Attachment A
Baxter Road Stabilization Alternatives Analysis

MEMORANDUM

TO: Kara Buzanoski, Director of Public Works, Town of Nantucket

FROM: Nicolle Burnham, Milone & MacBroom, Inc.

DATE: October 1, 2013

RE: Alternatives Analysis Summary
Baxter Road Temporary Stabilization
Nantucket, Massachusetts
MMI #2967-11

Per request of the town of Nantucket, Milone & MacBroom, Inc. has evaluated potential methods of stabilizing Baxter Road to protect access to private residences and existing sewer and water utilities located beneath the roadway. As noted on our memorandum of September 24, 2013 the goal of this current effort is to maintain vehicular access and utility service to the residential properties on Baxter Road from Bayberry Lane north to the Sankaty Head Lighthouse. The project limits evaluated by MMI are limited to those areas where Baxter Road appears in imminent danger of failure from bank failure. Specifically, our project area extends from 85 to 91 Baxter Road and from 99 to 107.

Design Criteria

For the purposes of MMI's work, measures installed will be considered temporary and intended to provide some level of protection for the short term, while long term solutions are considered by the SBPF and the town. The town has requested that the measures implemented under MMI's work consider a three year life. Given the varied erosion rates from year to year it is not possible to guarantee a specific design life of any stabilization measure here.

After considering the project site and having discussions with Haley & Aldrich, who has performed geotechnical evaluations on behalf of SBPF, we evaluated four potential stabilization methods:

1. Steel sheet piling along the toe of the bluff
2. Steel sheet piling along the top of the bluff (adjacent to Baxter Road)
3. Geotubes along the toe of the bluff
4. Grout injections for soil stabilization beneath the glacial till layer

Attached please find a matrix that compares each alternative, a plan view that depicts the installation location of each, and cross sections views that detail each alternative. Each alternative is described below.

Alternate 1

This alternate would entail driving steel sheet piling along the toe of the bluff for a distance of approximately 1720 feet, essentially through the project sections defined above, and to a depth of approximately 20 feet. The sheet piling would serve to protect the toe of slope from erosion due to wave action. To maintain this system, sand may have to be replaced along the waterward face of sheeting periodically as erosion occurs. Construction would result in steel sheeting being visible from the existing ground surface to elevation 22.0, with an average exposed height of five feet. Not only would this create less than desirable aesthetics, the sheeting would create an unnatural physical barrier paralleling the shoreline. The bulkhead would likely be capped with poured-in-place concrete. This option, focusing on

addressing the toe of slope, is considered technically feasible but costly and unlikely to be permitted by the Town's Conservation Commission.

Alternate 2

The second alternative would involve driving steel sheet piling along the edge of Baxter Road, or the edge of the town-owned roadway right-of-way, generally to the limits described above. The intent is to protect the town-owned infrastructure, rather than address toe failure. The premise behind this alternative is that the sheet piling would support the roadway in the event of a total or partial but significant slope failure. Theoretically this alternative is viable, however considering the practicality of construction and geotechnical limitations of the area, several issues suggest that driving sheeting along the roadway is not feasible. First, the sheets would be very long and difficult to drive through the thick glacial till layer. Additionally, a substantial tieback system would be required, extending under the street and likely conflicting with utilities. The depth of the sheets would be determined, in part, by the assumed retained height based on some failure scenario. Accommodating a complete slope failure would be largely infeasible, and planning for a partial failure would be difficult given the nature of the sandy soil layer along the toe of slope and difficulty in establishing slope stability in conjunction with the sheet piling. Finally, while this alternative attempts to protect the roadway and related infrastructure, it affords no protection for the privately owned properties. For these reasons, this alternative has been deemed infeasible.

Alternative 3

This alternative entails placement of sand-filled geotextile tubes along the toe of slope to provide temporary protection from wave and tidal action. This alternative is largely constructible, the sand fill is readily available, and the option presents a costs effective, short term solution for protecting the toe of slope within the town's study area. In protecting the slope, this treatment may result in short-term slope stabilization. It is critical to understand, however, that these structures could be overtopped and/or undermined even with detailed design consideration. Failure of the geotubes could result in failure of Baxter Road and we cannot predict when this may occur. While these measures are considered temporary, the installation of geotextile tubes can be expected to retard slope failure and can be designed to prevent slope failure from normal tidal events. While there would be some impact to aesthetics, we would anticipate this alternative can be permitted locally, given its temporary nature. For these reasons this alternative is deemed a viable option for the short-term.

Alternative 4

Alternative 4 was presented by Haley & Aldrich (H&A) in our discussions with them. The grout would be injected into the cohesionless sand layer at the toe of the slope and would serve to strengthen or enhance the properties of the otherwise weak soil. From our discussions with H&A and based on their previous findings in the field, the grouted sand layer would be approximately 35 feet thick. The weak sand layer is overlain by a thick glacial till. This material in itself can be stabilized under normal conditions, however given it is founded on the cohesionless underlying sand makes the glacial till susceptible to failure as has been the case. This alternative has the advantage of being low impact when compared to other options, particularly given the fact the grout will be 'invisible' from the surface following construction and restoration of the impacted areas. While this alternative may be cost prohibitive as a temporary solution, we are not dismissing this option and recommend it be studied further.

Discussion on Alternatives

After discussing this project with Haley and Aldrich we find that the selected alternative for short-term improvements should be one which, at a minimum, protects the cohesionless sand layer along the toe of

the slope. Ideally the best long term solution should be one which stabilizes the cohesionless sand layer more permanently. Based on these principles, Alternative 2 has been deemed infeasible. Haley & Aldrich prepared a memorandum detailing this further in a memorandum to SBPF dated September 27, 2013. Based on where our investigations have led us thus far, we recommend the town pursue Alternative 3, sand filled geotextile tubes at the toe of slope, to provide short-term protection while long term solutions are further explored.

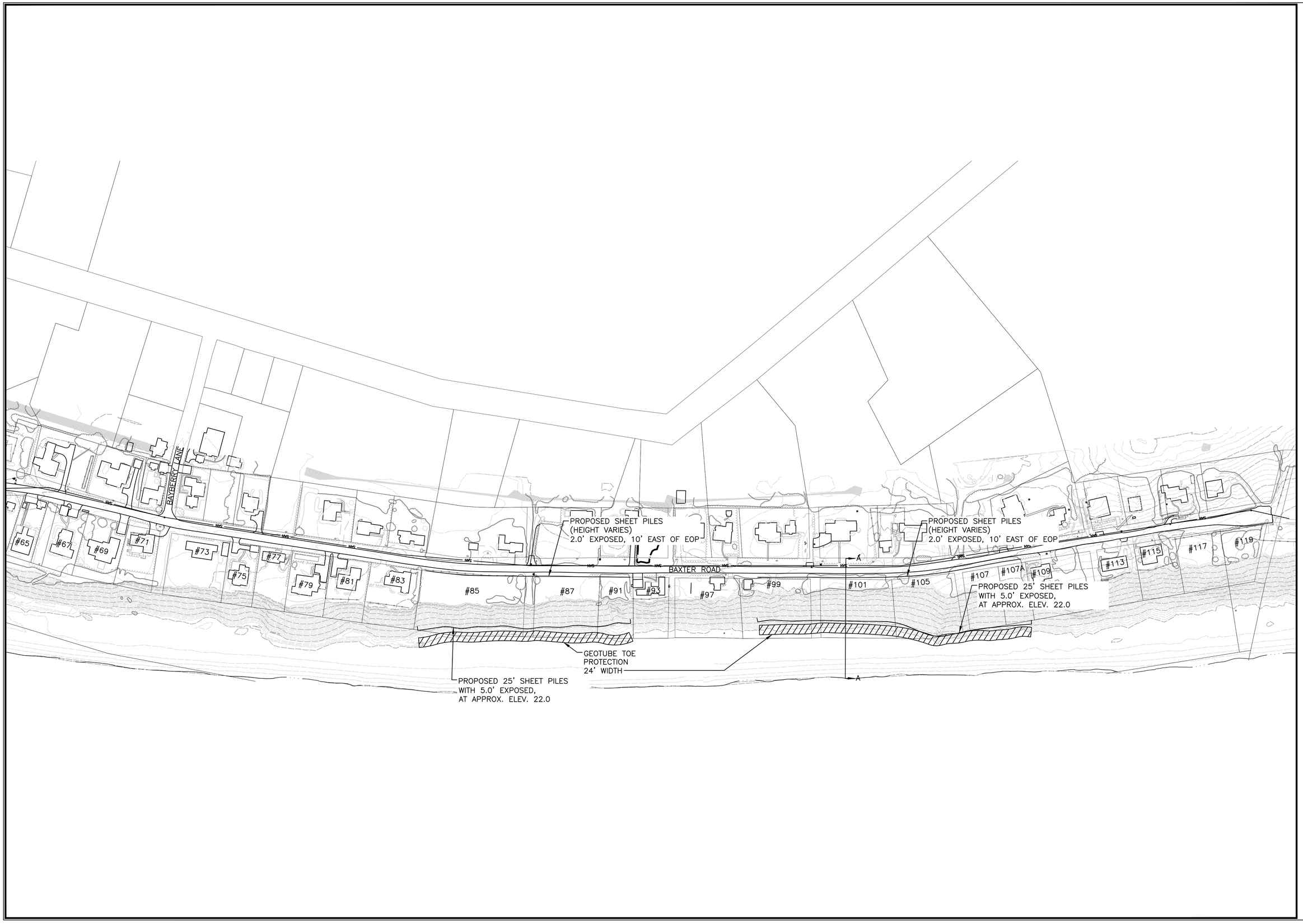
Further Discussion

In reviewing the slope stability analysis completed by Haley & Aldrich in 2007 and their memorandum of September 27, 2013 we note that their conclusions indicate that the slope would be stable at and approximately 40 degree angle. The current slope in our project area ranges from 31 to 40 degrees with some sections near the top of slope as steep as 56 to 68 degrees. The implication is that the top of the slope in our project area is inherently unstable, even with toe protection. In 2007 Haley & Aldrich recommended toe stabilization combined with flattening the slope as the appropriate means of stabilizing this area. None of the options we evaluated suggest grading the slope. In our opinion we need to make the town aware of this issue, but we would not use a lack of proposed grading as a means to delay short term toe revetment installation. Without doing anything the bank will likely fail. By installing the toe revetment the failure may be delayed long enough to develop a long term solution.

In addition to the toe stabilization we recommend that “run-on” to this slope from roadway and lawn drainage and irrigation water be avoided. As the soils at the top of slope become saturated, weight is added to the bank, increasing the instability.

Emergency Preparedness

In a letter to the town dated September 24, 2013 we recommended that emergency planning measures be developed to address emergency access and water and sewer service the Baxter Road in the event that failure occurs. To that end, we suggest the town develop a written action plan to provide physical access, water and sewer facilities to the dwellings on Baxter Road in the event of a failure of one or more of those town-owned facilities. In addition to having a written plan, with buy-in from appropriate emergency and other staff, securing the necessary permissions and/or materials which may be necessary to respond in an emergency situation would obviously improve response time. We understand the town has initiated this process.



