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## Appendix A

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June 09, 2016

HFX-00231668-A0 / 60.2

Mr. Vidya Limaye, PhD, P. Eng.  
President, SHM Canada Consulting Limited (SHM)  
255 Lacewood Drive, Suite 303  
Halifax, NS B3M 4G2

Re: Bear Point Wharf Reconstruction  
**Summary of Geotechnical Investigation and Pile Recommendations**

Dear Vidya,

**Exp** Services Inc. (**exp**) is pleased to provide SHM with this letter report, summarizing the results of the geotechnical investigation work performed for the proposed wharf reconstruction at Bear Point, NS. Previous documentation and geotechnical reports for historic work provided by SHM and PWGSC were reviewed, and it was agreed that further investigation was required in order to attain more information for pile design, particularly with respect to the bedrock underlying the site.

## **Methodology**

A barge drill, provided by Lantech Drilling (Moncton NB), was used to carry out six boreholes around the existing wharf structure. The field work was supervised by an **exp** technician who logged the boreholes and collected representative soil and bedrock samples. A representative from GHD was on site to retrieve soils samples from several boreholes for environmental testing purposes.

**Exp** was responsible for service clearances to confirm that underground utilities were not present at the borehole locations. This is provided as general information only. Third parties should make their own inquiries with local authorities to confirm the presence or absence of utilities.

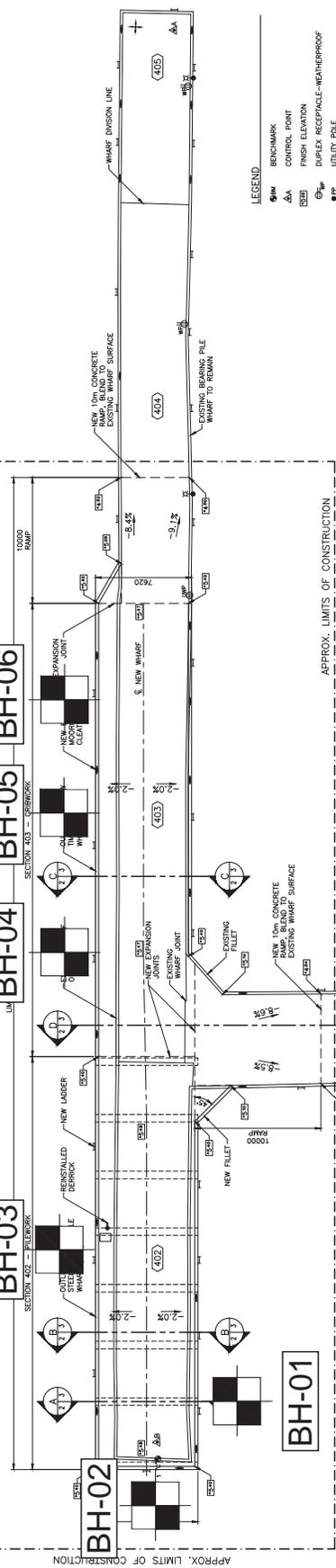
The borehole locations were selected to cover the area where the new wharf would be constructed and were advanced to depths ranging from approximately 5.1 m to 10.0 m below the harbour bottom. This corresponds to approximate elevations between -7.4 m and -12.5 m. The locations of the boreholes are shown on attached Figure 1, which is based on SHM drawing S2 of 6.

## **Subsurface Conditions**

Subsurface conditions consisted of a very soft organic silt harbour bottom, overlying fractured granitic bedrock. Sandy glacial till deposits were described in historic reports but were not encountered in the current boreholes.

In general, the elevation of the bedrock in the current boreholes was similar to the elevations indicated in the 1952/1956 borings, although the overburden types and thicknesses were not consistent with the current investigation.

DATE: 2016-05-20  
PROJECT: WHARF RECONSTRUCTION



**LEGEND**

- BENCHMARK
- CONTROL POINT
- FINISH ELEVATION
- DUPLEX RECEPTACLE-WATERPROOF
- UTILITY POLE
- UTILITY POLE WITH LUMINAIRE
- MARKET TRANSVERSE POINT
- NAVIGATION LIGHT
- MOORING CLEAT
- LADDER
- UTILITY SERVICES SHROUD
- STRUCTURE 403

