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January 26, 2011 File No. 144-01

Morse Construction Attn: Mr. Glenn Morse P.O. Box 1466 Scarborough, ME 04070

Re: 218 Wash

218 Washington Avenue Slope Stability

Portland, Maine

Dear Glenn

Soil Metrics LLC is pleased to present the results of a stability analysis for a proposed steep riprap slope at your 218 Washington Avenue residence in Portland, Maine. The project involves adding a parking lot to the left side of an existing residence (looking down slope). The lot will be approximately 70 feet long and approximately 40 feet deep, and constructed out of imported fill with a side slope away from Washington Avenue of 1H:1V. A plan showing the approximate dimensions of the parking lot in relation to the existing house is shown on the attached Figure 1, from Blais Civil Engineers. The plan currently calls for the 1H:1V slope to be covered with riprap. This report presents the results of a stability analysis performed to evaluate the global stability of the proposed new slope, and to assess if reinforcing might be necessary to enhance the stability.

<u>Subsurface Conditions and Assumed Soil Properties</u>: Six borings were drilled at the site at locations shown on Figure 1 in 2006 by Sebago Technics for a previous project at the site. The logs, included in Appendix A, indicate the subsurface conditions consist of the following from the ground surface:

<u>Topsoil</u>: Consisting of very loose to loose brown silty sand (SM) with roots. The thickness was 0.3 foot.

<u>Fill</u>: Consisting of very loose to medium dense, brown well graded sand with silt (SW-SM) to silty sand (SM), to poorly graded sand with silt (SP/SM) with various amounts of gravel, wood, bricks, bituminous and cinders. The thickness varied from 3.7 to 9.7 feet.

Marine Fan (Sand): Consisting of medium dense, brown to light brown well-graded sand with Gravel (SW). Up to 9 feet of this stratum was encountered.

<u>Marine Sand</u>: Consisting of loose to medium dense brown poorly graded sand with silt (SP/SM); to silty sand (SM). The thickness varied from 6 to 11 feet.

<u>Marine Clay</u>: Consisting of medium stiff, gray brown lean clay (CL). One boring near the bottom of the slope may have penetrated the clay deposit, indicating a thickness of 5.8 feet. The other borings were terminated in the stiff clay.

The borings were not extended to refusal and were terminated in a medium stiff clay except at B5 indicated above. Figure 2 is an interpretive subsurface profile through the center line of the proposed embankment fill. Borings B-2 (top of slope) and B4 (bottom of slope), were used to develop a subsurface profile of foundation conditions beneath the proposed embankment fill and forms the basis of the stability analysis.

Page 2

The stiff clay stratum is interpreted as about 5-feet thick. Below the stiff clay, two additional strata of clay are assumed, with a slightly lower undrained shear strength.

There were no laboratory tests performed on the samples recovered from the borings. Engineering properties for the slope stability analysis were assumed based on the Standard Penetration Test (SPT) N-values and experience with similar materials. The assumed soil parameters used in the analysis are listed below in Table 1.

Table 1
Summary of Engineering Properties used in Stability Analyses

Soil Type	Unit W	/eight (pcf)	Strength Parameters						
	Moist	Saturated	Effective Internal Angle of Friction (degrees)	Cohesion (psf)					
New Fill for embankment	135	135	35	0					
Existing fill	135	120	30	0					
Marine sand	115	115	30	0					
Stiff Clay	115	115	0	1,500					
Lower assumed clay strata	110	110	0	1,000					

Stability Analysis Results:

Global stability analyses were conducted to assess the impact of the fill placement on the stability of the foundation soils, and the internal stability of the steep 1H:1V final slope configuration. The analyses were conducted using the computer program Slope/W (2007). A series of analyses a were conducted and are summarized below.

<u>Case 1 Figure 3, Existing Conditions</u>: The existing factor of safety was calculated as about 1.5 to 1.6 for surfaces passing through the loose fill and marine sands.