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PLAN VIEW - SLOPE STABILIZATION ALTERNATIVES

BAXTER ROAD
SLOPE STABILIZATION

NANTUCKET, MASSACHUSETTS

RSD	SW	---
DESIGNED	DRAWN	CHECKED

SCALE: 1" = 100'

DATE: SEPT. 27, 2013

PROJECT NO.: 2967-11

SHEET NO.: 1 OF 6

SHEET NAME:

STABILIZATION ALTERNATIVE	DESCRIPTION	ALTERNATIVE ADVANTAGES	ALTERNATIVE DISADVANTAGES	APPROXIMATE CONSTRUCTION ESTIMATE	APPROXIMATE CONSTRUCTION DURATION
ALTERNATIVE #1 STEEL SHEET PILES	SHEET PILES DRIVEN AT TOE OF SLOPE, AT APPROXIMATE ELEVATION 22.0. PILES TO BE 25.0' LONG WITH 5.0' LEFT EXPOSED	SHEETING PROVIDES SOLID PROTECTION FROM UNDERMINING AND EROSION OF TOE THROUGH WAVE ACTION DURING STORMS. PILES INSTALLED IN SAND LENS AT TOE OF SLOPE MORE EASILY INSTALLED. SOIL COMPOSITION REQUIRES LESS IMPACT OR VIBRATION TO REACH DESIRED INSTALLATION DEPTH. INSTALLATION FROM BEACH PROVIDES RESULTS IN FEWER DISRUPTIONS TO BAXTER ROAD VEHICLE TRAFFIC AND LOCAL RESIDENTS.	STEEL SHEETING IS A FORM OF HARD ARMORING EROSION PROTECTION. WAVE REFLECTION MAY BECOME A CONCERN IF THE SAND IN FRONT OF THE SHEETING ERODES. ANY SAND WHICH ERODES FROM IN FRONT OF THE SHEETING WILL NEED TO BE REPLENISHED PRIOR TO REMOVAL OF SHEETING. SAND MAY NEED TO BE REPLENISHED EACH SPRING. CRANE AND OTHER EQUIPMENT WILL REQUIRE ADDITIONAL MOBILIZATION TO REMOVE PILES. MATERIAL/EQUIPMENT WILL NEED TO BE BARGED TO SHORE. DANGER OF FLANKING AT ENDS.	SHEET PILE ESTIMATE APPROXIMATE TOTAL SHEET PILE WALL LENGTH = 1,270 FT TYPICAL DRIVEN DEPTH = 25.0 FT UNIT PRICE = $50/SF INSTALLED SHEETING COST = $1,587,500 SAND REPLENISHMENT ESTIMATE TOTAL REPLENISHMENT VOLUME = 6,600 CY UNIT PRICE = $50/CY SAND REPLENISHMENT COST = $330,000 (PER APPLICATION) TOTAL ESTIMATED COST = $1,917,500	ESTIMATED DAILY OUTPUT = 1000 SF PER 8 HOUR DAY TOTAL BURIED SHEETING SQUARE FOOTAGE = 28,575 SF ESTIMATED CONSTRUCTION DURATION = 29 WORK DAYS
ALTERNATIVE #2 STEEL SHEET PILES	SHEET PILES DRIVEN AT THE TOP OF SCONSET BLUFF, APPROXIMATELY 10' EAST OF THE EASTERN EDGE OF BAXTER ROAD.	SHEETING CAN BE INSTALLED FROM THE TOP OF THE BLUFF, ELIMINATING THE NEED TO BARGE EQUIPMENT ONTO THE BEACH. SHEETING SHOULD PREVENT SUDDEN CATASTROPHIC COLLAPSE OF BAXTER ROAD AND EXISTING UTILITIES SHOULD THE BLUFF ERODE AND RETREAT TOWARDS THE ROADWAY.	TO PREVENT GLOBAL FAILURE OF THE SLOPE PILES WILL NEED TO HAVE A LENGTH OF 80 FT OR MORE. INSTALLATION IS IN CLOSE PROXIMITY TO RESIDENCES. DUE TO THE DENSE SOIL COMPOSITION AT THE TOP OF THE BLUFF THE SHEET PILES WILL NEED TO BE HAMMERED INTO THE GROUND. THIS INSTALLATION TECHNIQUE WILL BE DISRUPTIVE TO RESIDENTS. DRIVING OF PILES IN CLOSE PROXIMITY TO EXISTING WATER MAIN ALONG BAXTER ROAD COULD CREATE UNSEEN DAMAGE AND/OR LEAKS. SHEET PILE INSTALLATION AT TOP OF BLUFF DOES NOT PREVENT/RETARD EROSION AT THE TOE OF THE SLOPE. IF THE SLOPE FAILS UP TO THE SHEET PILES FUTURE REMOVAL MAY BECOME DIFFICULT/IMPOSSIBLE. CRANE WILL NEED TO BE INSTALLED WITHIN BAXTER ROAD, BLOCKING ACCESS TO AREAS TO THE NORTH.	SHEET PILE ESTIMATE APPROXIMATE TOTAL SHEET PILE WALL LENGTH = 1,160 FT TYPICAL DRIVEN DEPTH = 80 FT UNIT PRICE = $50/SF INSTALLED SHEETING COST = $4,640,000 TOTAL ESTIMATED COST = $4,640,000	ESTIMATED DAILY OUTPUT = 750 SF PER 8 HOUR DAY TOTAL BURIED SHEETING SQUARE FOOTAGE = 92,800 SF ESTIMATED CONSTRUCTION DURATION = 124 WORK DAYS
ALTERNATIVE #3 SAND-FILLED GEOTUBES	LARGE GEOTEXTILE TUBE FILLED WITH SAND. INSTALLED AT TOE OF SLOPE TO PROTECT AGAINST UNDERMINING OF SAND TOE.	INSTALLATION MATERIAL (OTHER THAN GEOTUBE) IS AVAILABLE ON ISLAND. INSTALLATION CAN BE COMPLETED WITH A RELATIVELY SMALL WORK CREW IN A VERY SHORT TIMEFRAME IN A COST-EFFECTIVE MANNER. TOE SCOUR IS PREVENTED BY THE ADDITION OF A GEOTEXTILE FABRIC WING WHICH IS PART OF THE GEOTUBE SYSTEM. REMOVAL OF GEOTUBE AT COMPLETION OF TEMPORARY STABILIZATION REQUIRES ONLY THE REMOVAL OF GEOTEXTILE FABRIC. SAND FILLING COULD REMAIN ON BEACH, IF DESIRED, WHICH COULD BE USED FOR FUTURE REPLENISHMENT.	GEOTEXTILE FABRIC COULD BE TORN BY LARGE DEBRIS CONTAINED WITHIN STORM WAVES. SAND BACKFILL MAY NEED TO BE REPLENISHED AFTER EACH STORM SEASON. SAND DELIVERY SYSTEM AT TOP OF BLUFF (CRANE W/HOPPER, CONVEYOR BELT, ETC.) COULD BE DISRUPTIVE TO RESIDENTS. DANGER OF FLANKING AT ENDS OF GEOTUBE.	GEOTUBE ESTIMATE APPROXIMATE TOTAL GEOTUBE LENGTH = 1,220 FT UNIT PRICE = $560/LF INSTALLED GEOTUBE COST = $683,200 SAND BACKFILL ESTIMATE TOTAL BACKFILL VOLUME = 4,300 CY UNIT PRICE = $50/CY SAND BACKFILL COST = $215,000 TOTAL ESTIMATED COST = $898,200	ESTIMATED DAILY OUTPUT = 150 FT PER 8 HOUR DAY APPROXIMATE TOTAL GEOTUBE LENGTH = 1,220 SF ESTIMATED CONSTRUCTION DURATION = 9 WORK DAYS
ALTERNATIVE #4 GROUT INJECTION	SHAFTS ARE DRILLED INTO THE SLOPE FROM THE TOE UPWARD, FOLLOWED BY PRESSURE INJECTION OF GROUT WHICH HARDENS/STRENGHTENS THE WEAK SAND AT THE BASE OF THE SLOPE.	WEAK SAND LAYER AT BASE OF BLUFF IS HARDENED, INCREASING ITS RESISTANCE TO EROSION DUE TO STORM WAVE ACTION. GROUTING CAN BE COMPLETED FROM THE BEACH, ELIMINATING POTENTIAL IMPACTS TO RESIDENTS. GROUT COMPOSITION DOES NOT CHANGE THE APPEARANCE OF SAND. GROUTED SECTION SHOULD NOT REQUIRE ANY MAINTENANCE.	TO ADEQUATELY STRENGTHEN THE SLOPE, GROUTING WOULD BE REQUIRED OVER A RELATIVELY LARGE AREA (35 FT HEIGHT X 35 FT DEPTH). SOIL GROUTING NEEDS TO BE USED IN TANDEM WITH ADDITIONAL SLOPE STABILIZATION TO PROTECT AGAINST WAVE SCOUR (E.G. GEOTUBE). MATERIAL/EQUIPMENT WILL NEED TO BE BARGED ONTO THE BEACH FOR INSTALLATION. GROUT COMPOSITION NEEDS TO BE CUSTOMIZED BASED ON EXISTING SOIL CONDITIONS, INCREASING LEAD TIME. ESTIMATED CONSTRUCTION DURATION IS EXCESSIVE BASED ON PROJECT NEEDS.	GROUT INJECTION ESTIMATE APPROXIMATE GROUT CROSS SECTIONAL VOLUME = 80 CY/FT TOTAL GROUTED SLOPE LENGTH = 1,220 FT UNIT PRICE = $375/CY INSTALLED GROUTING COST = $36,600,000 GEOTUBE ESTIMATE INSTALLED GEOTUBE COST (FROM ABOVE) = $845,950 TOTAL ESTIMATED COST = $37,445,950	ESTIMATED DAILY OUTPUT = 500 CY PER 8 HOUR DAY TOTAL GROUTED VOLUME = 97,600 CY ESTIMATED CONSTRUCTION DURATION = 196 WORK DAYS

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TYPICAL CROSS SECTION - SLOPE STABILIZATION

BAXTER ROAD SLOPE STABILIZATION

NANTUCKET, MASSACHUSETTS

RSD	SW	---
DESIGNED	DRAWN	CHECKED

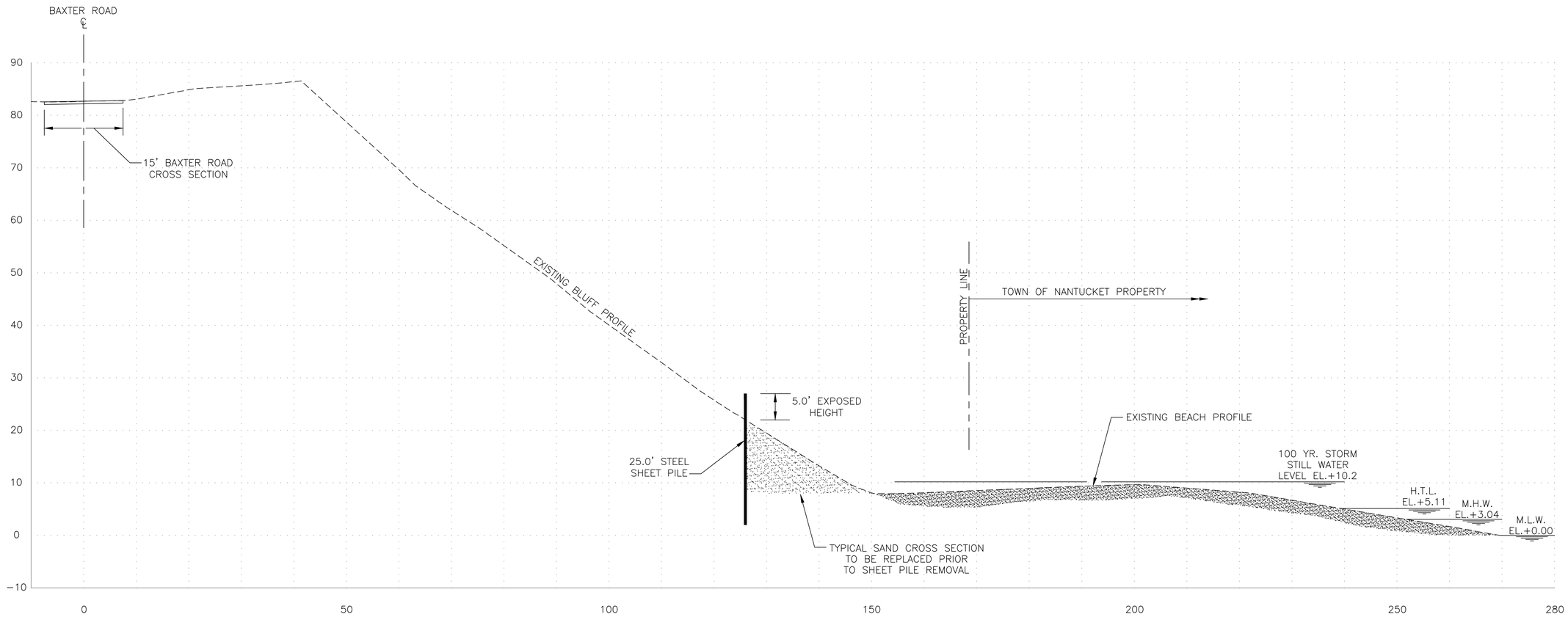
SCALE: N.T.S.

