FVTs) were performed at regular intervals to measure the undrained shear strength of the native clayey soils. Boreholes were backfilled with auger cuttings and bentonite hole-plug as applicable upon completion.

The elevations of the boreholes were determined by GHD's field staff using level and rod method, in combination with elevations, which were provided by JD Barnes who were hired directly by the Client. It should be noted that depth to base of canal for BH13 was measured from the barge deck, down to where the casing contacted competent material up to the water surface. Top of barge deck was then compensated over to the canal wall cap, which was then surveyed relative to existing nearby elevation data. The elevation of BH14 was determined in a similar way by measuring from the ice surface down to where the casing met competent material and then measured to existing nearby elevation data provided by JD Barnes.

Table 3.1 below provides the measured borehole locations and elevations.

Table 3.1 Borehole Location and Elevation

Location	Northing	Easting	Elevation (masl)
BH13	5029498	446750	61.73
BH14	5029325	446663	60.47
BH18	5029460	446733	66.31
BH19	5029421	446710	65.04

Note: Coordinates are in UTM Zone 18 NAD 83

3.2 Laboratory Testing

The laboratory testing component of this Geotechnical Field Investigation consisted of five grain size analyses and six Atterberg limits. The results of the grain size analyses were used in the descriptions below, and the Atterberg limits results are plotted on the Borehole Logs.

4. Subsurface Conditions

General descriptions of the subsurface conditions are summarized in the following sections, with a graphical representation of each borehole on the Borehole Logs, attached as Appendix A at the end of this report. Notes on Boreholes are also provided in Appendix A.

4.1 Asphaltic Concrete

The surface of the Rideau Canal Eastern Pathway has a continuous asphalt pavement structure. Borehole BH19 was advanced through the asphaltic concrete surface. The asphalt was approximately 50 mm thick in the tested location.

4.2 Topsoil

Borehole BH18 was advanced into a grassed boulevard strip on the shoulder of Colonel By Drive. Topsoil was encountered at this location and had an approximate thickness of 100 mm. It was described as silt and organics, dark brown in colour and moist.

4.3 Fill Soils

Fill soils were found to be underlying the topsoil and asphalt surface, at BH18 and BH19 respectively. The fill at BH18 was described as a sand trace gravel fill, which became finer grained with depth and had an organic rich seam at approximately 3.5 mbgs. The fill was described as compact to loose, brown in colour and moist. In BH19 the fill was described in three layers, the first being the granular pavement consisting of silty sand and gravel, grey in colour and damp, with an approximate thickness of 350 mm. The next layer was a gravel and sand, compact, dark brown in colour and damp. The final layer of fill was described as a sandy silt with some organics, loose, dark greyish brown and moist, with some pieces of ash or coal recovered at approximately 3.5 mbgs.

4.4 Sediments

Boreholes BH13 and BH14 were advanced into the canal bed, the surface of which was covered with sediment. The sediment was described as silty sand with trace or some gravel and organics, loose to very loose, dark grey and wet. The layer was found to be thickest in BH13, with an approximate thickness of 2.0 m, and thinnest in BH14 with an approximate thickness of 0.5 m.

4.5 Silty Clay or Silt and Clay

A native silty clay or clay and silt deposit was encountered in all of the boreholes. The silty clay was found to have a stiff to very stiff brownish grey to dark brown crust in BH18 and BH19. The crust varied in thickness however, in both locations it ended at an approximate elevation of 60 and 59 masl in BH18 and BH19 respectively.

Below the crust in BH18 and BH19 and in general for BH13 and BH14, the silty clay was described as stiff in consistency, brownish-grey or grey in colour, and was recovered in a moist to wet condition. BH13, BH14 and BH18 were described as having trace sand or sand seams which were observed starting at approximately 55.7, 55.7 and 59.3 masl in BH13, BH14 and BH18, respectively and persisted with depth. BH13, BH18 and BH19 were described as having organic staining present, which was observed starting between 57.7, 54.8 and 58.9 masl in BH13, BH18 and BH19 respectively and persisted with depth.

The silty clay extended to an approximate elevation of 48 masl in BH19. This was the only borehole where soil sampling took place to this depth and was the only borehole that penetrated the full depth of this layer.

Atterberg limit testing was completed on three representative samples from boreholes BH18 and BH19 from approximately 6.9 and 14.0 mbgs in BH18 and 5.3 and 12.8 mbgs in BH19. The samples analyzed in BH18 were SS9, SS11 and SS13 at depths of 6.9-7.5, 8.4-9.0 and 13.0-13.6 mbgs respectively. The samples analyzed in BH19 were SS6, SS8 and SS11 at depths of 5.3-5.9, 7.6-8.2 and 12.2-12.8 mbgs respectively. In general the material varies between borehole location and borehole depth such that the material is one of silty clay, clay and silt, silt and clay, or clayey silt, however all Atterberg results indicate a classification of low plasticity clay.The results of the Geotechnical Laboratory Analysis is presented in Table 4.1 below.

Table 4.1 Geotechnical Laboratory Analysis

Sample ID and Depth (mbgs)	% Gravel	% Sand	% Silt	% Clay	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content	USCS
BH18-SS9, 6.9-7.5	0	2	30	68	32	24	8	40	CL Lean Clay
BH18-SS11 8.4-9.0	0	6	57	37	32	23	9	27	CL Lean Clay
BH18-SS13 13.0-13.6	0	4	48	48	32	19	13	33	CL Lean Clay
BH19-SS6 5.3-5.9	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	32	22	11	49	CL
BH19-SS8 7.6-8.2	0	9	62	29	32	16	16	26	CL Lean Clay
BH19-SS11 12.2-12.8	0	1	34	65	32	18	16	47	CL Lean Clay

4.6 Silt and Sand

A native sand and silt trace gravel and clay deposit was encountered in BH19 at an approximate elevation of 48 masl. This is the only borehole location which was sampled to this elevation and in which this layer was encountered. This sand and silt layer was described as compact, grey and wet.

5. Groundwater

No boreholes had monitoring wells installed however, some interpretations were made based on moisture contents of soil samples from BH18 and BH19. BH18 had a moisture content taken from SS9 at an approximate elevation of 59.0 masl which had a moisture content of 40.5 percent in a silty clay material which could be interpreted to be below the water table. BH19 had a moisture content taken from SS6 at an approximate elevation of 59.5 masl, which had a moisture content of 49.5 percent in a silty clay material which could also be interpreted to be below the water table. Additionally, BH13 and BH14 were drilled in the canal, in which the summer water elevation is 64.1 masl.

