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Title - Sujet Hampton Harbour Approach	
Solicitation No. - N° de l'invitation EB144-192089/A	**Amendment No. - N° modif.** 003
Client Reference No. - N° de référence du client EB144-19-2089	**Date** 2018-11-23
GETS Reference No. - N° de référence de SEAG PW-$PWA-110-5819	
File No. - N° de dossier PWA-8-80086 (110)	**CCC No./N° CCC - FMS No./N° VME**
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Solicitation Amendment 003 is being raised to incorporate the following:

Insert:

Geotechnical; Investigation Report for Hampton Wharf, NS

All other terms and conditions remain the same.

GEOTECHNICAL INVESTIGATION
HAMPTON WHARF
HAMPTON, NOVA SCOTIA

Submitted to:

Public Works and Government Services Canada
1713 Bedford Row
Halifax, Nova Scotia □□□1T□

Submitted by:

Amec □o□ter □ □ee□er □n□ronment □ □nfr□□tructure
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1 INTRODUCTION

Amec Foster Wheeler Environment & Infrastructure, a division of Amec Foster Wheeler Americas Limited (Amec Foster Wheeler) has been retained by Public Works and Government Services Canada (PWGSC) in accordance with the RFP dated June 1[illegible] 2017 to carry out a geotechnical investigation at the site of the existing Hampton wharf. The site is located in Hampton, Nova Scotia.

The purpose of the investigation was to determine the subsurface conditions at the site and based on these conditions, to provide geotechnical design recommendations for the proposed repair of the existing wharf.

This report prepared specifically and solely for the proposed project described herein contains all of our findings and includes geotechnical design recommendations.

There should also be an ongoing liaison with Amec Foster Wheeler during both the detailed design and construction phases of the project to ensure that the recommendations in this report have been interpreted and implemented correctly. Also, if any further clarification and/or elaboration are needed concerning the geotechnical aspects of this project, Amec Foster Wheeler should be contacted immediately.

2 PROJECT AND SITE DESCRIPTION

The existing wharf approach consists of a sloped face timber pile and tie back system retaining wall. It is understood that the retaining wall requiring repairs has an approximate length of [illegible] m and spans from the bridge abutment to a more recently constructed retaining wall. According to historical records, the timber pile retaining wall was constructed in 1[illegible]7[illegible]. The timber piles have been displaced and tilted outward. The tieback system (tie rods connecting wales on the piles to a concrete anchor wall) is failing. The existing backfill material consists of granular fill.

The wharf's site is located in Hampton, Nova Scotia. The site location and project layout are shown on Figure 1.

3 INVESTIGATION PROCEDURE

The field work for the investigation was carried out under the supervision of Amec Foster Wheeler personnel on August 10 and September 1[illegible] 2017. A total of three boreholes ([illegible]1 to [illegible]) were drilled at the site to depths ranging from [illegible]7 to [illegible] m. The three boreholes were drilled just in front of the existing timber pile retaining wall at a distance of [illegible]1 and [illegible]7 m from the intersection of the wall with the bridge. The borehole locations are shown on the attached plan in Figure [illegible].

The boreholes were advanced using a track-mounted drill rig provided by Nova Drilling Inc. The soils encountered were sampled at continuous intervals using a [illegible]0mm OD split spoon sampler in order to assess the relative density and/or consistency of the subsoils. Standard Penetration Test (SPT) was carried out for each sample attempt.