APPROX. LIMITS OF CONSTRUCTION

BH-01

BH-03

BH-04

BH-05

BH-06

**Figure 1**  
**BOREHOLE LOCATION PLAN**

REV.	DESCRIPTION	DATE
2	ISSUED FOR REVIEW	MAY 19, 2016
1	ISSUED FOR REVIEW	MAY 19, 2016
0	ISSUED FOR REVIEW	MAY 19, 2016

PROJECT: WHARF RECONSTRUCTION  
BEAR POINT WHARF  
SHELBURNE COUNTY  
NOVA SCOTIA

PLAN OF NEW WORK

designed by:	UM
checked by:	UM
date:	JUN 26, 2016
scale:	
sheet:	
project number:	R.076829.001
drawn by:	
approved by:	
project manager:	Administrateur de projet TRC
no. of pages:	6
sheet no.:	S2 OF 6

### *Harbour Sediments*

The Harbour sediments surrounding the wharf were classified under the United Soil Classification System (USCS) as very soft Silt with organics 'ML' to very soft organic Silt 'OL'. The deposit was saturated, black in colour and exhibited a strong organic odor.

### *Bedrock*

The bedrock encountered at the site was Granodiorite near the surface which transitioned into Tonalite at depth. It was found to exhibit very poor to good quality, exhibited very close to close fracture spacing, with fractures predominantly oriented 45° to horizontal and occasional vertical fractures. UCS strength testing was performed on several intact sections of rock core, with results ranging from 70.0 MPa to 94.3 MPa, which would classify the rock strength as 'Strong'.

Although the parent rock strength is classified as 'Strong', the rock mass is highly fractured and the engineering behaviour of the unit will be dominated by the spacing and frequency of discontinuities in the highly fractured areas, rather than the rock strength.

## **Pile Recommendations**

The following design recommendations and geotechnical parameters are based on experience at similar sites and from published values for the types of soil and bedrock encountered on this site. We have performed wave equation analyses using GRL WEAP® to determine the pile set criteria to achieve the design capacity. We understand that HP 360x174 H-Piles have been specified for the site, with a factored design load in axial compression of 575 kN per pile. Using a geotechnical resistance factor of 0.4, the factored ultimate geotechnical pile capacity is 1437.5 kN. We understand that the piles will be equipped with a protective driving shoe, which we endorse.

Preliminary capacity and pile set analyses were completed using the above information with the use of several standard diesel hammers that would be typical for the proposed works, ranging from a Delmag D12-32 to a D19-42. We have assumed pile penetration into fractured bedrock of approximately 2 m to 3 m to complete our analyses. Based on the results, we recommend a pile set of at least 10 blows per inch, for two consecutive sets. The minimum rated hammer energy should be 42.5 kJ (31.3 kip-feet). This corresponds to a rated energy of 200 J/cm<sup>2</sup> for the proposed HP360x174, which is relatively low for a driven steel H pile. A maximum rated energy of 350 J/cm<sup>2</sup> is recommended for pile installation. We do not anticipate a risk of excessive stress or damage to the piles during driving based on our analyses, at the recommended pile set and rated energy.

The final pile set criteria may be established on the basis of PDA measurements taken during pile installation. The PDA measurements would supersede the results of our wave equation analyses.

We anticipate that driven steel H-Piles may penetrate approximately 2 m to 3 m into the fractured bedrock on this site, but may stop short of this penetration where pile tips encounter more competent, massive bedrock sections. It should be noted that pile penetration depends on many factors which are not currently known and precise estimates are not possible.

It is recommended that piles are installed over their entire length by driving with diesel, gravity, air or hydraulic pile hammers. Installation by vibratory hammer is not recommended.

Given the limited thickness of the very soft silt overburden, the use of a driving template, or similar means to control the pile location during driving, may be needed.

## Closure

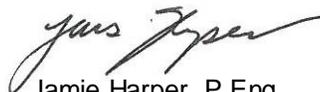
We trust this information meets your requirements. Please contact us if you have any questions, or require additional information.

Sincerely,



Brian Walker, P.Eng.  
Senior Geotechnical Engineer

exp Services Inc.



Jamie Harper, P.Eng.  
Geotechnical Engineer

exp Services Inc.



**exp** Services Inc.

*SHM Canada Consulting Limited  
Bear Point Wharf Reconstruction, Nova Scotia  
Project Number: **exp** HFX-00231668-A0  
June 09, 2016*

## **Appendix A Laboratory Test Results**



# Table 1- SUMMARY OF LABORATORY TEST RESULTS

CLIENT SHM Canada Consulting  
 LOCATION Bear Point Wharf, Bear Point, NS  
 PROJECT No. HFX-00231668-A0

TESTING:  
 Moisture Content: 1  
 Atterberg Limits: 0  
 Sieve Analysis: 1  
 Hydrometer Test: 0  
 UCS: 5