<u>Case 2 Figure 4: New Embankment - No reinforcing</u>: The minimum failure surfaces pass through the new embankment fill and loose marine. The minimum calculated factor was about 0.9 for surfaces passing through the end of the steep slope. Surfaces extending further into the fill and loose sand had factors of safety in the range of 1.1.

Case 3 Figures 5 through 7: New Embankment - Geogrid Reinforcement: The calculated minimum factor of safety is about 1.4 for slip surfaces that pass behind the reinforcing. The presence of the grid forces the minimum circles beyond the grid. Hypothetical slip surfaces that pass through the grid are on the order of 1.5 as indicated on Figure 6. The minimum calculated FS of 1.39 as indicated on Figure 5 assumes a water table surface at the base of the fill soils at a depth of 11 feet in Boring B2, and at about 6 feet below ground at Boring B-4. The borings were drilled in July 2006 and indicated dry conditions in both borings which were drilled to depths of 17 feet each. A water table was included in the stability analysis because water surfaces can increase seasonally. The surface depicted on the stability analysis profile is considered to be a reasonably conservative assumption, although the exact water table location is not known. The same analysis was re-run without a water table and the factor of safety was 1.6 as indicated on Figure 7. The actual factor of safety under most conditions is likely somewhere between 1.4 and 1.6. The above analyses were limited to depths explored by the borings, down to the stiff clay stratum with an undrained shear strength of 1,500 psf. As noted on the profile, a lower strength clay stratum was modeled to explore the impact that lower unknown/unexplored softer clay would have on the overall stability. Figure 8 shows the minimum calculated factor of safety of about 1.4 using an undrained shear strength of

1,000 psf. This seems like a reasonable assumption, however the only way to confirm deeper conditions would be to drill deeper borings.

Geogrid reinforcement will be necessary in order to improve the factor of safety in the embankment fill and shallow existing fill and marine sands. Details of the recommended grid elevations and lengths are provided on Figure 9. In order get the grid back far enough in the slope beneath the new fill, the existing slope will have to be cut back at a 1.5H to 1V angle to remove the existing fill. The bottom grid length is 27 feet at elevation 79 feet and extends from the back of the cut face to the end of the granular fill soil. The grid does not extend into the riprap. Ten layers of geogrid are necessary, spaced every 2 feet in elevation. The lengths increase by one foot up the slope to the upper layer (layer 10) at elevation 97 with a length of 36 feet.

The ends of the granular fill adjacent to the riprap will require wrapping in a geotextile to contain the fill and prevent it from unraveling and filtering into the riprap facing on the slope. The slope wrapping is shown on Detail A, Figure 9. Specifications for the geogrid, geotextile and granular backfill are indicated on Figure 9.

After the cut slope has been made, the existing subgrade on which the first layer of grid will be placed should be compacted with intense surface compaction. This can be accomplished using a vibratory roller or at least 30,000 pounds operating at a frequency of 30 cycles per second (Hz) and a minimum of 10 passes. Following the vibratory rolling, the surface should be compacted with at least 2 passes without vibration, to densify the near surface soils. New fill within the embankment should be placed in loose lift thicknesses of no more than 1-foot, and be compacted to 95 percent of ASTM D-1557.

The proposed construction includes a cast-in-place retaining wall to be built on the right side, perpendicular to the slope between the parking lot and the house. You may want to consider a segmental block, mechanically stabilized earth wall for this structure as it might be a cheaper alternative. Some of the geogrid for the slope reinforcement might be able to be utilized for the wall.

Thank you for the opportunity to provide geotechnical engineering services on this project. If you have any questions about this report, please do not hesitate to contact me.

Very truly yours,

SOIL METRICS LLC

Stephen J. Rabasca, P.E.