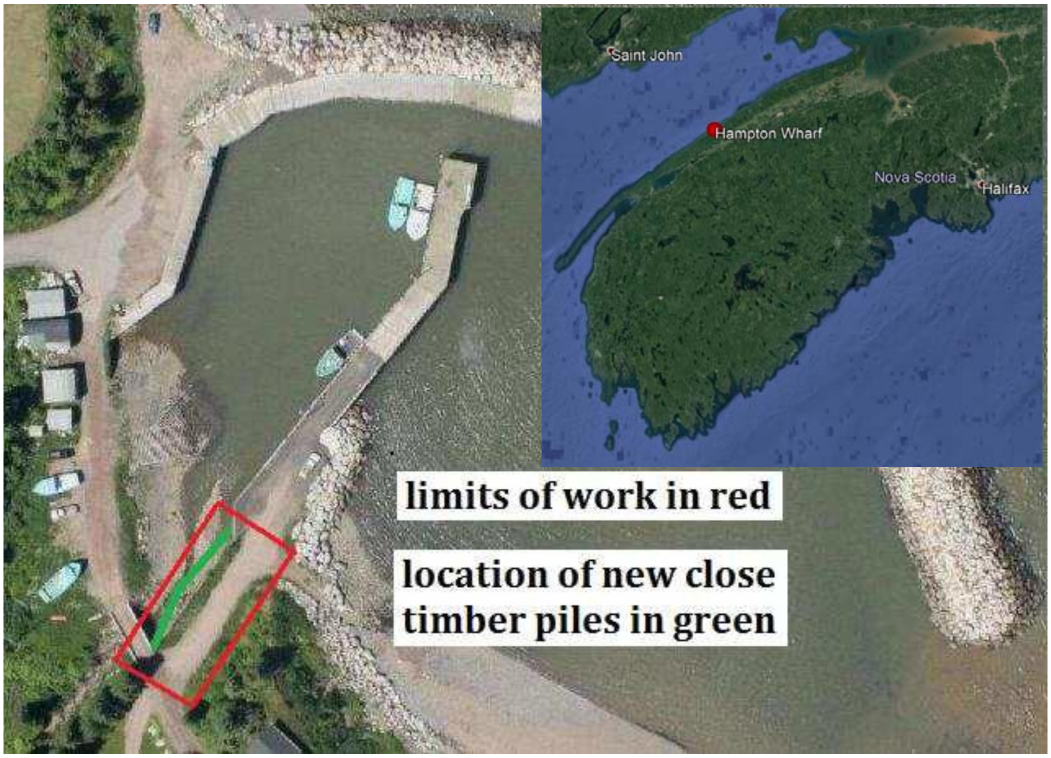

Figure 1: Site Location and Project Layout

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4 SUBSURFACE CONDITIONS

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4.1 Silty Sand with Cobbles

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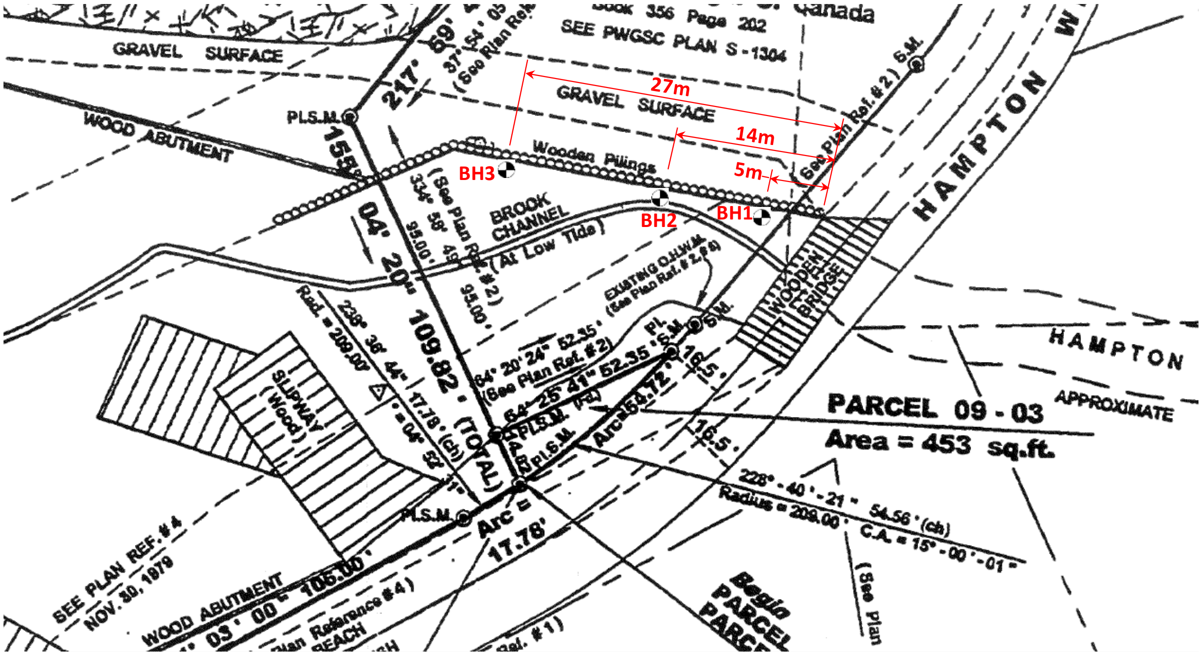

Figure 2: Borehole Location Plan

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4.2 Sandy Silty Clay

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4.3 Sandy Clay

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4.4 Inferred Bedrock

Bedrock was inferred below the [illegible] at [illegible] m depth below ground surface.