DATE: SEPT. 27, 2013

PROJECT NO.: 2967-11

SHEET NO.: 2 OF 6

SHEET NAME: MATRIX



SECTION A–A: ALTERNATIVE 1

STABILIZATION ALTERNATIVE	DESCRIPTION	ALTERNATIVE ADVANTAGES	ALTERNATIVE DISADVANTAGES	APPROXIMATE CONSTRUCTION ESTIMATE	APPROXIMATE CONSTRUCTION DURATION
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TYPICAL CROSS SECTION - SLOPE STABILIZATION - ALTERNATIVE 1

BAXTER ROAD
SLOPE STABILIZATION

NANTUCKET, MASSACHUSETTS

RSD	SW	---
DESIGNED	DRAWN	CHECKED

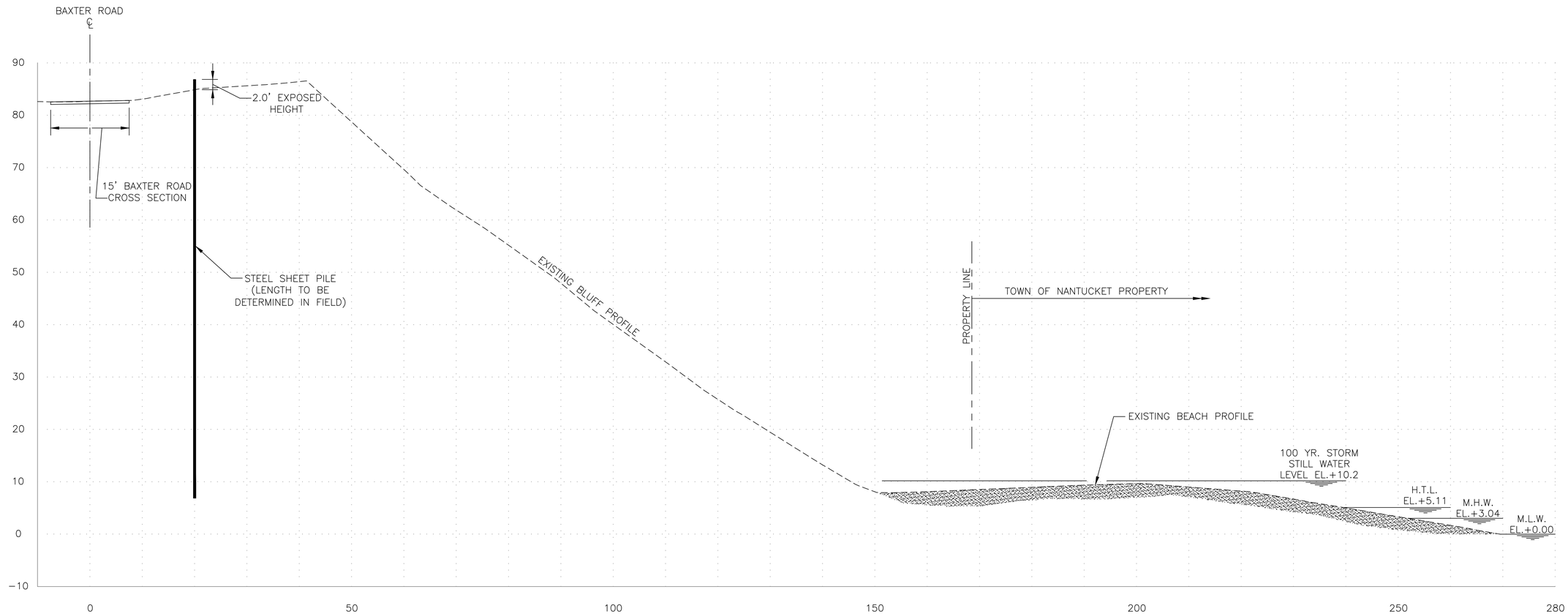
SCALE: 1" = 10'

DATE: SEPT. 27, 2013

PROJECT NO.: 2967-11

SHEET NO.: 3 OF 6

SHEET NAME: ALT 1



SECTION A–A: ALTERNATIVE 2

STABILIZATION ALTERNATIVE	DESCRIPTION	ALTERNATIVE ADVANTAGES	ALTERNATIVE DISADVANTAGES	APPROXIMATE CONSTRUCTION ESTIMATE	APPROXIMATE CONSTRUCTION DURATION
ALTERNATIVE #2 STEEL SHEET PILES	SHEET PILES DRIVEN AT THE TOP OF SCONSET BLUFF, APPROXIMATELY 10' EAST OF THE EASTERN EDGE OF BAXTER ROAD.	SHEETING CAN BE INSTALLED FROM THE TOP OF THE BLUFF, ELIMINATING THE NEED TO BARGE EQUIPMENT ONTO THE BEACH. SHEETING SHOULD PREVENT SUDDEN CATASTROPHIC COLLAPSE OF BAXTER ROAD AND EXISTING UTILITIES SHOULD THE BLUFF ERODE AND RETREAT TOWARDS THE ROADWAY.	TO PREVENT GLOBAL FAILURE OF THE SLOPE PILES WILL NEED TO HAVE A LENGTH OF 80 FT OR MORE. INSTALLATION IS IN CLOSE PROXIMITY TO RESIDENCES. DUE TO THE DENSE SOIL COMPOSITION AT THE TOP OF THE BLUFF THE SHEET PILES WILL NEED TO BE HAMMERED INTO THE GROUND. THIS INSTALLATION TECHNIQUE WILL BE DISRUPTIVE TO RESIDENTS. DRIVING OF PILES IN CLOSE PROXIMITY TO EXISTING WATER MAIN ALONG BAXTER ROAD COULD CREATE UNSEEN DAMAGE AND/OR LEAKS. SHEET PILE INSTALLATION AT TOP OF BLUFF DOES NOT PREVENT/RETARD EROSION AT THE TOE OF THE SLOPE. IF THE SLOPE FAILS UP TO THE SHEET PILES FUTURE REMOVAL MAY BECOME DIFFICULT/IMPOSSIBLE. CRANE WILL NEED TO BE INSTALLED WITHIN BAXTER ROAD, BLOCKING ACCESS TO AREAS TO THE NORTH.	SHEET PILE ESTIMATE APPROXIMATE TOTAL SHEET PILE WALL LENGTH = 1,160 FT TYPICAL DRIVEN DEPTH = 80 FT UNIT PRICE = $50/SF INSTALLED SHEETING COST = $4,640,000 TOTAL ESTIMATED COST = $4,640,000	ESTIMATED DAILY OUTPUT = 750 SF PER 8 HOUR DAY TOTAL BURIED SHEETING SQUARE FOOTAGE = 92,800 SF ESTIMATED CONSTRUCTION DURATION = 124 WORK DAYS

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TYPICAL CROSS SECTION - SLOPE STABILIZATION - ALTERNATIVE 2

BAXTER ROAD SLOPE STABILIZATION

NANTUCKET, MASSACHUSETTS

RSD	SW	---
DESIGNED	DRAWN	CHECKED

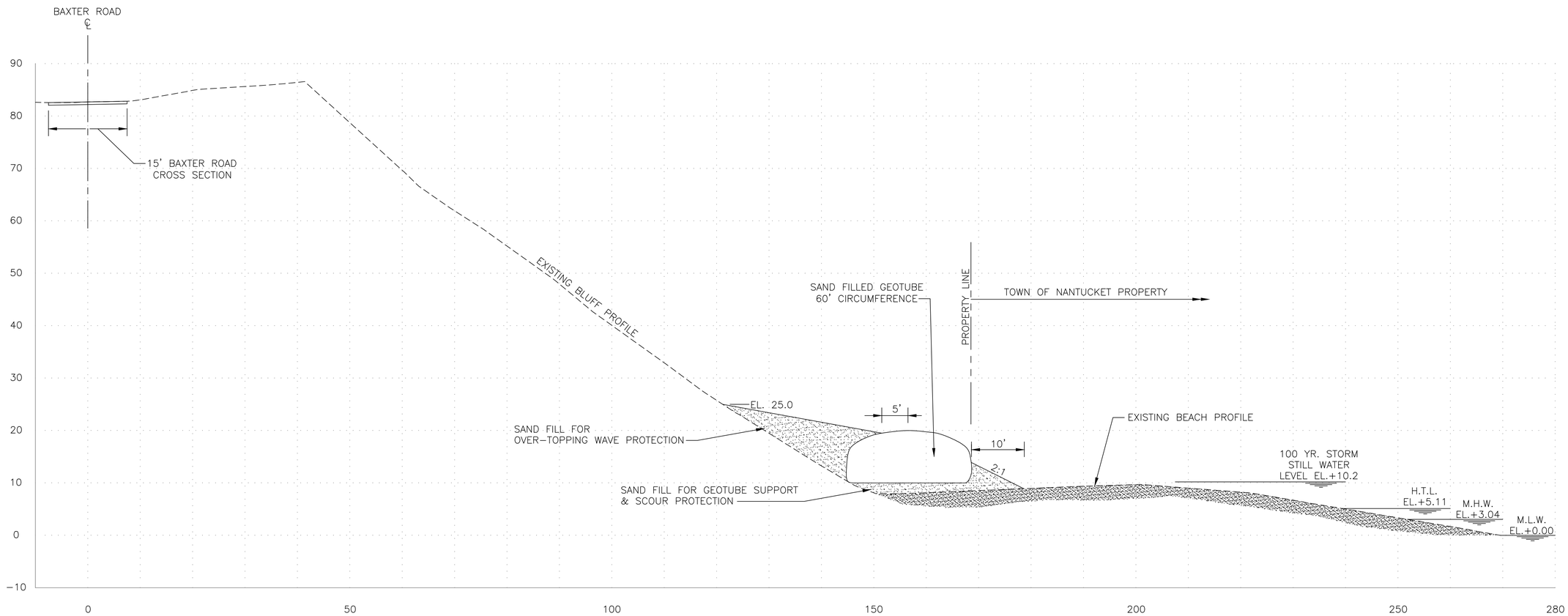
SCALE: 1" = 10'

DATE: SEPT. 27, 2013

PROJECT NO.: 2967-11

SHEET NO.: 4 OF 6

SHEET NAME: ALT 2



SECTION A–A: ALTERNATIVE 3

STABILIZATION ALTERNATIVE	DESCRIPTION	ALTERNATIVE ADVANTAGES	ALTERNATIVE DISADVANTAGES	APPROXIMATE CONSTRUCTION ESTIMATE	APPROXIMATE CONSTRUCTION DURATION
ALTERNATIVE #3 SAND–FILLED GEOTUBES	LARGE GEOTEXTILE TUBE FILLED WITH SAND. INSTALLED AT TOE OF SLOPE TO PROTECT AGAINST UNDERMINING OF SAND TOE.	INSTALLATION MATERIAL (OTHER THAN GEOTUBE) IS AVAILABLE ON ISLAND. INSTALLATION CAN BE COMPLETED WITH A RELATIVELY SMALL WORK CREW IN A VERY SHORT TIMEFRAME IN A COST–EFFECTIVE MANNER. TOE SCOUR IS PREVENTED BY THE ADDITION OF A GEOTEXTILE FABRIC WING WHICH IS PART OF THE GEOTUBE SYSTEM. REMOVAL OF GEOTUBE AT COMPLETION OF TEMPORARY STABILIZATION REQUIRES ONLY THE REMOVAL OF GEOTEXTILE FABRIC. SAND FILLING COULD REMAIN ON BEACH, IF DESIRED, WHICH COULD BE USED FOR FUTURE REPLENISHMENT.	GEOTEXTILE FABRIC COULD BE TORN BY LARGE DEBRIS CONTAINED WITHIN STORM WAVES. SAND BACKFILL MAY NEED TO BE REPLENISHED AFTER EACH STORM SEASON. SAND DELIVERY SYSTEM AT TOP OF BLUFF (CRANE W/HOPPER, CONVEYOR BELT, ETC.) COULD BE DISRUPTIVE TO RESIDENTS. DANGER OF FLANKING AT ENDS OF GEOTUBE.	GEOTUBE ESTIMATE APPROXIMATE TOTAL GEOTUBE LENGTH = 1,220 FT UNIT PRICE = $560/LF INSTALLED GEOTUBE COST = $683,200 SAND BACKFILL ESTIMATE TOTAL BACKFILL VOLUME = 4,300 CY UNIT PRICE = $50/CY SAND BACKFILL COST = $215,000 TOTAL ESTIMATED COST = $898,200	ESTIMATED DAILY OUTPUT = 150 FT PER 8 HOUR DAY APPROXIMATE TOTAL GEOTUBE LENGTH = 1,220 SF ESTIMATED CONSTRUCTION DURATION = 9 WORK DAYS