Enclosures:



Figure 1: Site and Boring Location Plan

Figure 2: Interpretive Subsurface Profile

Figure 3: Stability Analysis Results - Existing Conditions

Figure 4: Stability Analysis Results - Embankment - No Reinforcement

Figure 5: Stability Analysis Results - Embankment Reinforcement - Surfaces beyond Grid

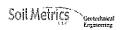
Figure 6: Stability Analysis Results - Embankment Reinforcement - Surfaces through Grid

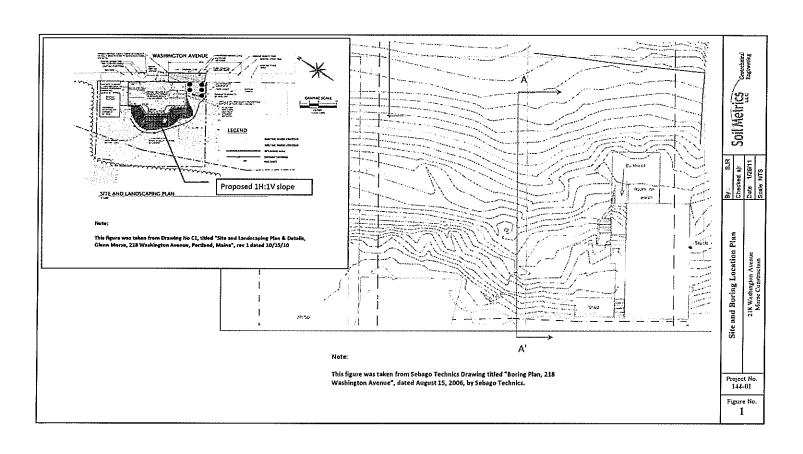
Figure 7: Stability Analysis Results - No Groundwater Table

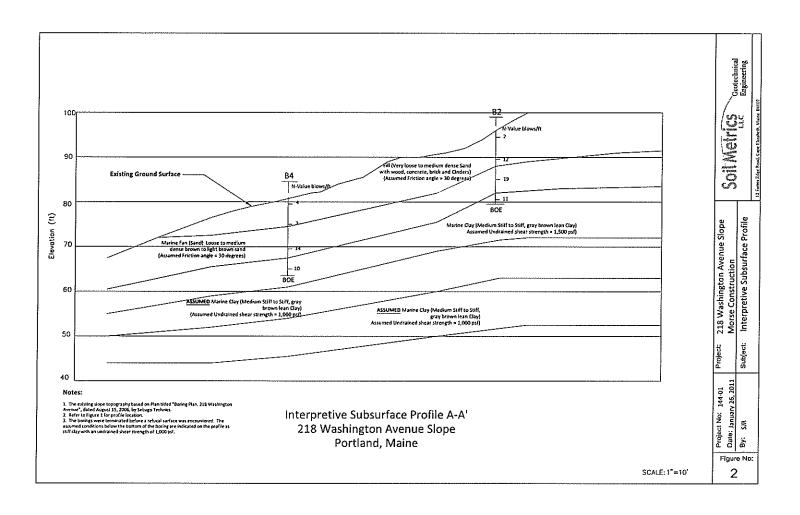
Figure 8: Stability Analysis Results - Deep softer Clay