4.5 Groundwater Conditions

Groundwater was not observed during drilling of the boreholes. However, the area is located in the tidal zone.

5 DESIGN RECOMMENDATIONS

5.1 General

It should be noted that the design recommendations for this project are provided for the guidance of the designers. The contractors bidding on or undertaking the work should make their own assessment of the site and interpretation of the recommendations provided as it affects their construction procedures and schedule.

As mentioned above, the existing closed face timber piles act as a [illegible] m long retaining wall to support the wharf. The maximum retained height of the wharf is about [illegible] m. The top of the piles are tied back with tie rods to a concrete anchor wall. As mentioned previously, the existing timber piles have been displaced and tilted outward as a result of failing tieback system.

The following is understood:

- The proposed repair of the wharf will include installation of a new retaining structure in front of the existing failing wall to provide required lateral support for the existing wharf.
- The new retaining structure will be constructed of pressure treated timber piles tied back to the existing concrete anchor wall.
- The new timber piles will have [illegible] to [illegible] mm tip diameter and [illegible] mm butt diameter.
- The gap between the existing wall and the new retaining structure will be filled with granular materials.
- There will be no vertical load on the piles other than their own weight.

5.2 Timber Piles

5.2.1 Structural Design

As per the [illegible] Canadian Foundation Engineering Manual (CFEM), the structural design of wood piles must conform with the requirements of Section [illegible] of the National Building Code of Canada ([illegible]). No special consideration needs to be given to handling stresses, but special precautions must be taken to protect the pile toe and head from damage due to driving stresses.

5.2.2 Penetration Depth

The CFEM ([illegible]) provides general guidelines for determining penetration depth of flexible sheet-pile retaining walls similar to the proposed retaining structure at Hampton Wharf.

As per CFEM ([illegible]), two different methods can be used for design of single-anchor wall systems, namely the "free-earth" and "fixed-earth" methods. Given the soft ground condition at the site, the “free-earth” method c□n be con□dered more □□□ro□r□te □nd □u□t□b□e for de□□n of □n□e □nc□or w□□□□□tem □t □□m□ton □ □□rf□T□e "free-e□rt□" met□od □□□ume□t□□t t□e w□□□ct□ □□ □ be□m □□□nn□n□two □u□□ort□□t□e□e be□n□t□e to□ □nc□or□□e □nd t□e □□□□□e □re□□ure of t□e e□rt□be□ow t□e □□rbour bottom □□e□t□e w□□□□free to rot□te or tr□n□□□te □or□ont□□□ □t □t□bottom end□□

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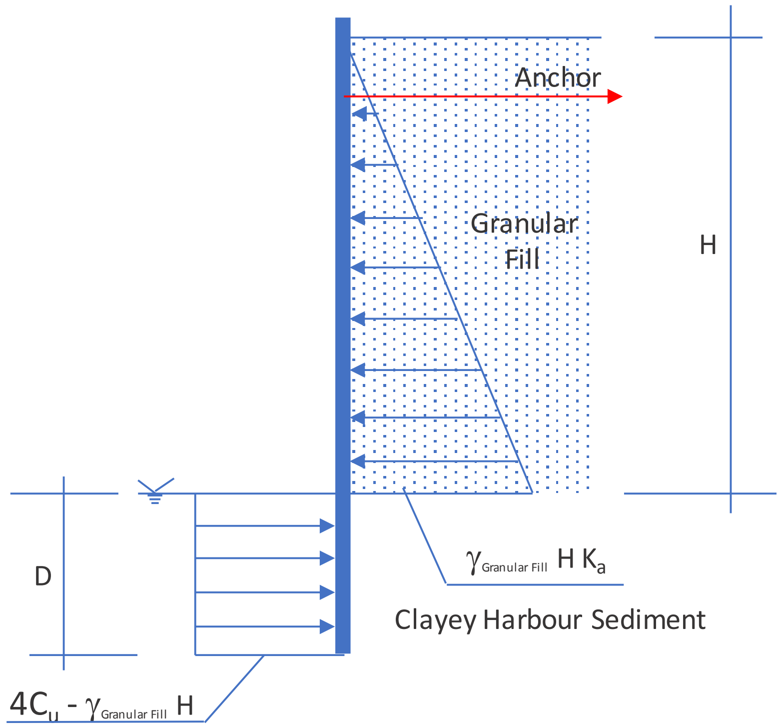