Soil Deposit	Borehole/Sample	Depth (m)	Water Content (%)	Atterberg Limits			Sieve Analysis			UCS (MPa)
				Liquid Limit	Plastic Limit	Plasticity Index	Gravel (%)	Sand (%)	Fines (%)	
Bedrock	BH-02/RC - 5	9.3								86.4
Bedrock	BH-02/RC - 8	14.0								77.5
Bedrock	BH-04/RC - 4	7.3								70.0
Bedrock	BH-05/RC - 3	6.0								88.8
Bedrock	BH-06/RC - 6	6.5								94.3
Silt	BH-01/SS - 2	4.6	70.5				0.0	10.9	89.1	

TEST SUMMARY Rev. 4/1/13 BEAR POINT BOREHOLE LOGS:GPJ DATA ENTRY.GDT 6/1/16 Printed by: harperj



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*SHM Canada Consulting Limited  
Bear Point Wharf Reconstruction, Nova Scotia  
Project Number: **exp** HFX-00231668-A0  
June 09, 2016*

## **Appendix B**

# **Descriptive Terms Used on Borehole Logs**

## **Borehole Logs**

## Descriptive Terms - Borehole and Test Pit Logs

Grain Size	0.01	0.1	1.0	10	100	1000	(mm)
	Clay&Silt	Sand			Gravel	Cobble	Boulder
	0.075	0.425	2.0	4.76	76.4	200	
Soils	Compactness (gravel, sand, tills)	<b>N, Range</b>	0 - 4	4 - 10	10 - 30	30 - 50	>50
		<b>Density</b>	V. Loose	Loose	Compact	Dense	V. Dense
Consistency (silt, clay)	<b>S, kPa</b>	< 12.5	12.5 - 25	25 - 50	50 - 100	100 - 200	
	<b>Consistency</b>	V. Soft	Soft	Firm	Stiff	V. Stiff	

Rock	<b>RQD</b>	<b>Overall Quality</b>			<b>Fracture Spacing</b>			
	0 - 25	Very Poor			< 50 mm Very Close			
	25 - 50	Poor			50 - 300 mm Close			
	50 - 75	Fair			0.3 - 1 m Moderate			
	75 - 90	Good			1 - 3 m Wide			
	90 - 100	Excellent			> 3 m Very Wide			
	<b>Comp. Str., MPa</b>	0.25 - 1	1 - 5	5 - 25	25 - 50	50 - 100	100 - 250	> 250
	<b>Description</b>	Extremely Weak	Very Weak	Weak	Medium Strong	Strong	Very Strong	Extremely Strong

### Sample Types (location to scale on log)

<b>SS</b>	Split Spoon	<b>B</b>	Shovel (bulk)
<b>T</b>	Shelby Tube	<b>H</b>	Carved Block
<b>P</b>	Piston	<b>V</b>	In Situ Vane
<b>F</b>	Auger	<b>NR</b>	No Recovery
<b>W</b>	Wash		

**Rock Cores: BQ (36.5mm), NQ (47.6mm), HQ (63.5mm)**

### Notation and Symbols

<p><b>N</b> - N-value from standard penetration test; blows by 475 J drop hammer to advance std. 50mm O.D. split spoon sampler 0.3m</p> <p><b>RQD</b> - percent of core consisting of hard, sound pieces in excess of 100mm long (excluding machine breaks)</p> <p><b>Recovery</b> - sample recovery expressed as percent or length</p> <p><b>S</b> - shear strength, kPa</p> <p><b>Sr</b> - shear strength, remoulded</p> <p><b>Dd</b> - dry density, t/m<sup>3</sup></p> <p><b>W</b> - natural moisture content, percent</p>	<p><b>PL</b> - plastic limit, percent</p> <p><b>LL</b> - liquid limit, percent</p> <p style="text-align: center;">▼</p> <p style="text-align: center;">▼</p> <p style="text-align: center;">▼</p> <p>- groundwater level</p> <p>- seepage</p>
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## SYMBOLS AND TERMS USED ON THE BOREHOLE AND TEST PIT RECORDS

### **Soil Description**

Behavioral properties (i.e., plasticity, permeability) take precedence over particle gradation in describing soils.