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TYPICAL CROSS SECTION - SLOPE STABILIZATION - ALTERNATIVE 3

BAXTER ROAD
SLOPE STABILIZATION

NANTUCKET, MASSACHUSETTS

RSD	SW	---
DESIGNED	DRAWN	CHECKED

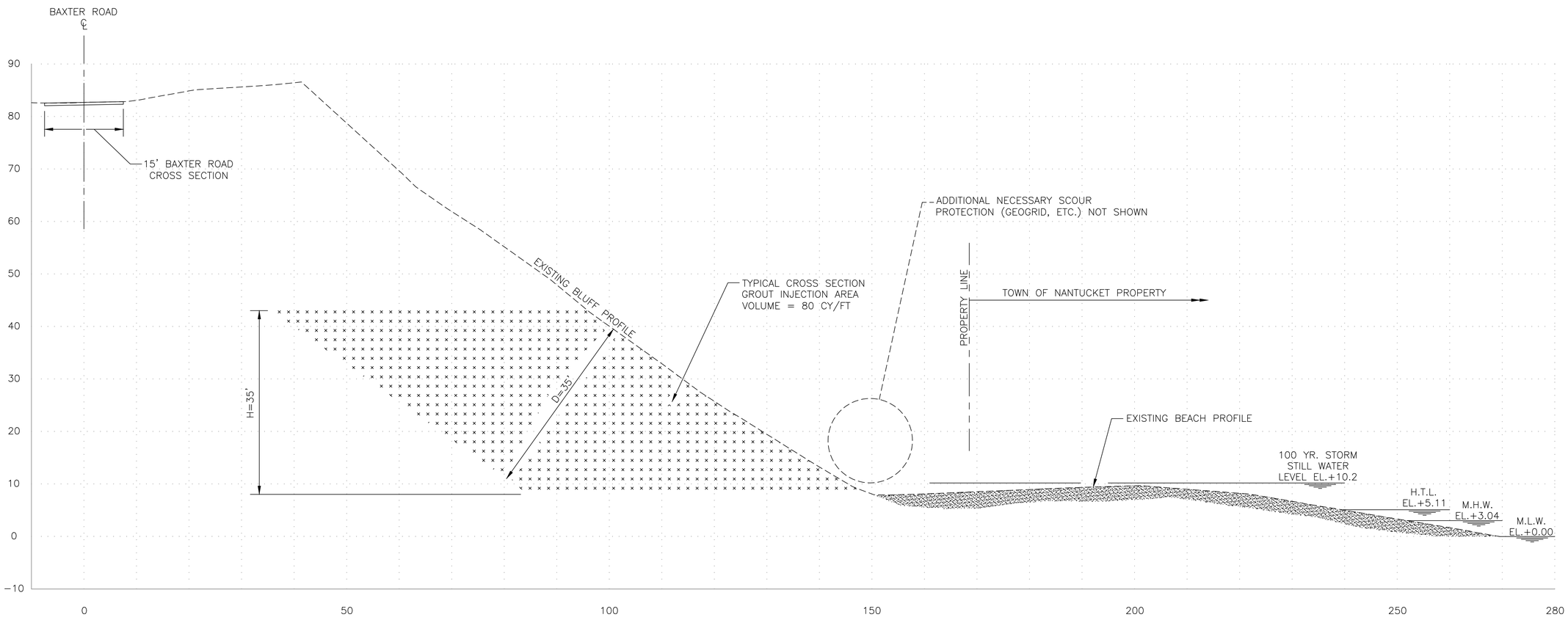
SCALE: 1" = 10'

DATE: SEPT. 27, 2013

PROJECT NO.: 2967-11

SHEET NO.: 5 OF 6

SHEET NAME: ALT 3



SECTION A–A: ALTERNATIVE 4

STABILIZATION ALTERNATIVE	DESCRIPTION	ALTERNATIVE ADVANTAGES	ALTERNATIVE DISADVANTAGES	APPROXIMATE CONSTRUCTION ESTIMATE	APPROXIMATE CONSTRUCTION DURATION
ALTERNATIVE #4 GROUT INJECTION	SHAFTS ARE DRILLED INTO THE SLOPE FROM THE TOE UPWARD, FOLLOWED BY PRESSURE INJECTION OF GROUT WHICH HARDENS/STRENGHTENS THE WEAK SAND AT THE BASE OF THE SLOPE.	WEAK SAND LAYER AT BASE OF BLUFF IS HARDENED, INCREASING ITS RESISTANCE TO EROSION DUE TO STORM WAVE ACTION. GROUTING CAN BE COMPLETED FROM THE BEACH, ELIMINATING POTENTIAL IMPACTS TO RESIDENTS. GROUT COMPOSITION DOES NOT CHANGE THE APPEARANCE OF SAND. GROUTED SECTION SHOULD NOT REQUIRE ANY MAINTENANCE.	TO ADEQUATELY STRENGTHEN THE SLOPE, GROUTING WOULD BE REQUIRED OVER A RELATIVELY LARGE AREA (35 FT HEIGHT X 35 FT DEPTH). SOIL GROUTING NEEDS TO BE USED IN TANDEM WITH ADDITIONAL SLOPE STABILIZATION TO PROTECT AGAINST WAVE SCOUR (E.G. GEOTUBE). MATERIAL/EQUIPMENT WILL NEED TO BE BARGED ONTO THE BEACH FOR INSTALLATION. GROUT COMPOSITION NEEDS TO BE CUSTOMIZED BASED ON EXISTING SOIL CONDITIONS, INCREASING LEAD TIME. ESTIMATED CONSTRUCTION DURATION IS EXCESSIVE BASED ON PROJECT NEEDS.	GROUT INJECTION ESTIMATE APPROXIMATE GROUT CROSS SECTIONAL VOLUME = 80 CY/FT TOTAL GROUTED SLOPE LENGTH = 1,220 FT UNIT PRICE = $375/CY INSTALLED GROUTING COST = $36,600,000 GEOTUBE ESTIMATE INSTALLED GEOTUBE COST (FROM ABOVE) = $845,950 TOTAL ESTIMATED COST = $37,445,950	ESTIMATED DAILY OUTPUT = 500 CY PER 8 HOUR DAY TOTAL GROUTED VOLUME = 97,600 CY ESTIMATED CONSTRUCTION DURATION = 196 WORK DAYS

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DESCRIPTION	DATE	BY

TYPICAL CROSS SECTION - SLOPE STABILIZATION - ALTERNATIVE 4

BAXTER ROAD
SLOPE STABILIZATION

NANTUCKET, MASSACHUSETTS

RSD	SW	---
DESIGNED	DRAWN	CHECKED

SCALE: 1" = 10'

DATE: SEPT. 27, 2013

PROJECT NO.: 2967-11

SHEET NO.: 6 OF 6

SHEET NAME: ALT 4

Attachment B
Boring Logs

Notes:
1. BASE PLAN DEVELOPED FROM EPSILON ASSOCIATES, INC. FIGURE 1, TITLED "PROPOSED APPROXIMATE LOCATIONS OF SEDIMENT DELIVERY BARGES AND TEMPORARY DISCHARGE TRENCHES, LIGHTHOUSE BEACH, NANTUCKET, MA" DATE 6/30/2004.
2. TOPOGRAPHIC CONTOURS FROM MASS GIS (2003).
3. BASE ORTHOPHOTO FROM MASS GIS (2003).
4. MASS WETLANDS DESIGNATIONS FROM MASS GIS (2007)
5. TEST BORING LOCATIONS BY HALEY & ALDRICH, INC., DRILLED BY GEOLOGIC, INC. JULY 23-27, 2007.
6. TRANSECT LOCATIONS BY HALEY & ALDRICH, INC.
MCQUADE 48-20
GUTTERSON 48-21
KORENGOLD 48-22
FURROW 49-8
B1(OW)
ACCESS ROAD
BAXTER RD
LUGOSCH 49-35
B2
RAUCH 49-34
THE BLUFF TRUST 49-33.1
B3
RITTER 49-33
B4
WEYMAR 49-32
POSNER 49-31
OSBORN 49-30
73 BAXTER ROAD TRUST 49-27
BAYBERRY LA
Transect 1: Lugosch North, 85 Baxter Rd.
Transect 2: Lugosch South, 85 Baxter Rd.
Transect 3: Ritter, 81 Baxter Rd.
Transect 4: Posner, 73 Baxter Rd.
TRANSECTS
BORING LOCATIONS
POST-1978 PROPERTY
PRE-1978 PROPERTY
ELEVATION CONTOURS (2003)
2 Foot Intervals
High Tide Line (4 Feet)
-14 Feet
MASS WETLANDS DESIGNATION (2007)
Coastal Bank, Bluff or Sea Cliff
Coastal Beach
Shrub Swamp
Open Water
N
W
E
S
0
100
200
1 INCH = 100 FEET
HALEY & ALDRICH
TERRACE FAILURE ANALYSIS
SCONSET BEACH PRESERVATION FUND
BAXTER ROAD
NANTUCKET, MA
SITE AND SUBSURFACE EXPLORATION PLAN
SCALE: AS SHOWN
SEPTEMBER 2007
G:\26694\Global\GIS\MapProjects\2007-0829-HA-FIGURE2.mxd

FIGURE 2

HALEY & ALDRICH — TEST BORING REPORT

Boring No. B1(OW)D/S

Project: TERRACE INSTALLATION FAILURE STUDY NANTUCKET, MA
Client: SCONSET BEACH PRESERVATION FUND C/O NETCO
Contractor: GEOLOGIC, INC.

File No. 26694-001
Sheet No. 1 of 3
Start: July 27, 2007
Finish: July 27, 2007
Driller: C. O'Donnel
H&A Rep.: D. Warren
Elevation: 79.0
Datum: MLW
Location: See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HSA	S	--	Rig Make & Model: Acker Scout Track
Inside Diameter (in.)	3 1/4	1 3/8	--	Bit Type: Cutting Head
Hammer Weight (lb)		140	-	Drill Mud: None
Hammer Fall (in.)		30	-	Casing: HSA Spun to 65.0 ft
				Hoist/Hammer: Cat-Head Doughnut Hammer
				PID Make & Model:

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	Stratum Change Elev/Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size*, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test: Dilatancy	Toughness	Plasticity	Strength
0	3 4 6 8	S1 9,10	0.0 1.0		SP/OL-OW	Loose brown poorly graded SAND (SP), intermixed with brown sandy ORGANIC SOIL (OL/OH), mps < 1 mm, no structure, no odor, dry -AEOLIAN/ORGANIC DEPOSITS-				35	35	40				
	9 100/5	S2 6	2.0 2.9	76.5 2.5	SM	Medium dense dark brown (organic), silty SAND (SM), mps < 1 mm, no structure, no odor, moist				25	30	45				
						Similar to above, except very dense -ORGANIC DEPOSITS-				25	30	45				
	52 55	S3 8	4.0 5.0		SP-SM	S3: Very dense dark orange brown, poorly graded SAND with silt (SP-SM), mps 0.5 in., no structure, no odor, moist		5	10	50	25	10				
5	63 48	S3A 10	5.0 6.0	74.0 5.0		NOTE: Similar material observed extremely well bonded in-situ in excavation adjacent to borehole. -GLACIAL TILL-										
	38 36 37 38	S4 17	6.0 8.0		SP	S3A: Very dense brown poorly graded SAND (SP), mps < 1 mm, no structure, no odor, dry				25	75					
					SP	S4: Very dense gray brown poorly graded SAND (SP), mps < 1 mm, no structure, no odor, dry -GLACIOFLUVIAL DEPOSITS-				30	65	5				
				70.5 8.5												
	17 20 25 24	S5 15	9.0 11.0		SM-SP	Very dense light gray silty SAND (SM), intermixed with layers of poorly graded SAND (SP), mps 0.5 in., weakly bonded in-situ, moist		5	5	20	40	25				
10	18 17 21 16	S6 15	11.0 13.0		SM	Dense gray silty SAND (SM), mps 0.75 in., no structure, no odor, wet -GLACIAL TILL-		10	10	20	35	25				
	13 20 36 42	S7 17	13.0 15.0		SM	Similar to above		10	10	10	45	25				
15	10 11 9 10	S8 16	15.0 17.0		SC/ML	Medium dense mottled gray to light brown clayey SAND (SC) to silty SAND (ML), mps 0.5 in., no structure, no odor, wet		5	5	10	35	45				
				62.0 17.0												
	11 16 32 22	S9 16	17.0 19.0		SP	Dense light brown to gray poorly graded SAND (SP), mps 0.75 in., well developed stratification, moist		5	5	60	30					
	12 15 24 27	S10 15	19.0 21.0		SP	Similar to above, except mps 1.5 in. -GLACIOFLUVIAL DEPOSITS-	5	5	10	60	20					
20	11 16	S11 17	21.0 23.0		SP-SW	Similar to above with occasional oxidized seams of well graded SAND (SW)	5	10	15	65	5					

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water
7/27/07	0900		9.0	11.0	9.0

Sample ID
O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (ft) 67.0
Rock Cored (ft) -
Samples S24

Boring No. B1(OW)D/S

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Toughness**: L - Low M - Medium H - High **Plasticity**: N - Nonplastic L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

***Note: Maximum particle size is determined by direct observation within the limitations of sampler size.**

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

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HALEY & ALDRICH

TEST BORING REPORT

Boring No. B1(OW)D/S

File No. 26694-001
Sheet No. 2 of 3

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	Well Diagram	Stratum Change Elev/Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size*, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
	18 14																
	16 26 36 28	S12 15	23.0 25.0			SP	Very dense light gray brown poorly graded SAND (SP), mps 0.75 in., well developed stratification, dry		5	5	60	30					
					54.0 25.0		-GLACIOFLUVIAL DEPOSITS-										
25	16 18 26 28	S13 17	25.0 27.0			SP	Very dense light brown poorly graded SAND (SP), mps 0.5 in., no structure, no odor, dry, trace shell fragments		5		35	60					
							-MARINE DEPOSITS-										
	24 23 33 41	S14 18	27.0 29.0			SP	Very dense light gray brown poorly graded SAND (SP), mps 0.5 in., well developed stratification, dry										
30	13 22 28 33	S15 17	30.0 32.0			SP-SM	Very dense light gray brown poorly graded SAND (SP) with silt, mps 1.0 in., well developed stratification, dry, occasional irregular oxidized pockets	5	5	5	60	25					
	22 42 41 52	S16 18	32.0 34.0			SP	Similar to above except mps 0.5 in.		5	5	60	30					
35	12 20 27 36	S17 18	35.0 37.0			SP	Similar to above, except dense		5	5	60	30					
	58 40 38 51	S18 15	37.0 39.0			SP	Similar to above, except very dense		5		65	30					
40	20 26 27 33	S19 17	40.0 42.0			SP	Similar to above, except mps 0.25 in.			5	55	40					
45	20 20 22 26	S20 14	45.0 47.0			SP	Similar to above, except dense with trace shell fragments			5	55	40					
50	16 20 24 32	S21 16	50.0 52.0			SP	Similar to above			10	60	30					

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

Boring No. B1(OW)D/S

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TEST BORING REPORT

Boring No. B1(OW)D/S

File No. 26694-001

Sheet No. 3 of 3

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	Well Diagram	Stratum Change Elev/Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size*, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
55	28 50 64 72	S22 18	55.0 57.0			SP	Similar to above except very dense with frequent very thin oxidized lenses and occasional thin laminae of gray sandy SILT (ML)			10	45	40	5				
							-MARINE DEPOSITS-										
60	25 38 44 53	S23 19	60.0 62.0			SP-SW	Very dense light gray brown poorly graded SAND (SP), interbedded with seams (1.0 to 2.0 in.) of well graded SAND (SW), mps 0.5 in., well developed stratification dry, trace shell fragments		5	15	50	30					
65	31 48 56 71	S24 18	65.0 67.0			SP	Very dense light gray brown poorly graded SAND (SP), mps 0.25 in., weakly stratified, no odor, dry, trace shell fragments with occasional irregular oxidized pockets and seams										
					12.0 67.0		BOTTOM OF EXPLORATION AT 67.0 FT NOTE: 1.0 in diameter observation wells installed at 67.0 ft and 18.0 ft in single borehole upon completion.										