Figure 3. Schematic lateral pressure distribution on anchored sheet pile wall in clay

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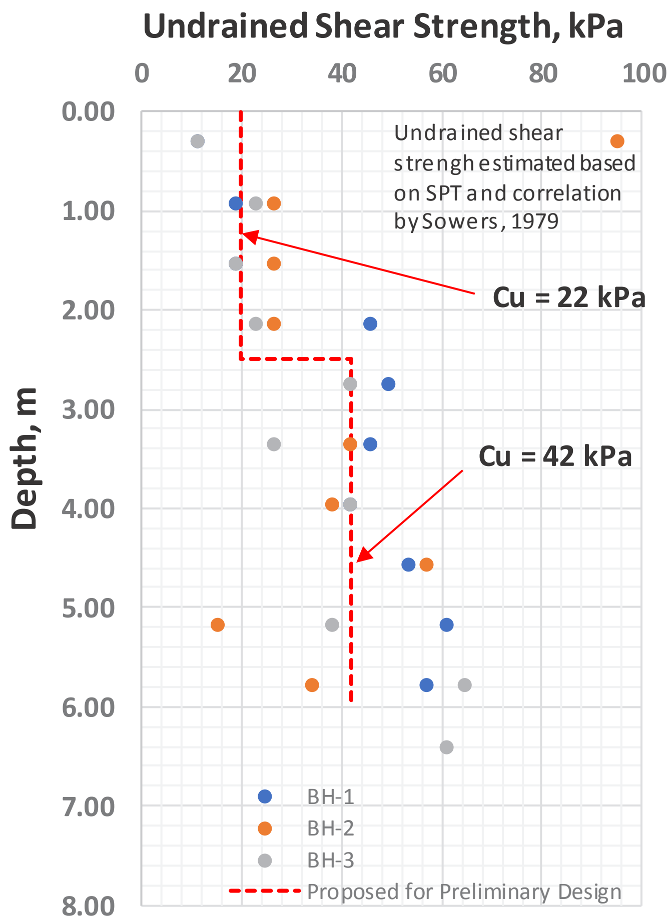

Figure 4. Proposed undrained shear strength of harbour sediment

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5.2.3 Negative Friction (down drag)

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5.2.4 Installation of Timber Piles

As per ASTM [illegible], when driving wood piles, low-velocity hammer blows should be used. For example, drop hammers and single acting steam/air hammers should have relatively small heights of fall and incorporate a soft cushion in the cap block. The size of the hammer used for the driving depends on local experience and on a number of factors, among them the weight of the pile, the pile diameter of head and toe, impedance and the soil properties. The hammer-rated energy should be about [illegible] 000 joules and should not exceed a value equal to 1[illegible]0 000 [illegible] Newton metres times the pile head diameter in metres.

The pile heads should be provided with protection in the form of a steel ring and the pile toe should be protected with a special steel driving shoe. Timber piles cannot withstand hard driving; over-driving with energy will lead to the destruction of the pile. To avoid this, driving must be stopped when high resistance to penetration is encountered. The set criteria should not exceed [illegible] blows/[illegible] mm.

Our understanding is that the new retaining wall will not be used to tie boats and therefore no dredging is required at the basin. Yet, a trench should be excavated in the harbour bottom to accommodate installation of the new timber piles. Our understanding is that the proposed trench will be offset 1 to [illegible] m from the base of existing wall and approximately [illegible]0[illegible] m deep. The trench is required to remove large cobbles and boulders from the harbour bottom that may obstruct pile driving operations. The trench should be backfilled with granular fill following the completion of new pile installations.

5.3 New Granular fill

5.3.1 Fill Gradation

The new granular fill to be placed between the new and the existing piles should consist of rock fill between [illegible]0 and [illegible]0 mm in size.