### **Terminology Describing Soil Structure**

<b>Desiccated</b>	Having visible signs of weathering by oxidation of clay minerals,
<b>Fissured</b>	Having cracks and, hence, a blocky structure
<b>Varved</b>	Composed of regular alternating layers of silt and clay
<b>Stratified</b>	Composed of alternating layers of different soil type, e.g., silt and sand
<b>Well Graded</b>	Having wide range in grain size and substantial amounts of all
<b>Uniformly Graded</b>	Predominantly of one grain size

Terminology used for describing soil strata based upon the proportion of individual particle sizes present:

<b>Trace, or occasional</b>	Less than 10%
<b>Some</b>	10–20%
<b>Adjective</b> (e.g., silty or sandy)	20–35%
<b>And</b> (e.g., silt and sand)	35–50%

The standard terminology to describe cohesionless soils includes the relative density, as determined by laboratory test or by the Standard Penetration Test “N”-value: the number of blows of 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2-inch (50.8 mm) O.D. splitspoon sampler one foot (305 mm) into the soil.

<b>Relative Density</b>	<b>“N” Value</b>	<b>Relative Density %</b>
Very Loose	<4	<15
Loose	4–10	15–35
Compact	10–30	35–65
Dense	30–50	65–85
Very Dense	50	>85

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by in-situ vane tests, penetrometer tests, unconfined compression tests, or occasionally by standard penetration tests.

### **Undrained Shear Strength**

<b>Consistency</b>	<b>kips/sq. ft.</b>	<b>kPa</b>	<b>“N” Value</b>
Very Soft	<0.25	<12.5	<2
Soft	0.25–.50	12.5–25	2–4
Firm	0.5–1.0	25–50	4–8
Stiff	1.0–2.0	50–100	8–15
Very Stiff	2.0–4.0	100–200	15–30
Hard	>4.0	>200	>30



# BOREHOLE RECORD

CLIENT SHM Canada Consulting

PROJECT No. HFX-00231668-A0

LOCATION Bear Point Wharf, Bear Point, NS

BOREHOLE No. BH-01

DATES of BORING May 17, 2016 WATER LEVEL \_\_\_\_\_

DATUM CVGD

DEPTH (m)	ELEV. (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					Undrained Shear Strength, kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	OTHER TESTS	20	40	60	80						
0	0.8	HARBOUR					mm				10	20	30	40	50	60	70	80	90
2	-1.3	Harbour Sediments SILT (ML), very soft, saturated, black. Strong Organic Odor.			SS	1	90	0		●									
5					SS	2	510	1	WC SVE	●									
6					SS	3	460	2		●									
7	-5.9	BEDROCK Grey Granodiorite transitioning to Tonalite with depth, strong, very poor to fair quality, very close to moderate fracture spacing, fractures oriented predominantly at 45 to 60 degrees to horizontal with some near vertical fractures.			SS	4	0	50 for 1"											
7					RC	5	100%	0											
8	-7.6				RC	6	78%	51											
8.4		End of Borehole @ 8.4 m Depth.																	

GEOTECHNICAL-ENVIRONMENTAL LOG Rev: 5/4/12 BEAR POINT BOREHOLE LOGS.GPJ DATA ENTRY.GDT 6/1/16 Printed by: harperj



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# BOREHOLE RECORD

CLIENT SHM Canada Consulting

PROJECT No. HFX-00231668-A0

LOCATION Bear Point Wharf, Bear Point, NS

BOREHOLE No. BH-02

DATES of BORING May 17, 2016 WATER LEVEL \_\_\_\_\_

DATUM CVGD

DEPTH (m)	ELEV. (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					Undrained Shear Strength, kPa										
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	OTHER TESTS	20	40	60	80							
0	2.4	HARBOUR																		
5	-2.5	Harbour Sediments SILT (ML), very soft, saturated, black. Strong Organic Odor.																		
6					SS	1	0	0												
7	-4.9	BEDROCK Grey Granodiorite transitioning to Tonalite with depth, strong, very poor to good quality, very close to moderate fracture spacing, fractures oriented predominantly at 45 to 60 degrees to horizontal with some near vertical fractures.  UCS = 86.4 MPa @ 9.3 m Depth.																		
8					SS	2	0	50 for 1"												
8					RC	3	52%	51												
9					RC	4	47%	80												
10					RC	5	50%	17	UCS											
11					RC	6	80%	73												
12					RC	7	100%	65												
14					RC	8	100%	73	UCS											
15	-12.5	End of Borehole @ 14.9 m Depth.																		