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

Boring No. B1(OW)D/S

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TEST BORING REPORT

HALEY & ALDRICH

Boring No. B2

Project TERRACE INSTALLATION FAILURE STUDY NANTUCKET, MA
Client SCONSET BEACH PRESERVATION FUND C/O NETCO
Contractor GEOLOGIC, INC.

File No. 26694-001
Sheet No. 1 of 3
Start July 26, 2007
Finish July 26, 2007
Driller C. O'Donnel
H&A Rep. D. Warren
Elevation 80.0
Datum MLW
Location See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HSA	S	--	Rig Make & Model: Acker
Inside Diameter (in.)	3 1/4	1 3/8	--	Bit Type: Cutting Head
Hammer Weight (lb)		140	-	Drill Mud: None
Hammer Fall (in.)		30	-	Casing: HSA Spun to 70.0 ft
				Hoist/Hammer: Cat-Head Doughnut Hammer
				PID Make & Model:

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	Stratum Change Elev/Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size*, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0						NOTE: Hand excavated.										
	1 1 4 5	S1 20	1.0 3.0	78.5 1.5	OL/OH	S1, Top 6.0 in.: Very soft brown sandy ORGANIC SOIL (OL/OH), mps < 1 mm, no structure, no odor, moist					30	70				
					SM	-GRASS MAT/TOPSOIL/FILL-				15	60	25				
				77.0 3.0	SP	Loose orange brown silty SAND (SM) mps < 1 mm, no structure, no odor, moist				30	65	5				
	5 7 8 8	S2 18	3.0 5.0			-AEOLIAN DEPOSITS-										
						Medium dense orange brown to light brown poorly graded SAND (SP), mps < 1 mm, no structure, no odor, moist										
5	6 7 22 34	S3 5	5.0 7.0		SP	Similar to above				50	50					
				74.0 6.0		-UPPER GLACIOFLUVIAL DEPOSITS-										
					CH/SP-SM	Hard mottled orange brown to gray brown fat CLAY (CH), interbedded with irregular seams and layers of gray brown poorly graded SAND with silt (SP-SM), mps 0.5 in., weakly stratified, no odor, moist		5	5	20	20	50				
	45 27 23 26	S3A 14 / S4 20	7.0 7.1 9.0		SM-ML	Very dense brown silty SAND (SM) to sandy SILT (ML), mps 0.75 in., moderately bonded in-situ, moist NOTE: Drill action indicates cobbles at 7.0 ft.		10	5		40	45				
10	15 24 25 26	S5 18	9.0 11.0		SM	Dense brown silty SAND (SM), mps 0.75 in., moderately bonded in-situ, moist		10	5	5	45	35				
						-GLACIAL TILL-										
	18 24 28 24	S6 17	11.0 13.0		SM-SP	Similar to above except very dense interbedded with layers of orange brown to gray poorly graded SAND (SP)		10	5	20	30	35				
	15 19 21 22	S7 20	13.0 15.0		SM-SP	Dense brown silty SAND (SM), interbedded with layers of poorly graded SAND (SP), mps 0.5 in., no structure, no odor, moist		5	5	25	45	20				
15	17 26 29 25	S8 19	15.0 17.0		SM-SP	Very dense brown silty SAND (SM), interbedded with light gray poorly graded SAND (SP), mps 0.5 in., no structure (SM), stratified (SP), no odor, moist		5	5	25	45	20				
	22 27 28 26	S9 18	17.0 19.0		SP-SM/SM	Very dense brown poorly graded SAND with silt (SP-SM), interbedded with occasional layers (less than 4.0 in.) of brown well bonded silty SAND (SM), mps 0.5 in., weakly stratified, dry NOTE: Drill action indicates cobbles at 18.0 ft.		5	5	25	50	15				
				60.5 19.5												
20	14 27 34 47	S10 19	20.0 22.0		SP	Very dense light brown to light gray poorly graded SAND (SP), mps 0.5 in., stratified, no odor, dry		5	5	55	35					

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water

Sample ID
O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (ft) 74.0
Rock Cored (ft) -
Samples S22

Boring No. B2

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Plasticity**: N - Nonplastic L - Low M - Medium H - High
Toughness: L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

***Note: Maximum particle size is determined by direct observation within the limitations of sampler size.**

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

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TEST BORING REPORT

Boring No. B2

File No. 26694-001

Sheet No. 2 of 3

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	Stratum Change Elev/Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size*, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
	32 40 43 41	S11 18	22.0 24.0		SP	Similar to above		5	5	60	30					
25	12 24 24 24	S12 18	25.0 27.0		SP	Similar to above, except dense, mps < 1 mm -GLACIOFLUVIAL DEPOSITS-				50	50					
30	10 25 42 52	S13 17	30.0 32.0		SP	Very dense light gray brown poorly graded SAND (SP), mps 1.0 in., well developed stratification, dry	5	5	5	65	20					
35	16 26 46 50	S14 19	35.0 37.0		SP	Similar to above, except mps 0.75 in.		10	5	60	25					
40	20 34 40 48	S15 20	40.0 42.0		SP	Similar to above NOTE: Drill action indicates coarse gravel/cobbles at 43.0 ft (possible ventifacts)		5	5	65	25					
45	20 33 50 59	S16 18	45.0 47.0		SP	Similar to above with occasional thin seams (less than 1.0 in) of well graded SAND (SW)			5	60	35					
50	14 18 16 15	S17 16	50.0 52.0		SP	Dense light gray brown poorly graded SAND (SP), mps 3/8 in., well developed stratification, dry		5	5	65	25					

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

Boring No. B2

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TEST BORING REPORT

Boring No. B2

File No. 26694-001

Sheet No. 3 of 3

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	Stratum Change Elev/Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size*, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
55	10 20 30 34	S18 20	55.0 57.0		SP	Similar to above, except mps 0.25 in.			5	65	30					
						-GLACIOFLUVIAL DEPOSITS-										
60	27 37 51 74	S19 17	60.0 62.0		SP	Very dense light gray brown poorly graded SAND (SP), mps 1.5 in., stratified, no odor, dry	5	5	5	60	25					
65	25 24 38 72	S20 20	65.0 67.0		SP/ ML/ SW/ CL	Similar to above, interbedded with frequent thin laminae and seams of brown sandy SILT (ML) and light gray lean CLAY (CL), one seam of brown well graded SAND with gravel (SW) at approximately 66.3 to 66.5 ft, mps 0.5 in.		5	10	25	40	20				
70	16 36 53 75	S21 16	70.0 72.0		SP	Similar to S19	5	5	5	65	20					
	59 68 85 50/2	S22 15	72.0 73.7		SP	Similar to above, except mps 1.0 in.	5	5	10	60	20					
				6.3 73.7		BOTTOM OF EXPLORATION AT 73.7 FT										

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

Boring No. B2

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TEST BORING REPORT

HALEY & ALDRICH

Boring No. B3

Project TERRACE INSTALLATION FAILURE STUDY NANTUCKET, MA
Client SCONSET BEACH PRESERVATION FUND C/O NETCO
Contractor GEOLOGIC, INC.

File No. 26694-001
Sheet No. 1 of 3
Start July 24, 2007
Finish July 24, 2007
Driller C. O'Donnel
H&A Rep. D. Warren
Elevation 80.0
Datum MLW
Location See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HSA	S	--	Rig Make & Model: Acker Scout Track
Inside Diameter (in.)	3 1/4	1 3/8	--	Bit Type: Cutting Head
Hammer Weight (lb)		140	-	Drill Mud: None
Hammer Fall (in.)		30	-	Casing: HSA Spun to 65.0 ft
				Hoist/Hammer: Cat-Head Doughnut Hammer
				PID Make & Model:

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	Stratum Change Elev/Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size*, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0						NOTE: Hand excavated.										
	5 5 7 6	S1 17	1.0 3.0		SP-SM	Medium dense orange brown poorly graded SAND with silt (SP-SM), mps 0.25 in., no structure, no odor, dry -AEOLIAN DEPOSITS-			5	60	25	10				
	6 6 5 7	S2 15	3.0 5.0	77.0 3.0	SP	Medium dense light brown poorly graded SAND (SP), mps < 1 mm, no structure, no odor, dry				35	65					
5	7 8 8 9	S3 12	5.0 7.0		SP	Similar to above, except brown, mps 0.5 in. -UPPER GLACIOFLUVIAL DEPOSITS-		5	5	65	25					
	21 27 31 32	S4 14	7.0 9.0	73.0 7.0	SM/ML	Very dense brown sandy SILT (ML), to silty SAND (SM), mps 0.25 in., weakly bonded, stratified, no odor, moist		5	5	5	40	45				
10	25 26 21 23	S5 17	9.0 11.0		SM/ML-SP	Similar to above, interbedded with frequent seams of light brown to gray poorly graded SAND (SP) -GLACIAL TILL-		5	5	25	30	35				
	21 27 25 22	S6 16	11.0 13.0		SM/ML-SP	Similar to above, except dense		5	5	25	30	35				
	11 12	S7 12	13.0 14.0	66.0 14.0	ML	Similar to S4		5	5	25	30	35				
	12 10	S7A 9	14.0 15.0		SP	Medium dense light brown poorly graded SAND (SP), mps 0.25 in., no structure, no odor, dry		5	5	40	50					
15	21 27 38 42	S8 10	15.0 17.0		SP	Similar to above, except very dense, mps 1.5 in. -GLACIOFLUVIAL DEPOSITS-	5	5	5	65	20					
	29 22 24 27	S9 17	17.0 19.0		SP	Similar to above, except dense, except mps < 1 mm				60	30					
20	14 25 26 23	S10 16	19.0 21.0		SP	Very dense light brown poorly graded SAND (SP), mps 0.25 in., stratified, no odor, dry			5	65	30					
	21 27	S11 15	21.0 23.0		SP-SW	Similar to above, except light brown to gray interbedded with occasional seams of well graded SAND (SW), mps 0.5 in., stratified, no odor, dry		5	10	60	25					

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water

Sample ID
O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (ft) 67.0
Rock Cored (ft) -
Samples S31

Boring No. B3

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Plasticity**: N - Nonplastic L - Low M - Medium H - High
Toughness: L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

***Note: Maximum particle size is determined by direct observation within the limitations of sampler size.**

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

H&A-TEST BORING-07-1 COPY OF HA-LIB07-1_MDD.GLB HA-TB+CORE+WELL-07-1.GDT G:\26694\001\FIELD DATA\2007 0925_26694-001TB.GPJ Sep 28, 07