5.3.2 Consolidation Settlement under the New Fill

The new fill placed between two walls (existing and new) will introduce additional weight on the soft harbour sediment causing it to settle. The settlement typically comprises of three components, namely: immediate settlement, consolidation settlement and secondary compression (creep). The magnitude of each component varies depending on the soil type and properties. Typically, consolidation settlement dominates in saturated or nearly saturated fine grain soils.

To accurately estimate the consolidation settlement under the new fill, advanced field sampling program combined with advanced soil laboratory testing is required. However, this program and testing is outside of the current scope.

Based on our preliminary estimate, the consolidation settlement under the new fill is not expected to exceed [illegible]0 cm with [illegible]0% consolidation to be completed within four years (or less). These estimates were made based on the following assumptions:

- The thickness of the new fill is [illegible]1 m;
- Offset distance between the new and the existing timber piles will be [illegible] m or less.

- The thickness of the soft harbour sediment ranges between [illegible] and 10 m and the harbour sediment is underlain by low permeability bedrock [illegible]
- The consolidation characteristics of the soft harbour sediment were approximated based on published empirical correlations.

6 CLOSURE

A geotechnical investigation provides only a limited sampling of a site. The recommendations contained in this report are based solely on the conditions encountered at the borehole locations. Should any conditions be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to permit reassessment of our recommendations.

This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied. The limitations of this report are expressed in Appendix A. Any use which a third party makes of this information, or any reliance on or decisions made based on it, are the responsibility of such third parties. Amec Foster Wheeler accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Sincerely,

AMEC Foster Wheeler Environment & Infrastructure
A division of AMEC Foster Wheeler Americas Limited

[illegible], M.A.Sc., P.Eng.
Senior Geotechnical Engineer

[illegible], Ph.D., P.Eng.
Geotechnical Engineer

APPENDIX A

BOREHOLE LOGS

GENERAL REPORT NOTES

STANDARD PENETRATION TEST—SPT

The standard penetration values are recorded on the Borehole Records as N values. The N values are the number of blows required to advance a standard, 50 mm diameter, split spoon sampler a distance of 305 mm into the soil using a 63.5 kg hammer freely falling a distance of 760 mm.

DYNAMIC CONE PENETRATION TEST----DCPT

This is a similar procedure to that used in driving a standard 50 mm split spoon sampler except that a cone is driven rather than a soil sampler. A variety of cones can be used. Often the cones are 51 mm diameter with a 60 degree taper from the tip.

SAMPLE TYPE ABBREVIATION USED ON BOREHOLE LOGS

S.S.	Split spoon	S. H.	Shelby tube	W.S.	Wash sample
A.S.	Auger sample	R. C.	Rock Core	P.	Sample pushed

SOIL DESCRIPTION

The standard terminology to describe cohesionless soils includes the compactness condition as generally determined by the SPT.

The standard terminology to describe cohesive soils includes the consistency, which is based on various methods of determining undrained shear strength, and by SPT

Cohesionless Soils.		**Cohesive Soils**		
Compactness Condition	N Values	Consistency	N Values	Undrained Shear Strength, kPa
Very loose	0 – 4	Very soft	0 – 2	< 12.5
Loose	4 – 10	Soft	2 – 4	12.5 - 25
Compact	10 – 30	Firm	4 – 8	25 – 50
Dense	30 – 50	Stiff	8 – 15	50 - 100
Very Dense	> 50	Very stiff	15 – 30	100 – 200
		Hard	>30	>200

NOTE

The soil conditions, profiles, comments, conclusions and recommendations found in this report are based upon samples recovered during the field work. Soils are heterogeneous materials, and, consequently, variations may be encountered at site locations away from where the samples were obtained. During construction, competent, qualified personnel should verify that no significant variations exist from those described in the report.