It should be noted that levels above are interpreted and are subject to seasonal fluctuations and in response to precipitation and snowmelt events. A hydrogeological investigation, PTTW, submittals for an EASR, or quantity estimates were not part of GHD's scope of work for this geotechnical investigation.

6. Limitation of the Investigation

This report is intended solely for AECOM Consultants Inc. and is prohibited for use by others without GHD's prior written consent. This report is considered GHD's professional work product and shall remain the sole property of GHD. Any unauthorized reuse, redistribution of or reliance on the report shall be at the Client and recipient's sole risk, without liability to GHD. Client shall defend, indemnify and hold GHD harmless from any liability arising from or related to Client's unauthorized distribution of the report. No portion of this report may be used as a separate entity; it is to be read in its entirety and shall include all supporting drawings and appendices.

The data presented in this report are in accordance with our present understanding of the project, the current site use, ground surface elevations and conditions, and are based on the scope of work approved by the Client and described in the report. The services were performed in a manner consistent with that level of care and skill ordinarily exercised by members of Geotechnical Engineering professions currently practicing under similar conditions in the same locality. No other representations, and no warranties or representations of any kind, either expressed or implied, are made. 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.

The information provided in this report is based on the subsurface at the time of the study.

It is recommended that GHD be retained during construction of all foundations and during earthwork operations to confirm the conditions of the subsoil are actually similar to those observed during our study. The intent of this requirement is to verify that conditions encountered during construction are consistent with the findings in the report and that inherent knowledge developed as part of our study is correctly carried forward to the construction phases.

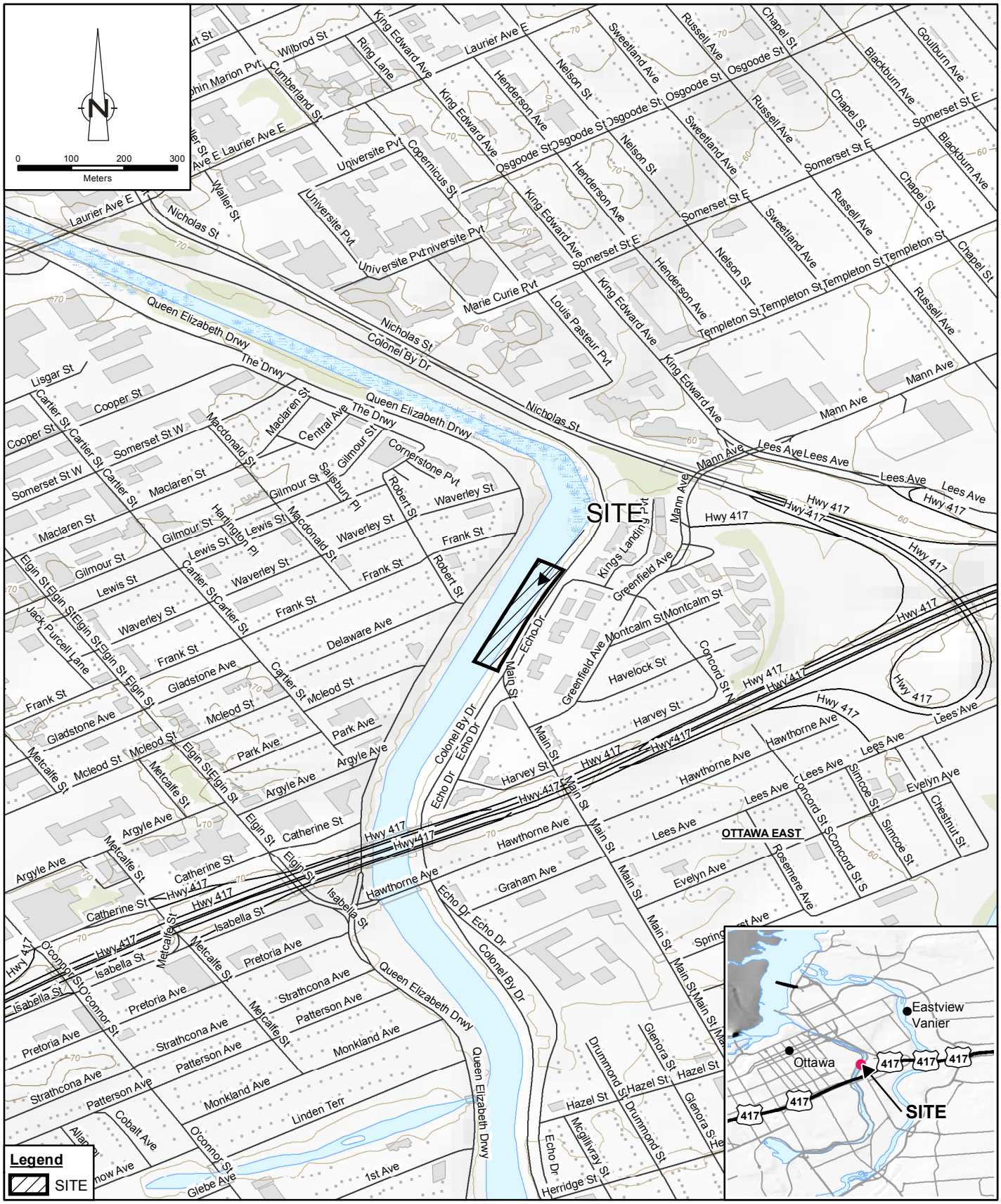
It is important to emphasize that a soil investigation is, in fact, a random sampling of a site and the comments included in this report are based on the results obtained at the four test hole locations only. The subsurface conditions confirmed at these four test locations may vary at other locations. Soil and groundwater conditions between and beyond the test locations may differ both horizontally and vertically from those encountered at the test locations and conditions may become apparent during construction, which could not be detected or anticipated at the time of our investigation. Should any conditions at the site be encountered which differ from those found at the test locations, we request that we be notified immediately. If changed conditions are identified during construction, no matter how minor, this report shall be considered invalid until sufficient review and written assessment of said conditions by GHD is completed.