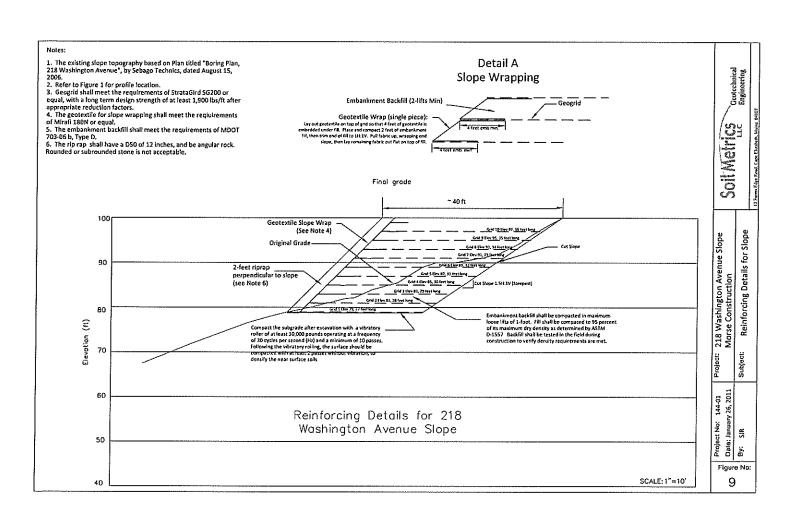
Figure 9: Slope Reinforcement Details

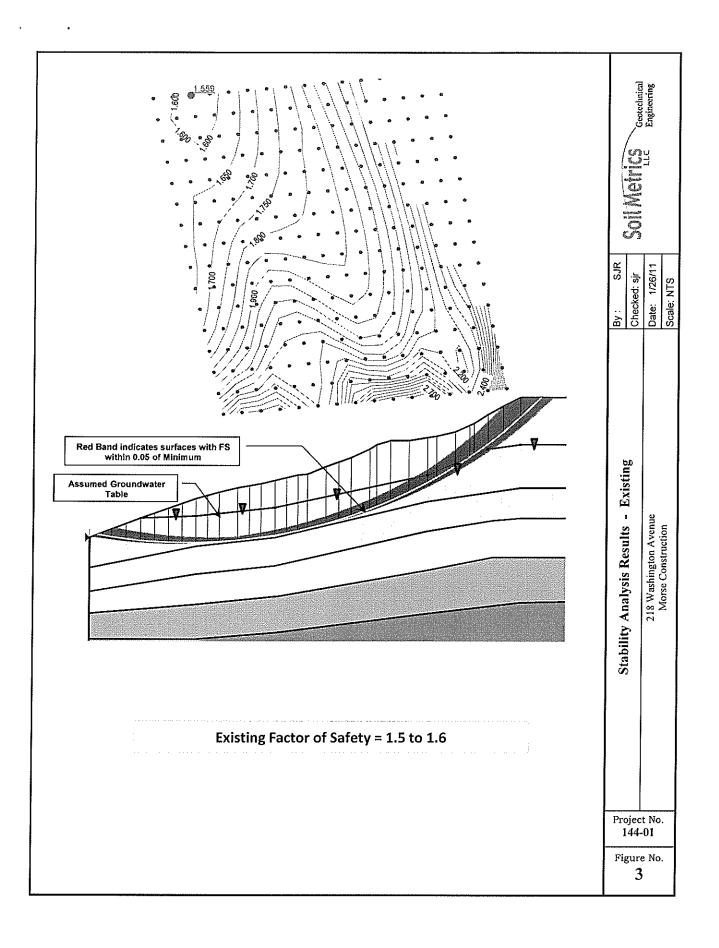
Appendix A - Sebago Technics Boring Logs