LOG OF BOREHOLE BH1

PROJECT No.:	TV177001	ELEVATION:	---
CLIENT:	PWGSC	DATUM:	
PROJECT NAME:	PRO Delhaven & Hampton	METHOD:	SS / Auger
LOCATION:	Hampton Warf	DIAMETER:	100 mm
DATE DRILLED:	9-14-17	WATER LEVEL:	
LOGGED BY:	A. Gale	CONTRACTOR:	Nova Drilling

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DEPTH (m)	ELEVATION (m)	STRATIGRAPHIC DESCRIPTION	TYPE	NUMBER	RECOVERY (mm)	N-VALUE or RQD%	OTHER TESTS
0		Red / Brown, silty SAND with cobbles, small boulders and clay	SS	1	25	3	
		Red / Brown, sandy silty CLAY (CL-ML)	SS	2	500	5	
1			SS	3	425	5	
2			SS	4	600	12	S, L, M
			SS	5	225	13	
3			SS	6	225	12	
4			SS	7	600	11	
			SS	8	450	14	
5			SS	9	250	16	
6			SS	10	450	15	
			SS	11	200	77 / 400mm	
		Inferred Grey, sand stone bedrock	AU				
		End of Borehole @ 6.7 m					

UNDRAINED SHEAR STRENGTH (kPa): △ Peak ▲Residual — 20 40 60 80

STANDARD PENETRATION TEST Blows/0.3m ● — 20 40 60 80

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%) — 10 20 30

>>

LOG OF BOREHOLE BH2

PROJECT No.:	**TV177001**	ELEVATION:	**---**
CLIENT:	**PWGSC**	DATUM:	
PROJECT NAME:	**PRO Delhaven & Hampton**	METHOD:	**SS / Auger**
LOCATION:	**Hampton Warf**	DIAMETER:	**100 mm**
DATE DRILLED:	**9-14-17**	WATER LEVEL:	
LOGGED BY:	**A. Gale**	CONTRACTOR:	**Nova Drilling**

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DEPTH (m)	ELEVATION (m)	STRATIGRAPHIC DESCRIPTION	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE or RQD%	OTHER TESTS	STANDARD PENETRATION TEST Blows/0.3m (plotted)
0		Red / Brown, silty SAND with cobbles, small boulders and clay	SS	1	100	25		●
1		Red / Brown, sandy silty CLAY (CL-ML)	SS	2	325	7		●
			SS	3	325	7		●
2			SS	4	500	7		●
			AU					
3			SS	5	25	11		●
4			SS		0	10		●
			SS	6	350	15		●
5			SS	7	300	4		●
6			SS	8	450	9		●
7		Red / Brown, sandy CLAY with occasional cobbles	AU					
8								
		End of Borehole @ 8.8 m						

UNDRAINED SHEAR STRENGTH (kPa): △ Peak ▲Residual — 20 40 60 80
STANDARD PENETRATION TEST Blows/0.3m — 20 40 60 80 ●
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%) — 10 20 30

LOG OF BOREHOLE BH3

PROJECT No.:	**TV177001**	ELEVATION:	**---**
CLIENT:	**PWGSC**	DATUM:	
PROJECT NAME:	**PRO Delhaven & Hampton**	METHOD:	**SS / Auger**
LOCATION:	**Hampton Warf**	DIAMETER:	**100 mm**
DATE DRILLED:	**9-14-17**	WATER LEVEL:	
LOGGED BY:	**A. Gale**	CONTRACTOR:	**Nova Drilling**

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DEPTH (m)	ELEVATION (m)	STRATIGRAPHIC DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE or RQD%	OTHER TESTS	UNDRAINED SHEAR STRENGTH (kPa) △ Peak ▲Residual 20 40 60 80 / STANDARD PENETRATION TEST Blows/0.3m 20 40 60 80 ●	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L / WATER CONTENT (%) 10 20 30
0		Red / Brown, silty SAND with cobbles, small boulders and clay			SS	1	100	3			
		Red / Brown, sandy silty CLAY (CL-ML)			SS	2	125	6			
1					SS	3	600	5			
2					SS	4	375	6			
					SS	5	225	11			
3					SS	6	125	7			
4					SS	7	125	11			
					AU	8					
5					SS	9	250	10			
6					SS	10	500	17	S, M		
					SS	11	400	16			
		End of Borehole @ 6.7 m									

APPENDIX B

LAB TEST RESULTS

Appendix B. Summary of Laboratory Results

Project No.: TV177001
Client: PWGSC
Project Name: PRO Delhaven & Hampton
Location: Hampton Warf

GENERAL INFORMATION:

Number of BH/TP: 3
Total Length of Drilling: 22.3 m

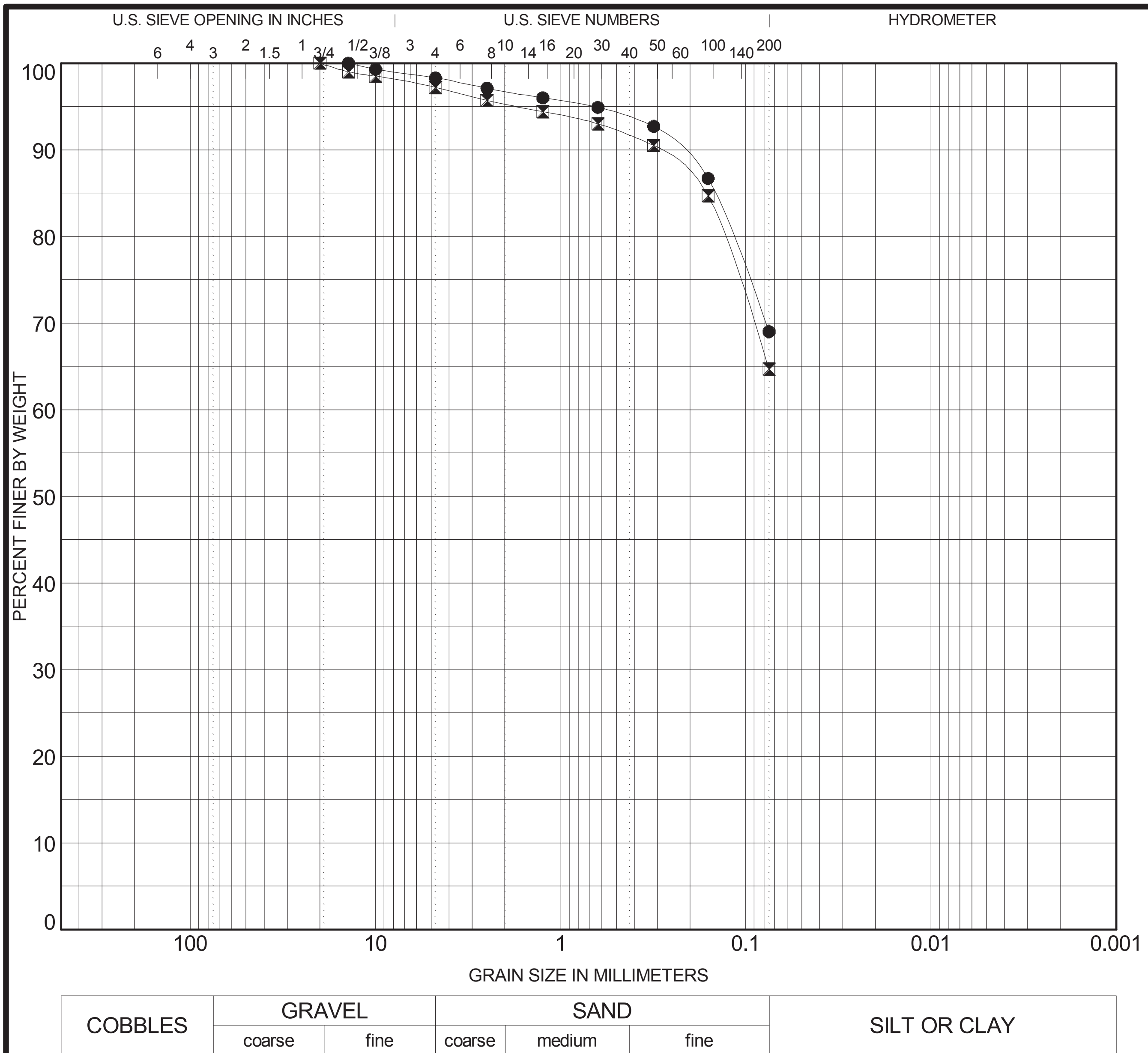
SAMPLING:

Auger Cuttings 4
Split Spoon 30

LAB TEST STATISTICS:

Moisture Content: 2
Atterberg Limits: 1
Sieve Analysis: 2
Hydrometer Analysis: 0

Borehole	Depth (m)	Liquid Limit	Plastic Limit	Plasticity Index	% Gravel	% Sand	% Silt and Clay	Class-ification	Water Content (%)	Dry Density (Mg/m^3)	Void Ratio
BH1	2.13	20	13	7	1.7	29.3	69.0	CL-ML	20.0		
BH3	5.79				2.8	32.5	64.7	CL-ML	18.1		