All of Which is Respectfully Submitted,

GHD

Steven Wheeler, BSc

Gerardo Cardenas, P. Eng.



Source: MNRF NRVIS, 2018. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2018.
Coordinate System: GCS WGS 1984

AECOM CONSULTANTS INC.
RIDEAU CANAL EASTERN PATHWAY
SITE 3
OTTAWA WALLS PROJECT

11149792-A1
Jun 25, 2018

SITE LOCATION MAP

FIGURE 1

GIS File: Q:\GIS\PROJECTS\11149000s\11149792\Layouts\INT001\11149792-A1(INT001)GIS-OT006.mxd

Source: MNRF NRVIS, 2017. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2018.
Aerial: Image ©2018 Google

0 10 20 30
Meters

Coordinate System:
NAD 1983 CSRS MTM 9

Legend

- Borehole Location
- Corehole Location

AECOM CONSULTANTS INC.
RIDEAU CANAL EASTERN PATHWAY
SITE 3
OTTAWA WALLS PROJECT

BOREHOLE AND COREHOLE LOCATION PLAN

11149792-A1
Jun 25, 2018

FIGURE 2

GIS File: Q:\GIS\PROJECTS\11149000s\11149792\Layouts\INT001\11149792-A1(INT001)GIS-OT005.mxd

Appendices

Appendix A
Borehole Logs
Notes on Borehole and Test Pit Logs

REFERENCE No.: 11149792-A1 ENCLOSURE No.: 1

BOREHOLE No.: BH13

ELEVATION: 61.73 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: AECOM Consultants Inc.

PROJECT: Geotechnical Investigation

LOCATION: Ottawa Walls

DESCRIBED BY: S. Wheeler CHECKED BY: B. Vazhbakht

DATE (START): 9 May 2018 DATE (FINISH): 9 May 2018

LEGEND

- SS Split Spoon
- GS Auger Sample
- ST Shelby Tube
- Water Level
- Water content (%)
- Atterberg limits (%)
- N Penetration Index based on Split Spoon sample
- N Penetration Index based on Dynamic Cone sample
- Cu Shear Strength based on Field Vane
- Cu Shear Strength based on Lab Vane
- S Sensitivity Value of Soil
- Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA					
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD	SCALE FOR TEST RESULTS 50kPa 100kPa 150kPa 200kPa 10 20 30 40 50 60 70 80 90
meters	61.73		GROUND SURFACE			%	ppm	N	
			SEDIMENTS- Silty sand trace gravel and organics, dark grey, very loose, wet		SS1	2/24		2	
			*Only coarse gravel pieces recovered, assumed soft sediments with gravel limiting recovery		SS2	2/24		4	
					SS3	3/24		5	
2.0	59.6		**SILTY CLAY-** Grey, stiff, moist		SS4	8/24		5	
					SS5	24/24		2	
4.0					SS6	24/24		2	
			*Organic staining noted in samples		FV1 FV2				S=15.5 S=10.5
			*Tried collecting a Shelby tube sample which returned empty. Followed with split spoon to obtain sample.		ST/SS	4/24			
6.0			*Becoming Silt and Clay, trace sand, wet		SS7	5/24		WH(24)	
			*No recovery		SS8	0/24		7	
					SS9	10/24		WH(24)	
8.0			*Limited recovery		SS10	0.5/24		WH(24)	
			*Becoming silty clay, moist		SS11	24/24		WH(24)	
					SS12	24/24		3	
10.0	51.7		End of borehole at approximately 10.1 m depth						
12.0									
14.0									
16.0									
18.0									
20.0									
22.0									

NOTES:
*FV indicates Field Vane Test
*Pocket Pen values to be used by GHD only
*Elevations surveyed by GHD Field Staff

BOREHOLE LOG 11149792-A1 - BOREHOLE LOGS.GPJ INSPEC_SOL.GDT 25/6/18

REFERENCE No.: 11149792-A1 ENCLOSURE No.: 2

BOREHOLE No.: BH14

ELEVATION: 60.47 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: AECOM Consultants Inc.

PROJECT: Geotechnical Investigation

LOCATION: Ottawa Walls

DESCRIBED BY: S. Wheeler CHECKED BY: B. Vazhbakht

DATE (START): 14 February 2018 DATE (FINISH): 14 February 2018

LEGEND

- SS Split Spoon
- GS Auger Sample
- ST Shelby Tube
- Water Level
- Water content (%)
- Atterberg limits (%)
- N Penetration Index based on Split Spoon sample
- N Penetration Index based on Dynamic Cone sample
- Cu Shear Strength based on Field Vane
- Cu Shear Strength based on Lab Vane
- S Sensitivity Value of Soil
- Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA					
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD	SCALE FOR TEST RESULTS 50kPa 100kPa 150kPa 200kPa 10 20 30 40 50 60 70 80 90
meters	60.47		GROUND SURFACE			%	ppm	N	
	59.9		**SEDIMENTS-** Silty sand some gravel, some organics dark grey, loose, wet		SS1	50		5	
					SS2	71		2	
	59.1		**SILTY CLAY-** Trace organics, dark grey-brown, stiff, damp		SS3	100		2	
2.0			*Organics and ash cinders from 0.7-0.8 m		FV1				S=4.3 S=2.3
			CLAY and SILT- Dark grey, firm, damp		FV2				
					SS4	100		4	
			*Becoming trace sand seams		SS5	100		5	
4.0					SS6	100		6	
			*Becoming wet		SS7	100		5	
					SS8	0		PH	
6.0					SS9	0		PH	
					SS10	0		PH	
					FV3				S=4.6
	52.8				SS11	4		4	
8.0			End of borehole at approxiamtely 7.7 m depth						
10.0									
12.0									
14.0									
16.0									
18.0									
20.0									
22.0									

NOTES:
*FV indicates Field Vane Test
*Pocket Pen values to be used by GHD only
*Elevations surveyed by GHD Field Staff
*PH indicates Push Hammer

BOREHOLE LOG 11149792-A1 - BOREHOLE LOGS.GPJ INSPEC_SOL.GDT 25/6/18

REFERENCE No.: 11149792-A1 ENCLOSURE No.: 3

BOREHOLE No.: BH18

ELEVATION: 66.31 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: AECOM Consultants Inc.