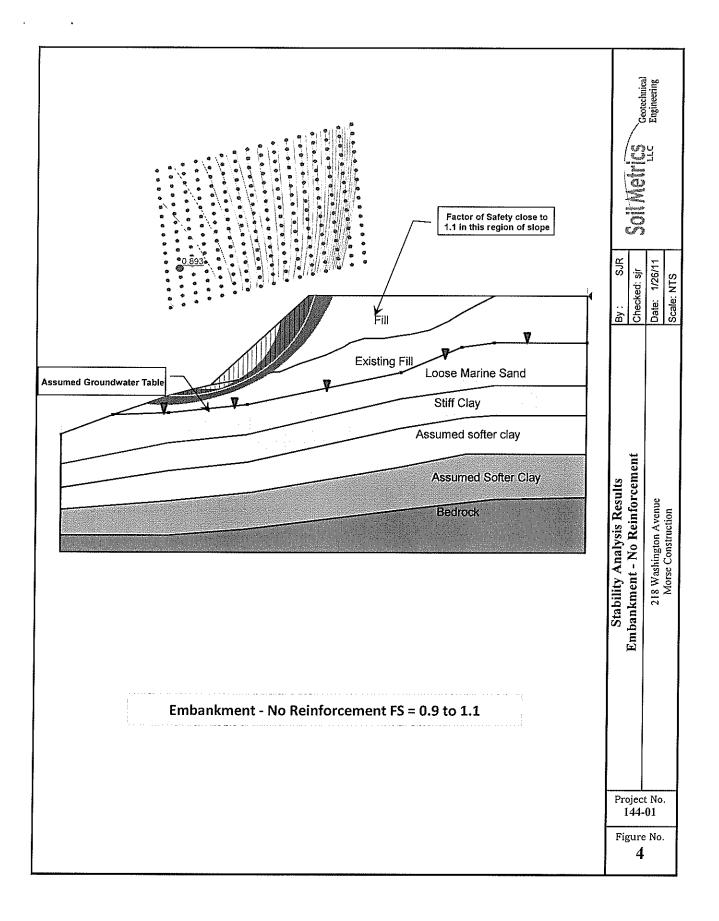


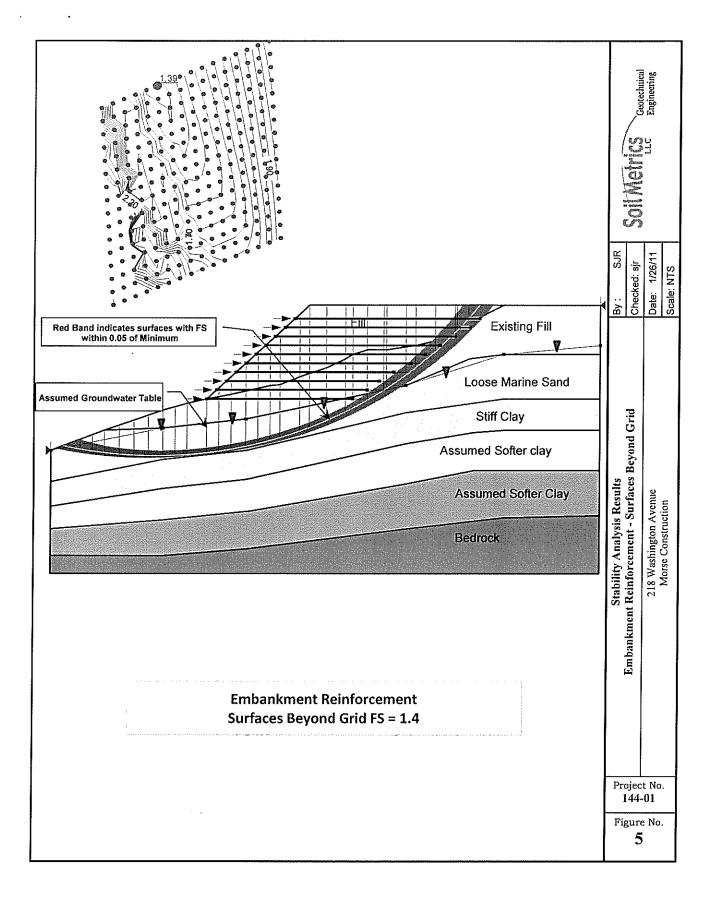


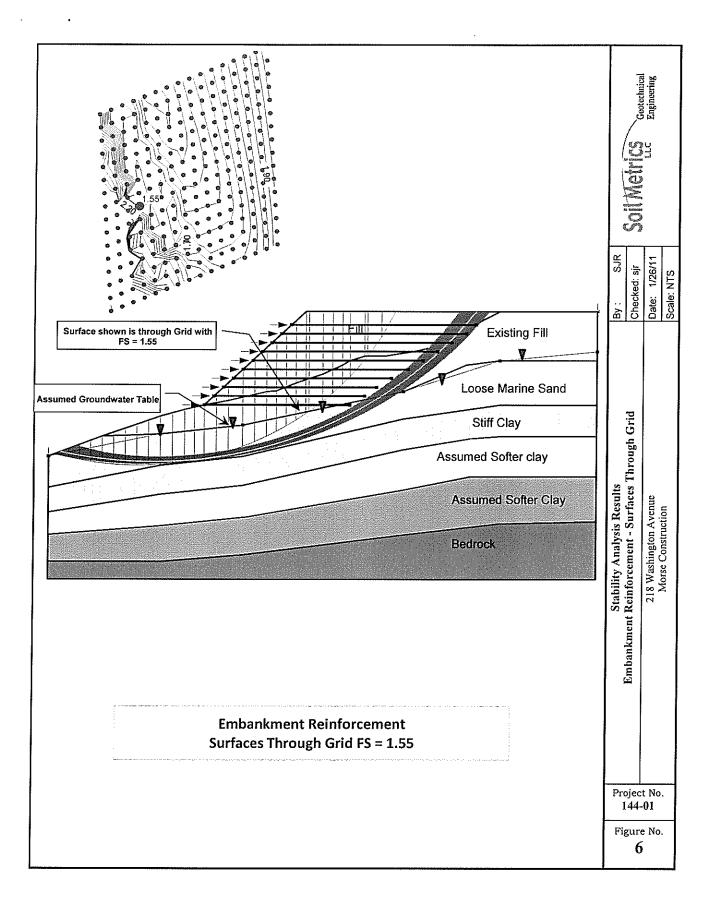


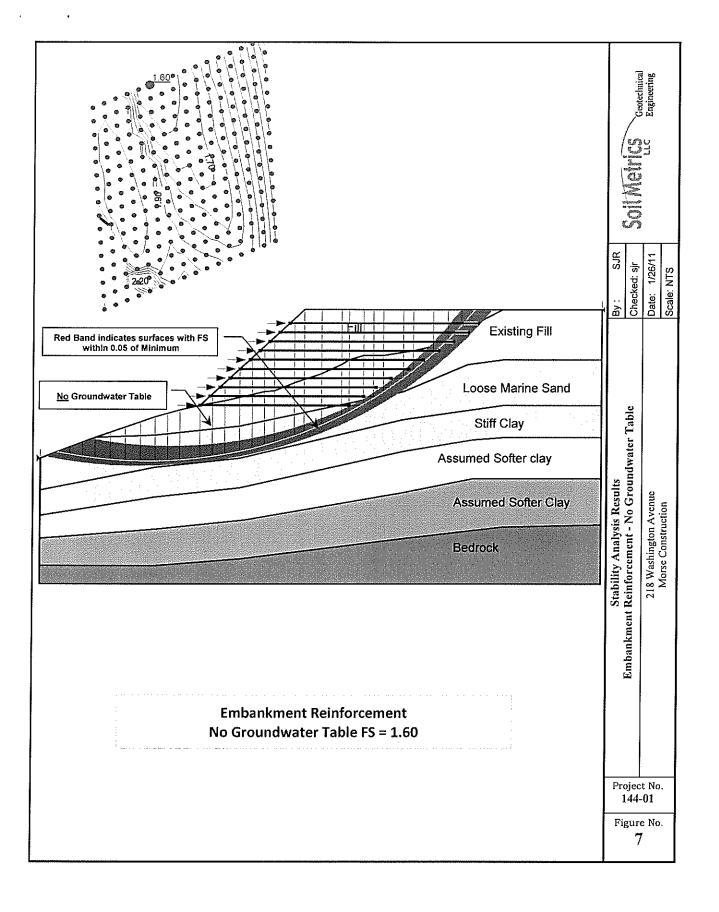


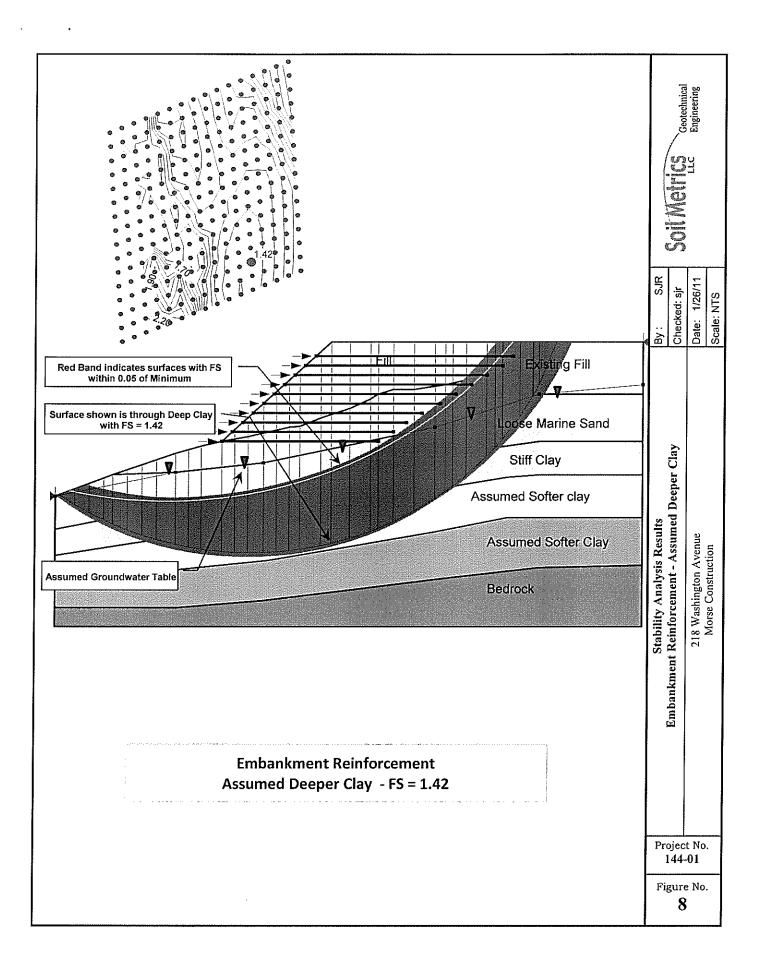












APPENDIX A

BORING LOGS

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→ 15 -	2	S4	15.0			s₩	Loose, light brown we	ll-graded	SAND with gravel	(SW), mps = 1.0 in.,	10	5	40	40	5											
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	-,	Water L	evel Data	<u></u>			Sample ID		Well Diagram			Su	וחתו	эгу	<u>_</u> _				<u> </u>	۵						
Date	Time	Elapsed Time (hr.)	Bottom of Casing	Bottom of Hole	to: Water	Ŧ	Open End Rod Thin Wall Tube	[2]	Riser Pipe Screen Filler Sand	Overburden (Linear Rock Cored (Linear	ft)	-				17.0										
7/27/06	1530			14.0	Dry		Undisturbed Sample Split Spoon Sample		Cuttings Grout	Number of Samples	i	-				45	—	—	_							
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Field	Tests	Dilatancy:	R - Ra	pid S-Slo	w N - None		Plasticity:		Bentonite Seal Nonplastic L - L	.ow M • Medium H •	Hic	h								\dashv						
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SEBAC TECHI INC.							Т	EST	BORING F	REPO	PRT	· · · · · · · · · · · · · · · · · · ·				Pa			B4		
PROJECT LOCATION CLIENT CONTR.	ON ACTOR		HINGT CONST LEST B	RUCTIO	NUE, PC		ND, M	MAINE				STI JOB NO. PROJECT MGR. FIELD REP. DATE STARTED DATE FINISHED		S. K.		ANK STE		NSO			