	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**BH1**	**2.13 m**	**SANDY SILTY CLAY(CL-ML)**	**20**	**13**	**7**		
⧗	**BH3**	**5.79 m**	**SANDY SILTY CLAY(CL-ML)**					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**BH1**	**2.13 m**	**14**				**1.7**	**29.3**	**69.0**	
⧗	**BH3**	**5.79 m**	**20**				**2.8**	**32.5**	**64.7**	

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GRAIN SIZE DISTRIBUTION

Project No.: TV177001
Client: PWGSC
Project Name: PRO Delhaven & Hampton
Location: Hampton Warf

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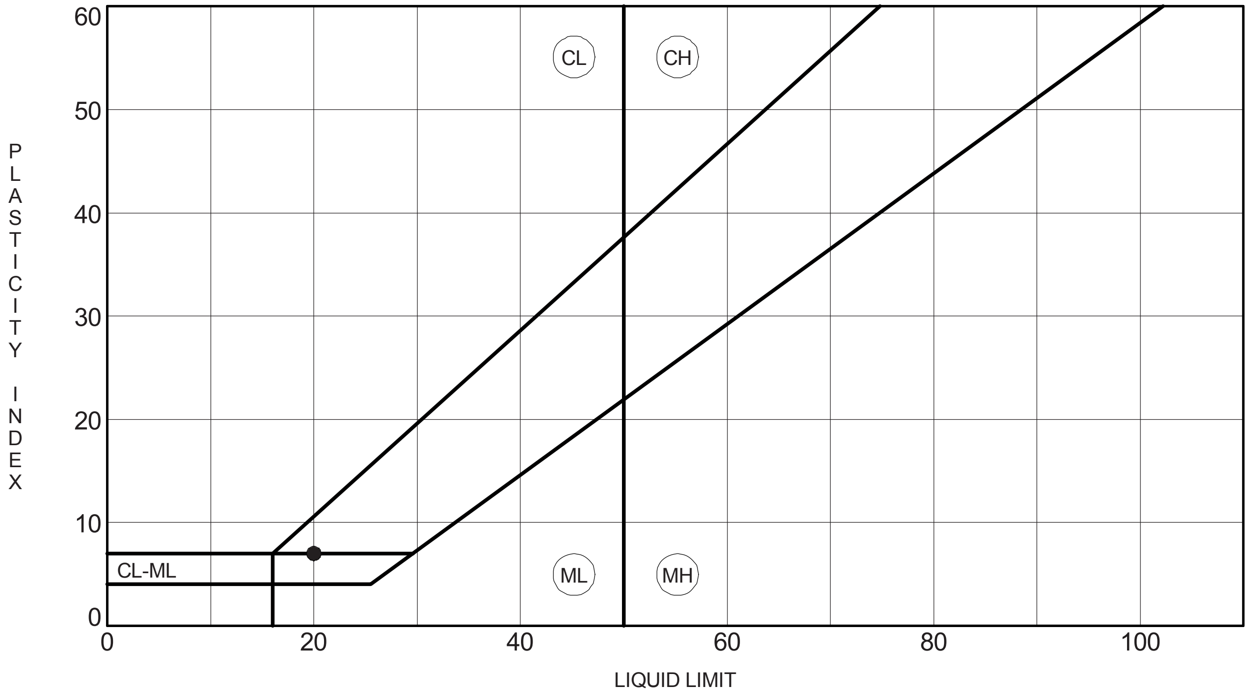

	Specimen Identification		LL	PL	PI	Fines	Classification
●	**BH1**	**2.13 m**	**20**	**13**	**7**	**69**	**SANDY SILTY CLAY(CL-ML)**

ATTERBERG LIMITS' RESULTS (Appendix B)

Project No.: TV177001
Client: PWGSC
Project Name: PRO Delhaven & Hampton
Location: Hampton Warf

APPENDIX C

REPORT LIMITATIONS

REPORT LIMITATIONS

The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environmental aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the geotechnical engineer be retained during the construction to confirm that the subsurface conditions across the site do not deviate materially from those encountered in the test holes.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

The comments made in this report relating to potential construction problems and possible methods of construction are intended only for the guidance of the designer. The number of test holes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied.

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. Amec Foster Wheeler Environment & Infrastructure accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.