PROJECT: Geotechnical Investigation

LOCATION: Ottawa Walls

DESCRIBED BY: S. Wheeler CHECKED BY: B. Vazhbakht

DATE (START): 20 April 2018 DATE (FINISH): 20 April 2018

LEGEND

- SS Split Spoon
- GS Auger Sample
- ST Shelby Tube
- Water Level
- Water content (%)
- Atterberg limits (%)
- N Penetration Index based on Split Spoon sample
- N Penetration Index based on Dynamic Cone sample
- Cu Shear Strength based on Field Vane
- Cu Shear Strength based on Lab Vane
- S Sensitivity Value of Soil
- Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA					
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD	SCALE FOR TEST RESULTS 50kPa 100kPa 150kPa 200kPa 10 20 30 40 50 60 70 80 90
meters	66.31		GROUND SURFACE			%	ppm	N	
	66.2		**TOPSOIL-** Silt and organics, dark brown, moist		GS1				
			FILL- Sand trace gravel, compact, brown, moist		SS1	13/24		11	
2.0			*Becoming silty, damp		SS2	15/24		12	
			*Becoming Sand and Silt		SS3	14/24		5	
			*Becoming moist, dark grey organic seam, approximatley 0.1 m thickness		SS4	4/24		2	
4.0			*Becoming Sandy Silt		SS5	15/24		3	
	61.7		**SILTY CLAY-** Brownish grey, very stiff, damp		SS6	24/24		5	
					SS7	24/24		4	
6.0					SS8	24/24		6	
			*Becoming grey with trace sand		SS9	17/24		4	
8.0			*Becoming stiff and moist		SS10	24/24		2	
			*Becoming Silt and Clay, wet		SS11	24/24		WH(24)	
					FV1				S=9
10.0					ST1	24/24			
					FV2				S=6
12.0			*Black staining present		SS12	24/24		WH(24)	
			*Remould test could not be completed		FV3				
			*Becoming Clay and Silt		SS13	24/24		WH(24)	
14.0			*Remould test could not be completed		FV4				
					GS2				
	51.1		Began DCPT at approximately 15.2 m depth						
16.0									
18.0									
20.0									
	45.0		DCPT ended at approximately 21.3 m depth						
22.0									

NOTES:
*FV indicates Field Vane Test
*Pocket Pen values to be used by GHD only
*Elevations surveyed by GHD Field Staff

BOREHOLE LOG 11149792-A1 - BOREHOLE LOGS.GPJ INSPEC_SOL.GDT 25/6/18

REFERENCE No.: 11149792-A1 ENCLOSURE No.: 4

BOREHOLE No.: BH19

ELEVATION: 65.04 m

BOREHOLE LOG

Page: 1 of 1

CLIENT: AECOM Consultants Inc.

PROJECT: Geotechnical Investigation

LOCATION: Ottawa Walls

DESCRIBED BY: S. Wheeler CHECKED BY: B. Vazhbakht

DATE (START): 16 April 2018 DATE (FINISH): 16 April 2018

LEGEND

- SS Split Spoon
- GS Auger Sample
- ST Shelby Tube
- Water Level
- Water content (%)
- Atterberg limits (%)
- N Penetration Index based on Split Spoon sample
- N Penetration Index based on Dynamic Cone sample
- Cu Shear Strength based on Field Vane
- Cu Shear Strength based on Lab Vane
- S Sensitivity Value of Soil
- Shear Strength based on Pocket Penetrometer

SCALE		STRATIGRAPHY		SAMPLE DATA					
Depth BGS	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery	OVC	Penetration Index / RQD	SCALE FOR TEST RESULTS 50kPa 100kPa 150kPa 200kPa 10 20 30 40 50 60 70 80 90
meters	65.04		GROUND SURFACE			%	ppm	N	
	65.0		**ASPHALT-** Approximately 0.05 m thick		GS1				
	64.6		**FILL-** Granular pavement, approximately 0.35 m thick		SS1	4/24		18	
			FILL- Gravel and sand, dark brown, compact, damp		SS2	3/24		10	
2.0	62.8		**FILL-** Sandy silt, some organics, dark grey-brown, loose, moist		SS3	5/24		4	
			*Pieces of ash/coal recovered in split spoon		SS4	14/24		1(24)	
	61.4		**SILTY CLAY-** Dark brown, stiff, damp		FV1				S=3.2
4.0					SS5	24/24		3	
			*Becoming light brown		SS6	24/24		WH(24)	
6.0	58.9		**CLAYEY SILT -** Trace sand, dark grey, stiff, wet, organic staining		SS7	24/24		WH(24)	
					FV2				S=4
8.0			*Becoming light grey		SS8	24/24		WH(24)	
			*Remould test could not be completed		FV3				
	55.9		**SILTY CLAY-** Dark grey, stiff, wet, organic staining		SS9	24/24		WH(24)	
10.0					FV4				S=4.7
					SS10	24/24		WH(24)	
			*Remould test could not be completed		FV5				
12.0			*Becoming trace sand		SS11	24/24		WH(24)	
			*Remould test could not be completed		FV6				
14.0			*Becoming Clay and Silt, grey, loose, wet						
					SS12	18/24		1	
16.0									
	48.0		**SILT AND SAND -**Trace clay, grey, compact, wet		SS13	0/24		10	
18.0					SS14	18/24		17	
			*Becoming trace gravel		SS15	24/24		8	
			*Becoming some clay		SS16	8/24		14	
20.0	45.2		End of borehole at approximately 19.8 m depth						
22.0									

NOTES:
*FV indicates Field Vane Test
*Pocket Pen values to be used by GHD only
*Elevations surveyed by GHD Field Staff

BOREHOLE LOG 11149792-A1 - BOREHOLE LOGS.GPJ INSPEC_SOL.GDT 25/6/18

Notes on Borehole and Test Pit Reports

Soil description :

Each subsurface stratum is described using the following terminology. The relative density of granular soils is determined by the Standard Penetration Index ("N" value), while the consistency of clayey sols is measured by the value of undrained shear strength (Cu).