Elevation Item	1	ft Casir	Datu	ım Sampler	1 Core B			Location ke & Mo		B47/5	3	Hammer Type	Del	lliing	Mar		T	Гас	log i	o che	ince
Type Inside Di	ameter (in.) Weight (ib.)	HSA 1.5		\$\$ 1.375			Tru AT\	ck [Tripod Geoprobe		Cat-Head Winch Roller Bit	Safety Doughnut		Вe	nlon lyme	iite			Mell	iod l	Depth
Hammer					alaine.		Skk				Cutting Head	Drilling Notes:		rave!		San	rd			ield	Test
Depth (ft	Sampler) Blows per in.		Sa	mple th (ft.)	Well Hagram	Stra Cha (ft	пде	USCS Symbol	(density/consistency,	colos, GR		escription DL, maximum particle sixe*, peologic interpretation)		Т	ų.	E	Т.	% Fines	-	,,	Piasticity
- 0 -	2 2 2	S1		0.0			*******	SM	Very loose, light brow mps = 1.0 in., dry	n silty S		(), traces concrete,	5	10	10	30	25	20			
	2	6	2	2.0		11.	5	SM	Very loose, brown sill	y sand	-FILL, with gravel (SM), tr	aces brick, mps = 1.0 in.	5	10	30	20	20	is		_	
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D-4-	- There	Water L Elapsed		Depth	in feet t	0:	#	0 (Sample ID Open End Rod			Overburden (Linear	ft.)	Sui	mma	ify	1	7.0			
Date 7/27/2006	Time	Time (hr.)	Botto: Casi	ing i	tom of lole	Wate		T :	Thin Wall Tube Undisturbed Sample		Filler Sand Cuttings Grout	Rock Cored (Linear Number of Samples	ft)	_				 4S			- -
						Dry			Split Spoon Sample Seoprobe	[EZ]	Concrete Bentonile Seal	BORING NO.				{	84				