HALEY & ALDRICH

TEST BORING REPORT

Boring No. B3

File No. 26694-001
Sheet No. 2 of 3

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	Stratum Change Elev/Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size*, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
	27 32															
	14 22 24 32	S12 18	23.0 25.0		SP	Similar to above, except dense with no well graded seams, frequent thin oxidized laminae				65	35					
25	13 19 23 22	S13 16	25.0 27.0		SP	Dense light gray poorly graded SAND (SP), mps 0.25 in., stratified, no odor, dry, occasional irregular oxidized pockets (less than 1.0 in.)			5	60	35					
	13 16 29 27	S14 15	27.0 29.0		SP	Dense light gray brown poorly graded SAND (SP), 1 mm, stratified, no odor, dry, one piece decomposed coarse gravel in spoon tip										
30	17 23 24 32	S15 20	29.0 31.0		SP	Dense light gray brown poorly graded SAND (SP), mps 0.25 in., weakly stratified, no odor, wet			5	45	50					
	25 33 34 36	S16 18	31.0 33.0		SP	Similar to above, except very dense			5	50	45					
	13 18 26 28	S17 20	33.0 35.0		SP	Similar to above, except dense -GLACIOFLUVIAL DEPOSITS-			5	45	50					
35	21 22 26 26	S18 15	35.0 37.0		SP	Similar to above			5	60	35					
	34 32 33 39	S19 18	37.0 39.0		SP	Similar to above, except very dense			5	45	50					
40	24 26 25 32	S20 20	39.0 41.0		SP	Similar to above with well developed stratification and occasional thin seams of well graded SAND (SW)			10	50	40					
	46 51 55 47	S21 20	41.0 43.0		SP	Similar to above, except mps 0.75 in.		5	10	60	25					
	23 39 48 45	S22 17	43.0 45.0		SP	Similar to above, except mps 0.25 in.			5	65	30					
45	16 41 45 46	S23 19	45.0 47.0		SP	Similar to above			5	55	40					
	25 40 29 30	S24 16	47.0 49.0		SP	Similar to above			5	65	30					
50	32 50 44 73	S25 20	49.0 51.0		SP	Similar to above			5	55	40					
	55 55 40 37	S26 18	51.0 53.0		SP	Similar to above			5	65	30					
	18 25 36	S27 17	53.0 55.0	27.0 53.0	SP	Similar to above, except light gray -MARINE DEPOSITS			5	55	40					

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

Boring No. B3

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HALEY & ALDRICH

TEST BORING REPORT

Boring No. B3

File No. 26694-001
Sheet No. 3 of 3

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	Stratum Change Elev/Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size*, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
	37															
55	32 33 22 24	S28 16	55.0 57.0		SP	Similar to above			10	60	30					
	60 62 54 60	S29 15	57.0 59.0		SP	Similar to above -MARINE DEPOSITS-			5	55	40					
60	24 35 56 65	S30 18	60.0 62.0		SP	Very dense light gray poorly graded SAND (SP), mps 0.25 in., weakly stratified, no odor, dry			5	40	55					
65	25 42 56 46	S31 20	65.0 67.0		SP	Similar to above with occasional thin oxidized seams			5	50	45					
				13.0 67.0		BOTTOM OF EXPLORATION AT 67.0 FT										

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

Boring No. B3

HALEY & ALDRICH

TEST BORING REPORT

Boring No. B4

Project TERRACE INSTALLATION FAILURE STUDY NANTUCKET, MA
Client SCONSET BEACH PRESERVATION FUND C/O NETCO
Contractor GEOLOGIC, INC.

File No. 26694-001
Sheet No. 1 of 3
Start July 25, 2007
Finish July 25, 2007
Driller C. O'Donnel
H&A Rep. D. Warren
Elevation 82.0
Datum MLW
Location See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HSA	S	--	Rig Make & Model: Acker Scout Track
Inside Diameter (in.)	3 1/4	1 3/8	--	Bit Type: Roller Bit
Hammer Weight (lb)		140	-	Drill Mud: None
Hammer Fall (in.)		30	-	Casing: HSA Spun to 70.0 ft
				Hoist/Hammer: Cat-Head Doughnut Hammer
				PID Make & Model:

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	Stratum Change Elev/Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size*, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0				81.0		NOTE: Hand excavated. -GRASS MAT/TOPSOIL/FILL-										
	1 1 4 5	S1 18	1.0 3.0	1.0	SM	Loose orange brown silty SAND (SM), mps < 1 mm, no structure, no odor, moist -AEOLIAN DEPOSITS-				20	65	15				
	4 5 9 10	S2 16	3.0 5.0	79.5 2.5	SP	Medium dense light brown to brown poorly graded SAND (SP), mps 0.25 in., weakly stratified, no odor, dry -UPPER GLACIOFLUVIAL DEPOSITS-			5	65	30					
5	7 15 16 18	S3 20	5.0 7.0		SP	Top 10.0 in., dense brown poorly graded SAND (SP), mps 0.75 in., no structure, no odor, dry		5	10	60	25					
					SP	Bottom 10.0 in., dense brown silty SAND (SM) mps < 1 mm, no structure, no odor, moist					80	20				
	18 20	S4 9	7.0 8.0	74.0 8.0	SP	Dense brown poorly graded SAND (SP), mps 0.25 in., no structure, no odor, dry			5	55	40					
	22 26	S4A 9	8.0 9.0		SM	Dense brown silty SAND (SM), trace fine gravel, weakly bonded in-situ, no odor, moist, mps 0.75 in.		5	5	5	35	50				
10	21 24 26 20	S5 18	9.0 11.0		SP/ ML	Dense brown, poorly graded SAND (SP), mps 0.25 in., no structure, no odor, dry with one layer brown sandy SILT (ML), similar to S4A from approximately 9.5 to 10.0 ft -GLACIAL TILL-		5	5	40	25	25				
	16 20 21 15	S6 20	11.0 13.0	71.0 11.0	SP/ SP-SM	Dense light gray brown poorly graded SAND (SP), interbedded with occasional seams of brown poorly graded SAND with silt (SP-SM), mps 0.25 in., weakly stratified, occasional oxidized seams, dry			5	55	30	10				
	12 13 15 16	S7 14	13.0 15.0		SP	Medium dense light gray poorly graded SAND (SP), mps 0.25 in., weakly stratified with occasional irregular oxidized seams, no odor, dry -GLACIOFLUVIAL DEPOSITS-			5	65	30					
15	7 8 19 21	S8 6 S8A 12	15.0 17.0 15.5 17.0	67.0 15.0 66.5 15.5	ML/ SM	Loose brown sandy SILT to silty SAND with gravel (ML/SM), mps 0.5 in., weakly bonded stratified, no odor, moist -GLACIAL TILL (FLOW TILL)-		15	5	5	25	50				
					SP	Medium dense light gray brown poorly graded SAND (SP), mps 1.0 in., no structure, no odor, dry	5	5	5	55	30					
	7 8 19 21	S9 15	17.0 19.0		SP	Similar to above, except mps 0.75 in. -GLACIOFLUVIAL DEPOSITS-		5	5	65	25					
20	20 46 51 32	S10 6	19.0 21.0		SP	Very dense brown poorly graded SAND (SP), mps 1.5 in., no structure, no odor, dry NOTE: Poor recovery, spoon pushing coarse gravel.	5		5	20	70					
	24 23	S11 16	21.0 23.0		SP	Dense light brown to gray brown poorly graded SAND (SP), mps 0.25 in., weakly stratified, no structure, no odor, dry			5	60	35					

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water

Sample ID
O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (ft) 74.0
Rock Cored (ft) -
Samples S26

Boring No. B4

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Toughness**: L - Low M - Medium H - High **Plasticity**: N - Nonplastic L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

***Note: Maximum particle size is determined by direct observation within the limitations of sampler size.**

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

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HALEY & ALDRICH

TEST BORING REPORT

Boring No. B4

File No. 26694-001

Sheet No. 2 of 3

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	Stratum Change Elev/Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size*, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
	23 25															
	14 15 20 23	S12 17	23.0 25.0		SP	Similar to above			5	60	35					
						-GLACIOFLUVIAL DEPOSITS-										
25	22 32 30 31	NR	25.0 27.0			NOTE: No recovery 25.0 to 27.0 ft.										
	40 42 50 48	S13 4	27.0 29.0		SP	Very dense brown poorly graded SAND (SP), mps 0.25 in., no structure, no odor, moist NOTE: Poor recovery, spoon pushing cobble/gravel.			5	60	35					
30	16 33 20 19	S14	29.0 31.0		SP	Very dense light gray brown poorly graded SAND (SP), mps 0.25 in., well developed stratification, dry with occasional irregular oxidized pockets			5	55	40					
	8 12 19 21	S15 17	31.0 33.0		SP	Similar to above, except dense with highly oxidized layer from approximately 32.0 to 32.5 ft			5	55	40					
	19 18 25 26	S16 16	33.0 35.0		SP	Similar to above with minor oxidation			5	45	50					
35	18 18 22 42	S17 18	35.0 37.0		SP	Similar to above			5	60	35					
	38 53 42 58	S18 20	37.0 39.0		SP	Similar to above, except very dense with trace coarse gravel mps 1.5 in.	5		5	65	25					
40	17 34 30 32	S19 18	40.0 42.0		SP	Similar to above, except mps 0.5 in.		5	5	65	25					
45	26 36 41 45	S20 18	45.0 47.0		SP	Similar to above		5	5	55	35					
50	20 31 36 39	S21 18	50.0 52.0		SP	Similar to above		5	5	65	25					

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

Boring No. B4

TEST BORING REPORT

HALEY & ALDRICH

Boring No. B4

File No. 26694-001
Sheet No. 3 of 3

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	Stratum Change Elev/Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size*, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
55	28 45 44 39	S22 16	55.0 57.0		SP	Similar to above		5	5	65	25					
						-GLACIOFLUVIAL DEPOSITS-										
60	23 31 21 28	S23 19	60.0 62.0		SP	Very dense light gray brown poorly graded SAND (SP), mps 0.75 in., well developed stratification, no odor, dry										
65	32 34 33 81	S24 19	65.0 67.0		SP/ SW	Similar to above with frequent thin seams (less than 1.0 in.) of brown well graded SAND (SW), mps 0.75 in.		10	10	50	30					
				13.5 68.5												
70	32 47 55 56	S25 21	70.0 72.0		SP-SM	Very dense light gray poorly graded SAND with silt (SP-SM), mps 0.75 in., weakly stratified, no odor, dry		10	5	35	50					
	28 26 24 28	S26 18	72.0 74.0		SP	Similar to above, except mps 1.5 in. with no stratification	5	5	5	35	50					
						-MARINE DEPOSITS-										
				8.0 74.0		BOTTOM OF EXPLORATION AT 74.0 FT										

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

Boring No. B4

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Attachment C
Haley and Aldrich Memorandum Regarding Sheet Pile Installation (DRAFT)

Haley & Aldrich, Inc.
465 Medford St.
Suite 2200
Boston, MA 02129

Tel: 617.886.7400
Fax: 617.886.7600
HaleyAldrich.com

MEMORANDUM

27 September 2013
File No. 26694-001

TO: Sconset Beach Preservation Fund
c/o Les Smith, Epsilon Associates

FROM: Haley & Aldrich, Inc.
Mark X. Haley

SUBJECT: Evaluation of steel sheeting adjacent to Baxter Rd.

At your request, we have reviewed the proposed option for driving steel sheet piling at the edge of Baxter Road. The purpose of the sheet pile wall would be to provide temporary protection for the utilities located beneath Baxter Rd. from damage due to bank erosion. Although details of the proposal were not available to us, we have made certain assumptions. These include the following:

- Depth of sheeting 45 to 50 ft. below Baxter Road grade, approximately one half of slope height.
- Sheeting would be designed to cantilever about 20 ft. (Note: normal steel sheeting can only cantilever to about a 20 ft. height without bracing. If the sheet pile wall was required to retain a greater height of soil, bracing would be required.)
- A 'Z-type' sheet would be used.
- Sheet piling would be vibrated into place not top driven. This method of installation was selected to reduce vibrations during pile driving.
- That the sheeting can be driven through the dense near surface soils. (Note; the soils in upper portion of the slope consist of dense glacial till that will be difficult to advance a pile through.)

At first glance this proposal would appear to provide near surface soil retention adjacent to the road, but upon further evaluation of the option, a number of issues may make this option detrimental to the overall slope stability. These include the following:

- The sheeting line will create a joint or vertical plane at the edge of road, that may result in a shear plane, resulting in slope instability.
- Disturbance of the soil on both sides of the sheeting will allow water to seep into this zone and have the potential for weakening the soil and reducing slope stability.
- Having evaluated this slope in 2007 and again in 2012, the erosion and slope failure occurs from loss of ground at the toe of slope. The existing medium sand stratum at the toe of slope is highly erodible and once eroded by wave action the

slope becomes undermined causing slope failure of the soils above. This proposed option does not address toe of slope instability.

- The steel sheeting would probably only extend about half the height of slope, and could thus be undermined causing a significant global slope failure.
- The sheet pile line will prevent water flow towards the ocean, and water will build up behind the sheeting thus increasing the hydrostatic pressures in the slope, increasing the horizontal driving force and decreasing the stability of the slope.
- Installation of the sheeting will cause vibrations and potential downward movement of the soils along the slope face.

It is our opinion; that options to consider for slope stabilization on a temporary or permanent basis should be focused at the existing toe of slope. Protecting the soils at the toe of slope from erosion will reduce the undermining of the slope and slope instability. Based on recent surveys, summer 2013, the slope angles in the area of Lots 99,101 and 105 are in the range of 31 to 40 degrees except near top of slope where the slope is much steeper in the range of 56 to 68 degrees. Based on our slope evaluations in 2007 slope angles less than about 40 degrees are stable but become unstable when the slope angle approaches 45 degrees especially in a rain event where water is added to the soil stratigraphy.