Classification (Unified system)

Clay	< 0.002 mm		
Silt	0.002 to 0.075 mm		
Sand	0.075 to 4.75 mm	fine	0.075 to 4.25 mm
		medium	0.425 to 2.0 mm
		coarse	2.0 to 4.75 mm
Gravel	4.75 to 75 mm	fine	4.75 to 19 mm
		coarse	19 to 75 mm
Cobbles	75 to 300 mm		
Boulders	>300 mm		

Terminology

"trace"	1-10%
"some"	10-20%
adjective (silty, sandy)	20-35%
"and"	35-50%

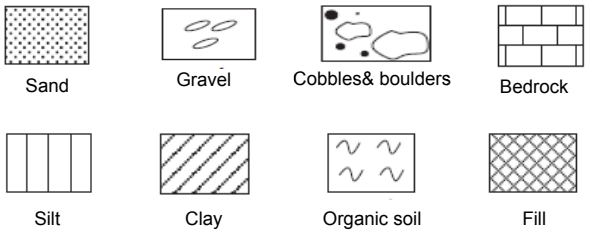
Relative density of granular soils	Standard penetration index "N" value (BLOWS/ft – 300 mm)
Very loose	0-4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

Consistency of cohesive soils	Undrained shear strength (Cu) (P.S.F)	(kPa)
Very soft	<250	<12
Soft	250-500	12-25
Firm	500-1000	25-50
Stiff	1000-2000	50-100
Very stiff	2000-4000	100-200
Hard	>4000	>200

Rock quality designation

"RQD" (%) Value	Quality
<25	Very poor
25-50	Poor
50-75	Fair
75-90	Good
>90	Excellent

STRATIGRAPHIC LEGEND



Samples:

Type and Number

The type of sample recovered is shown on the log by the abbreviation listed hereafter. The numbering of samples is sequential for each type of sample.

SS: Split spoon
SSE, GSE, AGE: Environmental sampling
ST: Shelby tube
PS: Piston sample (Osterberg)
AG: Auger
RC: Rock core
GS: Grab sample

Recovery

The recovery, shown as a percentage, is the ratio of length of the sample obtained to the distance the sampler was driven/pushed into the soil

RQD

The "Rock Quality Designation" or "RQD" value, expressed as percentage, is the ratio of the total length of all core fragments of 4 inches (10 cm) or more to the total length of the run.

IN-SITU TESTS:

N: Standard penetration index
R: Refusal to penetration
N_c: Dynamic cone penetration index
Cu: Undrained shear strength
Pr: Pressure meter
k: Permeability
ABS: Absorption (Packer test)

LABORATORY TESTS:

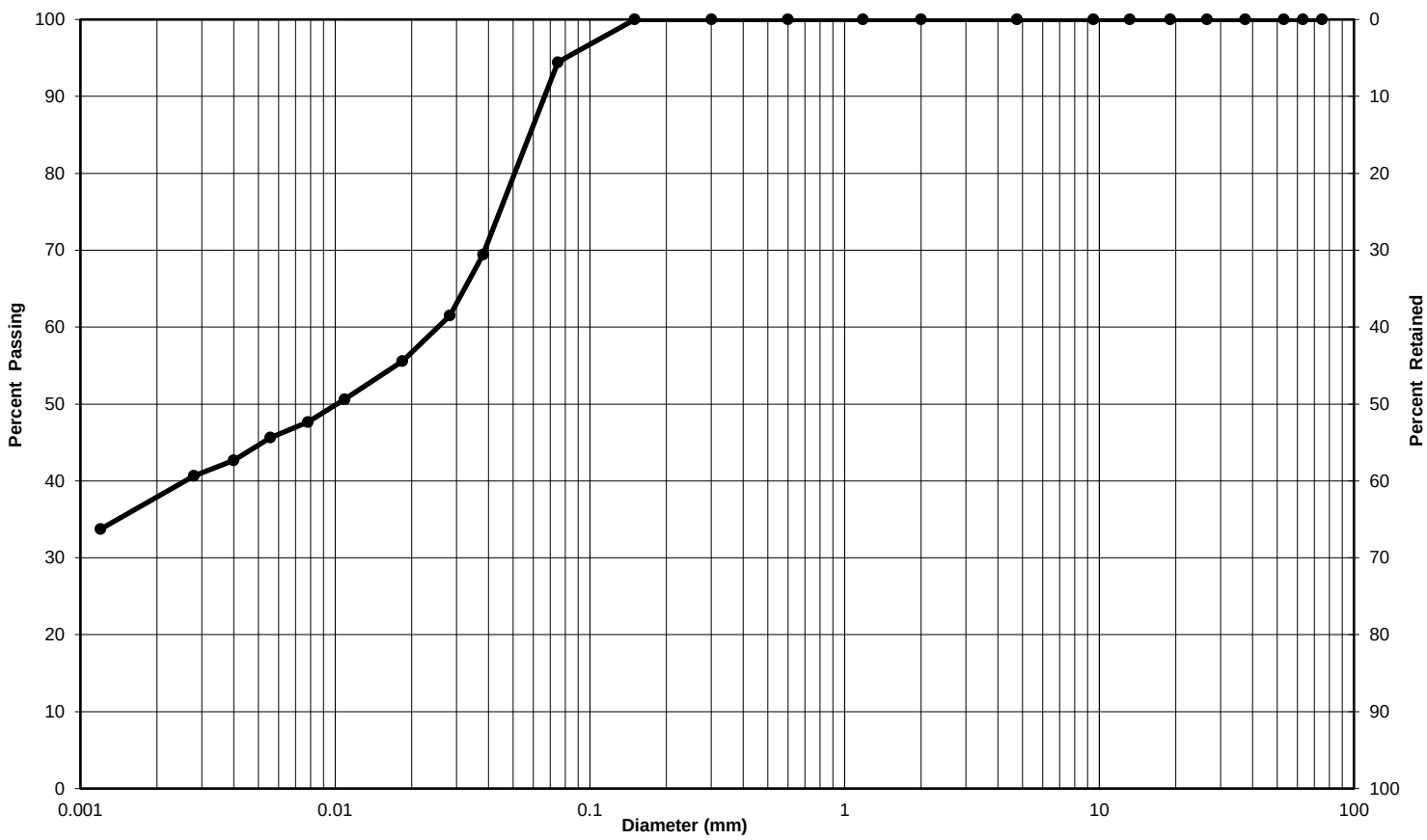
I_p: Plasticity index
W_l: Liquid limit
Wp: Plastic limit
H: Hydrometer analysis
GSA: Grain size analysis
A: Atterberg limits
w: Water content
γ: Unit weight
C: Consolidation
CS: Swedish fall cone
CHEM: Chemical analysis
O.V.: Organic vapor