Field	Tests	Dilatancy: Toughness		Rapid Low M	- Mediun	n H-I	High	o je dat		- None	L - Low M - Me	Low M - Medium H - dium H - High V - V tions of sampler size.			<u> </u>						
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SEBAG		TEST BORING REPORT														BORING NO. B5 Page 1 of									
INC. PROJECT LOCATION CLIENT CONTRA DRILLER	ON ACTOR	218 WAS MORSE	HINGTON CONSTRUC TEST BORI			, MAINE			STI JOB NO. PROJECT MGR. FIELD REP. DATE STARTED DATE FINISHED		K.	72 RAN	IK EPHI 06			of									
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Depth (ft.)	Sampler Blows per In.		Sample	Well) Diagram	Stratum Change (ft.)	USCS Symbol	Visual-i (densky/consistency, co	Manual Identification & D lor, GROUP NAME & SYMEC Disture, optional descriptions, g	escription L, maximum particle size*.	% Coarse g	% Fine		Wedken W Fine	% Fires	-	Toughness a	Plasicky Strength								
- c -	2 3 4 2	\$1 8	2.0	1 0 10 10 10 10 10 10 10 10 10 10 10 10	****************	SM	gravel piece, grass rool	IO (SM), traces bituminous s to 0.1 in, dry -FILL- el in cuttings from 2.0 to 4.				20	30 30	20			,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,								
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- 5 -	5 5	S2 24	5.0		- 100	SM	Loose, gray-brown mol clay lenses, damp	tled silty SAND (SM), mp		60	20														