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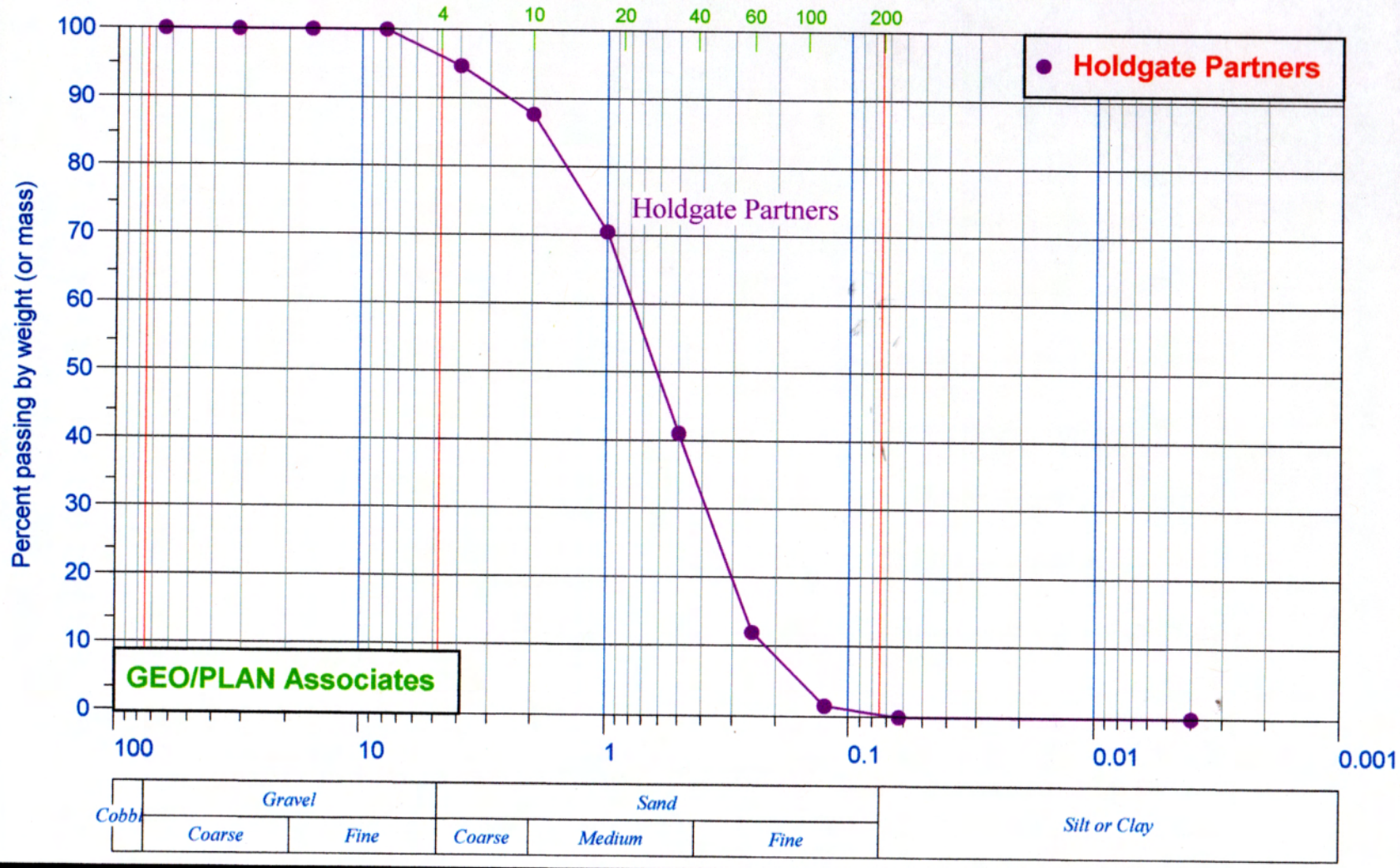
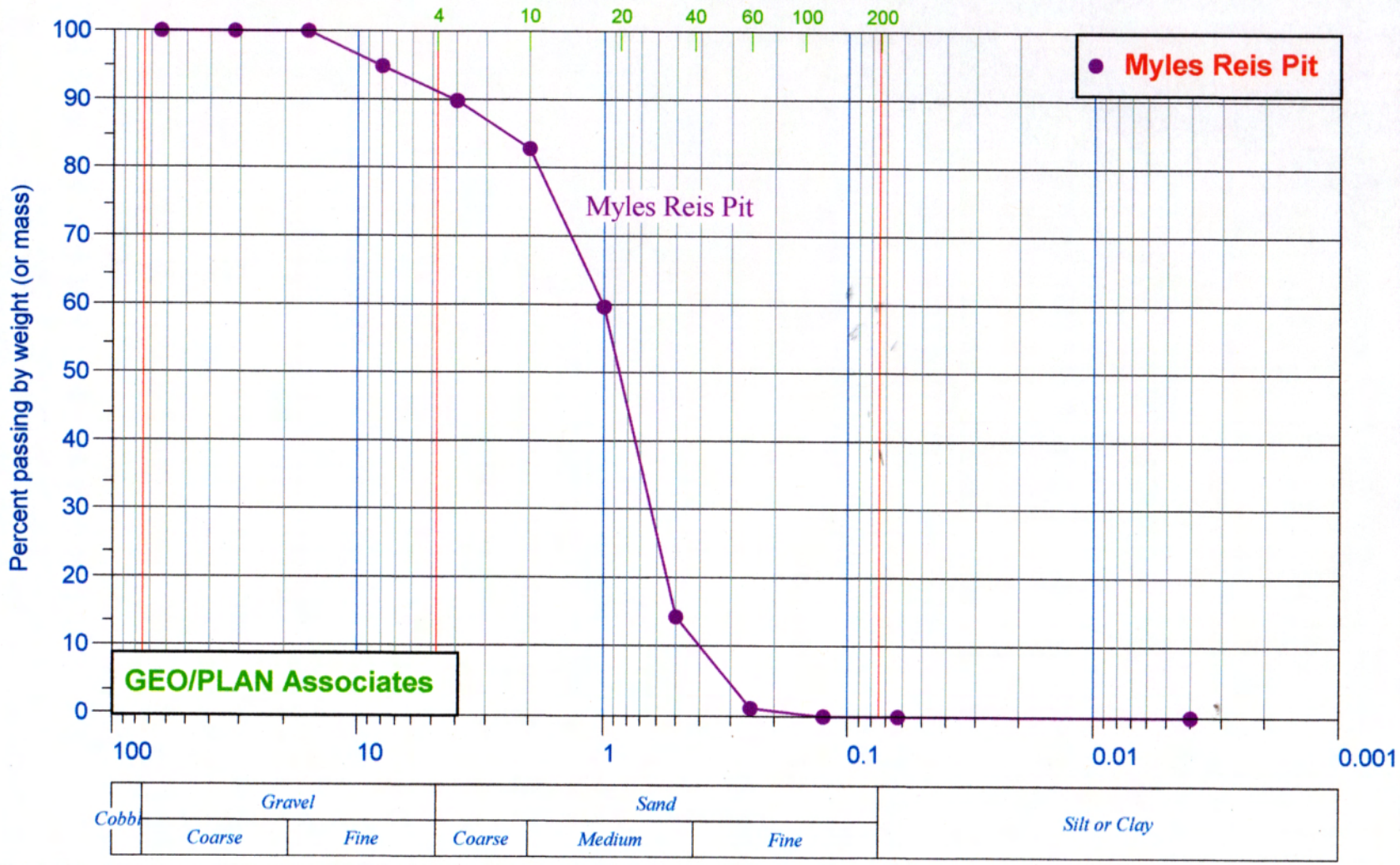
Attachment D
Sand Source Data and Analysis

EPSILON ASSOCIATES NANTUCKET PROJECT



EPSILON ASSOCIATES NANTUCKET PROJECT



GEO/PLAN Associates
Sediment Grain Size Analysis
Client:Epsilon Associates
Project: Nantucket, MA
Project Location: Nantucket, MA
Project No.
Date: October 2011

Sample: **Holdgate Partners**

Phi	Cum Wt	Total Wt	% Wt	Cum %	Sand Only % Wt	Sand Only Cum %
>-5	0.00	0.00	0.00	0.00	0.00	0.00
-4	0.00	0.00	0.00	0.00	0.00	0.00
-3	0.00	0.00	0.00	0.00	0.00	0.00
-2	6.51	6.51	5.43	5.43	5.43	5.43
-1	14.87	8.36	6.97	12.40	6.97	12.40
0	35.37	20.50	17.10	29.50	17.10	29.50
1	70.62	35.25	29.39	58.89	29.39	58.89
2	105.38	34.76	28.99	87.88	28.99	87.88
3	118.26	12.88	10.74	98.62	10.74	98.62
4	119.91	1.66	1.38	100.00	1.38	100.00

Phi	Total Wt	Bkr Wt	Corr. Wt	Wt Frac	% Wt	Bk No.
Silt	0.0000	0.0000	0.0000	0.0000	0.0000	--
Clay	0.0000	0.0000	0.0000	0.0000	0.0000	--
		Disp. Wt	0.0000			

Wt. Coarse	119.9100
Wt Fine	0.0000
Total Wt	119.9100

Phi	Wt %	Phi Mid Pt	Wt % Mid Pt	Mid pt - Mean (=X)	X sq	X sq Wt %
>-5	0.00	-5.50	0.00	-6.07	36.88	0.00
-4	0.00	-4.50	0.00	-5.07	25.73	0.00
-3	0.00	-3.50	0.00	-4.07	16.59	0.00
-2	5.43	-2.50	-13.57	-3.07	9.44	51.26
-1	6.97	-1.50	-10.46	-2.07	4.30	29.96
0	17.10	-0.50	-8.55	-1.07	1.15	19.68
1	29.39	0.50	14.70	-0.07	0.01	0.16
2	28.99	1.50	43.48	0.93	0.86	24.92
3	10.74	2.50	26.85	1.93	3.71	39.89
4	1.38	3.50	4.83	2.93	8.57	11.83
Silt	0.00	6.00	0.00	5.43	29.45	0.00
Clay	0.00	9.00	0.00	8.43	71.02	0.00
TOTAL	100.00		57.28			177.69

Total Sample		Mean =	0.57	Variance = 1.78
				Sample SD = 1.33
Coarse Only	100.00		57.28	177.69
		Mean =	0.57	Variance = 1.78
				Sample SD = 1.33

Gravel	Sand	Silt	Clay	Total
12.4	87.6	0.0	0.0	100.0

Sand	Silt	Clay	Total
100.0	0.0	0.0	100.0

GEO/PLAN Associates
Sediment Grain Size Analysis
Client:Epsilon Associates
Project: Nantucket, MA
Project Location: Nantucket, MA
Project No.
Date: October 2011

Sample: **Myles Reis Pit**

Phi	Cum Wt	Total Wt	% Wt	Cum %	Sand Only % Wt	Sand Only Cum %
>-5	0.00	0.00	0.00	0.00	0.00	0.00
-4	0.00	0.00	0.00	0.00	0.00	0.00
-3	5.91	5.91	5.05	5.05	5.05	5.05
-2	12.01	6.11	5.22	10.27	5.22	10.27
-1	20.16	8.15	6.97	17.24	6.97	17.24
0	47.07	26.92	23.02	40.25	23.02	40.25
1	100.01	52.94	45.27	85.53	45.27	85.53
2	115.54	15.53	13.28	98.81	13.28	98.81
3	116.91	1.37	1.17	99.98	1.17	99.98
4	116.93	0.03	0.02	100.00	0.02	100.00

Phi	Total Wt	Bkr Wt	Corr. Wt	Wt Frac	% Wt	Bk No.
Silt	0.0000	0.0000	0.0000	0.0000	0.0000	--
Clay	0.0000	0.0000	0.0000	0.0000	0.0000	--
		Disp. Wt	0.0000			

Wt. Coarse	116.9300
Wt Fine	0.0000
Total Wt	116.9300

Phi	Wt %	Phi Mid Pt	Wt % Mid Pt	Mid pt - Mean (=X)	X sq	X sq Wt %
>-5	0.00	-5.50	0.00	-5.43	29.47	0.00
-4	0.00	-4.50	0.00	-4.43	19.61	0.00
-3	5.05	-3.50	-17.68	-3.43	11.76	59.37
-2	5.22	-2.50	-13.05	-2.43	5.90	30.80
-1	6.97	-1.50	-10.45	-1.43	2.04	14.22
0	23.02	-0.50	-11.51	-0.43	0.18	4.23
1	45.27	0.50	22.64	0.57	0.33	14.78
2	13.28	1.50	19.92	1.57	2.47	32.78
3	1.17	2.50	2.93	2.57	6.61	7.75
4	0.02	3.50	0.07	3.57	12.75	0.27
Silt	0.00	6.00	0.00	6.07	36.86	0.00
Clay	0.00	9.00	0.00	9.07	82.29	0.00
TOTAL	100.00		-7.13			164.19

Total Sample		Mean =	-0.07	Variance = 1.64
				Sample SD = 1.28
Coarse Only	100.00		-7.13	164.19
		Mean =	-0.07	Variance = 1.64
				Sample SD = 1.28

Gravel	Sand	Silt	Clay	Total
17.2	82.8	0.0	0.0	100.0

Sand	Silt	Clay	Total
100.0	0.0	0.0	100.0

GEO/PLAN ASSOCIATES
30 MANN STREET
HINGHAM, MASSACHUSETTS 02043-1316
Voice & Fax: (781) 740-1340
Email: GeoPlanAssoc@gmail.com

October 20, 2011

Epsilon Associates
P.O. Box 700
Maynard, Massachusetts 01754-0700

Attention: Mr. Les Smith

Re: Sediment Compatibility Analysis, Siasconset Beach

Dear Mr. Smith:

I performed size analyses of composite sediment samples from two sand pits from Nantucket in October, 2011. The purpose of this letter is to evaluate the suitability of these pit sediment sources as mitigation sediment for a segment of beach along Siasconset Beach, Nantucket. The project area is within previously-identified sampling sites designated as sediment sampling transects (Line 15 through Line 19). Extensive sediment sampling of the area (beach, bank, dune) was performed in 2006 along these lines and adjacent areas by Coastal Planning and Engineering, Inc. Other grain size data from this beach area is available from earlier sampling in 1998, 2001 and 2003. Some of these samples I collected and analyzed.