Appendix B
Laboratory Analysis

Particle-Size Analysis of Soils
MTO LS-702 (Geotechnical)

Client:	Aecom Consultants Inc.	**Lab No.:**	G-18-002
Project, Site:	Ottawa Walls Project / Rideau Canal	**Project No.:**	11149792-A1

Borehole No.:	18	Sample No.:	SS11
Depth:	27.5' - 29.5'	Enclosure:	-



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silt and Clay, trace Sand	0	6	94
Clay-size particles (<0.002 mm):			37 %

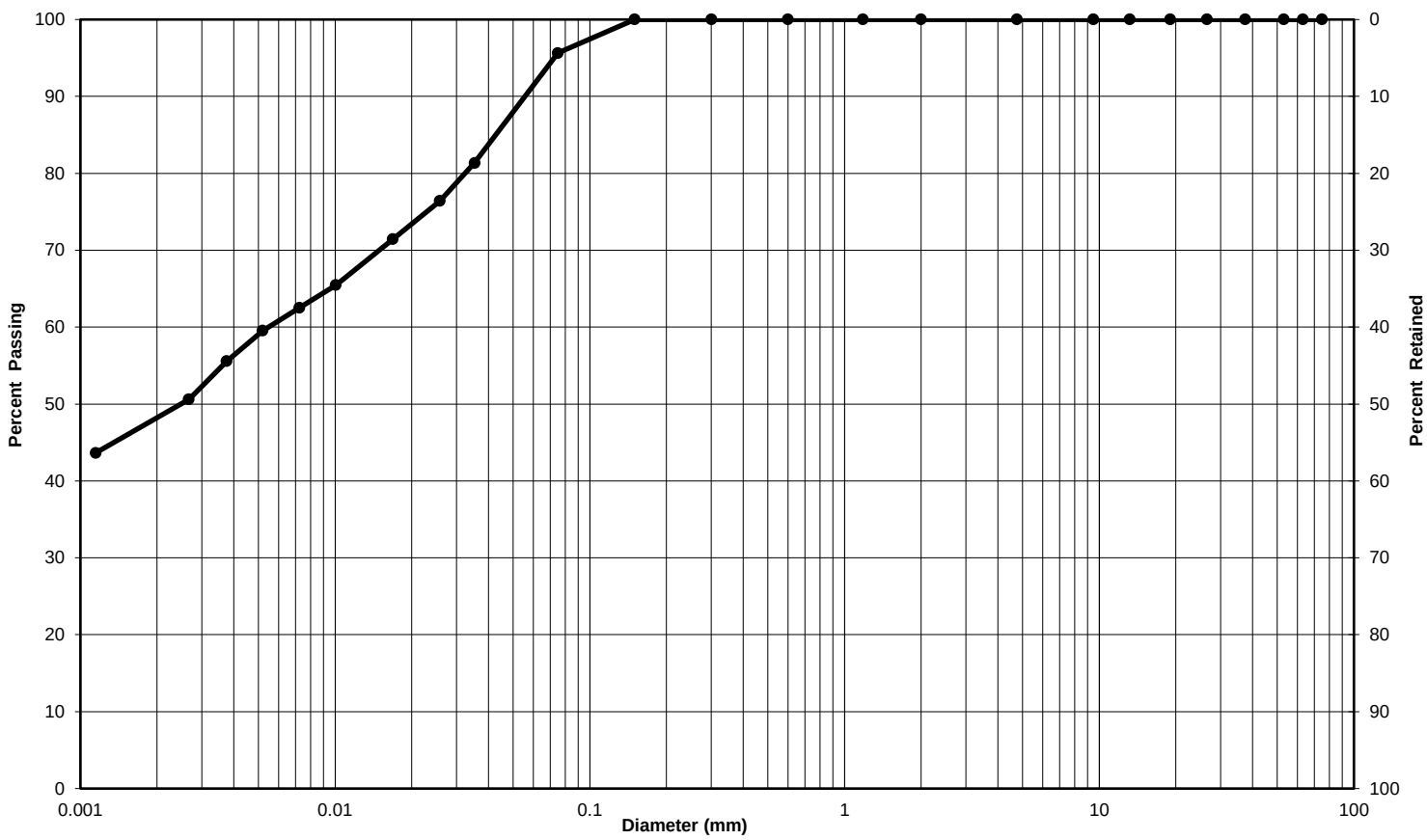
Remarks:

Performed by:	D. Umutoni	**Date:**	June 14, 2018
Verified by:	E. Bennett	**Date:**	June 15, 2018

Particle-Size Analysis of Soils
MTO LS-702 (Geotechnical)

Client:	Aecom Consultants Inc.	**Lab No.:**	G-18-002
Project, Site:	Ottawa Walls Project / Rideau Canal	**Project No.:**	11149792-A1

Borehole No.:	18	Sample No.:	SS13
Depth:	42.5' - 44.5'	Enclosure:	-



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Clay and Silt, trace Sand	0	4	96
Clay-size particles (<0.002 mm):			48 %