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→ 10 –	10 11 10	S3 15	10.0		**************************************		Medium dense, brown damp	poorly-graded SAND with	silt (SP), mps = 1.2 m.	s	5	4	0 40	10											
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Date 7/27/06	T(me	Elapsed Time (hr.)	Bottom of Casing	Bottom of Hole	Water	T T	O Open End Rod DEU Screen Overburden (Linear ft.) 22.0 T Thin Wall Tube ESI Filter Sand Rock Cored (Linear ft.) — U Undisturbed Sample ESI Cuttings Number of Samples 5S										- - -								
7/27/06	1355 Tests	Dilalancy: Toughness	 R - Ra	19.0 pid S - Slov M - Mediu	18.0 v N - None	G (Seoprobe Plasticity:	Concrete Bentonite Seal	BORING NO. Low M - Medium H - dium H - High V - V				В5				\exists								
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Depth (it.)	Sampler Blows per In.		Sample Depth (it	Well) Diagram	Stratum Change (fL)	USCS Symbol	(density/consistency,	color, GRO	Identification & De DUP NAME & SYMBOL Iptional descriptions, ge	, maximuso particle size",		Т	% Coarse		% Fire	% Fines	Dilatancy		_							
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7/27/06	1445		-	9.0	Dry		Split Spoon Sample		Grout						_		_	_	_	4						
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Field	Tosts	Dilatancy:		pid S-Slo			Plasticity:	N	- Nonplastic L - I	ow M - Medium H					_				_	٦						
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