The composite or mean sizes are compiled below for comparison. While the methodologies for analysis are consistent, the reporting of the data, the lateral extent of the sampling along Siasconset Beach, and the field sampling methods may vary. This doesn't affect the documentation of the sand characteristics, and that the resulting time-series provides a measure of variability of the natural sands over time. These mean sizes and other characteristics are compiled below.

A. Proposed Pit Sediment Sources:

Holdgate Partners Mean: 0.57 phi (coarse sand)
88% sand 12% gravel
(most gravel granules or finer; <4mm); mud (insignificant)

Myles Reis Pit Mean –0.07 phi (very coarse sand)
83% sand 17% gravel
(most gravel fine pebbles or finer; <8mm); mud (insignificant)

B. Natural Bank Sediments

2001: 2 phi, (medium - fine sand) includes 8% mud
2003: 1.8 phi (medium sand) includes 5.5% pebbles or granules
2006: 0.45 phi (coarse sand) includes minor fine pebbles/granules

The bank sediments vary between medium-fine sand to coarse sand, and contain varying amounts of fine gravel and mud. Direct observation of this coastal bank has shown that, although dominantly sand, there is frequently a mud and gravel component and periodically mud layers and clay banks are part of the deposit. The fine or coarse tails and the variation in sizes are typical for glacial outwash sediments in this setting.

C. Beach Sediments

1998: 1.5 phi (medium sand)
2001: 1.0 phi (medium – coarse sand)
2003: 0.9 phi (coarse sand)
2006: 0.7 phi (coarse sand) [Line 15 – Line 19]

The more recent 2006 samples are coarser than the earlier samples, either due to natural variation in sand sizes over time, or any cyclic changes relating to energy. Regardless of the cause, these four sampling intervals indicate that the natural sediment on the beach is not coarser than the 0.7 phi 2006 samples.

D. Discussion

Compatible beach sediment is not sand that exactly matches the existing beach, but rather sediment that is stable and can coexist with the naturally deposited sediment in the coastal setting. If the compatibility of the sediment is evaluated relative to potential stability on the beach (which is generally the case), **compatible sediment is equal or coarser than the existing sediment**.

Both of the proposed source areas are also glacial outwash sediments. Both samples have insignificant mud (<1%), which is a plus for compatibility, as mud is quickly lost, and is the most common aesthetic and water turbidity objection. Both of the proposed source areas are geologically the same material (outwash sediments) from the same vicinity as the natural bank materials. Both samples contain gravel. While the gravel does not match surface beach sediment samples, small gravel is a visible component on these beaches and shallow nearshore. Importantly, both samples are coarse sand, which has the greatest likelihood of remaining stable on the Siasconset Beach. While the sizes are reported as means, there are ranges of sizes finer and coarser in all samples. However, both the natural beach sediment and both potential pit sources have very small amounts of sand finer that medium sand. This is the component of the sand that is most likely to be quickly lost from the beach. Therefore, the wave sorting will likely re-sort nourishment sand to have comparable sizes to existing conditions, or coarser, so most of the source material will have as great a probability of remaining within the adjacent beach system as the natural bank material.

Both source pits sediment samples are slightly coarser than both the natural bank and the existing beach sediments. Much of the variation in mean size is due to the differences in gravel content. The differences in gravel content, however, are not significant. Grain size is measured by weight, which is affected by gravel greater than if it were measured by volume, which is how sediment is specified for mitigation purposes. Therefore, both proposed source pit sediments are beach-compatible sediments.

Please feel free to contact me if there are further questions concerning the evaluation of these sand samples.

Yours truly,

Peter S. Rosen

Peter S. Rosen, Ph. D.

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September 4, 2013

Ms. Maria Hartnett
Epsilon Associates
3 Clocktower Place
Suite 260
Maynard, MA

Re: Evaluation of borrow area sand relative to natural coastal bank sand

Dear Ms. Hartnett:

I have evaluated the suitability of sand from two sand pits on Nantucket, Holdgate and Reis, for use to replace natural nourishment of beach sand from a portion of coastal bank on Baxter Road, Sconset, where a revetment is proposed.

I am using the same composite sand analysis for the two sand pits as I have used in previous evaluations (January 17, 2012). The coastal bank data is derived from the 2006 detailed sampling of the coastal bank by CP&E. The samples within the revetment area were combined to create a composite statistics.

These data are evaluated using the method of James (1974) to estimate the Overfill Factor (R_A), which estimates the additional amount of borrow area sand required to be equal to a given volume of beach sand. In this analysis, I compared the sand pit sand to the natural bank sand, and the result estimates how much additional sand, if any, is necessary to equal a volume of natural coastal bank feeding the adjacent beach.

I also reviewed earlier coastal bank samples in this area and noted that these composite samples were finer than the 2006 data. Therefore, 2006 is a worst-case of all the data available, and therefore yields a conservative estimate.

The attached diagram shows that the Overfill Factor for both sand sources is 1, in the range described by James as "Stable." This means that one cubic yard of sand from the pit is equivalent to one cubic yard of sand from the coastal bank.

This is not surprising, since in this setting the sand pits and the coastal bank are the same geological unit (glacial outwash) sampled in different locations.

I understand that there is some concern that the coastal bank sand is coarsening over time. Both from my evaluation of the sediment data, and my personal knowledge of that coastal bank over several decades, I do not believe that this is a trend of the bank deposits. There is a good deal of natural variation of the sand in a deposit of this size, even at a given time. However, the sediment throughout the bank and the outwash deposit in general, including the 1998, 2003, and 2006 sample sets is remarkably uniform in the medium sand range (1 to 2 phi), with good to moderate sorting values.

Please feel free to contact me if you have any further questions.

Yours truly,

Peter S. Rosen

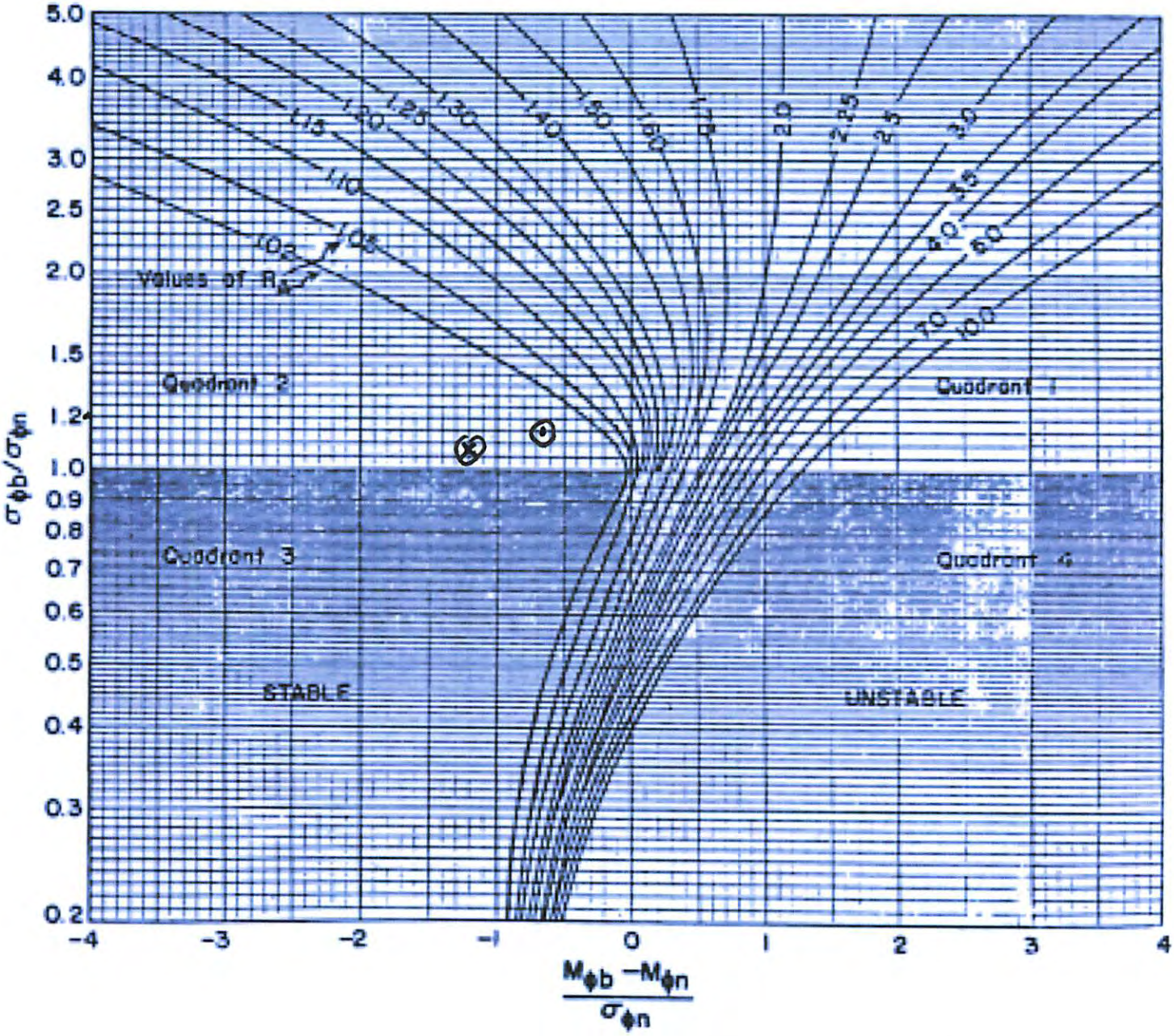
Peter S. Rosen, Ph. D.
Coastal Geologist

Attachments:

1. James Overfill Factor Plot
2. Data worksheet

JAMES OVERFILL FACTOR (R_A)

'BEACH': 2006 BANK COMPOSITE FROM REVETMENT AREA.



SOURCE: ⊙ HOLDGATE

⊗ REIS

Sconset Beach James Overfill Calculation Worksheet 4-Sep-13

Borrow area to bank comparisons

Borrow Area:	Beach/Bank	sd borrow/ sd beach	mean borrow - mean beach/ sd beach	Overfill Factor (RA)
Holdgate Pit	2006 bank data	1.14	-0.66	1
Reis Pit	2006 bank data	1.09	-1.21	1
Bank Composite	(based on samples in revetment project area)			
2006 bank composite	mean	1.34		
	sd	1.17		

2006 Bank Samples within Revetment area		
	Mean (phi)	Phi Sorting
L12 UBK	2	0.95
L12 MBK	1.14	1.28
L12 LBK	1.15	0.85
L13 UBK	2.4	0.93
L13 MBK	2.48	1.17
L13 LBK	0.57	0.77
L14 UBK	1.25	0.73
L14 MBK	1.78	1.36
L14 LBK	1.31	1.02
L15 UBK	1.26	1.31
L15 MBK	1.8	1.38
L15 LBK	1.48	1.44
L16 UBK	1.2	1.51
L16 MBK	1.23	1.3
L16 LBK	0.96	1.37
L17 UBK	1.12	1.42
L17 MBK	1.44	1.32
L17 LBK	0.73	1.22
L18 UBK	1.37	1
L18 MBK	0.8	1.01
L18 LBK	0.76	1.2
Mean of Samples in Revetment Project Area		
	1.34	1.17

Source:

2006 Data from CP&E spreadsheets, Lines 12-18