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# BOREHOLE RECORD

CLIENT SHM Canada Consulting

PROJECT No. HFX-00231668-A0

LOCATION Bear Point Wharf, Bear Point, NS

BOREHOLE No. BH-03

DATES of BORING May 18, 2016 WATER LEVEL \_\_\_\_\_

DATUM CVGD

DEPTH (m)	ELEV. (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					Undrained Shear Strength, kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	OTHER TESTS	20	40	60	80						
0	2.4	HARBOUR					mm				10	20	30	40	50	60	70	80	90
5	-2.5	Harbour Sediments SILT (ML), very soft to very stiff, saturated, black. Strong Organic Odor.			SS	1	0	1		●									
7					SS	2	330	26			●								
8	-5.7	BEDROCK Grey Granodiorite transitioning to Tonalite with depth, strong, very poor to poor quality, very close to close fracture spacing, fractures oriented predominantly at 45 to 60 degrees to horizontal with some near vertical fractures.			SS	3	10	50 for 1"											
9					RC	4	20%	0											
10					RC	5	14%	0											
11	-8.2	End of Borehole @ 10.7 m Depth.			RC	6	44%	25											

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# BOREHOLE RECORD

CLIENT SHM Canada Consulting

PROJECT No. HFX-00231668-A0

LOCATION Bear Point Wharf, Bear Point, NS

BOREHOLE No. BH-04

DATES of BORING May 18, 2016 WATER LEVEL \_\_\_\_\_

DATUM CVGD

DEPTH (m)	ELEV. (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					Undrained Shear Strength, kPa										
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	OTHER TESTS	20	40	60	80							
0	1.8	HARBOUR					mm				10	20	30	40	50	60	70	80	90	
5	-2.8	Harbour Sediments SILT (ML), very soft, saturated, black. Strong Organic Odor.			SS	1	0	1		●										
6	-4.3	BEDROCK Grey Granodiorite transitioning to Tonalite with depth, strong, very poor to fair quality, very close to close fracture spacing, fractures oriented predominantly at 45 to 60 degrees to horizontal with some near vertical fractures. UCS = 70.0 MPa @ 7.3 m Depth.			SS	2	50	1		●										
						SS	3	0	50 for 1"		●									
7						RC	4	54%	51	UCS										
8						RC	5	19%	11											
11						RC	6	19%	12											
12	-10.1	End of Borehole @ 11.9 m Depth.																		

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# BOREHOLE RECORD

CLIENT SHM Canada Consulting PROJECT No. HFX-00231668-A0  
 LOCATION Bear Point Wharf, Bear Point, NS BOREHOLE No. BH-05  
 DATES of BORING May 18, 2016 WATER LEVEL \_\_\_\_\_ DATUM CVGD

DEPTH (m)	ELEV. (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					Undrained Shear Strength, kPa									
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	OTHER TESTS	20	40	60	80						
0	0.8	HARBOUR																	
1																			
2																			
3																			
4	-2.6	Harbour Sediments																	
	-3.7	SILT (ML), very soft to hard, saturated, black. Strong Organic Odor.																	
5		BEDROCK																	
		Grey Granodiorite transitioning to Tonalite with depth, strong, very poor to poor quality, very close to close fracture spacing, fractures oriented predominantly at 45 to 60 degrees to horizontal with some near vertical fractures. UCS = 88.8 MPa @ 6.0 m Depth.																	
6																			
7																			
8																			
9																			
10																			
11	-9.6	End of Borehole @ 10.5 m Depth.																	
12																			
13																			
14																			
15																			
16																			

GEOTECHNICAL-ENVIRONMENTAL LOG Rev: 5/4/12 BEAR POINT BOREHOLE LOGS.GPJ DATA ENTRY.GDT 6/1/16 Printed by: harperj



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# BOREHOLE RECORD

CLIENT SHM Canada Consulting

PROJECT No. HFX-00231668-A0

LOCATION Bear Point Wharf, Bear Point, NS

BOREHOLE No. BH-06

DATES of BORING May 18, 2016 WATER LEVEL \_\_\_\_\_

DATUM CVGD

DEPTH (m)	ELEV. (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					Undrained Shear Strength, kPa											
					TYPE	NUMBER	RECOVERY	N-VALUE OR RQD	OTHER TESTS	20	40	60	80								
0	1.1	HARBOUR					mm				10	20	30	40	50	60	70	80	90		
4	-2.3	Harbour Sediments SILT (ML), very soft to very stiff, saturated, black. Strong Organic Odor.			SS	1	10	1		●											
5	-4.2	Coarse Grained Granite Gravel, compact, saturated, grey.			SS	2	40	1		●											
6	-4.8				SS	3	300	28				●									
6	-4.8	BEDROCK Grey Granodiorite transitioning to Tonalite with depth, strong, very poor to poor quality, very close to close fracture spacing, fractures oriented predominantly at 45 to 60 degrees to horizontal with some near vertical fractures. UCS = 94.3 MPa @ 6.5 m Depth.			SS	4	380	16			●										
7					SS	5	0	50 for 1"													
8	-7.4				RC	6	43%	43	UCS												
8	-7.4				RC	7	15%	0													

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