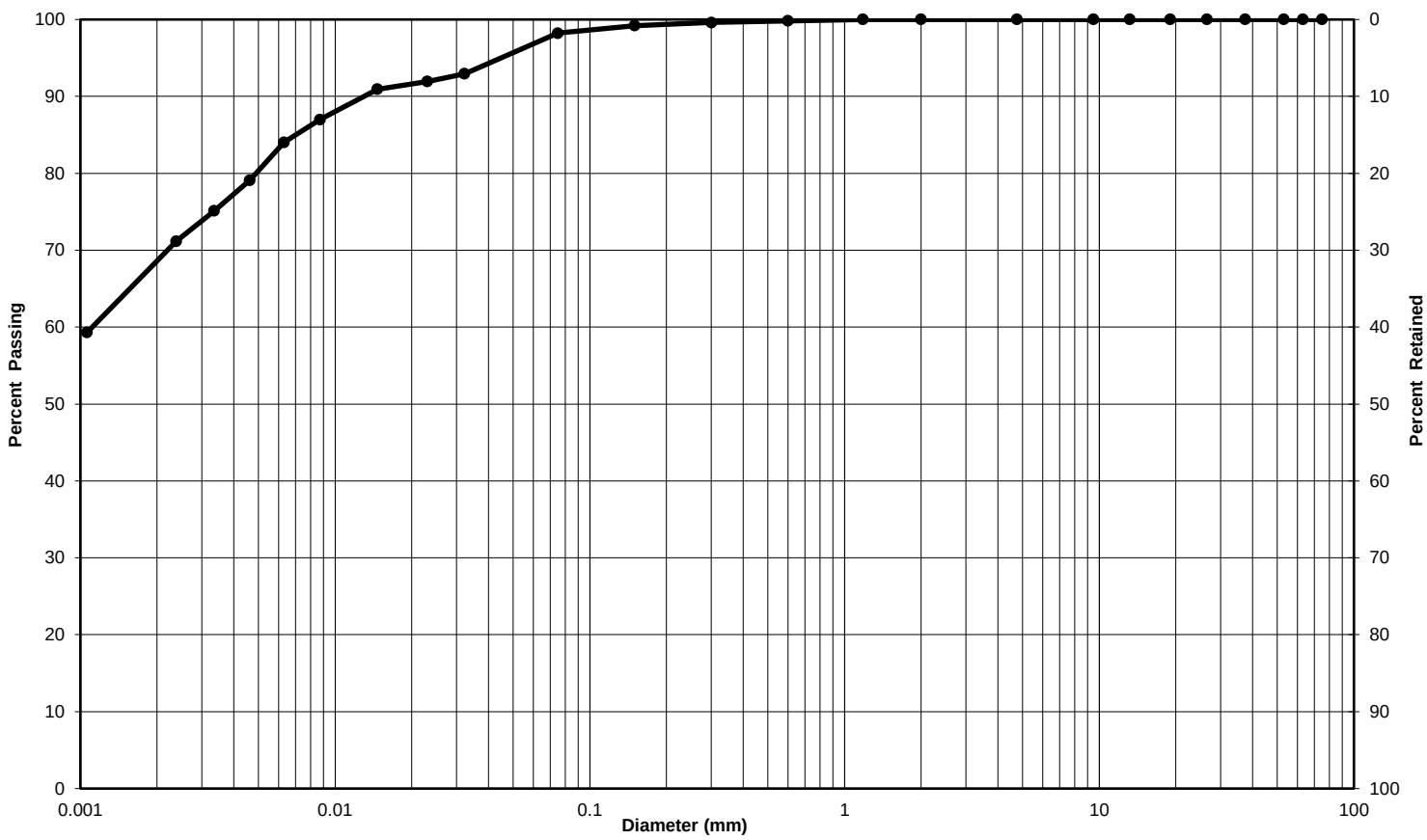
Remarks:

Performed by:	D. Umutoni	**Date:**	June 14, 2018
Verified by:	E. Bennett	**Date:**	June 15, 2018

Particle-Size Analysis of Soils
MTO LS-702 (Geotechnical)

Client:	Aecom Consultants Inc.	**Lab No.:**	G-18-002
Project, Site:	Ottawa Walls Project / Rideau Canal	**Project No.:**	11149792-A1

Borehole No.:	18	Sample No.:	SS9
Depth:	22.5' - 24.5'	Enclosure:	-



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty Clay, trace Sand	0	2	98
Clay-size particles (<0.002 mm):			68 %

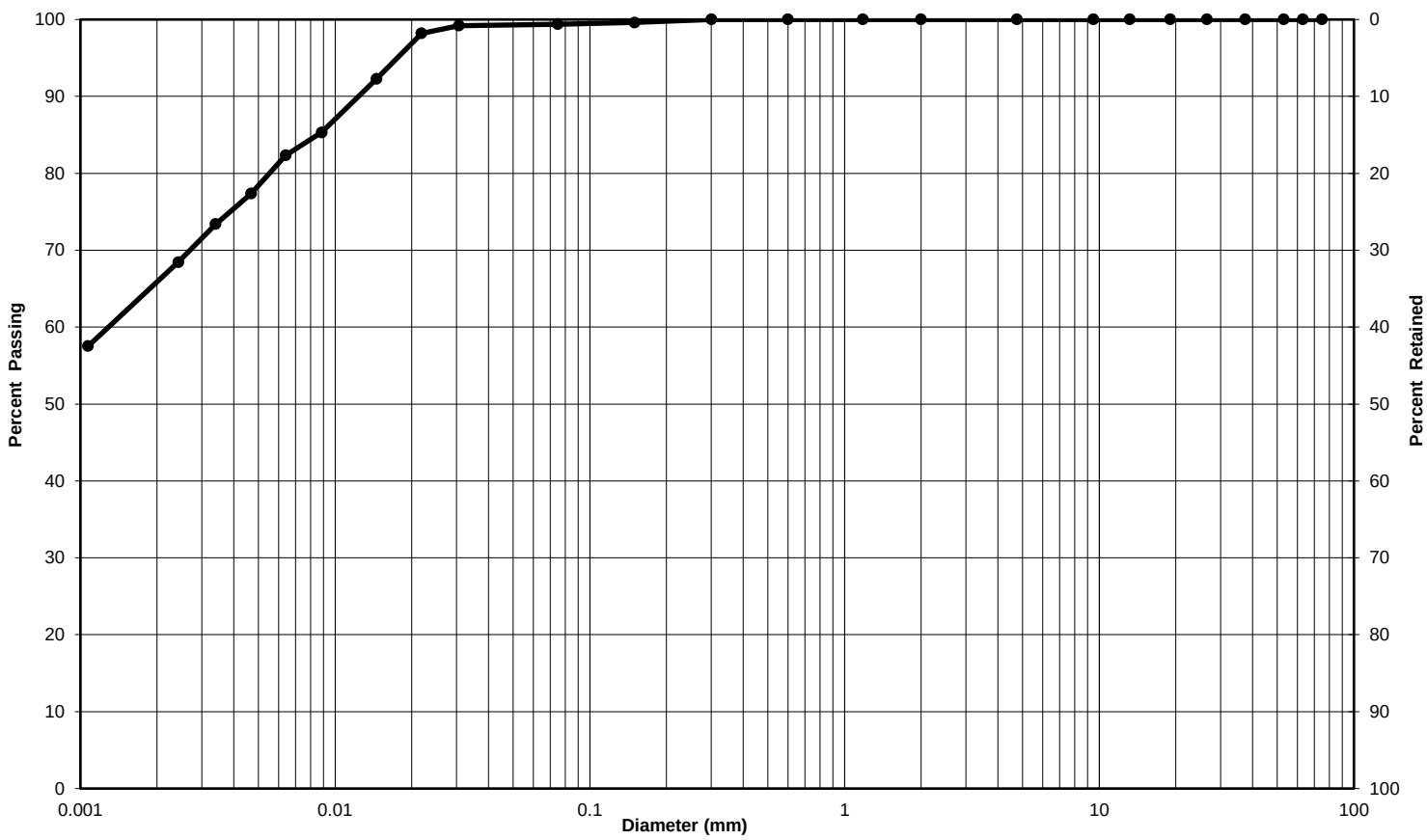
Remarks:

Performed by:	D. Umutoni	**Date:**	June 14, 2018
Verified by:	E. Bennett	**Date:**	June 15, 2018

Particle-Size Analysis of Soils
MTO LS-702 (Geotechnical)

Client:	Aecom Consultants Inc.	**Lab No.:**	G-18-002
Project, Site:	Ottawa Walls Project / Rideau Canal	**Project No.:**	11149792-A1

Borehole No.:	19	Sample No.:	SS11
Depth:	40' - 42'	Enclosure:	-



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty Clay, trace Sand	0	1	99
Clay-size particles (<0.002 mm):			65 %

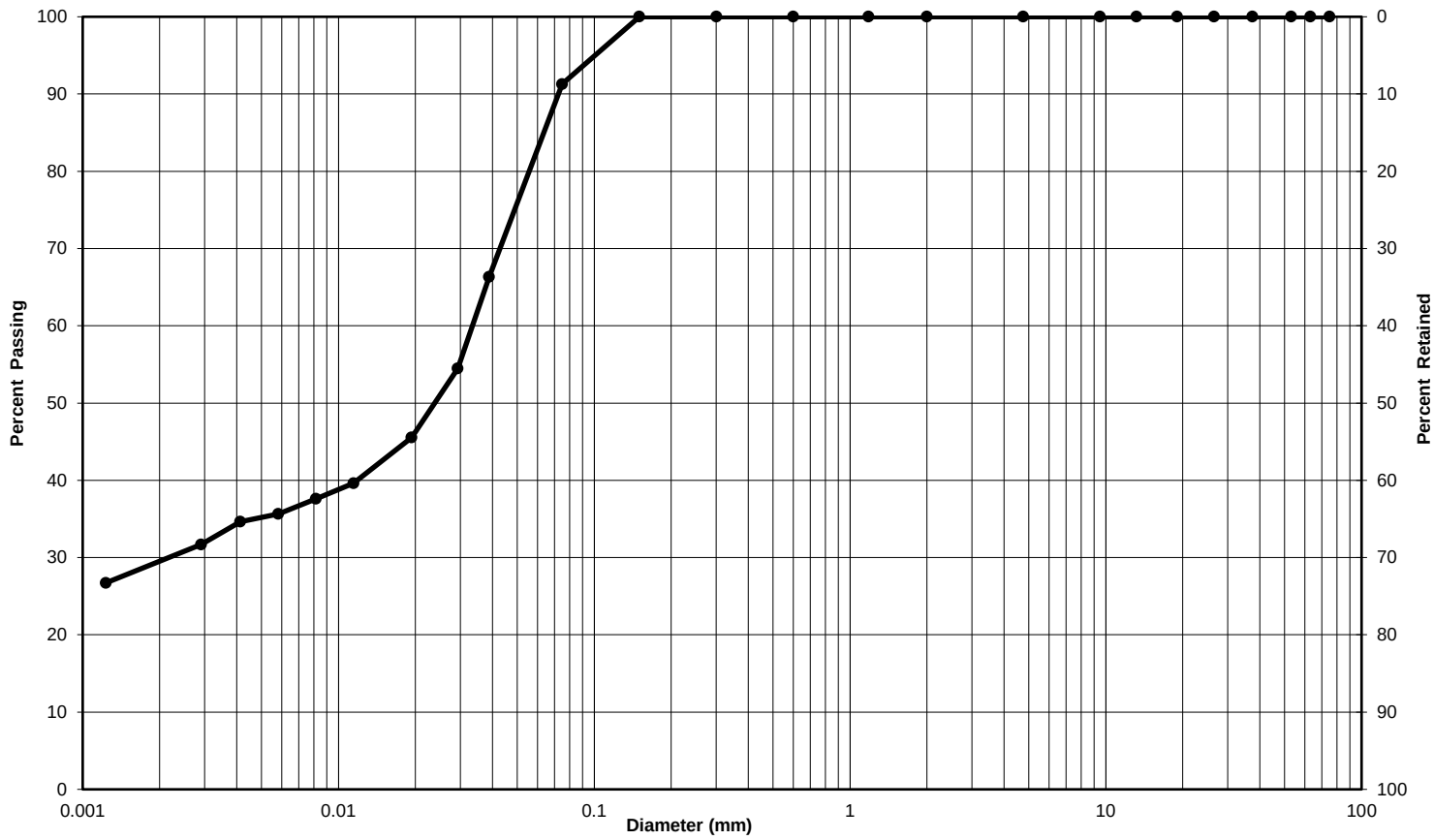
Remarks:

Performed by:	D. Umutoni	**Date:**	June 14, 2018
Verified by:	E. Bennett	**Date:**	June 15, 2018

Particle-Size Analysis of Soils
MTO LS-702 (Geotechnical)

Client:	Aecom Consultants Inc.	**Lab No.:**	G-18-002
Project, Site:	Ottawa Walls Project / Rideau Canal	**Project No.:**	11149792-A1

Borehole No.:	19	Sample No.:	SS8
Depth:	25' - 27'	Enclosure:	-



Clay & Silt	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Clayey Silt, trace Sand	0	9	91
Clay-size particles (<0.002 mm):			29 %

Remarks:

Performed by:	D. Umutoni	**Date:**	June 14, 2018
Verified by:	E. Bennett	**Date:**	June 15, 2018

about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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